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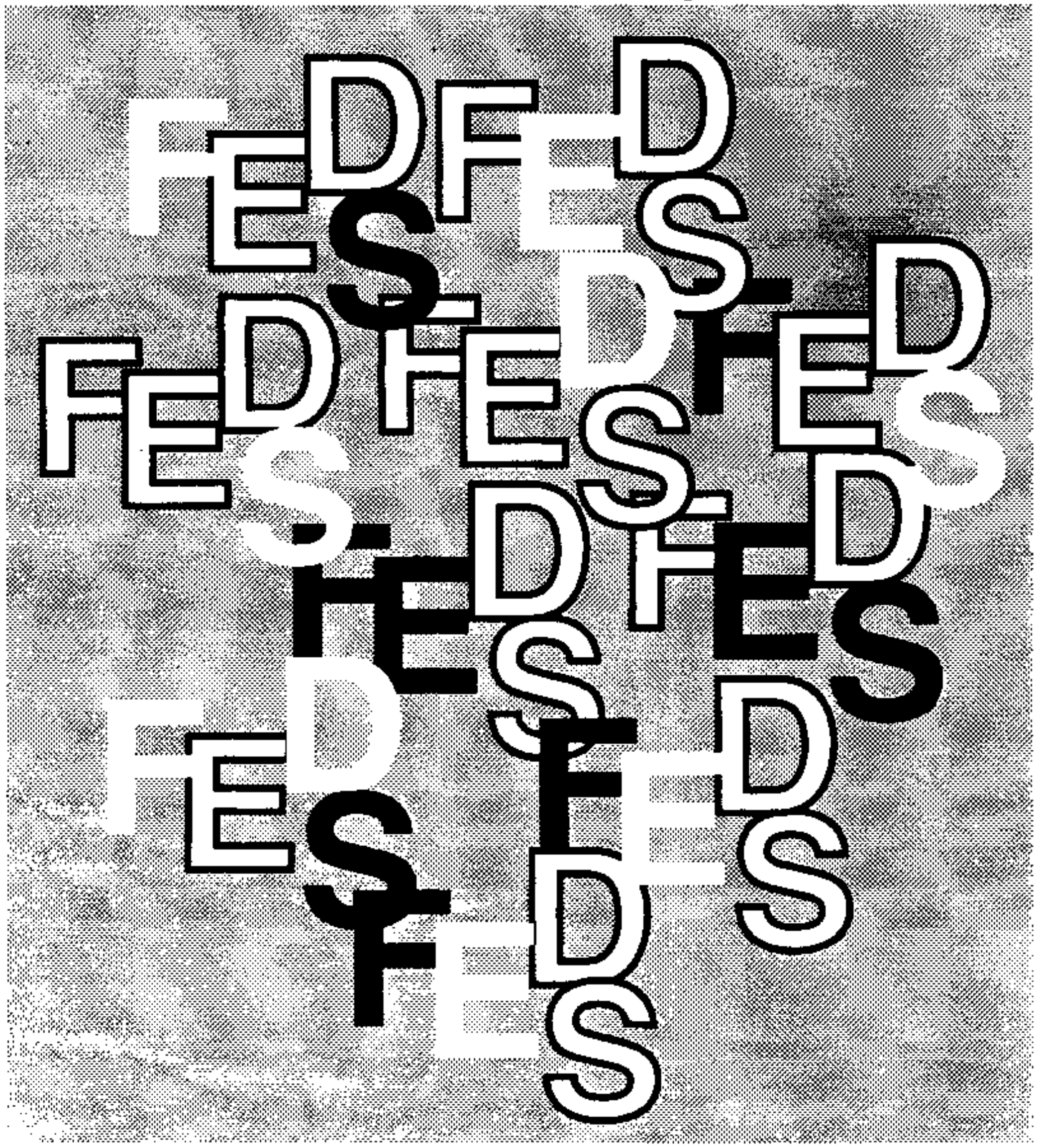

Working Studies 1: Part 1

OPERATING PROCEDURES AND THE CONDUCT OF MONETARY POLICY: CONFERENCE PROCEEDINGS

Special Issue Editors:
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Operating Procedures and the Conduct of Monetary Policy:
Conference Proceedings

ABSTRACT

The Federal Reserve System, through its Committee on Financial Analysis, sponsored a conference on monetary policy operating procedures and strategies which was hosted by the Federal Reserve Bank of St. Louis on June 18-19, 1992. An update on the academic and System staff views of such issues seemed desirable because it had been a decade since the last broad examination of operating procedures, which appeared in "New Monetary Control Procedures".[1] Since that time, the Federal Reserve has shifted from reserve-based operating procedures tied closely to movements in transactions money to discretionary changes in reserve conditions keyed to a variety of indicators of developments in broad money and credit, financial markets more generally, and the economy. Meanwhile, the operating procedures of foreign central banks have also been evolving, perhaps with implications and lessons for the Federal Reserve. The conference was intended to review these developments and relate them to achievement of longer-term objectives for the United States economy, and to stimulate further thinking and research on topics related to the design and execution of monetary policy.

To these ends, System economists prepared and presented the papers in this volume, which were reviewed by discussants. Professor Bennett McCallum of Carnegie-Mellon University and Professor John Taylor of Stanford University were invited to discuss specific papers and provide overviews of the entire conference proceedings. Their overviews appear at the end of this volume.

The conference was organized by Al Broaddus (then Director of Research and currently President) and Marvin Goodfriend of the Federal Reserve Bank of Richmond and by David Lindsey (Deputy Director) and David Small of the Division of Monetary Affairs of the Board of Governors of the Federal Reserve System.

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April 2, 1993

1. Board of Governors, 1981. A more narrowly focused study was conducted by the Federal Reserve Bank of New York in "Intermediate Targets and Indicators for Monetary Policy: A Critical Survey", 1990.

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FEDERAL RESERVE TOOLS IN THE MONETARY POLICY PROCESS IN RECENT DECADES

Ann-Marie Meulendyke[1]

Most students of money and banking in the United States would identify open market operations, reserve requirements, and the discount rate as the basic tools of monetary policy. They would add that open market operations are the primary, most actively employed tool because of their flexibility and ease of use. The historical roles of open market operations in the conduct of monetary policy under the guidelines established by the Federal Open Market Committee (FOMC) were examined in some detail in an earlier article by the author.[2] This article provides parallel treatment for reserve requirements and the discount window. Both articles focus on the years since the 1951 Treasury-Federal Reserve Accord, an agreement that freed the Federal Reserve from the obligation to peg interest rates on U.S. Treasury debt and enabled it to resume an independent monetary policy.

Before beginning the review of reserve requirements and the discount window, it may be helpful to summarize the main findings on open market operations. Since the Accord, the FOMC has used various money and credit measures, as well as assessments of the underlying economic and price picture, as intermediate objectives to guide the settings of its operating instruments. Reserve measures and interest rates have alternated as the FOMC's primary guide for day-to-day operations.

In the first two decades after the Accord, the Trading Desk at the New York Federal Reserve Bank carried out the FOMC's instructions

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1. Manager and Senior Economist, Open Market Department, Federal Reserve Bank of New York. Ted Tulpan provided excellent research assistance. The author wishes to thank Peter Sternlight, Betsy White, John Wenninger, Bruce Kasman, and Spence Hilton of the New York Federal Reserve and Robert Hetzel of the Richmond Federal Reserve for helpful comments on an earlier draft.

2. Ann-Marie Meulendyke, "A Review of Federal Reserve Policy Targets and Operating Guides in Recent Decades," *Intermediate Targets and Indicators for Monetary Policy: A Critical Survey*, Federal Reserve Bank of New York, July 1990. Reprinted from Federal Reserve Bank of New York *Quarterly Review*, vol. 13, no. 3 (Autumn 1988), pp. 6-17.

for achieving the desired average behavior of various measures of bank credit. Operating decisions were keyed to free reserves--reserves in excess of those needed to meet reserve requirements less reserves borrowed at the discount window--and to the tone and feel of the money markets. By the 1970s, the monetary aggregates had replaced credit measures as intermediate targets and the day-to-day emphasis shifted toward controlling the overnight interbank rate, called the federal funds rate.

During the 1970s, adjustments to the federal funds rate were generally small, and at times there was a reluctance to make necessary increases in the rate. Partly as a result, money growth persistently exceeded its targets, and inflationary pressures reached clearly unacceptable levels by the latter part of the decade. In 1979, the FOMC changed its approach to policy. Under the new procedures, it targeted levels of nonborrowed reserves, a measure that was closely linked through reserve requirement ratios to desired growth rates of a narrowly defined measure of money, M1. In addition, it allowed the federal funds rate to move over a much wider range than before to increase the likelihood that money growth would be brought under control. Although these procedures contributed to increased fluctuations in both money and interest rates, they did help to bring down average money growth and inflation.

At the same time, however, the creation of money substitutes and the deregulation of interest rates were making M1 a less reliable guide to future behavior of economic activity and prices. Consequently, the FOMC changed procedures once again late in 1982, adopting a borrowed reserve procedure resembling the free reserve technique of the 1960s. The degree of reserve pressure--defined as the volume of reserves that banks as a group were forced to borrow at the discount window--was adjusted judgmentally when developments in the economy, money, or prices suggested that a change was appropriate. Over time, the borrowing relationship that underpinned this approach has become less dependable. Consequently, the Desk has once again come to rely more closely on the behavior of the federal funds rate, although the rate has not become a formal target.

RESERVE REQUIREMENTS

This section reviews the various roles of reserve requirements in the monetary policy process. It describes how the monetary authorities, charged with determining appropriate reserve requirements, have responded to the distinct and sometimes conflicting interests of the Federal Reserve, the banks, and the Treasury.

Particular attention is given to the different parties' views of the optimal level of reserve requirements. Historically, banks have sought to minimize reserve requirements. Because the reserves that banks must hold against their deposits do not pay interest, the requirements act as an implicit tax on deposit creation. By contrast, the Treasury has sometimes resisted efforts to lower requirements because reserves provide it with an indirect source of revenue. The effective tax is sensitive to both the level of required reserves and of interest rates and has consequently been subject to considerable variation over time.

The Federal Reserve, approaching the issue from a somewhat different perspective than either the Treasury or the banks, has viewed requirements as a mechanism that can help to stabilize the demand for reserves. It has sought to make them high enough to promote that stability but low enough to minimize the distortions in resource allocation that inevitably accompany any tax. The Board's most recent cuts in requirements were intended to reduce the implicit tax on banking. The lowered requirements reduced the effective tax to less than $1 billion; it helped depositories improve earnings and deal more effectively with both strains on their capital and dramatically increased insurance premia. Along with their desirable effects, however, the recent reductions brought required reserves to levels that no longer met many banks' reserve needs for clearing purposes. Consequently, the total demand for reserves became more difficult to predict, and the use of open market operations became more complicated.

The history of reserve requirements since the 1951 Accord encompasses numerous regulatory changes and legislative initiatives that attempted to address these conflicting interests. Effective required reserve ratios have been cut substantially on balance over the years, both to reduce the distorting impact of the implicit tax on the behavior of banks and their customers and to change reserve pressures. Reserve requirements since the Accord are shown in Chart 1. Required reserve balances at the Federal Reserve are currently very similar in level to those of the early 1950s despite the massive growth in deposits over the intervening decades.

The Roles of Reserve Requirements

Over the years, analysts have attributed several different roles to reserve requirements in the policy process. The literature since World War II has most commonly cited two--money control and revenues for the Treasury.[3] Reserve requirements could affect the process of monetary control by their existence and through changes in the mandated ratios of reserves to deposits. The existence of requirements provides the linkage that allows changes in reserve levels, accomplished through open market operations, to encourage a change in monetary deposits. In theory, in a system where required reserves are a specified fraction of deposits, an increase in the amount of reserves provided to the banking system should be associated with an increase in reservable deposits in an amount that is a multiple of the reserve increase. The size of the multiple would be the inverse of the required reserve ratio, as in the classic textbook reserve multiplier process. In practice, the relationships linking reserves and deposits are far from precise, partly because not all deposits are subject to the same reserve requirement ratios and partly because excess and borrowed reserve levels can vary.

The primary direction of causality linking deposits and reserves will depend upon the Federal Reserve's guidelines for reserve provision. Regardless of its operating procedures, the Fed has found the existence of reserve requirements to be a valuable tool of monetary policy because

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3. See Marvin Goodfriend and Monica Hargraves, "A Historical Assessment of the Rationales and Functions of Reserve Requirements," Federal Reserve Bank of Richmond *Review*, March-April 1983, for an excellent review of the rationales for reserve requirements.

requirements contribute to a stable demand for reserves.[4] A number of observers have argued that reserve requirements are not essential because banks would demand reserves in any case to settle transactions with other banks and to avoid overdrafts.[5] Many Federal Reserve commentators have rejected this claim, contending that the voluntary demand for reserves would probably not be stable in the absence of requirements because the banks would always be trying to minimize excess reserves but would have varying degrees of success depending on each period's reserve flows.[6]

The Board of Governors of the Federal Reserve System may also change reserve requirement ratios to influence monetary policy. To force a contraction in deposits, the Board can raise requirements; to encourage more expansion, it can lower requirements. Although such measures may accomplish desired adjustments in reserve availability, they tend to be a blunt instrument, not well suited to fine tuning. The Federal Reserve discovered that problem in the 1930s, when legislation first gave it the power to change reserve requirements. In recent decades, it has generally used open market operations to cushion the immediate impact of a reserve requirement change.

As noted earlier, reserve requirements have also been seen as a source of revenue for the Treasury since they represent an implicit tax

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4. Gordon H. Sellon, Jr., "The Instruments of Monetary Policy," Federal Reserve Bank of Kansas City *Economic Review*, May 1984, pp. 3-20, discusses this issue.

5. For examples, see Deane Carson, "Is the Federal Reserve System Really Necessary?" *Journal of Finance*, vol. 19, no. 4 (December 1964), pp. 652-61; and Robert E. Hall, "A Free Market Policy to Stabilize the Purchasing Power of the Dollar," in Barry Seigel, ed., *Money in Crisis: The Federal Reserve, The Economy, and Monetary Reform*, Pacific Studies in Public Policy (Cambridge, Massachusetts: Ballinger, 1984), pp. 303-21. Thomas Mayer, *Monetary Policy in the United States* (New York: Random House, 1968), pp. 39-43, discusses the theoretical arguments against requirements but concludes that they are useful, giving reasons similar to those cited in the text.

6. Richard D. Porter and Kenneth J. Kopecky, "The Role of Reserve Requirements as a Public Policy Tool," *Conference on Reserve Requirements and the Role of the Federal Reserve System*, Washington, D.C., January 18-19, 1979.

on deposit creation. Required reserves on which no interest is paid reduce bank earnings--at least to the extent that the level of reserves exceeds what banks would hold voluntarily. They also enhance the revenues of the Federal Reserve because the Fed buys interest bearing Treasury debt when it supplies the reserves. The Treasury benefits indirectly because the Federal Reserve turns its profits over to the Treasury. How burdensome a given level of requirements will be for banks depends on several factors, but especially on the level of nominal interest rates: the higher the rates, the greater the earnings forgone. Mindful of the "tax" effects of increasing reserve requirement ratios, the Federal Reserve has often turned to other tools when it wanted to tighten policy.

Policy Responses to Conflicts between Treasury Revenues and Money Control. Federal Reserve and government policies toward reserve requirements from the end of World War II through 1980 were significantly influenced by ongoing strains arising from the different reserve objectives of the government, the Federal Reserve, and the banks. Membership in the Federal Reserve was voluntary for state-chartered banks, so they could escape the tax by dropping their membership. (State requirements were lower and generally could be met by maintaining balances at other banks, for which services were provided, and sometimes by holding Treasury bills, which paid interest.) The Federal Reserve wanted reserve requirements to be broad based enough to facilitate money control.[7] The Fed believed that reserve requirements could be set in a way that would strengthen the linkages between reserves and money and between reserves and short-term interest rates. The existing structure encouraged departures from Federal Reserve membership that weakened those linkages.

The Federal Reserve proposed two solutions to this conflict during the 1970s. First, it called for universal membership so that all banks would be subject to the Fed's reserve requirements. Second, it proposed paying interest on required reserves to offset the banks'

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7. G. William Miller, "Proposals on Financial Institution Reserve Requirements and Related Issues," testimony before the House Committee on Banking, Finance and Urban Affairs, July 27, 1978.

revenue loss and to make membership in the Federal Reserve System attractive.[8] The generally high nominal interest rates prevailing during the 1970s made requirements particularly onerous and increased the incentive to surrender membership. Negotiations to address these issues culminated in the Monetary Control Act of 1980 (MCA). The act extended reserve requirements to all depository institutions while allowing membership to remain voluntary. It also lowered required reserve ratios to reduce the implicit tax on member banks.

Although the lower requirements helped to ease the implicit tax on banks, the exceptionally high interest rates of the early years of the 1980s lifted the implicit tax so that the potential earnings of many depositories were significantly diminished and their ability to pay competitive rates thereby constrained. Wide spreads between market rates and deposit rates encouraged depositors to move funds into instruments exempt from reserve requirements. The Federal Reserve continued to ask for the right to pay interest on required reserve balances (in conjunction with allowing interest on demand deposits) but its appeals were not successful.[9]

The eight-year phase-in period for the new reserve requirement structure mandated by the MCA discouraged the Fed from making changes in requirements for monetary policy purposes. The role of requirements in money control continued to be discussed; it was especially important between 1979 and 1982 when the Fed was seeking to control M1 by adjusting nonborrowed reserves.[10] Thereafter, as the Fed moved away

8. Both the Federal Reserve's proposals for legislation and some alternative proposals appear in Miller, "Proposals on Financial Institution Reserve Requirements."

9. See statement by J. Charles Partee before the Subcommittee on Financial Institutions Supervision, Regulation and Insurance of the House Committee on Banking, Finance and Urban Affairs, October 27, 1983, reported in the *Federal Reserve Bulletin*, November 1983, pp. 850-51.

10. To improve the linkage between reserves and deposits, the Federal Reserve did switch from lagged reserve accounting to almost-contemporaneous reserve accounting, a change that was announced in 1982 but not put into effect until 1984.

from M1 control, the reserve-M1 linkage received less attention. Nevertheless, even now the linkage is used to forecast required reserves and banks' demand for reserves.

Required Reserves and Their Role in Bank Liquidity. In the nineteenth and early twentieth centuries, most analysts believed that an important function of required reserves was providing liquidity to the banks. Most postwar commentary on reserve requirements has, however, downplayed the idea. Many writers have pointed out that if banks have to hold reserves to meet requirements, they cannot simultaneously use those reserves to make loans or handle unexpected withdrawals.[11] That conclusion is almost certainly appropriate when the object is to provide liquidity over time.

Nonetheless, reserve balances do provide a very important form of liquidity for periods shorter than the time interval over which requirements must be met on average (one or two weeks in recent decades). These balances constitute a clearing mechanism for interbank check and wire transfers. Far from being sterile balances sitting idly at the Federal Reserve, as they are described in many textbooks, reserves actually flow from one depository institution's account to another's many times a day.

The short-run liquidity role of reserve requirements garnered some attention within the Federal Reserve during the 1980s. At that time, the Fed was seeking an explanation for observed increases in excess reserves.[12] Understanding the importance of the Fed's findings

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11. Before the founding of the Federal Reserve, there was no regular mechanism to produce extra reserves to meet seasonal credit needs. Small banks kept part of their reserves in the form of deposits at large banks and used those reserves to meet their seasonal needs. The withdrawal of interbank deposits from the large cities actually extinguished reserves, forcing interest rates to climb sharply higher at those times. These liquidity problems have been widely discussed. See, for instance, Thomas Mayer, James S. Duesenberry, and Robert Z. Aliber, *Money, Banking, and the Economy*, 3d ed. (New York: W.W. Norton and Company, 1987), pp. 28-29.

12. The large volumes of daylight overdrafts also alerted the Federal Reserve to some banks' heavy dependence on reserve balances for clearing activities.

requires a brief review of the composition and uses of required reserves.[13]

Since 1959, banks have been able to satisfy reserve requirements by holding vault cash and reserve balances at the Federal Reserve. Beginning in 1968, the vault cash applied to meeting reserve requirements in the current period was the vault cash banks had held in an earlier period. Consequently, vault cash could not play a role in meeting the banking system's marginal reserve requirements once a reserve maintenance period began. Since the reserve requirement restructuring of the 1980s, many depository institutions, including small commercial banks, thrifts, and credit unions, were able to meet their reserve requirement with vault cash alone. It does not appear, however, that the requirements determine the institutions' holdings of vault cash; instead these institutions base their holdings on anticipated customer demands for currency and a strong preference not to be embarrassed by shortages of cash. For institutions that consistently meet or more than meet their reserve requirements with vault cash ("nonbound" institutions), reductions in the level of the requirements are of no consequence.[14]

Those medium and large depository institutions that do not cover their whole requirement with vault cash ("bound" institutions) have to hold on average during each reserve maintenance period sufficient reserve balances at the Federal Reserve to meet the remainder of their requirement (called required reserve balances). But those reserve balances also serve as the means of payment for the clearing and settlement process. Any depository that does even a portion of its own clearing of checks or funds wires has to maintain a reserve balance to facilitate that clearing.

The volume of transactions executed each day using reserve accounts as a means of payment has long been high relative to the

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13. The following discussion draws heavily from Ann-Marie Meulendyke, "Monetary Policy Implementation and Reserve Requirements," internal working paper, September 1992, pp. 3-5.

14. The Federal Reserve excludes surplus vault cash from its measures of total and nonborrowed reserves.

balances held in the accounts. For many depositories, reserve balances turn over many times a day. That turnover rate has had an upward trend. The trend reflects cuts in reserve requirements that occurred between 1980 and 1984, and again in 1990 and 1992, and increases in the volume of transactions being processed by the Federal Reserve.[15] Charts 2 and 3 show recent patterns in these measures.[16] The daily flows have a large predictable component, but considerable potential for surprise remains. The Federal Reserve generally processes instructions to pay out reserve balances even if the action puts the sending bank into overdraft. The Fed imposes a penalty charge on any institution that ends the day overdrawn. Consequently, depository institutions have to aim for a significant positive end-of-day balance to minimize the risk of an inadvertent overdraft, regardless of their reserve requirements. When reserve requirements were reduced, it became more common for precautionary needs to exceed required reserve balances.

Depository institutions can deal with these additional precautionary reserve needs by holding excess reserves, but this strategy is costly since no interest is paid on reserves. When required reserve balances declined in the early 1980s and again at the end of 1990, depositories continued to try to minimize excess reserve holdings, but they were restricted in their ability to do so as the difficulties in avoiding overnight overdrafts became more severe. If they ended up with excess reserves, they might not be able to work them off later in the same maintenance period without risking being overdrawn. In trying to cope with the narrowing of ranges of reserve balances that were

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15. Since 1980, depositories have been able to establish required clearing balances to provide some reserve management flexibility. These are additional reserve balances that depositories agree in advance to hold. In return, they receive credits to pay for priced Federal Reserve services. The level of priced services used by a depository provides an effective maximum demand for required clearing balances. Required clearing balances were fairly small until after the 1990 cut in reserve requirements, when many large banks started to hold them.

16. Fedwire transactions have the largest impact on reserve balances, but other wire transfer operations and check processing transactions also lead to reserve transfers. These other transactions raise the turnover rate for reserve balances even further.

acceptable in the management of reserves, depositories devoted considerable resources to monitoring internal reserve flows. In the process, they became less tolerant of excess reserves early in maintenance periods because of their diminished ability to work them off in subsequent days. These developments restricted the depositories' day-to-day flexibility in managing reserves, caused more frequent bulges in excess reserves, and added to end-of-day volatility in the federal funds rate.

Reserve Requirements in the 1950s and Early 1960s

At the time of the Treasury-Federal Reserve Accord of 1951, reserve requirement ratios on demand deposits of Federal Reserve member banks were 24 percent for banks located in "central reserve cities" (New York and Chicago), 20 percent for member banks in "reserve cities" (other cities with Federal Reserve Banks or branches), and 14 percent for "country banks" (the term for all other member banks). The reserve ratio for time and savings deposits was 6 percent for member banks in all locations.

During the fifteen years between 1951 and 1966, requirements were raised on five occasions and were lowered ten times.[17] The changes in reserve requirements were sometimes made in conjunction with complementary changes in the discount rate, while at other times the moves were made independently. Open market operations were used to cushion the changes in reserve requirements, so that hardly any of the immediate impact of the reserves released or absorbed was felt as a change in excess or borrowed reserves.

In those years, the Federal Reserve formally described reserve requirements as a policy tool used to make reserves more or less plentiful so as to alter credit availability and money market interest

17. Reserve requirement ratios were changed for several reasons over these years. Although many of the changes were undertaken to make reserves more or less costly as part of the monetary policy process, changes were also made to meet seasonal reserve demands and to implement the 1959 legislation aimed at equalizing reserve ratios at central reserve and reserve city banks. In addition, ratios were slightly modified in 1966 when tranches were introduced for both demand and time deposits. At the same time, savings accounts were separated from time deposits for required reserve calculations.

rates--the near-term policy goals of the time.[18] Its decisions about reserve requirements were, in practice, constrained by the exodus of small banks from the Federal Reserve System in the 1950s. Legislation passed in 1959 addressed an apparent inequity between large and small banks in an attempt to make membership more attractive for the small banks. Country banks had lower nominal reserve requirements, but they often had to tie up relatively large sums in non-interest-earning balances that did not serve any other purpose. (A reserve city bank generally handled payment clearing for them.) Because of their customer bases, most country banks had to hold relatively high amounts of vault cash, but they could not use these holdings to satisfy requirements. The 1959 act permitted the Fed to count vault cash toward meeting reserve requirements. That change--implemented in three steps during 1959 and 1960--reduced effective requirements, especially for country banks. It was hoped that the lower requirements would encourage those banks to remain members of the Federal Reserve.

Contemporary Views of Reserve Requirements. A commonly held view about reserve requirements was expressed by a presidential commission appointed in 1963 to study financial institutions. The commission concluded that "there is, within broad limits, little basis for judging that in the long run one level [of reserve requirement ratios] is preferable to another in terms of facilitating monetary policy."[19] The commission felt that the effects of requirements on bank earnings and Treasury revenues should be the primary factor considered in choosing reserve ratios. While it saw the advantages to bank profitability of a significant cut, it believed that the cost to the Treasury would be too great.

Some academic literature of the time offered other views on reserve requirements and monetary control. Several articles and books dealt with the concept of fractional reserve requirement ratios and

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18. Board of Governors of the Federal Reserve System, *Annual Report*, various years.

19. Report of the Committee on Financial Institutions to the President of the United States. Walter W. Heller, Chairman. Washington, D.C.: Government Printing Office, 1963, p. 12.

described the strengths and weaknesses of that structure. Tolley analyzed the tax implicit in reserve requirements.[20] He suggested that the level of reserve requirement ratios and hence of the amount of the tax had come about by accident. He then tried to establish a rationale for such a tax. He believed that under a gold standard, a system in which real resources had to be devoted to producing money, a fee was appropriate to encourage people to economize on the use of money. But when the cost of producing money is trivial, as it is with fiat money, the only justification for a charge is that the government could benefit from the revenues arising from the Federal Reserve's provision of reserves. Tolley went on to observe, however, that the government's gains would cause misallocation of resources as banks took actions to reduce the effect of the tax. Such a distortion would argue for very low reserve requirements. But Tolley thought very low requirements might make monetary control difficult because shifts between currency (which is effectively subject to a 100 percent reserve requirement) and deposits would have a large impact on the amount of money created, as would mistakes in estimating reserve provision. Hence, he recommended that interest be paid on required reserves so that requirements would not need to be reduced.

Friedman also discussed how shifts in preferences between currency and deposit holdings could ease or tighten reserve conditions.[21] He reiterated the arguments from the 1930s for 100 percent reserve requirements. Such requirements had been proposed as a solution to the unpredictable multiplier effects of fractional reserve accounting arising from the differential treatment of deposits and currency. Friedman also recognized the undesirable tax effect of 100 percent requirements and described the inevitable incentive for money and credit provision to move outside the regulated area of banking. To combat that problem, he recommended paying interest on reserves. Later,

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20. George S. Tolley, "Providing for Growth of the Money Supply," *Journal of Political Economy*, December 1957, pp. 477-85.

21. Milton Friedman, *A Program for Monetary Stability* (New York: Fordham University Press, 1959), pp. 65-76.

the Federal Reserve seriously considered the proposal to pay interest on reserves; it has periodically requested authority to do so from the Congress.

Reserve Requirements in the Latter Part of the 1960s and 1970s

Reserve requirements continued to be raised and lowered to reinforce tightening or easing moves implemented with other tools during the rest of the 1960s and 1970s. Requirements were increased four times and decreased seven times during these years.[22] Sensitivity to the membership problem sometimes made the Federal Reserve Board hesitant to raise requirements. On occasion, the Board raised them just on large time deposits--deposits mostly issued by the large banks, which were the least able to give up the services provided by Fed membership. The combination of higher inflation and higher interest rates that emerged during these years drew increasing attention to the tax burden of reserve requirements and the related question of differential treatment of member and nonmember banks.

The Federal Reserve appointed a study group headed by Robert Black to review reserve requirement ratios. The group reported its recommendations in 1966.[23] The primary result of that study was the decision to move from near-contemporaneous reserve requirements with one-week reserve maintenance periods for reserve city banks and two-week periods for country banks to weekly reserve periods for all member banks with a two-week lag between the computation and maintenance periods. This change was believed to make calculating requirements easier for the banks and the New York Fed's Trading Desk.[24]

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22. The count does not include the 1972 restructuring that raised requirements for some banks and lowered them for others, as described later in the text.

23. Robert P. Black, *Report of the Ad Hoc Subcommittee on Reserve Proposals*, May 13, 1966.

24. The other change was to permit banks to carry forward reserve excesses up to 2 percent of required reserves for one reserve period. (Banks already had the authority to carry forward 2 percent of reserve deficiencies.)

Lagged reserve requirements weakened the direct linkage between reserves and money, making it harder, in theory, to manipulate reserves as a means of controlling money. For the most part, the Federal Reserve did not see any reason to be concerned because it was not attempting to control money in this way. Instead, the Fed was attempting to affect money growth indirectly by influencing the demand for money. It altered the cost of obtaining reserves and hence the cost at which credit was provided.[25]

In 1972, another Federal Reserve reform addressed the problem of retaining member banks. For both reserve city and country banks, reserve requirement ratios were to be graduated on the same schedule by volume of deposits. The change represented a significant cut in reserve requirements for small banks in Federal Reserve cities and caused some large banks outside of Federal Reserve cities to face higher requirements. The series of graduated steps in the required reserve schedule further weakened the relationship between required reserves and monetary deposits, an outcome that distressed those economists who wanted to see the Federal Reserve control reserves in order to control money growth. At the time, the Federal Reserve was targeting the federal funds rate and reserve requirements were lagged, so the concerns were not immediately relevant to operations.[26]

Nonetheless, Federal Reserve membership continued to decline. The Federal Reserve proposed paying interest on reserves on a couple of

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25. Lyle E. Gramley and Samuel B. Chase, Jr., "Time Deposits in Monetary Analysis," *Federal Reserve Bulletin*, October 1965, pp. 1380-1404.

26. Nonetheless, shortly afterwards the Federal Reserve did take limited steps to use reserve targeting when it experimented with reserves on private deposits. See Ann-Marie Meulendyke, "A Review of Federal Reserve Policy Targets and Operating Guides in Recent Decades," *Intermediate Targets and Indicators for Monetary Policy: A Critical Survey*, Federal Reserve Bank of New York, July 1990, pp. 463-64.

occasions in the 1970s to halt the decline, but the revenue loss to the Treasury engendered strong congressional opposition.[27]

The Monetary Control Act and Reserve Requirements in the 1980s

At the end of the 1970s, the Federal Reserve once again tried to achieve universal membership. Although it did not literally accomplish that, it did achieve, through the 1980 MCA, the most important goal associated with expanded membership: the extension of reserve requirements to all depository institutions. Furthermore, the Fed was permitted to collect deposit data on an ongoing basis from all but the smallest depositories, enabling it to improve both estimates of actual money and forecasts of future money. Reserve requirement ratios for member banks were cut over a four-year period from a top rate of 16 1/4 percent to a top rate of 12 percent on transactions deposits. A low reserve tranche was also established of 3 percent on the first $25 million of deposits, with the amount allowed to rise over time.[28] Nonmember banks and thrifts that faced the increases in requirements were given an eight-year phase-in period to reach the final levels of requirements specified in the act. The Federal Reserve Board retained the option to adjust reserve ratios within specified bands.

The MCA was directed toward improving the Fed's ability to control money. It focused on deposits in M1, the primary intermediate policy variable at the time. It did not, however, provide any scope for using reserves to control M2, a secondary target at the time the act was passed but the primary monetary target later in the decade. Money market mutual fund balances remained exempt, and MCA actually took away from the Federal Reserve the power to impose reserve requirements on personal time and savings deposits.

Aside from the changes to reserve requirements mandated by the legislation, only minor modifications were made to reserve requirements

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27. Specific proposals to pay interest on reserves were introduced in the Congress in 1977 and 1978. See Stuart E. Weiner, "Payment of Interest on Reserves," Federal Reserve Bank of Kansas City *Economic Review*, January 1985, pp. 20-21.

28. In 1982, the Garn-St Germain Act modified the reserve requirement structure further to introduce a zero requirement tranche.

during the 1980s.[29] Because the structure of requirements had been set within specified limits by the MCA, it was generally felt that there was little point to considering policy-related changes in the ratios. Such changes would have been difficult to implement during the eight-year phase-in period. Since the legislation had not given the Federal Reserve the option to pay interest on reserve balances, the Board might have hesitated to raise requirements because of the implied increase in the tax burden.[30] Furthermore, the Federal Reserve believed it could achieve its objectives just as well through open market operations and discount window policy.

Excess Reserve Behavior and Potential Problems with Reserve Requirements. The Federal Reserve saw increasing evidence during the 1980s that depository institutions were having difficulty managing reserves. These observations suggested that reserve requirements might be inadequate for smooth monetary operations. Normal levels of excess reserves rose fairly steadily in the years following passage of the MCA. Some of the increase was the inevitable result of extending reserve requirements to nonmember depository institutions.[31] But member bank excess reserves were also rising, in a pattern that contrasted with their behavior during much of the 1970s, when they generally hovered in a range near $200 million. The search for explanations led to several discoveries. It was observed that excess reserves tended to move inversely to required reserves not met by vault cash, both period to

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29. In March 1983, the Board eliminated reserve requirements on time deposits with an initial maturity of two and one-half years or more. In September 1983, it reduced the minimum maturity for exemption from requirements to eighteen months.

30. The MCA did provide for payment of interest on supplemental reserve requirements if such requirements were needed for monetary control. The provision has not been used.

31. At some point during the phase-in period, vault cash no longer met all of the larger nonmember institutions' requirements, and they opened reserve accounts at the Federal Reserve. Only then could these institutions have excess reserves. (Previously, they may have had excess reserves from their own perspective in the form of surplus vault cash and deposits at correspondents, but the Federal Reserve does not count these in its reserve measures.)

period and over time, as balances held at Federal Reserve Banks trended lower.[32] The sharp drop in required reserve balances between 1980 and 1984 occurred as lower reserve requirements were being phased in for member banks under MCA and the spread of automatic teller machines was encouraging rapid expansion of vault cash holdings (Chart 1).

Average required reserve balances rose again in the next few years, but excess reserves continued to expand at member banks as well as at nonmember banks. Conversations with officials at a number of banks underscored the growing role of large payments flowing through their reserve accounts. The volume of wire transfers over Fedwire--the Federal Reserve's wire transfer system--grew rapidly (Chart 3), making it increasingly difficult for banks to predict reserve balances. Since the Federal Reserve penalized end-of-day overdrafts, banks had to be careful not to aim for too low a reserve balance lest an unexpected late day outflow (or an expected receipt that did not arrive) should leave them overdrawn. These discoveries suggested that for a number of banks, reserve balances needed to meet requirements were not very different in size from those needed to manage clearing and settlement and to avoid overdrafts.

These factors were taken into account by the Federal Reserve in estimating the aggregate demand for excess reserves.[33] But they did not lead to serious discussions of the structure of reserve requirements during the 1980s.

Cuts in Reserve Requirements in the 1990s

The Federal Reserve Board eliminated reserve requirements on nontransaction deposits at the end of 1990. In explaining its action, the Board indicated that the existing structure had been designed

32. David Jones, "Excess Reserves under MCA," November 10, 1983, and David Small and Brian Madigan, "An Analysis of Excess Reserves," July 1, 1986, internal memoranda, Board of Governors of the Federal Reserve System.

33. Ann-Marie Meulendyke, *U.S. Monetary Policy and Financial Markets*, Federal Reserve Bank of New York, 1990, chap. 6.

"primarily to permit greater precision of monetary control when policy focused on reserve aggregate targeting." It went on to describe the changing conditions that had prompted its move:

> In subsequent years, as the Federal Reserve moved away from the procedures in effect in the early 1980s, which required a broad reserve base, reserve requirements on nonpersonal time accounts have become somewhat of an anachronism. Moreover, the current 3 percent requirement has placed depository institutions at a disadvantage relative to other providers of credit, spawning efforts to circumvent the requirement.
>
> The Board took action at this time also in response to mounting evidence that commercial banks have been tightening their standards of creditworthiness [a development that] has in recent months begun to exert a contractionary influence on the economy. . . . Lower reserve requirements at any given level of money market interest rates will reduce costs to depository institutions, providing added incentive to lend to creditworthy borrowers.[34]

The reduction in reserve requirements boosted earnings for some depository institutions but, as indicated earlier, it had the undesirable side effect of complicating reserve management for many institutions. With lower routine levels of required reserve balances, their ability to accept reserve variability from day to day within a two-week reserve maintenance period without either incurring an expensive overdraft or being stuck with unusable excess reserves was reduced. Depositories found they had to use considerable resources to hold down excess reserves. The action also complicated operations of the Open Market Trading Desk at the New York Federal Reserve Bank.

Relatively modest reserve excesses often inspired sharp declines in the federal funds rate, even on days that were not the ends of maintenance periods. Depositories had less ability to absorb and make use of the excess reserves because they could not run large deficiencies in subsequent days without ending overdrawn. When a number of depositories discovered toward the end of a day that they had excess reserve positions and tried to sell the funds into the interbank federal

34. *Federal Reserve Bulletin*, February 1991, p. 95.

funds market, their efforts often pushed the funds rate down sharply, sometimes almost to zero. At that time of day, it is too late for open market operations to be undertaken to affect that day's reserves. Hence, depositories as a group could not eliminate the excesses except by repaying discount window loans. In 1991, routine borrowing from this source was already at very low levels, so little could be repaid.

Low reserve balances also increased the likelihood of an incipient overdraft. Depositories that discovered they were overdrawn late in the day generally tried to cover the overdrafts by borrowing in the federal funds market. If funds were scarce systemwide, sufficient reserves might not be available. Depositories could obtain reserves from the discount window, but in the early months of 1991, many banks were unusually reluctant to borrow for fear that such a step could be read as a sign that they were in trouble. That reluctance to borrow often caused federal funds to be bid to very high levels before some banks finally turned to the window to cover the shortages.

The Desk's Approach to Managing Reserves in this Environment. At the time of the 1990 reserve requirement cut, the Desk was formally targeting borrowed reserves.[35] Because the relationship between borrowing and the funds rate remained unreliable, however, the Desk was also taking considerable guidance from the federal funds rate. The Desk still attempted to achieve the levels of nonborrowed reserves believed consistent with demands and the desired degree of reserve pressure, but demands became harder to gauge after the cut in requirements.[36] In choosing its reserve management strategy, the Desk had traditionally focused on two-week average reserve levels that banks had to hold over

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35. Ann-Marie Meulendyke, "A Review of Federal Reserve Policy Targets and Operating Guides in Recent Decades," *Intermediate Targets and Indicators for Monetary Policy: A Critical Survey*, Federal Reserve Bank of New York, July 1990, describes the formal procedures. Recent modifications are discussed in "Monetary Policy and Open Market Operations during 1990," Federal Reserve Bank of New York *Quarterly Review*, Spring 1991, pp. 66-74.

36. See "Monetary Policy and Open Market Operations during 1991," Federal Reserve Bank of New York *Quarterly Review*, Spring 1992, pp. 80-88.

the maintenance period as a whole, although it had also made efforts to avoid extreme movements in daily reserve levels. Once reserve requirements were reduced, the Desk had to pay increased attention to daily levels because of the depositories' diminished tolerance for being short or long relative to their requirements. The Desk often found that the funds rate in the morning was not a good guide to reserve availability; the rate sometimes plunged or rose sharply late in the day when the depositories finally discovered that reserves were plentiful or scarce.

Because market participants judged the Fed's policy stance by the behavior of the federal funds rate, the signaling of policy intentions sometimes conflicted with the desired reserve management strategy. If, for instance, an estimated reserve shortage coincided with a funds rate level below that perceived to be the target, the Desk had to decide whether to meet the estimated reserve need. If it met the need, it would risk giving a misleading indication that the stance of policy had been eased. But not meeting the need would increase the chances of a sharp rise in the funds rate late in the day, possibly accompanied by heavy discount window borrowing. Such greater than desired reserve pressure imposed an unintended cost on the banks and involved a risk that observers could be misled about policy. Although these conflicts had been a periodic feature of reserve management for years, they increased in frequency once levels of required reserve balances fell.

Reserve balances rose during 1991, helping to ease somewhat the difficulties of reserve management. However, another cut in reserve requirement ratios in April 1992 once more lowered the range of flexibility in day-to-day management of reserves, although typical reserve balance levels remained above those of the early part of 1992.[37]

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37. A series of papers prepared by the staff of the Federal Reserve Bank of New York after the 1990 cut in required reserve ratios considers the operational difficulties of low required reserve ratios and evaluates possible solutions. Overall, the papers suggest that the best solution to the reserve management problems encountered with low

THE ROLE OF THE DISCOUNT WINDOW IN POLICY IMPLEMENTATION

Like reserve requirements, the discount window has played a supporting role to open market operations in the monetary policy process. This section describes the guiding principles for discount window borrowing. It reviews the two main features of that borrowing, the rules that govern the use of the facility and the rate or rates that are charged. It then provides a chronological review of developments in the behavior of borrowing from the 1950s to the present.

The Philosophy behind the Discount Window Mechanism

Federal Reserve views of the discount window's roles changed considerably between the founding of the Federal Reserve in 1914 and the 1930s as open market operations gradually replaced discount window borrowing as the primary source of Federal Reserve credit. Then, between 1934 and 1950, the discount window fell into disuse, and there was little consideration of the roles of the window as a policy tool.

The Federal Reserve's concept of the policy role of the discount window was reexamined after the 1951 Accord and again in the latter half

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reserve balances would be to pay interest on reserves so that requirements could be increased without raising the costs to depository institutions.

The collection of papers also evaluates other alternatives. A return to more routine use of the discount window would provide the banking system with valuable flexibility, but overcoming the current strong reluctance to borrow appears to be a difficult challenge.

In the absence of such changes, only one of the other alternatives could provide more than modest help to the reserve management process: permitting banks to end the day overdrawn. Nonetheless, permitting overdrafts would have significant drawbacks. If this approach were to be seriously considered, permitted overdrafts would have to be collateralized and made subject to a modest charge. Even so, it seems to go against the thrust of efforts to reduce daylight overdrafts and could be seen as weakening the essential discipline of a reserve requirement structure.

Other approaches deserving consideration include expanding reserve carryovers and shortening the vault cash lag, variants of which have recently been introduced by the Board of Governors. These approaches, however, would raise reserve management flexibility only slightly.

of the 1960s. Both studies led to some modifications in the rules for borrowing but did not change the underlying philosophy. Most of the rule changes since the early 1970s have been small and have addressed specific concerns.

Since the Accord, the Federal Reserve's discount window policy has discouraged persistent reliance on borrowing. That stance has ensured that borrowed reserves generally represent only a modest share of total reserves. The Fed believes that the discount window should serve as a safety valve, a temporary source of reserves when they are not readily available from other sources.[38] The window in recent decades has been available to healthy banks for occasional, but not continuous, use.[39] Borrowing has been rationed through a variety of means that have encouraged a "reluctance to borrow." The degree of reluctance shown by the banks has varied considerably over the years, even in the absence of changes in the guidelines for borrowing.

At the same time, the Fed has counted on there being some amount of borrowing because borrowing is an element in the reserve adjustment process. In this context, the window has played a vital role in meeting unexpected reserve needs. Various open market operating procedures depend on some degree of stability in the banks' demand for borrowed reserves, but the administrative guidelines and changing bank attitudes have made this stability difficult to achieve. For much of the time since the mid-1960s, the discount rate has been below competing market rates, in particular the overnight federal funds rate. Consequently, administrative restrictions rather than the rate have had the biggest role in limiting the amount of borrowing. Banks have responded to the profit incentive to borrow, but in doing so they have had to factor in

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38. All borrowing from the Federal Reserve must be fully collateralized.

39. At times, the Fed also provides extended credit at market-based rates to banks whose financial difficulties have cut them off from regular sources of financing. Banks using the facility must work with their regulators toward a solution. That type of borrowing is not a monetary policy tool, and thus is not a focus of this piece.

some nonprice costs--such as potential loss of future access to the window--that are difficult to estimate.

During the 1980s, increasing financial difficulties and bank failures led banks to become more reluctant to borrow, even under conditions that would formerly have led them to borrow. The rise in banking crises made many banks fearful that if they borrowed, rumors would start that they were in financial trouble. Thus, the demand for borrowing became even less predictable, reducing the value of the relationship between borrowing and the spread between the Federal funds rate and the discount rate.

The direct cost represented by the rate charged for discount window borrowing has also played some role in the policy process. Changes in the rate have normally attracted general attention to the state of monetary policy, giving rate changes the potential for an announcement effect. The extent of the announcement effect has varied over time, depending on the verbal message given with the rate change and the way borrowing was being used in the policy process. Sometimes the Fed has sought to signal policy changes when it changed the rate. At other times it deliberately downplayed the significance of the move.

Changes in the discount rate are voted by the Boards of Directors of the twelve Federal Reserve Banks and approved by the Board of Governors. The governors generally approve changes in the rate when they want to signal a change in the stance of policy or when market rates have moved significantly away from the discount rate, so that the discount rate is "catching up" with the changes. Rate changes have normally complemented the guidelines established by the FOMC for the conduct of open market operations.

The discount rate per se has not, in the post-Accord period, been regarded as a primary means of influencing the amount of discount window borrowing. Indeed, because short-term interest rates have frequently exceeded the discount rate since the mid-1960s, rationing of the use of the window has had to be accomplished through means other than the rate. There have been numerous recommendations over the years that the rate be given the primary role in rationing credit, either because the approach was more straightforward and less arbitrary than rationing administratively or because the use of a below-market rate implied a subsidy. The specifics of the relationship between the discount rate and open market policy changed modestly when the techniques of policy implementation were changed but have throughout relied on administered disincentives to borrow.

The Discount Window in the 1950s Through the mid-1960s

Borrowing jumped dramatically in the early 1950s. It rose from an average of $130 million in 1950 to an average of $800 million in 1952. By December 1952, it had reached $1.6 billion. Interest rates rose after the Accord, and the discount rate lagged behind. (Chart 4 shows borrowed reserves and their share of total reserves between 1950 and 1965, along with the discount rate and short-term interest rates.) The cost structure made borrowing attractive for the first time since the early 1930s. An excess profits tax instituted in 1951 increased the incentive to use the discount window because borrowings served as an offset in computing the tax.

A Federal Reserve System committee was established in 1953 to examine the history of the rationales for borrowing. The committee concluded that the established "tradition against borrowing" should be encouraged because it contributed to the soundness of individual banks and the banking system.[40] The committee report served as the basis of the 1955 revisions to Regulation A, the regulation governing use of the window.[41]

The report observed that the founders of the Federal Reserve had expected the discount window to be the primary source of Federal Reserve credit. In the early years of the Federal Reserve, many member banks borrowed a substantial portion of the reserves they needed from the window; indeed, it was not unusual for a bank to borrow continuously. By contrast, in the years before the founding of the Federal Reserve, a bank that was heavily dependent on borrowed funds, rather than on its own capital and deposits, was believed to be more vulnerable to failure.

40. System Committee on the Discount and Discount Rate Mechanism, "Report on the Discount Mechanism," March 12, 1954.

41. *Federal Reserve Bulletin*, January 1955, pp. 8-14.

The committee noted that the development of open market operations during the 1920s as an alternative source of Federal Reserve credit made possible a gradual move to discourage heavy borrowing. Once again, banks that borrowed persistently came to be seen as more likely to fail, and this view was reinforced during the early 1930s when the number of bank failures soared. Mindful of this negative image, the banks themselves became reluctant to borrow and instead built up holdings of excess reserves during the latter part of the 1930s. This course of action was simplified by the monetization of the vast gold inflows inspired by the revaluation of gold in 1934 and by the approach of war in Europe in the latter years of the decade.[42]

By the early 1950s, however, a decade and a half with low numbers of bank failures had apparently reduced the banks' own reluctance to borrow to such an extent that many banks were inclined to return to the window when doing so became profitable. The committee felt this behavior should be discouraged. It reiterated the belief that a bank that used its own resources to meet increased demands for credit was healthier than one that was dependent on borrowed funds. In its 1954 report, the committee recommended that routine reserve provision be accomplished almost entirely through open market operations. The report also recommended limiting the term of borrowing to fifteen days under normal circumstances. It noted that most banks had emerged from the war with substantial portfolios of government securities that could be sold to raise additional funds for seasonal or other purposes. The regulations that were subsequently adopted guided discount officers in distinguishing between appropriate and inappropriate borrowing. Borrowing was considered inappropriate when the funds were used for normal business activities. In particular, the committee disapproved of borrowing to profit from interest rate differentials.

The role of the discount window during the rest of the 1950s and early 1960s generally followed the pattern set out by the committee's

42. Ann-Marie Meulendyke, *U.S. Monetary Policy and Financial Markets*, 1990, Chap. 2.

guidelines. There was some debate about whether the reluctance to borrow was motivated by the banks' own caution or by Federal Reserve restrictions. Some banks almost never borrowed, suggesting an internally generated reluctance. Many banks, however, apparently took account of the full cost of borrowing, including potential loss of future access, and borrowed when it was profitable. In that context, borrowing was rarely a large bargain. In fact, the discount rate was often slightly above short-term Treasury bill rates, although both borrowing and the incentive to borrow varied cyclically. Normally, borrowing was only a modest share of total Federal Reserve credit.

The Board of Governors approved periodic adjustments to the discount rate and issued a statement of purpose with each adjustment. Often the changes lagged market rates, and the Board explained its action as an effort to catch up with market rates. When the discount rate was low relative to other short-term rates, borrowing often rose. (The primary alternative rate was the Treasury bill rate in the 1950s; the federal funds market grew in importance during the 1960s.)

Some academic economists criticized the discount mechanism. They did not like the fact that banks were given mixed signals about borrowing, with the relatively low discount rate often encouraging use of the window while the administrative guidelines were discouraging it. They felt that the rules made it difficult to judge whether policy was tight or easy.[43] The authors preferred a rate that was set above market rates--a penalty rate--but urged that no administrative restrictions be placed on borrowing.

Discount Window Policy in the Late 1960s and 1970s

Higher interest rate levels in the latter half of the 1960s, especially the "tight money" episode of 1966, encouraged more borrowing (Chart 5). The decline in membership was also garnering attention, and there was concern the discount window was not sufficiently available to small

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43. See Milton Friedman, *A Program for Monetary Stability* (New York: Fordham University Press, 1959), pp. 38-41; A James Meigs, *Free Reserves and the Money Supply* (Chicago: University of Chicago Press, 1962); and Warren Smith, "The Discount Rate as a Credit-Control Weapon," *Journal of Political Economy*, April 1958, pp. 171-77.

member banks. A series of studies were undertaken during the late 1960s under the guidance of a steering committee of Federal Reserve Governors and Presidents.[44] The studies reviewed the history of the discount mechanism, compared the discount window with the tools and techniques of foreign central banks, evaluated some of its problems, and presented several possible reforms. The steering committee endorsed the practice of permitting banks to borrow only intermittently. It wanted to continue the administrative disincentives to frequent borrowing, but it was troubled that some banks seemed to get little or no benefit from the window. The summary report recommended some changes to make borrowing more convenient, especially for small unit banks with large seasonal swings in loan demand and limited access to the national credit markets. The report's recommendation of a special seasonal borrowing privilege for small member banks was adopted in 1973 and remains in effect, although it has been modified somewhat in recent years.[45]

The report also proposed that one form of adjustment credit should consist of a basic borrowing privilege that would give all (member) banks some access at reasonable cost to Federal Reserve credit based on published guidelines for amount and frequency of borrowing. Even the proposed basic borrowing privilege did not envision continuous borrowing: if a bank needed additional credit, its borrowing would be subject to scrutiny. The approach was not adopted, although the proposed frequency schedule did influence the informal guidelines used by the discount officers in subsequent years. Finally, the study brought to light considerable inconsistencies in the administration of the window by the different Federal Reserve Banks. Efforts were made to improve coordination in order to minimize those differences.

During the 1970s, Federal Reserve monetary policy focused on adjusting the federal funds rate to respond to deviations in money

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44. Board of Governors of the Federal Reserve System, *Reappraisal of the Federal Reserve Discount Mechanism*, 1971.

45. The seasonal borrowing privilege was extended to nonmember banks under the MCA. In 1992, the Board began charging a market rate on seasonal borrowing tied to the federal funds rate and certificate of deposit rates.

growth from desired ranges. The discount window generally played a subsidiary role in the process.[46] Changes in the discount rate were often motivated by changes in market rates, as they had been in earlier decades, although occasionally changes were intended to create an announcement effect.[47] The amount of borrowing generally increased as the federal funds rate rose relative to the discount rate, a relationship that suggested that banks were seeking to maximize profits through their borrowing decisions. The Open Market Trading Desk took that relationship into account when choosing how many nonborrowed reserves to provide, since the amount of desired borrowing affected the reserve levels consistent with the desired funds rate.

Relation between Discount Policy and Reserve Targeting from 1979 to 1982.

Borrowing took on increased importance after the October 1979 changes to reserve operating procedures. Under the new procedures, the Trading Desk provided only the level of nonborrowed reserves estimated to be consistent with targeted M1. If depositories needed additional reserves to meet their requirements because M1 was above target, they would have to borrow them at the discount window. In practice, the system was structured so that there was some borrowing even when M1 was on target. Only when M1 was far below target for a while in 1980 was

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46. Economists have debated the importance of the discount rate as a mechanism for changing policy. Sometimes Federal Reserve announcements indicated that the rate was changed to catch up with market rates. Other times they cited monetary policy concerns. At issue is whether these announcements had an impact beyond that of open market operations. See Cook and Hahn, "The Information Content of Discount Rate Announcements and Their Effect on Market Interest Rates," *Journal of Money, Credit, and Banking*, vol. 20, no. 2 (May 1988), pp. 168-80; Lombra and Torto, "Discount Rate Changes and Announcement Effects," *Quarterly Journal of Economics*, February 1977, pp. 171-76; and Daniel L. Thornton, "The Market's Reaction To Discount Changes: What's Behind The Announcement Effect? Federal Reserve Bank of St. Louis, Working Paper Series, November 1991, pp. 2-23.

47. In November 1978, reserve requirements, the discount rate, and the funds rate target were all raised simultaneously as a dramatic gesture to attack the rising rate of inflation and weakening exchange value of the dollar.

borrowing allowed to drop to frictional levels, leading the federal funds rate to fall below the discount rate.

The adjustment mechanism depended heavily on the enforced reluctance to borrow. When banks borrowed to satisfy their reserve requirement, they reduced their future access to the discount window. Consequently, when the banking system as a whole had to borrow a higher volume of reserves to meet requirements, individual banks would bid up the federal funds rate as they tried to avoid being one of the banks that turned to the window. The process gave banks the message to cut back on deposit-expanding activities. Chart 6 gives key borrowing and interest rate relationships during these years.

The move to the new procedures inspired discussion of the appropriate guidelines for setting and changing the discount rate. Some Board members initially had expected that the discount rate would be changed more frequently than before to keep it more closely aligned with market rates. In practice, the basic discount rate was changed fairly frequently--sixteen times between October 1979 and October 1982--but it still moved much less than the funds rate. At times, unprecedented weekly average spreads developed between the funds rate and the discount rate.

During two periods of exceptionally restrictive provision of nonborrowed reserves, in 1980 and again in 1981, the volume of borrowing ran very high. The Board introduced a surcharge on frequent borrowing by large banks as part of the Administration's credit restraint program in March 1980.[48] The frequency limits for access at the basic rate were similar to those that had been proposed a decade earlier for the basic borrowing privilege. In addition, banks did not have unlimited access to the discount window even when they paid the surcharge. The

48. A more detailed discussion of the rationale underlying the program of credit restraint is given in a statement by Frederick H. Schultz, Vice Chairman, Board of Governors of the Federal Reserve System, before the Subcommittee on Access to Equity Capital and Business Opportunities of the House Committee on Small Business, April 2, 1980. It is reprinted in the *Federal Reserve Bulletin*, April 1980.

funds rate often exceeded even the combined basic rate and surcharge--which reached a high of 18 percent in 1981.[49]

Borrowed Reserve Targeting in the 1980s and Early 1990s

Borrowed reserve targeting replaced nonborrowed reserve targeting in 1983 as the primary guide for choosing desired reserve levels. The shift in emphasis removed the automatic linkage between reserves and money targets. Borrowed reserve targeting made more formal use of the relationship between the amount of borrowing and the spread between the federal funds rate and the discount rate that arises from the restrictions on heavy use of the discount window. As was the case under the previous procedures, forcing increased borrowing tended to lead the banks to bid up the federal funds rate relative to the discount rate as they sought to avoid having to borrow. Reduced borrowing encouraged less aggressive bidding for Federal funds and the rate would fall. The FOMC raised borrowed reserve objectives when it wanted to tighten policy and lowered them when it wanted to ease policy.[50] Chart 7 shows key borrowing and rate relationships during these years.

A change in the discount rate was viewed as a substitute for a change in the borrowing assumption. Whenever the discount rate was raised or lowered, the FOMC made an explicit decision whether that action by itself accomplished the desired policy adjustment. On some occasions, the amount of assumed borrowing was left unchanged so that the average federal funds rate would be expected to rise or fall by the same amount as the discount rate move. At other times, the borrowing allowance was changed in a direction that lessened the impact of the discount rate change. For example, the FOMC would raise the borrowing

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49. The surcharge was initially imposed in March 1980. It was then removed in May of that year, only to be reimposed in September. In 1981, the surcharge underwent further changes. It was increased in May, reduced in September, reduced again in October, and finally eliminated in November.

50. Marvin Goodfriend, "Discount Window Borrowing, Monetary Policy, and the Post-October 6, 1979 Federal Reserve Operating Procedure," *Journal of Monetary Economics*, September 1983, pp. 343-56, offers a critique of that relationship and suggests that it will inevitably be unreliable.

assumption when the discount rate was lowered so that the average funds rate would not fall by as much as the discount rate.

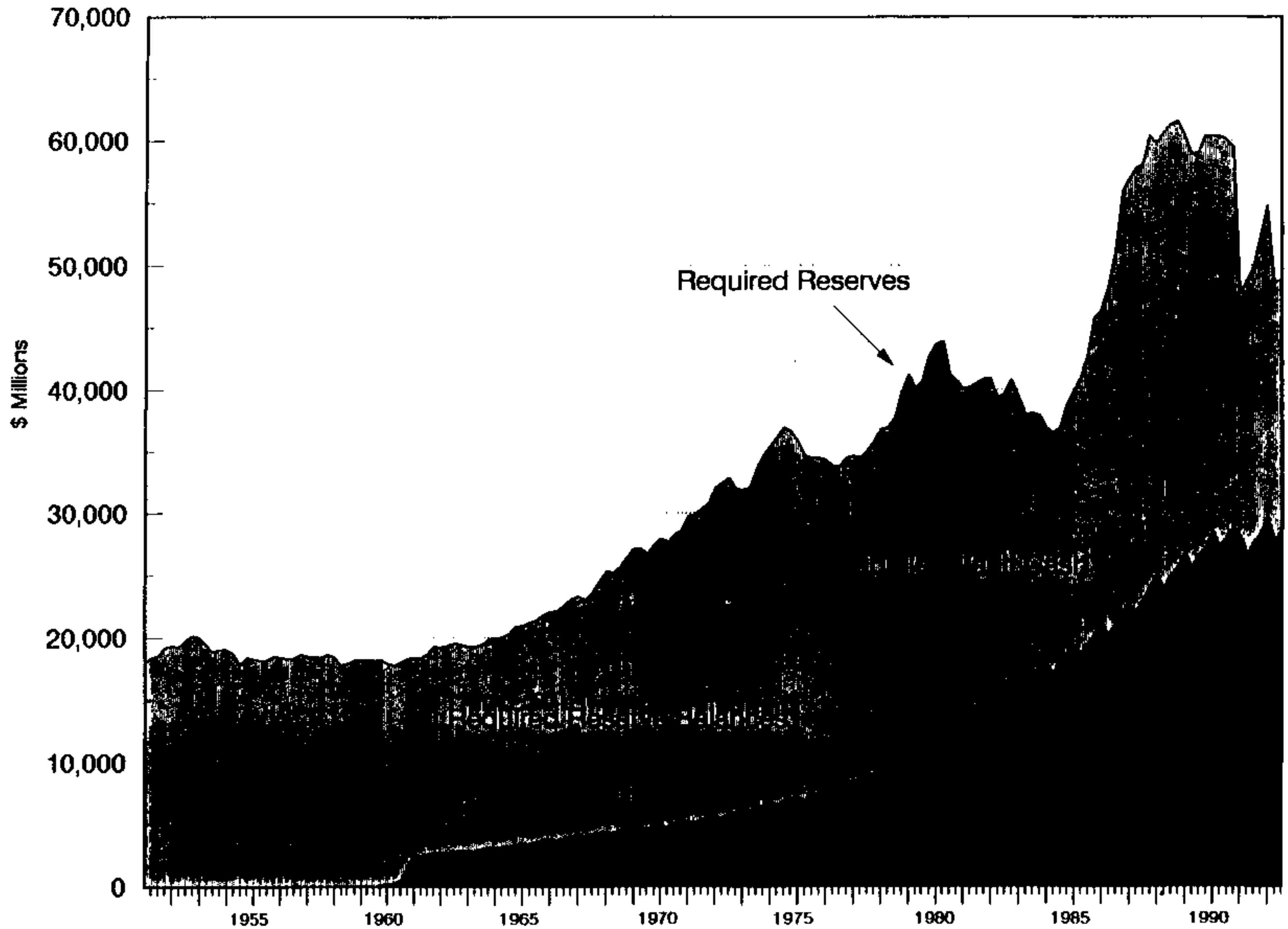
Increased Reluctance to Borrow in the 1980s and Early 1990s. A series of banking crises and failures beginning in 1982 reintroduced a source of reluctance to borrow that had largely disappeared after the 1930s. Once again, banks became concerned that borrowing at the discount window might be interpreted as a sign that they were so weakened financially that they could not borrow funds from normal sources. The concern was especially high in 1984, when Continental Illinois National Bank suffered a crisis of confidence, experienced runs by its large depositors, and was forced to borrow massive amounts from the Federal Reserve to keep operating. Continental's experience made many other banks more hesitant to borrow, and wider spreads of the funds rate over the discount rate emerged for a given amount of borrowing fostered by the Federal Reserve. As more banking crises developed and then were resolved, the reluctance to borrow became alternately more and less severe, but it never returned to its pre-1984 pattern.

By the fall of 1987, the borrowing relationship became sufficiently uncertain that the Federal Reserve felt compelled to reduce its reliance on it as a guide to policy. Since that time, the Fed has given greater weight to indicators of money market conditions such as the federal funds rate. Nonetheless, the extreme reluctance to borrow and the resulting uncertainty about how banks will respond to changing levels of reserve availability have also introduced some volatility of the funds rate. When banks have not wanted to borrow, they have reacted to a reserve shortage by bidding up the funds rate to very high levels before they finally turn to the discount window. Indeed, on one occasion in 1990, the funds rate reached 100 percent, a level not seen even when interest rates and borrowing levels were routinely much higher a decade earlier. While efforts have been made to explain to the banks and the public that occasional borrowing is an appropriate action to relieve temporary shortages of reserves, the message has so far had limited impact.

The reluctance to borrow has compounded the reserve management difficulties associated with low reserve requirements, described in the previous section. The low requirements reduced depositories' ability to handle normal day-to-day variation in reserve flows because the range of reserve levels that fell between excess reserves and overdrafts narrowed. The extreme reluctance to borrow weakened one means for banks to recover from an unexpected reserve shortage.

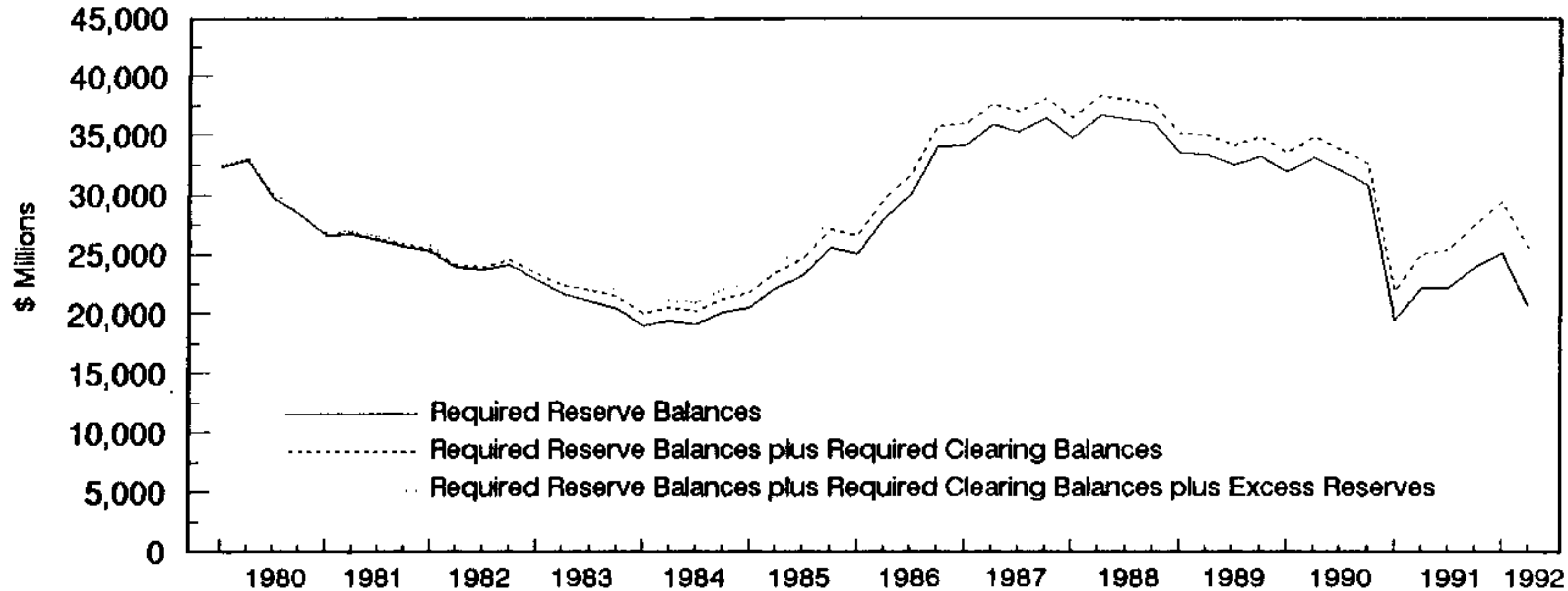
The problems that arise when borrowing and required reserves do not behave as desired underscore the importance of these tools. The policy process benefits when both reserve requirements and the discount window can play their assigned supporting roles in the monetary policy process. Open market operations can be hard pressed to achieve policy goals without their help.

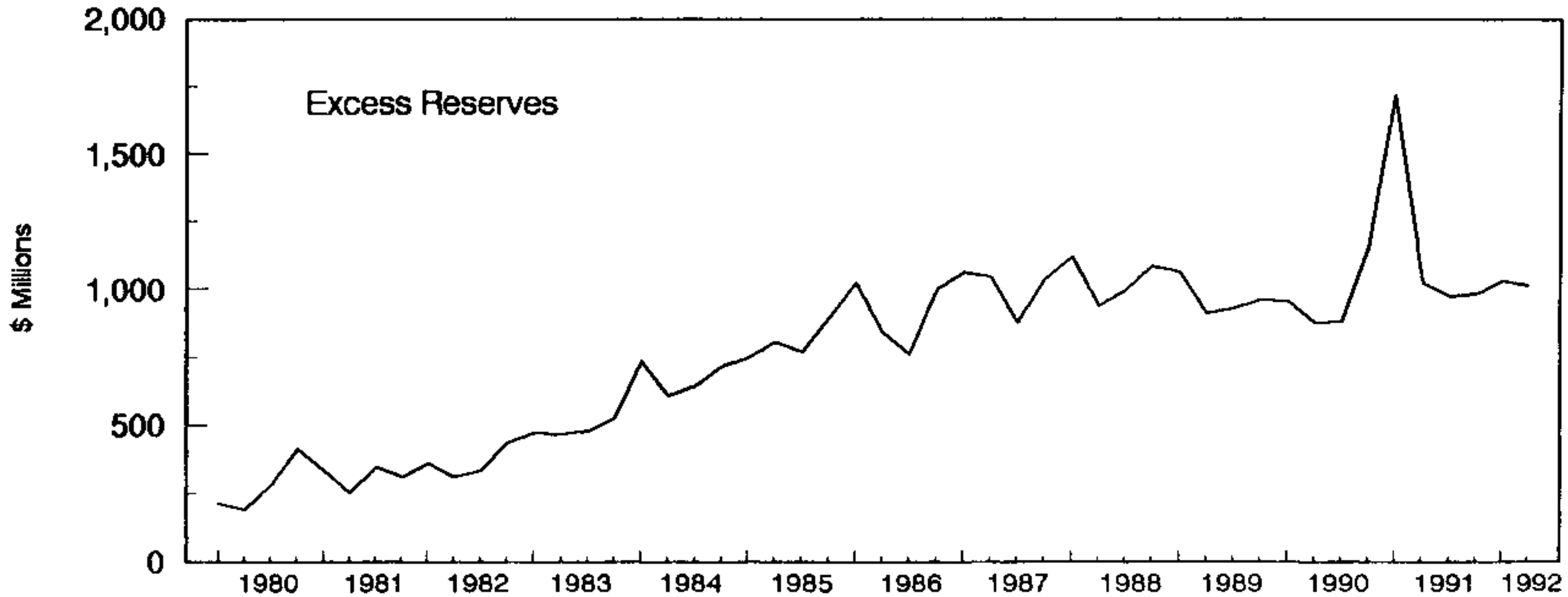
1. Required Reserves and Applied Vault Cash 1951-1992*



* All figures are quarterly averages.
Note: Before December 1959, the Federal Reserve did not allow vault cash to count towards the fulfillment of reserve requirements.

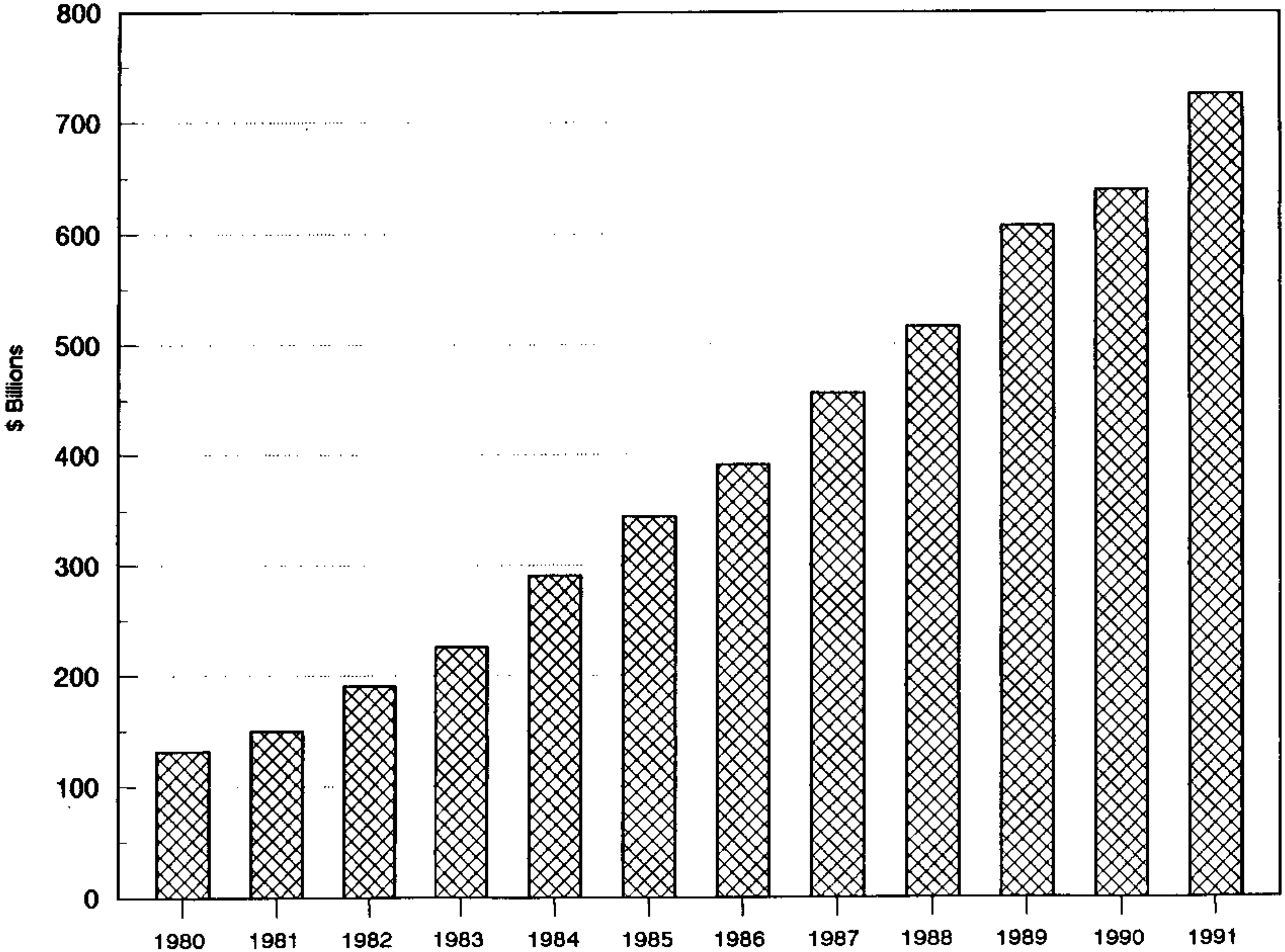
2. Required Balances and Excess Reserves





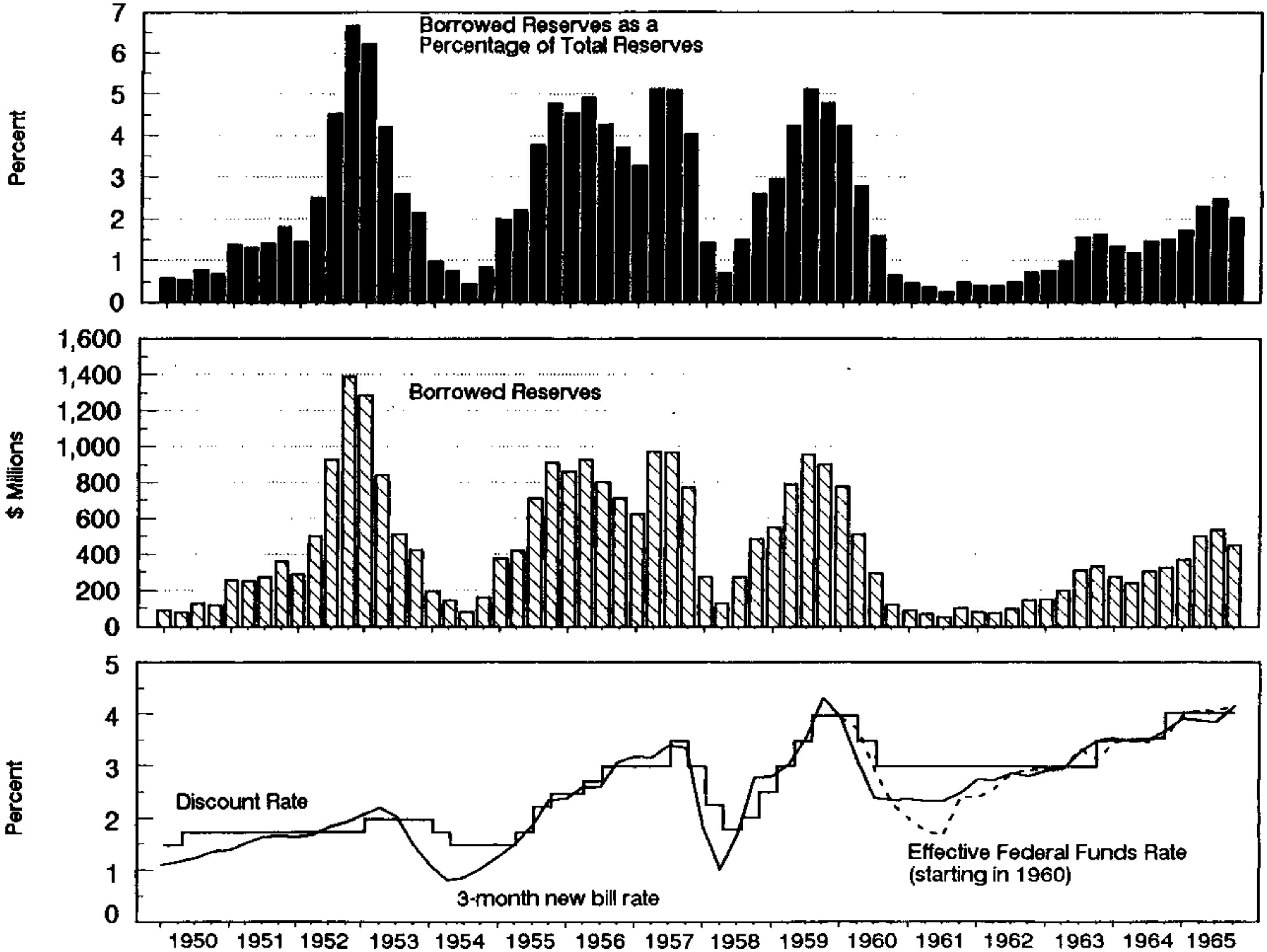
Note: All figures are quarterly averages.

3. Systemwide Fedwire Activity*



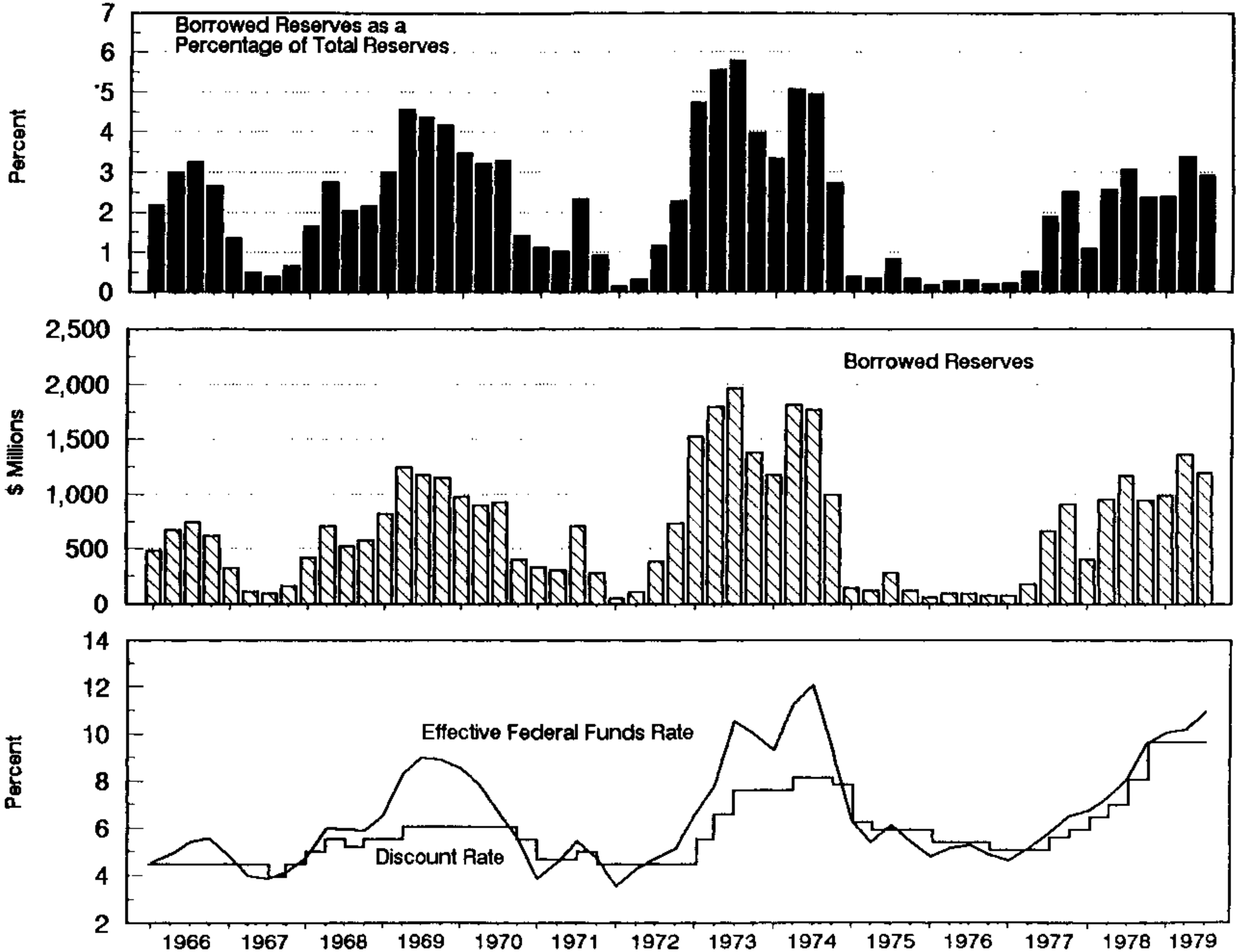
* Daily averages.

4. Borrowed Reserves and Selected Interest Rates 1950-1965



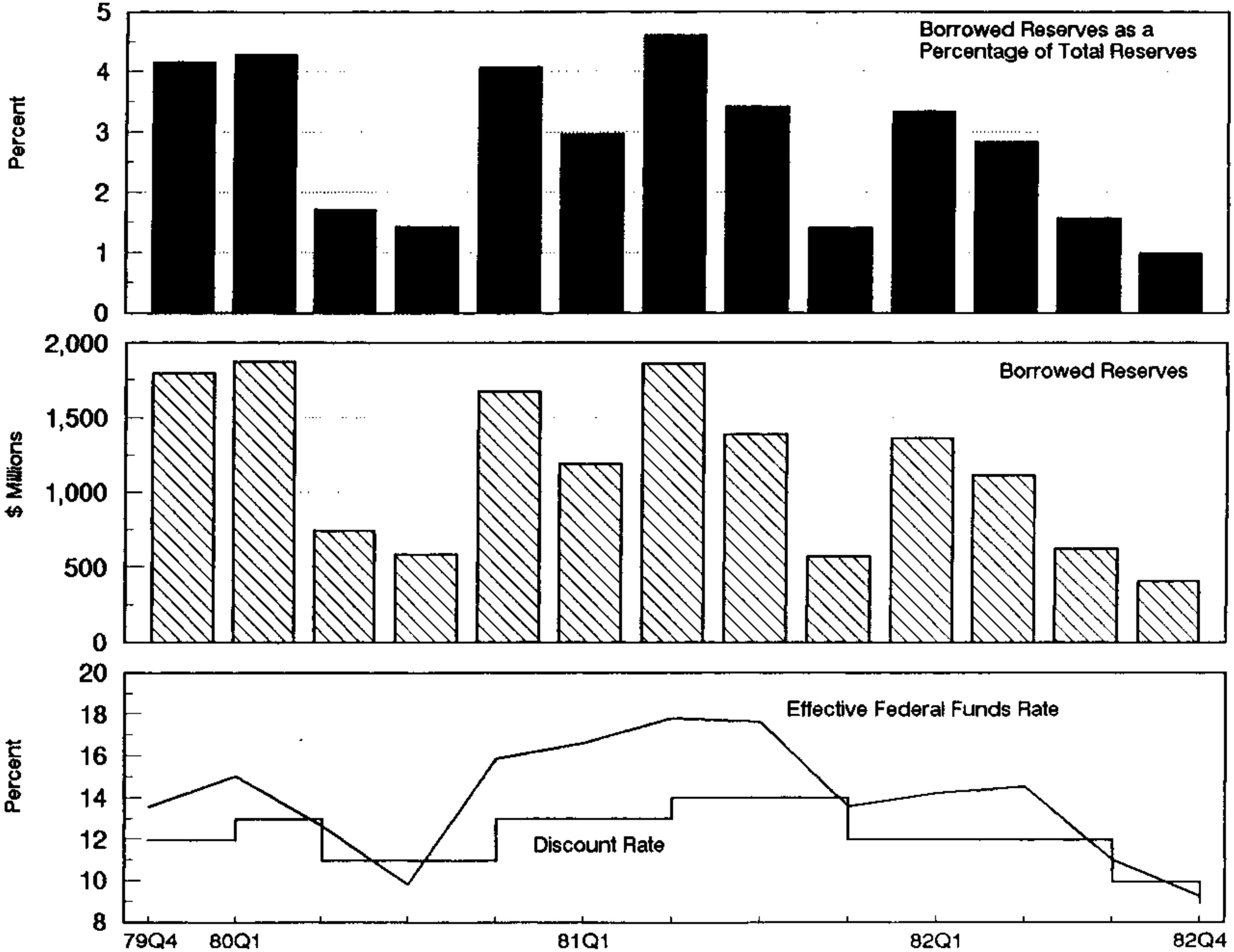
Note: Quarterly averages except for discount rate. Discount rate is the rate in effect on the last day of the quarter.

5. Borrowed Reserves and Selected Interest Rates 1966-1979



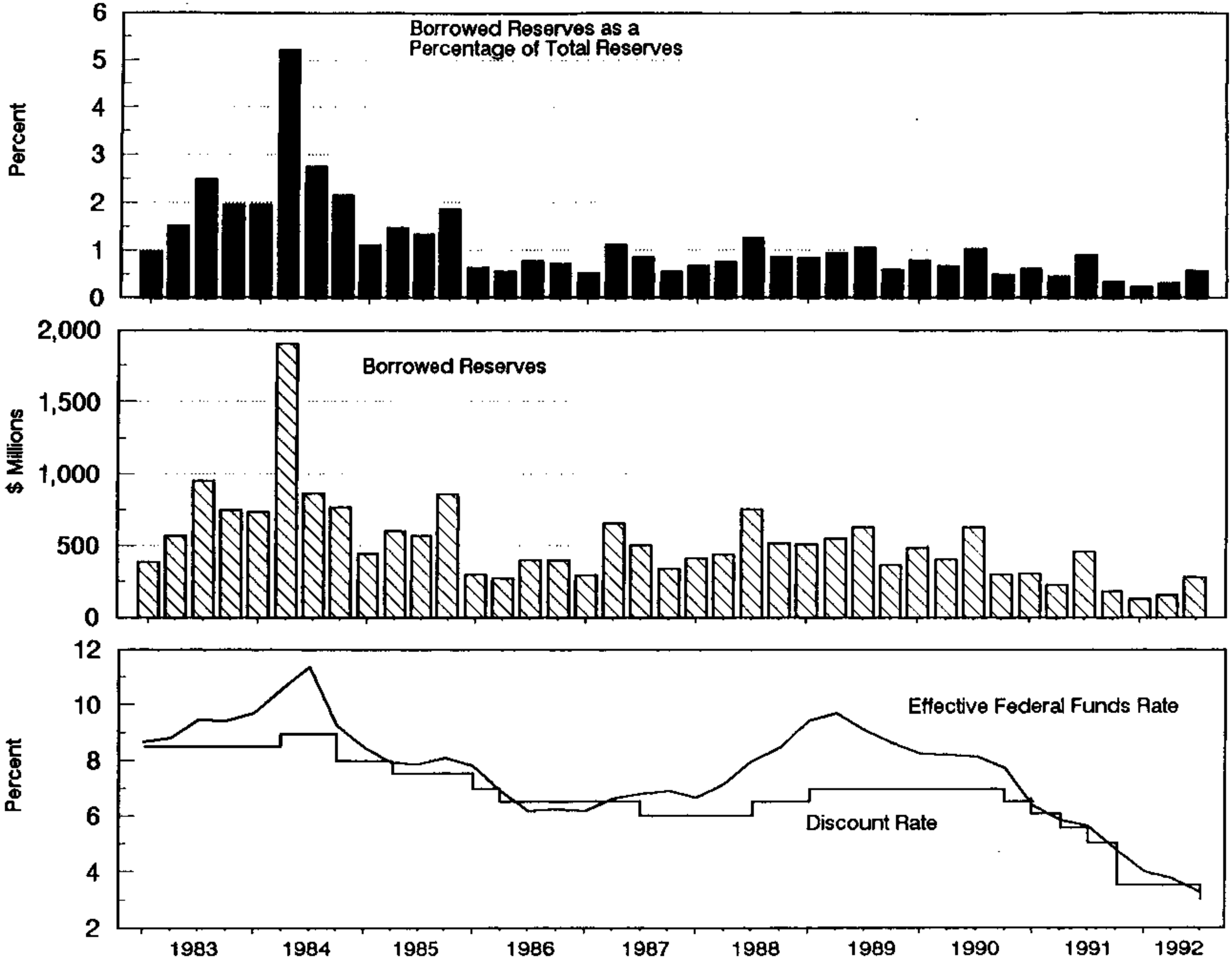
Note: Quarterly averages except for the discount rate. Discount rate is the rate in effect on the last day of the quarter.

6. Borrowed Reserves and Selected Interest Rates 1979-1982



Note: Quarterly averages except for the discount rate. Discount rate is the rate in effect on the last day of the quarter.

7. Borrowed Reserves and Selected Interest Rates 1983-1992



Note: Quarterly averages except for the discount rate. Discount rate is the rate in effect on the last day of the quarter.

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A Note on Theories of Money Stock Determination

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The purpose of this brief review of theories of money stock determination is to encourage economists to once again work on such models. The current lack of interest in them probably explains the irrelevance of textbook discussions to the actual monetary arrangements that determine the money stock.

A discussion of money stock determination needs to make explicit whether the central bank is using an interest rate or the quantity of reserves as its policy instrument. This choice possesses different implications for the way in which the central bank gives the money stock and the price level well-defined equilibrium values. It also yields different implications for which of the behavioral relationships of the public are key for determining the money stock. For example, textbook discussions, which do not clearly identify the policy instrument, confuse the roles of the "three tools" of monetary policy: open market operations, reserve requirements, and the discount window. For example, textbooks do not mention that in the 1970s when the Fed targeted the funds rate directly, changes in required reserves ratios and in the discount rate had no first-order effects on the money stock.

EARLY BANK-RATE THEORIES

Henry Thornton in his book Paper Credit (1802) and in speeches before Parliament (1811) formulated the first theory of money stock determination with rate targeting by the central bank. (See Hetzel 1987.) Thornton's model is in the quantity theory tradition, which explains the determination of the

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price level through the interaction of a money supply and money demand function. The key element of his theory is that the public cares only about real variables, that is, real quantities and relative prices. In particular, the real rate of interest is only transitorily affected by changes in fiat money creation. (This idea is now referred to as the natural rate hypothesis.) Money creation allows the central bank to set the market rate at a different value than the real rate adjusted for expected inflation, but only transitorily. The flip side of the natural rate hypothesis is that only the central bank can give nominal variables like the money stock and the price level well-defined values. Thornton argued that the Bank of England, despite its real-bills rhetoric, gave nominal variables determinate values by targeting the exchange rate.

Thomas Joplin (1823) gave Thornton's idea of a natural rate of interest its modern meaning as the real rate of interest that equates saving and investment. With the Resumption Act of 1819 that returned Britain to the gold standard, the idea of a central bank that creates fiat money virtually disappeared. Joplin thought that the banking system, through variation in its reserves-deposits ratio, created changes in money that caused transitory divergences in the market and the natural rate. This idea reappeared later in the work of Knut Wicksell (1898) and Irving Fisher (1918).

With the supremacy of the gold standard in the nineteenth century, the idea of central bank money creation practically disappeared and, along with it, the idea of a natural rate of interest. David Hume's price-specie flow mechanism became the basic model of money stock determination in the nineteenth century. Wicksell was unique in reinventing the idea of a natural rate of interest, but he had no central bank in his model. He also made no distinction between real and nominal variables.

Abandonment of the gold standard in World War I, as in the Napoleonic Wars, led to the reemergence of theories of fiat money creation. Gustav Cassel (1928) developed the market rate-natural rate theory of Thornton and Wicksell. He pointed out that achieving price level determinacy required more than equality of the market rate and the natural rate. An infinite number of price levels are consistent with equality of these two rates. Cassel argued that the central bank should vary its discount rate in order to keep the price level at a targeted value. Interest in theories of money stock determination in which the central bank uses an interest rate as its policy variable disappeared in the Depression with the prevalence of elasticity pessimism.

THE RESERVES-MONEY MULTIPLIER THEORY

The reserves-money multiplier theory emerged at the end of World War I. It had been advanced occasionally in the nineteen hundreds, but had never caught on (Humphrey 1987). Pigou (1917) and Keynes (1923) advanced it in the United Kingdom. In the United States, Phillips (1921) built up the reserves-money multiplier formula from a deposit expansion process whereby a reserve injection creates deposits as it passes from bank to bank. This deposit creation process continues until the newly-created reserves are absorbed into required reserves.

The Phillips' description of the deposits creation process was flawed from the beginning. Even if changes in aggregate reserves are exogenous, bank deposit creation is constrained by the interest rate on reserves in the interbank market for reserves, not the quantity of reserves a bank holds. By the 1920s, there was a Fed funds and a call money market that allowed banks to buy and sell reserves. Quantity theorists, however, liked the idea of the reserves-deposits expansion process because it provided an easy refutation to real bills proponents who argued that banks cannot create deposits. Quantity theorists could use the Phillips' story to argue that real bills proponents failed to understand that what is true for the individual bank is not necessarily true for the banking system.

The revival of models of money stock determination in the 1950s centered on reserves-money multiplier models. Why did quantity theorists turn to these models given that the Fed was targeting free reserves, which is an indirect procedure for targeting the interest rate? In the 1950s, economists had not yet rediscovered the natural rate hypothesis and the idea of a natural rate of interest. Without these concepts, quantity theorists could not model money stock determination with central bank rate targeting in a way that made the money supply function differ from the money demand function by depending crucially on central bank behavior. The reserves-money multiplier theory offered an easy explanation of how central banks control the price level by controlling the supply of money.

In the 1970s, Fed economists working on a monthly model for use at FOMC meetings rejected the reserves-money multiplier framework. (See Thomson, Pierce and Parry 1975 and Davis 1974.) Given the Fed's target for the funds rate, they viewed the money stock as being demand determined by the public's demand for money function. The problem with this view was that the price level was taken as determined outside the model. The model then did not distinguish between the determination of nominal and real money. With the price level exogenously determined, the Fed can vary the real quantity of reserves to control the (market and real) rate of interest and the nominal and real quantity of money demanded by the public. If the price level is endogenously determined, however, these models say nothing about the nominal quantity of money. While there is a determinate relationship between the interest rate and the real quantity of money, there is no determinate relationship between the interest rate and the nominal quantity of money.

RATIONAL EXPECTATIONS MODELS WITH RATE TARGETING

The key conceptual issue in models of money stock determination with rate targeting by the central bank is how nominal variables are rendered determinate, that is, given a well-defined equilibrium value? Patinkin (1965) pointed out that the central bank must "concern" itself with some nominal variable. In his model, that nominal variable is bank reserves. The price level is then rendered determinate through a real balance effect. Because an arbitrary rise in the price level reduces the real value of a variable the public cares about, bank reserves and money, it causes the public to reduce its real expenditure, and the price level is returned to its equilibrium value. When the central bank targets an interest rate, however, all nominal variables including bank reserves are determined endogenously. There is no real balance effect.

In the early 1980s, a number of economists figured out how to explain nominal determinacy with interest rate targeting by the central bank. The key papers were by Dotsey and King (1983); Canzoneri, Henderson and Rogoff (1983);

and McCallum (1981, 1986). Their models embodied the natural rate hypothesis so that only the central bank, not the public, could give nominal variables a well-defined equilibrium value. The initial models achieved nominal determinacy by causing the central bank to behave in such a way that the public's expectation of the future price level remained fixed. Where Patinkin fixed reserves, these models fixed the expected future value of the price level. They did so by not allowing base drift in money.

Goodfriend (1986) brought these models closer to actual central bank behavior by allowing the public's expectation of the future price level to vary in response to macroeconomic shocks. He did so by allowing base drift in the money stock where the amount of such drift depends upon the extent to which the central bank desires to smooth interest rates. Goodfriend gave the central bank a cost function that made it averse to large "jumps" in the price level relative to expectations. By making the central bank care both about the difference between the contemporaneous price level and the prior period's expectation of the contemporaneous price level and about the difference between the contemporaneous price level and the expected future price level, he imposed a level and a change constraint that made the public's expectation of the future price level well defined, while still allowing that expectation to change in response macroeconomic shocks.

Instead of a real balance effect, these models make use of a relative price effect. Given the public's expectation of the future price level, an arbitrary change in the contemporaneous price level changes the interest rate by changing expected inflation. Changes in the interest rate then affect the demand for money and the reserves-supplying behavior of the central bank in a way that returns the price level to an equilibrium value. The simplifying assumption that makes these models tractable analytically is rational expectations. This assumption allowed expectations to be determined in a simple enough way that the models could highlight how the central bank makes nominal values well defined by the control it exercises over the way the public forms its expectation of the future values of nominal variables.

AN EXAMPLE AND SOME BASIC PRINCIPLES

This section draws on the models briefly described above to highlight some of the basic concepts in a theory of money stock determination. Consider an example where the central bank implements monetary policy by setting an interest rate. The natural rate hypothesis implies that the central bank cannot set its interest rate target arbitrarily. It must have procedures that allow it to set its rate target in a way that tracks on average the economy's equilibrium interest rate. The central bank, however, is assumed to smooth changes in the economy's equilibrium interest rate by supplying reserves when market rates rise and withdrawing reserves when market rates fall. Changes in reserves and the money stock then emerge in response to the macroeconomic shocks that impinge upon the economy.

It is also necessary to make some assumption about the central bank's subsequent behavior toward the random changes in money introduced by rate smoothing. The central bank can either offset these changes subsequently, in part or in full, or incorporate them permanently into the level of the money stock. In practice, central banks follow the latter "let bygones-be-bygones" policy of base drift in money and prices.

Assume that a persistent real shock raises the equilibrium real rate of interest. For example, a new technology leads to increased investment. When the market rate rises initially, the central bank buys government securities. The monetary base and the money stock increase. Because the real rate of interest is ultimately determined solely by real factors like investment opportunities and the public's thrift, the real rate of interest must eventually rise to a higher equilibrium value that is independent of the increase in money. Similarly, the real quantity of money desired by the public will ultimately be unaffected by the actions of the central bank. The rise in market rates will make currency and bank reserves more costly to hold, but the return on bank deposits that pay interest will rise. The equilibrium real quantity of money may then either decrease or increase. In either event, the supply of money changes in a way that is largely unrelated to any change in the public's demand for real money. For this reason, it will be convenient to assume that the rise in market rates leaves the real quantity of money demanded by the public unchanged.

Ultimately, the change in the nominal quantity of money will not affect any of the new equilibrium values of the real variables, the real rate of interest and the real quantity of money. At the original price level, however, the public is now holding a larger quantity of real money balances. The price level must rise to return real money balances to their lower, equilibrium value. This example can be used to elucidate a number of key concepts in a theory of money stock determination.[2]

[2] For a somewhat different treatment, see any of the expositions by Milton Friedman that feature a helicopter drop of money, for example, Friedman (1992, Chapter 2).

First, the example illustrates the distinction between nominal and real variables. In the short run, macroeconomic shocks originating in the private sector produce changes in the nominal money stock. In the long run, however, the central bank exercises complete control over the nominal money stock. The central bank determines the amount of base money to create in response to such shocks. It also determines the extent to which the money created in response to shocks will affect permanently the level of the money stock.

In contrast, the public largely determines the real quantity of money. The qualification "largely determines" is added in recognition that the central bank can indirectly influence the real quantity of money in that a higher rate of inflation increases the cost of holding real money. The result of the example, however, is unaffected by this qualification. The increase in the stock of money does not ultimately increase the real quantity of money.

Second, it is important to keep separate the different popular meanings of the word "money." A theory of money stock determination concerns the quantity of money, defined as some monetary aggregate like the monetary base, M1 or M2. Money is often also used to mean credit. In this example, the increase in investment demand and higher real rate of interest will increase real saving and credit. Money is also often used to mean income. In the example, real income is probably largely unchanged, although the composition of output generating income will change to include more investment and less consumption. In the example, the real quantity of money, real credit, and real income can all behave differently.

Third, the example illustrates the quantity theory approach to analyzing the determination of the price level through the interaction of a money demand

and a money supply function. In the example, the money supply function shifts as the central bank buys government securities in response to a rise in interest rates. Because no corresponding shift in the money demand function occurs, the price level rises.

The nominal money demand function is the product of the price level and the real quantity of money desired by the public. The nominal money supply function depends upon the reserve-supplying behavior of the central bank. In the short run, shifts in this function depend upon the extent to which the central bank smooths the interest rate, that is, the extent to which it supplies reserves when the interest rate changes. In the long run, shifts in the money supply function depend upon the extent of base drift, that is, the extent to which, if at all, the central bank subsequently offsets the changes in money produced by changes in the interest rate. Finally, shifts in this function depend upon the trend rate of growth of money and inflation the central bank accepts and the public expects. A consequence of the natural rate hypothesis is that only the central bank can determine the trend rate of growth of money and prices.

Milton Friedman gave the quantity theory a particular empirical expression by arguing that shifts in the money supply function have historically been large relative to shifts in the money demand function. For this reason, over long periods of time, the price level and the nominal quantity of money move together. Friedman summarizes this view by saying that inflation is everywhere and always a monetary phenomenon. Note, however, that the analytical usefulness of the quantity theory only requires that unpredictable changes in money demand are small relative to shifts in the money supply function and to predictable shifts in money demand. Equivalently, unpredictable changes in money demand should be small relative to changes in nominal expenditure or output.

Note that with rate targeting the key behavioral relationships of the money supply function are not the reserves-currency and reserves-deposits ratios discussed in textbooks. Fluctuations in these ratios are automatically offset at the prevailing funds rate target. For example, if currency flows out of banks or if banks increase the desired level of excess reserves, the funds rate rises. In order to maintain its funds rate target, the central bank supplies reserves, thereby accommodating changes in these ratios and avoiding a change in bank deposits.

Fourth, what appears true for the individual is not necessarily true for individuals collectively. In the example, after the increase in the money stock, individuals believe they can reduce their money holdings to a desired lower level. The public, however, cannot reduce its nominal money holdings. The individuals who sold government securities to the central bank did so because they were offered a good price, not because they wanted to reduce their holdings of assets. After selling securities to the central bank, individuals allocate their increased cash among different assets to replace the securities they sold. Temporarily, the increased demand for assets keeps the interest rate below its new, higher equilibrium rate. As a consequence, real expenditure rises until the price level increases sufficiently to return real money balances to their original level. The interest rate then rises to its new, higher equilibrium value.

More generally, economic fallacies often arise out of inappropriate generalization of individual experience. To the individual, it appears that the cause of inflation is the rise in prices of individual commodities. The cause of inflation then is sought for in the determinants of the relative prices of individual commodities, rather than in the behavior of money.

Fifth, the central bank must ensure that the price level and money stock possess equilibrium values. The central bank, however, must do more than simply set an interest rate target that is consistent with the economy's natural rate of interest (augmented by expected inflation). At the central bank's prevailing rate target, an arbitrary perturbation in the price level will produce a corresponding change in the demand for bank credit and in bank deposits and money. All nominal magnitudes can then wander off aimlessly together. The central bank must keep some nominal value steady. How do central banks impart this nominal steadiness to equilibrium values?

Central banks dislike "large, unusual jumps" in nominal prices.[3] This concern imparts an "inertia" to the public's expectation of the future price level. Arbitrary changes in the contemporaneous price level, therefore, produce changes in the contemporaneous price level relative to the expected future price level. These changes create a relative price effect analogous to the real balance effect as the mechanism for eliminating arbitrary changes in the price level. Specifically, given an arbitrary change in the price level, some real or relative variable must change to produce an inverse change in the public's real expenditure. That change is the change in the price level relative to the expected future price level, which produces an inverse

[3] This statement is given content by defining jumps relative to expected values. See the discussion of Goodfriend (1987) above.

movement in the interest rate. The movement in the interest rate affects the reserve supplying behavior of the Fed and the public's demand for money in a way that returns the price level to its equilibrium value.

This relative price effect can be explained by analogy. Consider how nominal determinacy is achieved when the central bank of a country targets its exchange rate with another country. For the sake of argument, assume that the Fed targets the Deutsche Mark price of a dollar. As shown in equation (1), the DM/$ exchange rate equals the product of the ratio of the German price level (DM/German good) to the U.S. price level ($/US good) and the real terms of trade (German good/US good). The nominal benchmark for the dollar is the German price level. If the U.S. price level rises arbitrarily, the foreign exchange value of the dollar falls, and the Fed buys dollars with Deutsche marks. The monetary base and the money stock fall and the price level returns to its equilibrium level.

$$(1) \qquad \frac{DM}{\$} = \frac{\dfrac{DM}{\textit{German good}}}{\dfrac{\$}{\textit{US good}}} \cdot \frac{\textit{German good}}{\textit{US good}}$$

In the case of an interest rate target, the Fed targets the price of today's dollars ($\$_t$) in terms of tomorrow's dollars ($\$_{t+1}$), or one plus the interest rate. As shown in equation (2), this price equals the product of the ratio of the expected future price level to the contemporaneous price level and the real terms of trade with the future. With a rate target, the nominal benchmark is the expected future price level. Now, an arbitrary rise in the contemporaneous price level produces a fall in the ratio of the expected future price level to the contemporaneous price level, the first factor on the right side of (2). The fall in this ratio produces a decline in the market rate of interest by reducing the inflation premium. A decline in the market rate of interest produces an increase in the demand for money. It also prompts the central bank to sell securities. The demand for money increases, while the monetary base and the money stock fall, and the price level returns to its equilibrium level.

$$(2) \qquad \frac{\$_{t+1}}{\$_t} = \frac{E_t\left(\frac{\$}{good}\right)_{t+1}}{\left(\frac{\$}{good}\right)_t} \cdot \frac{(good)_{t+1}}{(good)_t}$$

Sixth, the public is forward looking. It must form an expectation of the future price level in order to determine a market rate of interest. In making saving and investment decisions, individuals care about the price of today's goods in terms of tomorrow's goods. They contract, however, in terms of the price of today's dollars in terms of tomorrow's dollars. Individuals must, therefore, form an expectation of the future purchasing power of the dollar. The central bank determines how the public forms that expectation.

Consider again the example of the real shock with rate smoothing by the central bank that causes money and prices to increase. If the public expects that the central bank will reverse the increase in money and prices in the future, then the public will expect a subsequent fall in prices, or at least a temporary reduction in inflation relative to trend. A temporary reduction in the inflation premium will for a while moderate the rise in the market rate produced by the rise in the equilibrium real rate. (This situation probably obtained in World War II.)

Alternatively, if the public expects the central bank to incorporate each period's random change in money and prices permanently into their future levels, the interest rate will rise immediately by the amount of increase in the equilibrium real rate (apart from a temporary liquidity effect). The public might even expect that the central bank will allow the rate of inflation to rise permanently, in which case the market rate will rise by more than the increase in the real rate. In this case, the price level will also rise by more than the increase in money.

As this discussion illustrates, the response of the public to today's action of the central bank depends upon what the public expects the central bank to do tomorrow. (The public may not actually watch the actions of the central bank, but it will respond to contemporaneous changes in the price level in a way that is consistent with the behavior of the price level that the central bank has produced over time.) For this reason, at least since the 1970s, economists have generally formulated their recommendations for the central bank as strategies to be maintained over time, rather than as particular policy actions. The idea is that the policymaker can predict the consequences of a policy action taken as part of a known strategy because he has some basis for predicting what the public anticipates in the way of subsequent policy actions (Lucas 1975).

Seventh, the example involves both monetary policy and fiscal policy. The monetary policy action undertaken by the central bank is the increase in the monetary base. Monetary policy, that is, the systematic behavior of the central bank, is described by the extent to which the central bank changes the monetary base when interest rates change and the extent to which such changes become permanently incorporated into the level of the monetary base. The fiscal policy side of the central bank's action is the reduction of the government debt held by the public due to the purchase of the government security. The revenue the government must collect in the future to pay off its debt falls. Taxpayers can increase their consumption.

Who pays for this windfall to taxpayers? When the price level rises, whoever holds money must add to his money holdings in order to maintain their real purchasing power. The money holder must refrain from consumption while restoring the real value of his cash balances to their former level. (The additional dollars held are like receipts showing payment of the tax.) There is a wealth transfer from holders of cash balances to taxpayers in general. Inflation is a tax levied on whoever holds money.

Pressure for inflation comes from confusion between money and wealth creation. This confusion turns on ignorance of all the principles listed above: the difference between money and credit or income; the difference between nominal and real money; the fallacy of generalizing on the basis of particular examples; failure to understand the central responsibility of the central bank for the behavior of the price level; and failure to realize that the public is forward looking in the way it forms its expectations of central bank behavior. Pressure for inflation, however, also comes from the fact that while money creation does not augment wealth, it can redistribute it. A central fact of the political economy of money creation, and of its eternal appeal, is that the tax money creation imposes does not have to be explicitly legislated.

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INTEREST RATE POLICY AND THE

INFLATION SCARE PROBLEM: 1979-1992

Marvin Goodfriend[1]

U.S. monetary policy since the late 1970s is unique in the post-war era in that rising inflation has been reversed and stabilized at a lower rate for almost a decade. The inflation rate of 3 to 4% per year, representing a reduction of 6% or so from its 1981 peak, is the result of a disinflationary effort that has been long and difficult.

This paper analyzes the disinflation by reviewing the interaction between Federal Reserve policy actions and economic variables such as the long-term bond rate, real GDP growth, and inflation. The period breaks naturally into a number of phases, with the broad contour of events as follows. A period of rising inflation was followed by disinflation which, strictly speaking, was largely completed in 1983 when inflation stabilized at around 4% per year. But there were two more "inflation scares" later in the decade when rising long-term rates reflected expectations that the Fed might once more allow inflation to rise. Confidence in the Fed was still relatively low in 1983, but the central bank has acquired more credibility since then by successfully resisting the inflation scares.

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1. The author is Vice President and Associate Director of Research at the Federal Reserve Bank of Richmond. The paper has benefitted greatly from discussions with Timothy Cook and Robert King, and from presentations at the 1992 NBER Summer Institute and the Board of Governors of the Federal Reserve System. Comments by John Boschen and George Moore were also very helpful.

I analyze the conduct of monetary policy using a narrative approach that pays close attention to monthly movements of long and short-term interest rates. My approach is intended to complement existing studies such as the VAR-based analyses by Bernanke and Blinder (1992) and Sims (1991), and the more conventional studies of the period by Friedman (1988) and Poole (1988). The goal is to distill observations to guide future empirical and theoretical analysis of monetary policy with the ultimate objective of improving macroeconomic performance. Based on a familiarity with the Fed over this period and the work of Fed economists, I interpret policy actions in terms of the Federal funds rate rather than a measure of money. I view the paper as a case study of the Federal Reserve's interest rate policy.

The Fed's primary policy problem during the period under study was the acquisition and maintenance of credibility for its commitment to low inflation.[2] I measure credibility by movements of inflation expectations reflected in the long term interest rate. For much of the period the Fed's policy actions were directed at resisting inflation scares signalled by large sustained increases in the long rate. A scare could take well over a year of high real short-term interest rates to contain. Moreover, just the threat of a scare appears to have made the Fed tighten aggressively in one instance and probably made it more cautious when pushing the funds rate down to encourage real growth on a number of occasions.

2. See Rogoff (1987) for a theoretical survey of credibility, reputation, and monetary policy.

Inflation scares are costly because resisting them requires the Fed to raise real short rates with potentially depressing effects on business conditions. Hesitating to react is also costly, however, because by revealing its indifference to higher inflation the Fed actually encourages workers and firms to ask for wage and price increases to protect themselves from higher expected costs. The Fed is then inclined to accommodate the higher inflation with faster money growth.

Inflation scares present the Fed with a fundamental dilemma whose resolution has decided the course of monetary policy in the post-war period. Prior to the 1980s, the Fed generated an upward trend in the inflation rate by reacting to inflation scares with a delay. The more prompt and even preemptive reactions since the late 1970s have been a hallmark of the recent disinflationary era.

The plan of the paper is as follows. First, I introduce and discuss the premises that underlie my interpretation of monetary policy in the body of the paper. The chronological analysis of policy is presented next. Finally, I summarize the main empirical findings in a series of observations chosen to sharpen further our interpretation and evaluation of the conduct of monetary policy. A brief conclusion follows.

PREMISES UNDERLYING THE INTERPRETATION OF POLICY

The first step in any study of monetary history is to choose an indicator of the stance of policy. For example, in their study of U.S.

monetary history Friedman and Schwartz (1963) focus on the monetary base because it summarizes monetary conditions whether or not a country is on the gold standard and whether or not it has a central bank. Focusing on the base allowed them to tie together a long period marked by many institutional changes, making possible their famous empirical findings about money, prices, and business conditions.

For my purposes, however, the base is not a good choice of indicator. Although the Fed could have used the base as its instrument by controlling it closely in the short-run, it has not chosen to do so. Instead, the Fed has chosen to use the Federal funds rate as its policy instrument. Hence this study, which seeks to investigate the short-run interactions between Fed policy and other economic variables, interprets policy actions as changes in the Federal funds rate. The remainder of this section discusses the premises underlying my interpretation of policy.

Interest Rate Targeting

Throughout its history the Fed's policy instrument has been the Federal funds rate or its equivalent. At times, notably from the mid to late 1970s, it has targeted the funds rate in a narrow band commonly 25 basis points wide (Cook and Hahn 1989). More often, it has targeted the funds rate indirectly, using the discount rate and borrowed reserve targets. Although the funds rate appears noisier under borrowed reserve targeting than under direct funds rate targeting, it is nevertheless tied relatively closely to a chosen Federal funds rate target (Goodfriend

1983). Since a borrowing target tends to be associated with a particular spread between the funds rate and the discount rate, targeting borrowed reserves lets a discount rate adjustment feed through one-for-one to the funds rate. Forcing banks to borrow more reserves at a given discount rate also raises the funds rate (Goodfriend and Whelpley 1986). The Fed has used the borrowed reserve procedure to help manage the funds rate since it ended its experiment with nonborrowed reserve targeting in October 1982 (Wallich 1984, Thornton 1988). Significant Federal funds rate movements since then should be viewed as deliberate target changes.

It is less obvious that Federal funds rate changes in the period of the New Operating Procedures from October 1979 to October 1982 should be interpreted as deliberate. Under those procedures, the Fed was to fix the path of nonborrowed reserves available to depository institutions so that increases in the money stock would force banks to borrow more reserves at the discount window and thereby automatically drive up the funds rate and other short term interest rates.

Despite the widespread emphasis on automatic adjustment in the description of the post-October 1979 procedures, however, it was well-recognized at the time that movements in the funds rate would also result from purely judgmental actions of the Federal Reserve (Levin and Meek 1981, Annual Reports of Open Market Operations 1981-83). These actions included: (1) judgmental adjustments to the nonborrowed reserve path taken at FOMC meetings that changed the initially expected reserves banks would be forced to borrow at the discount window (in effect, a funds rate target change by the FOMC), (2) judgmental adjustments to the nonborrowed reserve path between FOMC meetings, (3) changes in the discount rate, and (4) changes in the surcharge that at times during the period was added to the basic discount rate charged to large banks.

Cook (1989) presents a detailed breakdown of policy actions affecting the funds rate during this period showing that two-thirds of the funds rate movement was due to judgmental actions of the Fed and only one-third resulted from automatic adjustment. Moreover, as we shall see below, the large Federal funds rate movements in the nonborrowed reserve targeting period are overwhelmingly attributable to deliberate discretionary actions taken by the Fed to manage short-term interest rates. In light of this, it is more accurate to refer to the period from October 1979 to October 1982 as one of aggressive Federal funds rate targeting than one of nonborrowed reserve targeting.

The Role of Money

The Federal Reserve was established with a mandate to cushion short-term interest rates from liquidity disturbances. Between the Civil War and the creation of the Fed, such disturbances caused short rates to rise suddenly and sharply from time to time. While generally trading in a range between 4 and 7 percent, the monthly average call loan rate reported by Macaulay (1938) rose roughly 5 percentage points in one month on 26 occasions between 1865 and 1914. Moreover, as a result of banking crises, sudden changes of over 10 percentage points occurred 8 times during the same period. These episodes were distinctly temporary, ranging from one to four months, with many lasting for no more than one month. Such extreme temporary spikes are absent from interest rates since the founding of the Fed (Miron 1986, Mankiw, Miron, and Weil 1987).

In line with its original mandate, the Fed has routinely accommodated liquidity disturbances at a given targeted level of short-term interest rates. Furthermore, by giving banks access to the discount window the Fed has been careful not to exert excessively disruptive liquidity disturbances when changing its interest rate target.[3] It follows that easing or tightening has mainly been accomplished by changing the level of short rates to set in motion forces slowing the growth of money demand in order to allow a future reduction in money growth and inflation.

To view the Federal Reserve's policy instrument as the Federal funds rate is thus to set money to the side, since at any point in time money demand is accommodated at the going interest rate. This does not say, however, that money can be left out of account altogether. The Fed, the markets, and economists alike recognize that trend inflation is closely connected to trend money growth, and that achieving and

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3. Total reserve demand is not very interest elastic in the short run. So whenever the Fed cuts nonborrowed reserves to support a higher Federal funds rate target, it allows banks to satisfy a roughly unchanged reserve demand by borrowing the difference at the discount window. The negative relation between nonborrowed reserves and the funds rate in part reflects the administration of the discount window, which creates a positive relation between bank borrowing and the spread between the funds rate and the discount rate. Christiano and Eichenbaum (1991) emphasize the importance of this mechanism in understanding the liquidity effect.

maintaining price stability requires controlling money. During the period under study, money growth was often viewed as an important indicator of future inflation or disinflation by both the Fed and the markets.

Furthermore, we know from the work of McCallum (1981) and others that an interest rate policy just describes how changes in interest rates correspond to changes in the money stock. At a deeper level, then, there is an equivalence between talking in terms of interest rates or money. The important difference is that simple interest rate rules descriptive of policy have implications for how money and prices actually evolve over time (Goodfriend 1987, Barro 1989). We should keep this in mind when reviewing the current period for clues about how policy influences the inflation rate. Ultimately we seek to understand what it is about interest rate policy that turns one-time macroeconomic shocks into highly persistent changes in the growth of money and prices.

Interpreting Comovements Between Short and Long Rates

The Fed targets the funds rate in order to stabilize inflation and real economic growth as best it can. Output and prices, however, do not respond directly to weekly Federal funds rate movements but only to longer-term rates of perhaps six months or more. Hence, the Fed targets the funds rate with the aim of managing longer-term money market rates. It exercises its leverage as follows. The market determines longer-term rates (abstracting from a time varying term premium and default risk) as the average expected level of the funds rate over the relevant horizon.

To see why, consider the pricing of a three-month bank loan. A bank could fund the loan with a three-month CD, or it could plan to borrow Federal funds overnight for the next three months. Cost minimization and competition among banks keep the CD rate in line with the average expected future funds rate; competition in the loan market links loan rates to the CD rate and expected future funds rates. Finally, arbitrage among holders of money market securities links Treasury bill and commercial paper rates to CD rates of similar maturity.

Since simplicity is crucial in communicating policy intentions, the Fed manages its funds rate target to maintain an expected constancy over the near-term future. Target changes are highly persistent and seldom quickly reversed, so that a target change carries the expected level of the funds rate with it and thus longer-term money market rates too.[4] In this way, interest rate policy as practiced by the Fed anchors the short end of the term structure of interest rates to the current Federal funds rate.

By the above argument, the interest rate on long bonds too must be determined as an average of expected future short rates. At best, the Fed affects short-term real interest rates temporarily, so average future short rates over the horizon of a 30-year bond should sum to a real interest rate that varies in a range perhaps 1 or 2 percentage

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4. Goodfriend (1991) contains a discussion of evidence consistent with this view reported in Fama (1984), Fama and Bliss (1987), Mankiw, Miron, and Weil (1987), Hardouvelis (1988), and Cook and Hahn (1989).

points around 3% per year--plus the expected trend rate of inflation.[5] From this perspective, we can view fluctuations in the long-term rate as driven by: (1) a component connected with the current Federal funds rate target that anchors short maturity rates, and (2) a component driven by expectations of inflation. Because the present discounted value of coupon payments far out in the future is smaller at higher interest rates, we should expect a given funds rate target change to exert a greater effect on the long bond at higher rates of interest.[6] It is

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5. Consider a bond paying nominal interest (i) taxable at rate (τ), when the expected inflation rate is (π^e). The real after-tax ex ante return on such a bond is then $r = (1-\tau)i-\pi^e$, so the expected inflation rate over the life of the bond may be expressed as $\pi^e = [i - r/(1-\tau)](1-\tau)$.

Woodward (1990) reports market expectations of the after-tax real rate of interest on long-term bonds using quarterly data on British index-linked gilt-edged securities from 1982:2 to 1989:1. The ex ante post-tax real rate ranged from 1.5% to 3.2% per annum with a mean of 2.6%.

Assuming investors keep after-tax ex ante rates on long-term government bonds in the U.S. and U.K roughly equal, we can set $r = .026$ in the above expression to infer long-term expected inflation in the U.S. A tax rate in the U.S. of .20, for example, yields $\pi^e = [i-3.2](.8)$. If we take i as the yield to maturity on a 30-year U.S. government bond, then π^e is the average per annum inflation rate expected over the 30-year horizon.

The tax rate in the above expression is the marginal rate that applies to the relevant marginal investor, e.g., individual, corporation, or foreigner. The rate is difficult to determine. Its exact value, however, is not important for the analysis in the text. The analysis relies on the view that significant <u>changes</u> in the long-term nominal rate primarily reflect proportional movements in inflation expectations, a view supported by the narrow range of ex ante post-tax real rates reported by Woodward.

6. A given Federal funds rate target change will exert a greater effect on the long-term bond rate the shorter the average life of the security as measured by its duration. The duration of a coupon bond may be thought of as the term to maturity of an equivalent zero coupon bond that makes the same total payments and has the same yield. The duration of a 30 year coupon bond selling at par is approximately 1/r, where r is the yield to maturity. See Moore (1989). Thus, the duration of the 30 year government (coupon) bond discussed in the text is only about 12.5 years at an interest rate of 8% and 7.1 years at a 14% interest rate.

useful to distinguish three sources of interaction between the Federal funds rate and the long-term rate:

Pure Cyclical Funds Rate Policy Actions. The Fed routinely lowers the funds rate in response to cyclical downturns and raises it in cyclical expansions. I call such policy actions purely cyclical if they maintain the going trend rate of inflation. Even purely cyclical policy actions exert a pull on longer rates, however, so they are a source of positive comovement between the funds rate and the long rate. But because cyclical actions strongly influence only the first few years of expected future short-term interest rates, only a relatively small fraction of purely cyclical funds rate changes are transmitted to the long rate.

Long-Run Inflation. Changes in the trend rate of inflation are a second source of positive comovement between the funds rate and the long rate. While the long rate moves automatically with inflation expectations, the funds rate does not unless the Fed makes it do so. Nevertheless, the Fed can hold short-term real rates relatively steady in the presence of rising or falling inflation by moving the funds rate up or down to allow for a rising or falling inflation premium. In so doing, it causes short and long rates to move relatively closely together.

Aggressive Funds Rate Policy Actions. The Fed occasionally takes particularly aggressive funds rate policy actions to encourage real growth or to stop and reverse a rising rate of inflation. Aggressive actions combine a purely cyclical effect with a potential change in the long-run rate of inflation. The cyclical effect moves the long rate in the same direction as the funds rate, while the inflation effect moves the long rate in the opposite direction. Thus the net effect of aggressive actions on the long rate is somewhat complex.

Consider an aggressive reduction in the funds rate to encourage real growth. Initially, funds rate actions taken to fight recession pull the long rate down too. However, excessive easing that raises inflation can cause the long rate to reverse direction and begin to rise, even as the Fed continues to push short rates down. Thus we might expect to see the long rate move in the opposite direction from the funds rate near cyclical troughs. A sharp funds rate increase during the ensuing recovery exerts two conflicting forces. It tends to raise the long rate by reversing the cyclical funds rate decline, but it also reverses somewhat the expected rise in inflation, tending to lower the long rate. For a relatively brief recession with little excessive easing, the cyclical funds rate effect would dominate the inflation effect, so the long rate would tend to rise with the funds rate during the recovery. Thus, the long rate would move opposite from the funds rate for only a few months near a recession trough.

Now consider an aggressive increase in the funds rate intended to bring down the trend rate of inflation. Such a tightening potentially shifts both components of the long rate since short rates rise and expected long-run inflation may fall. One expects the first effect to dominate initially, however, because a large aggressive increase in short rates exerts an immediate significant upward pull on the long rate, while the public may not yet have confidence in the disinflation. If the Fed persists with sufficiently high short-term real rates, however, inflation and real growth eventually slow and the Fed can tentatively bring rates down somewhat. A declining long rate, at this point, would suggest that the Fed's disinflation has acquired some credibility.

Inflation Scares

I call a significant long rate rise in the absence of an aggressive funds rate tightening an "inflation scare", since it reflects rising expected long-run inflation.[7] Inflation scares are costly because the higher inflation that they signal reduces the efficiency of the payments system, with negative consequences for employment, productivity, and economic growth. Moreover, scares are costly because they present the Fed with a difficult dilemma. Resisting them requires the Fed to raise real short rates with potentially depressing effects on business conditions. But failing to respond promptly creates a crisis of confidence that encourages the higher inflation to materialize: workers and firms ask for wage and price increases to protect themselves from higher expected costs. In short, by hesitating, the Fed sets in motion higher inflation that it is then inclined to accommodate with faster

7. Since short maturity rates are anchored to the Federal funds rate target, they cannot convey as clear a signal of inflation expectations as the long rate. See Dotsey and King (1986) for more on the informational implications of interest rate rules.

money growth. The record of rising inflation and disinflation reviewed below contains examples of scares that resulted in higher money growth and inflation, as well as those that were successfully resisted by the Fed.[8]

A REVIEW OF INTEREST RATE POLICY

This study focuses on the period of disinflation beginning in October 1979. Nevertheless, I begin my review by briefly describing conditions in the immediately preceding years. For the most part, the data discussed throughout come from charts and tables included at the back of the paper.

Rising Inflation: the Late 1970s

Inflation was rising gradually in the late 1970s, with rates of 6.9%, 7.9%, and 8.6% in 1977, 1978, and 1979 as measured by fourth quarter over fourth quarter changes in the GDP deflator. The corresponding real GDP growth rates were 4.5%, 4.8%, and 2.5%. The persistent inflation scare throughout the late 1970s carried the 30-year government bond rate from 7.8% in early 1977 to 9.2% by September 1979. Over the same period, the Fed steadily increased the Federal funds rate from around 4.7% to 11.2%, raising short-term real rates from a range between 0 to -2% to between 0 and +2%. The negative short-term real rates at the

8. An inflation scare may be consistent with either a positive or a negative association between money or prices, on one hand, and unemployment or real growth on the other, depending on the nature of the underlying macroshock that sets it off.

beginning of the period suggest that initially the Fed was actively encouraging inflation in order to stimulate real growth, though the steady increase in real short rates indicates a modest effort to resist inflation.

Aborted Inflation Fighting: October 1979 to July 1980

By the time Paul Volcker became Fed Chairman in August 1979, oil price increases following the Iranian revolution in November 1978 greatly worsened the inflation outlook. Oil prices were to double by early 1980 and triple by early 1981 from November 1978 levels, and by the fall of 1979 the Fed felt that more drastic action was needed to fight inflation. The announcement on October 6, 1979 of the switch to nonborrowed reserve targeting officially opened the period of disinflation policy.

The first aggressive policy actions in this period took the monthly average funds rate from 11.4% in August 1979 to 17.6% in April 1980. Cook (1989) reports that only 1 percentage point of this 6 point rise can be attributed to automatic adjustment. Virtually all of it represented deliberate policy actions taken by the Fed to increase short-term interest rates. It was the most aggressive series of actions the Fed had taken in the post-war period over so short a time, although the 5 percentage point increase from January to September of 1973 was almost as large.

For its part, the 30-year rate rose sharply from 9.2% in August to a temporary peak of 12.3% in March after which it fell back to 11.4%

in April. A closer look reveals the sources of this sharp long rate rise. The sharp 2 percentage point monthly average funds rate rise from September to October pulled the long rate up about 0.6 percentage points. The monthly average funds rate then held in a range between 13.2% and 14.1% through February. January 1980 later turned out to be an NBER business cycle peak, and evidence of a weakening economy caused the Fed to pause in its aggressive tightening. But with the funds rate relatively steady, the long rate jumped sharply by around 2 percentage points between December and February, indicating a very serious inflation scare.

The scare was probably caused in part by the ongoing oil price rises, but the Fed's hesitation to proceed with its tightening may have contributed to the collapse of confidence. In any case, the Fed reacted with an enormous 3 percentage point increase of the monthly average funds rate in March, 1 percentage point of which was due to the automatic adjustment. The long rate hardly moved in response, suggesting that the positive effect of the aggressive rise was offset by a decline in expected inflation. Moreover, the long rate actually came down by 0.9 percentage points in April even as the Fed pushed the funds rate up another 0.4 percentage points, suggesting that the Fed had already begun to win credibility for its disinflation policy.

When one considers that business peaked in January, there is reason to believe that inflation would have come down as the recession ran its course in 1980 if the Fed had sustained its high interest rate policy. The imposition of credit controls in March, however, forced the

Fed to abort that policy. Schreft (1990) argues persuasively that by encouraging a decline in consumer spending the credit control program was largely responsible for the extremely sharp -9.9% annualized decline in real GDP in the second quarter of 1980. Supporting her view is the fact that personal consumption expenditures accounted for about 80% of the decline in real output, more than twice its average 35% contribution in post-war U.S. recessions.

Accompanying the downturn in economic activity was a sharp fall in the demand for money and bank reserves that, according to Cook (1989), caused a 4.2 percentage point automatic decline of the funds rate from April to July. The Fed enhanced the automatic easing with judgmental actions, e.g., reducing the discount surcharge, that reduced the funds rate by an additional 4.3 percentage points over this period.

The sharp interest rate decline coupled with the lifting of credit controls in July led to strong 8.4% annualized real GDP growth in the fourth quarter of 1980. In spite of the credit controls, or more accurately, because the credit controls caused the Fed to interrupt its inflation-fighting effort, inflation rose through the year from an annual rate of 9.8% in the first quarter to 10.9% in the fourth quarter as measured by the GDP deflator.

Aggressive Disinflation Policy: August 1980 to October 1982

It was clear in late summer and early fall of 1980 that inflationary pressures were as strong as ever. After being pulled down roughly 2 percentage points by the aggressive funds rate easing from April to

June, the 30-year rate rose by about 50 basis points between June and July as the Fed continued to push the funds rate down another 50 basis points. The reversal signalled an inflation scare induced by the excessively aggressive easing, and the Fed began an unprecedented aggressive tightening. Of the roughly 10 percentage point rise in the monthly average funds rate from July to December 1980, Cook (1989) attributes only about 3 percentage points to the automatic adjustment. Thus, the runup of the funds rate to its 19% peak in January 1981 marked a deliberate return to the high interest rate policy. As measured by the GDP deflator, which was rising at nearly a 12% annual rate in the first quarter of 1981, real short-term rates were a high 7% at that point.

As soon as the funds rate peak had been established, however, very slow growth in M1 and bank reserves automatically put downward pressure on the funds rate. According to Cook (1989), about 3.4 percentage points of the 4 percentage point drop in the funds rate between January and March was attributable to the automatic adjustment. Since the automatic adjustment had correctly signalled weakness in the economy in the second quarter of 1980, the Fed was initially inclined to let rates fall in early 1981. However, real GDP actually grew at a 5.6% annual rate in the first quarter, and when the strength of the economy became clear, the Fed took deliberate actions to override what it took to be a false signal that disinflation had taken hold. Reversing field, it ran the funds rate back up to 19% by June, using a series of deliberate tightening actions to supplement what Cook (1989) reports would only have been a 0.8 percentage point automatic funds rate rise.

It was not long before the aggressive disinflationary policy began to take hold. Annualized real GDP growth was -1.7% in the second quarter of 1981. The third quarter posted 2.1% real growth, but an NBER business peak was reached in July and real growth fell to -6.2% in the fourth quarter of 1981 and -4.9% in the first quarter of 1982. Meanwhile, the quarterly inflation rate as measured by the GDP deflator fell from 11.8% in the first quarter of 1981 to the 4.5% range by early 1982.

The Fed brought the funds rate down from 19% at the business peak in July to 13.3% in November and held the funds rate in the 13 to 15 percent range until summer 1982 when it brought short rates down another 4 percentage points to around 10%. The funds rate reduction through November 1981 was large in nominal terms, but when one considers that inflation had declined to the 4.5% range by early 1982, the funds rate decline actually represented a 1 or 2 percentage point rise in short-term real rates. Thus, one should still view policy as aggressively disinflationary in early 1982. As calculated by Cook (1989), automatic adjustments accounted for only 1 percentage point of the final 9 percentage point funds rate decline in the nonborrowed reserve targeting period, which ended formally in October of 1982. This last great decline should be seen as a deliberate funds rate easing calculated to achieve a sustained reduction in inflation without excessive harm to real growth.

The long rate provides a picture of the Fed's progress over the nonborrowed reserve targeting period in reducing the trend rate of inflation. The 30-year rate rose about 5 percentage points from a trough in June of 1980 to its 14.7% peak in October 1981. About 2 percentage points of that rise appears to be connected with the rundown and runup of the funds rate in 1980, the remaining 3 point gain through October 1981 reflected a continuing serious inflation scare. In fact, the sharp rise in the long rate after the funds rate had reached its peak in early 1981 may have contributed to the Fed's inclination to persist with its 19% funds rate until August 1981. Moreover, the discernable declining trend in the long rate from October 1981 to August 1982 indicates that the policy was still exerting disinflationary pressure. When the Fed finally decided to relax its disinflation policy by dropping the funds rate by over 4 percentage points in the summer of 1982, the long rate fell by around 3.5 percentage points along with it.

We can decompose this last decline in the long rate into a purely cyclical component and an inflation expectations component using evidence from earlier in the aggressive funds rate targeting period. The sharp 2 percentage point funds rate rise from September to October 1979 pulled the long rate up 0.6 percentage points; and the sharp 8.5 percentage point funds rate reduction between April and July 1980 pulled the long rate down 2 percentage points. Taking 25% as the fraction of cyclical funds rate policy actions transmitted to the long rate, about 2.5 percentage points of the 3.5 percentage point fall in the long rate in the summer of 1982 reflected a reduction of inflation expectations.

Establishing Credibility: November 1982 to Spring 1986

Real GDP growth was still poor in the second half of 1982, running -1.8% and 0.6% in the third and fourth quarters, respectively. Consequently, the Fed continued to ease after relaxing its disinflationary policy, pushing the monthly average funds rate down to 8.5% by February 1983. November 1982 turned out to be an NBER business cycle trough, and real GDP growth was 2.6% in the first quarter of 1983. But the Fed kept the funds rate around 8.5% through May while the long rate remained steady at around 10.5%. It gradually became clear, however, that a strong recovery had begun. Real GDP grew at a spectacular 11.3% annual rate in the second quarter of 1983 and at rates of 6.1%, 7.0%, 7.9%, and 5.4% in the following four quarters.

The Fed reacted to the recovery by raising the funds rate from 8.6% in May to 9.6% in August 1983. But the long rate rose simultaneously from 10.5% to 11.8%, initiating a serious inflation scare only a year after the Fed had relaxed its disinflation policy. Annualized quarterly inflation as measured by the GDP deflator was 4.8% or below throughout 1983 and 1984 with the exception of the first quarter of 1984, when it was 6%. Nevertheless, the long rate embarked on a spectacular rise to a 13.4% peak in June 1984. Amazingly, this was only about a percentage point short of its October 1981 peak, even though by 1984 inflation was 4 or 5 percentage points lower than in 1981.

The Fed tightened in an effort to resist the inflation scare, raising the funds rate to an 11.6% peak in August of 1984. The long rate began to decline in June 1984, indicating that the scare had been contained. The 7% real short rates needed to contain the scare ultimately brought quarterly real GDP growth down to the more normal 2 to 3 percent range in the second half of 1984. The Fed then lowered the funds rate rapidly by 3.2 percentage points from August to December and held it around 8% through 1985.

Meanwhile, the long rate fell about 6 percentage points from its June 1984 peak to the mid-7% range by the spring of 1986. By then, the long rate was 3 percentage points below where it had been at the start of the 1983 scare. The Fed's containment of the scare apparently made the public confident of another 3 percentage point reduction in the trend rate of inflation.

Maintaining Credibility: Spring 1986 to Summer 1990

Real GDP growth weakened considerably in the second quarter of 1986 to -0.3% from the strong 5.4% rate in the first quarter. With inflation appearing to have settled down in the 4% range, the Fed moved to encourage real growth by dropping the funds rate to the mid-6% range. Strong real growth in 1987 was accompanied by still another inflation scare in which the long rate rose about 2 percentage points from around 7.5% in March to 9.6% in October.

Although real GDP growth was very strong throughout the year, this time the Fed responded to the scare with only a relatively modest increase in the funds rate. As it happened, the October stock market crash contained the scare somewhat, but the long rate remained above 8%.

With real growth still reasonably strong in 1988, the Fed proceeded to raise the funds rate sharply from the 6 to 7% range in early 1988 to a peak of 9.8% in March 1989.

Though there was some evidence of a modest rise in inflation in 1988, the sustained funds rate tightening during the year is unique in that it was undertaken without a rise in the long rate. A preemptive tightening may have been needed to reverse the perception that policy had eased permanently following the stock market crash. At any rate, the result was an increase in credibility reflected in a further decline in the long rate in 1989. Though that fall was partially reversed in early 1990, a gently declining trend in the long rate was discernable by then, indicating growing confidence on the part of the public in the Fed's commitment to low inflation.

The 1990-91 Recession

The period of weak real growth in 1989 ending in an NBER business cycle peak in July 1990 may have been partly due to the high real short rates. Temporary oil price increases following the invasion of Kuwait, however, also helped account for the near zero real growth in the third quarter of 1990, -3.9% real growth in the fourth quarter, and -2.5% in the first quarter of 1991.

The Fed responded to the recession by bringing the funds rate down from slightly above 8% in the fall of 1990 to around 3% today. It is remarkable that this sustained easing has not yet caused the long rate to rise, even though real short rates are now around zero. Real short rates were also about zero when excessive easing sparked the inflation scare in July 1980, but they were around 4% when excessive easing triggered the June 1983 scare, and around 3% at the time of the scare in April 1987.[9] The real short rate floor at which easy policy becomes excessive no doubt varies to an extent with underlying real economic conditions such as government tax and spending policy, productivity shocks, or shifts in investment and consumer demand.[10] But long rates may also be more tolerant of aggressive funds rate easing when the public is more confident of the Fed's commitment to maintain a low trend rate of inflation.

OBSERVATIONS

The record of interest rate policy reviewed above contains a number of empirical findings that are important for interpreting and evaluating monetary policy. This section summarizes the main findings in a series of observations.

1) Inflation scares appear to be central to understanding the Fed's management of short-term interest rates. The gradual funds rate rise from 1977 to October 1979 was undertaken in an environment of slowly rising long rates. The sharp long rate rise in early 1980, during a 4 month pause in the funds rate rise, was probably an important

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9. The effect of the credit control program on consumer spending may account for the real rate getting as low as it did in 1980 before triggering a scare.

10. See, for example, the discussions in Campbell and Clarida (1987) and Poole (1988).

factor inducing the Fed to undertake its enormous 3 percentage point tightening in March. Sharply rising long rates in the first nine months of 1981 indicated that the Fed had yet to win credibility for its disinflationary policy, and probably contributed to the Fed's maintaining very high real short rates for as long as it did. On the other hand, the declining long rate from October 1981 to October 1982 encouraged the Fed to ease policy by indicating the public's growing confidence in the disinflation.

The serious inflation scare set off in the summer of 1983 largely accounts for the runup of the funds rate to August 1984. The credibility acquired by the Fed in containing that scare yielded a 3 percentage point reduction in the long rate that allowed the funds rate to come down further too. There was no inflation scare per se when the Fed raised the funds rate in 1988. Nevertheless, that series of actions may be understood as preemptive, taken to reverse a public perception that policy had permanently eased following the stock market crash. The current funds rate easing has yet to trigger a sustained rise in the long rate, but the possibility of an inflation scare has probably limited the funds rate decline somewhat.

2) One might reasonably have expected the aggressive disinflation policy beginning in late 1979 to reduce long-term interest rate volatility by quickly stabilizing long-term inflation expectations at a low rate. Yet the reverse was true initially. Long rates turned out to be surprisingly volatile due to a combination of particularly aggressive funds rate movements and inflation scares. Amazingly, it took until

1988 for the unusual long rate volatility to disappear.

3) One might also have expected the aggressive funds rate actions beginning in 1979 to be accompanied by opposite movements in the long rate. Again, the result was just the reverse. The aggressive actions moved the long rate in the same direction, apparently influencing the long rate primarily through their effect on short maturity rates. Only at funds rate peaks and troughs did the long rate move in the opposite direction. The long rate appeared to be influenced by a change in expected inflation only after sustained aggressive funds rate actions.

4) The long rate reached its peak in October 1981, indicating that it took two years for policy to reverse the rise in the trend rate of inflation. It would be a mistake, however, to conclude that acquiring credibility necessarily takes so long. On the contrary, a close look reveals that the long rate had already turned down in April 1980 while the funds rate was still rising, indicating that some credibility had been won by then. Credibility might even have been achieved sooner if the Fed had not hesitated temporarily between December 1979 and February 1980 to continue the aggressive funds rate tightening begun in October. In any case, the credit control program interrupted the disinflation policy in May 1980 and high interest rates were restored fully only in early 1981. The automatic adjustment feature of the nonborrowed reserve operating procedure then caused a sharp decline in the funds rate between January and March of 1981 that was only fully reversed by June. Thus, three interruptions account for

the delay in the Fed's acquisition of credibility for its disinflation policy.

5) Interestingly enough, the long rate was roughly in the same 8% range in the early 1990s as it was in the late 1970s, in spite of the 4 or 5 percentage point reduction in the inflation rate. Apparently, investors then perceived the 7 to 9% inflation rate as temporarily high, while, if anything, they perceive the current 3 to 4% rate as a bit below trend. The slowly declining long rate in the current period is indicative of the steady acquisition of credibility, but the high long rate indicates a lingering lack of confidence in the Fed.

6) The Fed appears to have remarkable latitude to push the Federal funds rate down in the recent recession without triggering a rise in the long rate. On three occasions when trying to encourage real growth in the 1980s (July 1980, June 1983, and April 1987) it could not push the funds rate more than 1 or 2 percentage points below the long rate before triggering an inflation scare; yet it pushed the funds rate 4 percentage points below the long rate in 1992.

The greater flexibility to reduce short rates evident in the current recession is reminiscent of that in early post-war recessions when the Fed presumably had more credibility. Chart 2 shows that the funds rate was pushed almost 3 percentage points below the long rate during the August 1957 - April 1958 recession before the long rate began to rise. The funds rate came down over 2 percentage points below the long rate in the April 1960 - February 1961 recession without much of a rise in the long rate.[11]

7) The preceding observation suggests a powerful argument in favor of a Congressional mandate for price stability. By reducing the risk of inflation scares, such a mandate would free the funds rate to react more aggressively to unemployment in the short run. Thus, a mandate for price stability would not only help eliminate inefficiencies associated with long-run inflation, but the added flexibility conferred on the funds rate might improve countercyclical stabilization policy as well.[12]

CONCLUSION

The paper used institutional knowledge of Fed policy procedures, simple economic theory, and the inflation scare concept to analyze and interpret interest rate policy as practiced by the Fed since 1979. It focused on the primary policy problem during the period: the acquisition and maintenance of credibility for the commitment to low inflation. We saw that the Fed might have acquired credibility for its disinflation relatively quickly in early 1980 had it been able to sustain a high interest rate policy then. After all, long term rates were roughly equal to the inflation rate in 1979, indicating that the public believed

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11. Kessel (1965) contains a good description and analysis of the cyclical relation between long and short rates.

12. See Black (1990) for a discussion of the benefits of price stability. Hetzel (1990 and 1992) discusses a proposal that the U.S. Treasury issue indexed bonds to provide a better indicator of long-run inflation expectations.

inflation was only temporarily high at the time. Unfortunately, a series of interruptions delayed the actual disinflation for two years, probably raising the cost in terms of lost output of acquiring credibility.

Soon after relaxing its disinflation policy in 1982, the Fed's credibility was again challenged with a serious inflation scare that carried the long rate up from 10.5% to 13.4%. It took 11 months and 7% real short rates to contain the scare, indicating how fragile the Fed's credibility was in 1983 and 1984. The long rate decline to the 7.5% range by the spring of 1986 reflected a big gain in credibility. Yet the Fed was tested by another scare in 1987 that ended with the stock market crash. The crash itself, however, then set in motion expectations of excessive easing that the Fed resisted with a 3 percentage point funds rate rise in 1988 and 1989, a tightening that probably weakened real growth somewhat in 1989 and 1990.

Reviewing the policy record makes one understand how fragile the Fed's credibility is and how potentially costly it is to maintain. Even after inflation had stabilized at around 4% in 1983, inflation scares and the Fed's reaction to them were associated with significant fluctuations in real growth. With that in mind, one cannot help but appreciate the potential value of a Congressional mandate for price stability that would help the Fed establish a credible commitment to low inflation. In fact, there is evidence that an interest rate policy assisted by such a mandate would work well. Both the Bundesbank and the Bank of Japan follow interest rate policies resembling the Fed's and yet, for the most part, they have achieved better macroeconomic performance. Perhaps it is because they each enjoy a stronger mandate for price stability than does the Fed.

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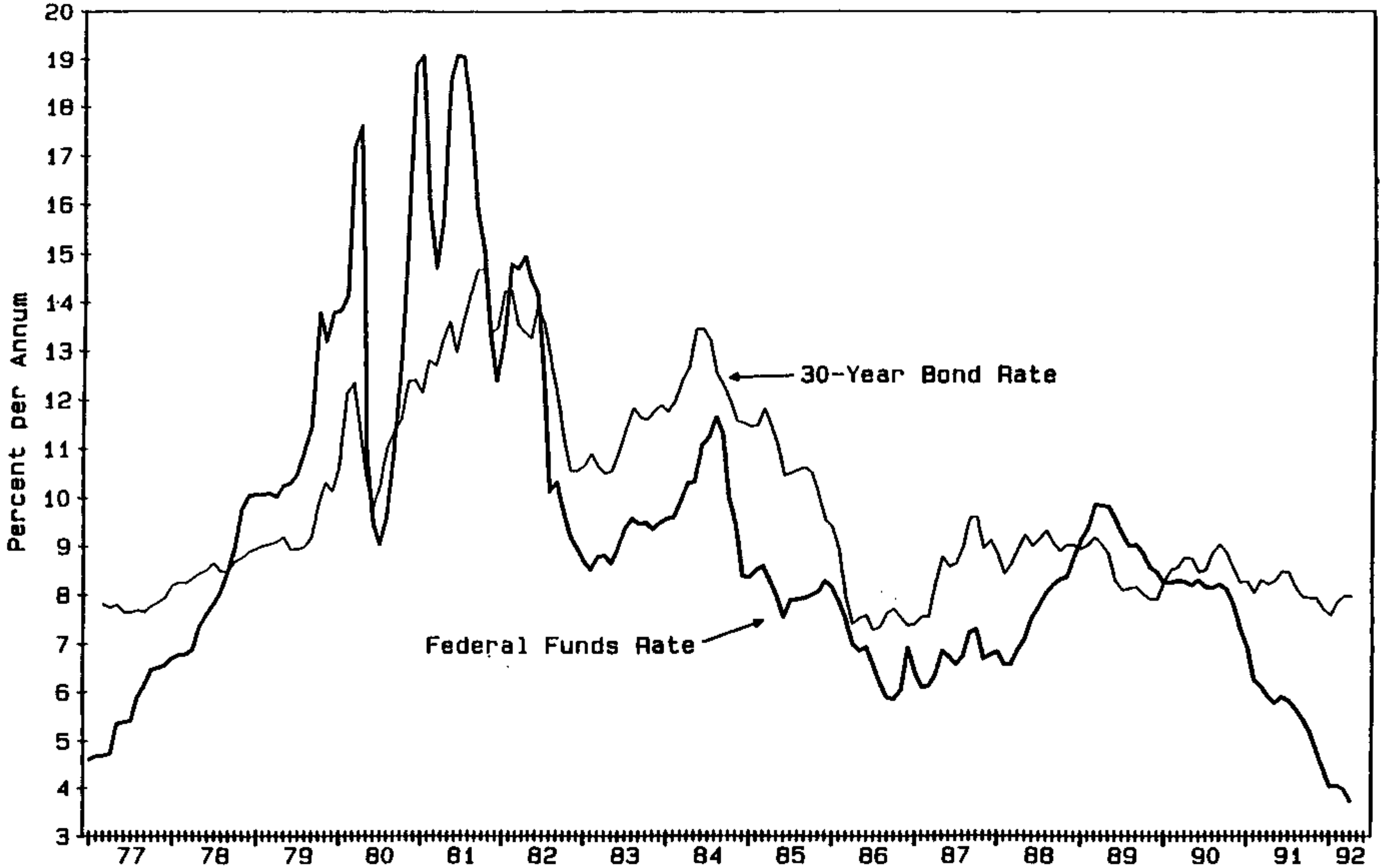
Chart 1

FEDERAL FUNDS RATE AND 30-YEAR BOND RATE

January 1977 - April 1992



Percent Change, 4Q to 4Q	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
Real GDP........	4.4	6.0	0.9	-0.2	-0.1	-1.1	6.7	4.8	3.3	2.2	4.5	3.3	1.7	-0.1	0.3
Implicit Price Deflator......	7.3	8.4	8.7	10.1	9.4	4.4	4.0	4.3	3.6	2.6	3.3	4.2	4.2	4.2	3.0

Chart 2

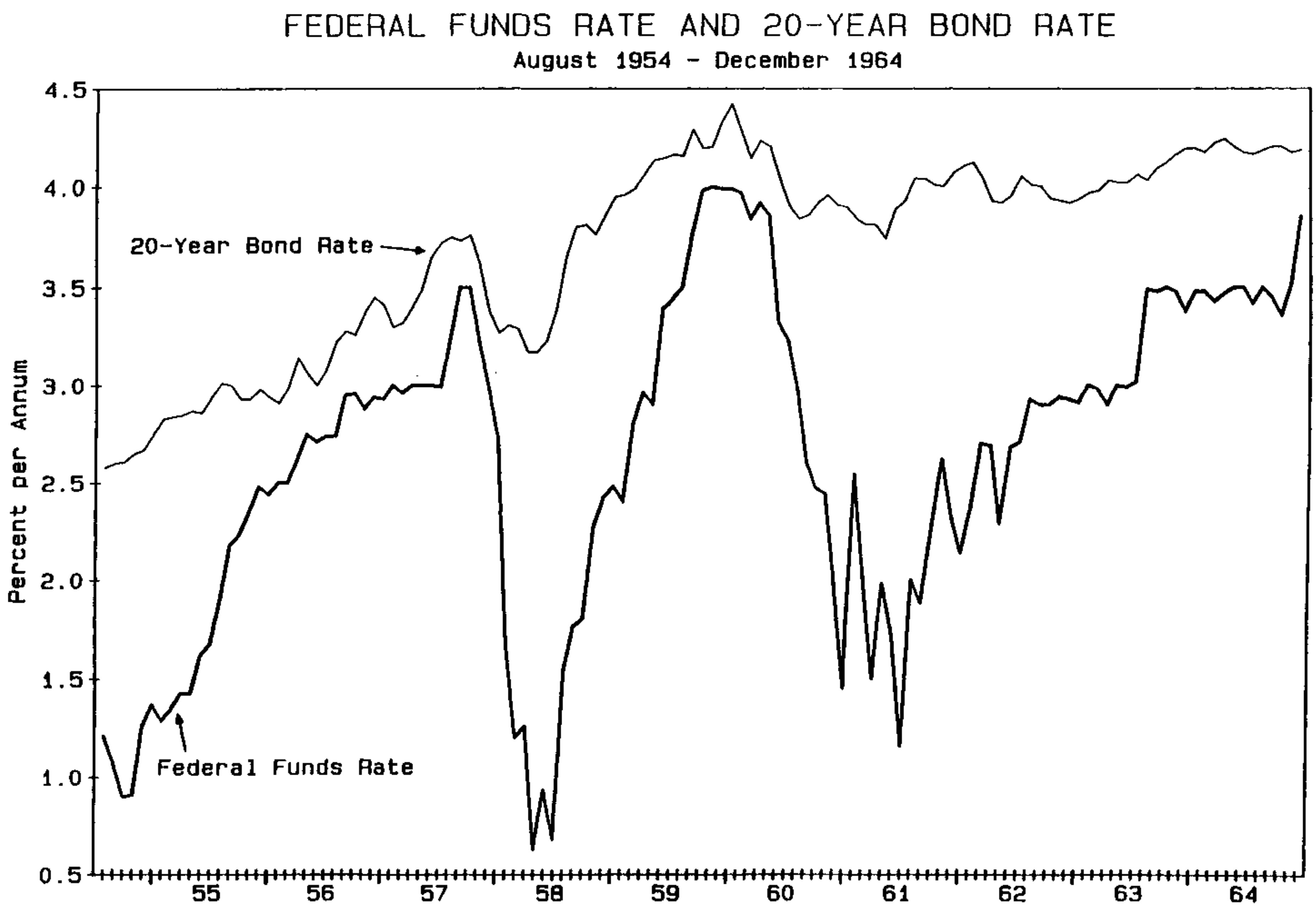

FEDERAL FUNDS RATE AND 20-YEAR BOND RATE
August 1954 - December 1964
20-Year Bond Rate
Federal Funds Rate
Percent per Annum
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
55
56
57
58
59
60
61
62
63
64

Table 1
FEDERAL FUNDS RATE AND 30-YEAR GOVERNMENT BOND RATE
January 1977 - April 1992

		Federal Funds Rate (Percent per Annum)	30-Year Govt. Bond Rate (Percent per Annum)
1977:	J	4.61	
	F	4.68	
	M	4.69	7.80
	A	4.73	7.73
	M	5.35	7.80
	J	5.39	7.64
	J	5.42	7.64
	A	5.90	7.68
	S	6.14	7.64
	O	6.47	7.77
	N	6.51	7.85
	D	6.56	7.94
1978:	J	6.70	8.18
	F	6.78	8.25
	M	6.79	8.23
	A	6.89	8.34
	M	7.36	8.43
	J	7.60	8.50
	J	7.81	8.65
	A	8.04	8.47
	S	8.45	8.47
	O	8.96	8.67
	N	9.76	8.75
	D	10.03	8.88
1979:	J	10.07	8.94
	F	10.06	9.00
	M	10.09	9.03
	A	10.01	9.08
	M	10.24	9.19
	J	10.29	8.92
	J	10.47	8.93
	A	10.94	8.98
	S	11.43	9.17
	O	13.77	9.85
	N	13.18	10.30
	D	13.78	10.12
1980:	J	13.82	10.60
	F	14.13	12.13
	M	17.19	12.34
	A	17.61	11.40
	M	10.98	10.36
	J	9.47	9.81
	J	9.03	10.24
	A	9.61	11.00
	S	10.87	11.34
	O	12.81	11.59
	N	15.85	12.37
	D	18.90	12.40
1981:	J	19.08	12.14
	F	15.93	12.80
	M	14.70	12.69
	A	15.72	13.20
	M	18.52	13.60
	J	19.10	12.98
	J	19.04	13.59
	A	17.82	14.17
	S	15.87	14.67
	O	15.08	14.68
	N	13.31	13.35
	D	12.37	13.45
1982:	J	13.22	14.22
	F	14.78	14.22
	M	14.68	13.53
	A	14.94	13.37
	M	14.45	13.24
	J	14.15	13.92
	J	12.59	13.55
	A	10.12	12.77
	S	10.31	12.07
	O	9.71	11.17
	N	9.20	10.54
	D	8.95	10.54
1983:	J	8.68	10.63
	F	8.51	10.88
	M	8.77	10.63
	A	8.80	10.48
	M	8.63	10.53
	J	8.98	10.93
	J	9.37	11.40
	A	9.56	11.82
	S	9.45	11.63
	O	9.48	11.58
	N	9.34	11.75
	D	9.47	11.88
1984:	J	9.56	11.75
	F	9.59	11.95
	M	9.91	12.38
	A	10.29	12.65
	M	10.32	13.43
	J	11.06	13.44
	J	11.23	13.21
	A	11.64	12.54
	S	11.30	12.29
	O	9.99	11.98
	N	9.43	11.56
	D	8.38	11.52
1985:	J	8.35	11.45
	F	8.50	11.47
	M	8.58	11.81
	A	8.27	11.47
	M	7.97	11.05
	J	7.53	10.45
	J	7.88	10.50
	A	7.90	10.56
	S	7.92	10.61
	O	7.99	10.50
	N	8.05	10.06
	D	8.27	9.54
1986:	J	8.14	9.40
	F	7.86	8.93
	M	7.48	7.96
	A	6.99	7.39
	M	6.85	7.52
	J	6.92	7.57
	J	6.56	7.27
	A	6.17	7.33
	S	5.89	7.62
	O	5.85	7.70
	N	6.04	7.52
	D	6.91	7.37
1987:	J	6.43	7.39
	F	6.10	7.54
	M	6.13	7.55
	A	6.37	8.25
	M	6.85	8.78
	J	6.73	8.57
	J	6.58	8.64
	A	6.73	8.97
	S	7.22	9.59
	O	7.29	9.61
	N	6.69	8.95
	D	6.77	9.12
1988:	J	6.83	8.83
	F	6.58	8.43
	M	6.58	8.63
	A	6.87	8.95
	M	7.09	9.23
	J	7.51	9.00
	J	7.75	9.14
	A	8.01	9.32
	S	8.19	9.06
	O	8.30	8.89
	N	8.35	9.02
	D	8.76	9.01
1989:	J	9.12	8.93
	F	9.36	9.01
	M	9.85	9.17
	A	9.84	9.03
	M	9.81	8.83
	J	9.53	8.27
	J	9.24	8.08
	A	8.99	8.12
	S	9.02	8.15
	O	8.84	8.00
	N	8.55	7.90
	D	8.45	7.90
1990:	J	8.23	8.26
	F	8.24	8.50
	M	8.28	8.56
	A	8.26	8.76
	M	8.18	8.73
	J	8.29	8.46
	J	8.15	8.50
	A	8.13	8.86
	S	8.20	9.03
	O	8.11	8.86
	N	7.81	8.54
	D	7.31	8.24
1991:	J	6.91	8.27
	F	6.25	8.03
	M	6.12	8.29
	A	5.91	8.21
	M	5.78	8.27
	J	5.90	8.47
	J	5.82	8.45
	A	5.66	8.14
	S	5.45	7.95
	O	5.21	7.93
	N	4.81	7.92
	D	4.43	7.70
1992:	J	4.03	7.58
	F	4.06	7.85
	M	3.98	7.97
	A	3.73	7.96

Table 2

FEDERAL FUNDS RATE AND 20-YEAR GOVERNMENT BOND RATE
August 1954 - December 1964

		Federal Funds Rate (Percent per Annum)	20-Year Govt. Bond Rate (Percent per Annum)
1954:	A	1.21	2.58
	S	1.07	2.60
	O	0.90	2.61
	N	0.91	2.65
	D	1.26	2.67
1955:	J	1.37	2.75
	F	1.29	2.83
	M	1.35	2.84
	A	1.43	2.85
	M	1.43	2.87
	J	1.62	2.86
	J	1.68	2.94
	A	1.90	3.01
	S	2.18	3.00
	O	2.24	2.93
	N	2.35	2.93
	D	2.48	2.98
1956:	J	2.44	2.94
	F	2.50	2.91
	M	2.50	2.99
	A	2.62	3.14
	M	2.75	3.06
	J	2.71	3.00
	J	2.74	3.08
	A	2.74	3.22
	S	2.95	3.28
	O	2.96	3.26
	N	2.88	3.37
	D	2.94	3.45
1957:	J	2.93	3.41
	F	3.00	3.30
	M	2.96	3.32
	A	3.00	3.40
	M	3.00	3.49
	J	3.00	3.65
	J	2.99	3.72
	A	3.24	3.75
	S	3.50	3.73
	O	3.50	3.76
	N	3.22	3.61
	D	2.98	3.38
1958:	J	2.72	3.27
	F	1.67	3.31
	M	1.20	3.29
	A	1.26	3.17
	M	0.63	3.17
	J	0.93	3.23
	J	0.68	3.39
	A	1.53	3.65
	S	1.76	3.80
	O	1.80	3.81
	N	2.27	3.76
	D	2.42	3.86
1959:	J	2.48	3.95
	F	2.40	3.96
	M	2.80	3.99
	A	2.96	4.06
	M	2.90	4.13
	J	3.39	4.14
	J	3.44	4.16
	A	3.50	4.15
	S	3.76	4.29
	O	3.98	4.19
	N	4.00	4.20
	D	3.99	4.33
1960:	J	3.99	4.42
	F	3.97	4.28
	M	3.84	4.14
	A	3.92	4.23
	M	3.85	4.20
	J	3.32	4.04
	J	3.23	3.91
	A	2.98	3.84
	S	2.60	3.86
	O	2.47	3.92
	N	2.44	3.96
	D	1.98	3.91
1961:	J	1.45	3.90
	F	2.54	3.84
	M	2.02	3.81
	A	1.50	3.81
	M	1.98	3.74
	J	1.73	3.89
	J	1.16	3.93
	A	2.00	4.04
	S	1.88	4.04
	O	2.26	4.01
	N	2.62	4.00
	D	2.33	4.07
1962:	J	2.14	4.10
	F	2.37	4.12
	M	2.70	4.04
	A	2.69	3.93
	M	2.29	3.92
	J	2.68	3.96
	J	2.71	4.05
	A	2.93	4.01
	S	2.90	4.00
	O	2.90	3.94
	N	2.94	3.93
	D	2.93	3.92
1963:	J	2.91	3.94
	F	3.00	3.97
	M	2.98	3.98
	A	2.90	4.03
	M	3.00	4.02
	J	2.99	4.02
	J	3.02	4.06
	A	3.49	4.03
	S	3.48	4.09
	O	3.50	4.12
	N	3.48	4.16
	D	3.38	4.19
1964:	J	3.48	4.19
	F	3.48	4.17
	M	3.43	4.22
	A	3.47	4.24
	M	3.50	4.20
	J	3.50	4.17
	J	3.42	4.16
	A	3.50	4.18
	S	3.45	4.20
	O	3.36	4.20
	N	3.52	4.17
	D	3.85	4.18

Table 3

QUARTERLY CHANGES IN REAL GDP AND GDP IMPLICIT PRICE DEFLATOR
(Seasonally Adjusted Compound Annual Rates)
1Q 1977 - 1Q 1992

		Real GDP (Percent)	Implicit Price Deflator (Percent)
1977:	1	6.0	6.1
	2	6.9	8.4
	3	5.7	7.4
	4	-0.8	7.3
1978:	1	2.8	5.7
	2	13.5	10.7
	3	3.1	8.3
	4	4.8	8.8
1979:	1	0.1	8.6
	2	0.4	8.4
	3	2.5	9.6
	4	0.7	8.1
1980:	1	1.7	9.8
	2	-9.9	9.6
	3	0.1	10.0
	4	8.3	10.9
1981:	1	5.6	11.8
	2	-1.7	7.5
	3	2.1	9.6
	4	-6.2	8.8
1982:	1	-4.9	4.5
	2	1.6	5.5
	3	-1.8	4.4
	4	0.6	3.4
1983:	1	2.6	4.8
	2	11.3	2.8
	3	6.1	4.2
	4	7.0	4.2
1984:	1	7.9	6.0
	2	5.4	4.1
	3	2.2	4.5
	4	2.7	2.6
1985:	1	2.7	4.9
	2	3.2	3.0
	3	5.2	2.6
	4	2.3	3.9
1986:	1	5.4	2.1
	2	-0.3	2.1
	3	2.3	2.9
	4	1.3	3.3
1987:	1	3.0	3.3
	2	5.1	2.9
	3	4.0	3.3
	4	5.9	3.6
1988:	1	2.6	3.6
	2	4.3	4.4
	3	2.5	5.1
	4	3.9	3.9
1989:	1	2.5	5.4
	2	1.9	4.2
	3	1.1	3.4
	4	1.2	3.7
1990:	1	1.7	4.4
	2	1.6	4.4
	3	0.2	4.7
	4	-3.9	3.2
1991:	1	-2.5	5.0
	2	1.4	3.1
	3	1.8	2.1
	4	0.4	1.7
1992:	1	2.4	3.1

COMMENTS ON "INTEREST RATE POLICY AND THE INFLATION SCARE PROBLEM: 1979-1992"

R. Alton Gilbert

Marvin Goodfriend states his goal in writing this paper as follows: "The goal is to distill observations to guide future empirical and theoretical analysis of monetary policy with the ultimate objective of improving macroeconomic performance." I expect this goal to be realized. I expect references to this paper as justification for using the federal funds rate as the measure of monetary policy actions and references by people who do theoretical and empirical work on credibility of central bank commitments to the control of inflation.

One reason the paper will be attractive to others is that it provides simple indicators of monetary policy actions and the credibility of monetary policy. The federal funds rate is the indicator of monetary policy actions; a rise (decline) in the federal funds rate indicates a tightening (easing) of policy. The long-term government bond rate is a measure of the credibility of Federal Reserve policy to control inflation. Changes in the long-term rate are interpreted as changes in long-term inflation expectations. A rise in the long-term government bond rate indicates that the commitment of the Federal Reserve to contain inflation in less credible to investors, and a fall in the rate indicates greater credibility. The paper uses these indicators of policy actions and credibility of policy to examine the conduct of monetary policy from October 1979 to 1992.

The purpose of my comments is to illustrate some problems in applying these simple indicators of monetary policy in interpreting specific events. Problems with using the federal funds rate as a measure of monetary policy actions are well known. Monetary policy actions may be inflationary even if the federal funds rate is rising, and policy actions may be deflationary even if the federal funds rate is falling. In many situations changes in interest rates must be supplemented with data on monetary aggregates to avoid errors in interpreting monetary policy actions.

INDICATORS OF MONETARY POLICY IN 1983-84

The problem of judging whether a rise in the federal funds rate indicates a tightening of monetary policy can be illustrated by referring to events in 1983-84. Goodfriend refers to the rise in the federal funds rate from 8.6 percent in May 1983 to 9.6 percent in August 1983 as a tightening of monetary policy. This rise in the federal funds rate was accompanied by a rise in the long-term interest rate. Thus, while the rise in the federal funds rate from May to August of 1983 is characterized as a tightening of monetary policy, it was not effective in ending the inflation scare. It took an additional rise of 2 percentage points in the federal funds rate in the following year to begin reversing the rise in the long-term rate.

Table 1 supplements the data on interest rates from Goodfriend's paper with growth rates of M1. Growth rates of M1 reflect the policy actions of the Federal Reserve, through reserve requirements and the effects of policy actions on reserves. During the spring and summer of 1983, M1 was rising rapidly. This was not a period of restrictive monetary policy. The rise in the federal funds rate from May to August of 1983 reflects the effects of an economic expansion on interest rates, rather than the effects of restrictive policy actions of the Federal Reserve. The federal funds rate peaked in the summer of 1984, when the Federal Reserve brought money growth to a halt. So when did the Federal Reserve begin tightening monetary policy? Adding information on M1 growth indicates that June 1983 is too early.

INDICATORS OF MONETARY POLICY IN 1979-81

Table 2 presents the same data for the years 1979-81. I am going backwards in time in examining 1979-81 because interpretation of movements in interest rates in this period is more complex than in the 1983-84 period.

Goodfriend's Analysis

First I present my understanding of Goodfriend's analysis. The Federal Reserve began tightening monetary policy in August 1979, but the large increase in the federal funds rate in March 1980 was necessary to gain credibility for the anti-inflation policy of the Federal Reserve. Declines in long-term rates after March 1980 reflect greater credibility of anti-inflation policy. Declines in the federal funds rate in May, June and July of 1980, however, undermined the credibility of the Federal Reserve's anti-inflation policy, causing the long-term rate to begin rising again in July 1980. The Federal Reserve began tightening policy again in August 1980, but long-term rates did not peak until October 1981, two years after the Federal Reserve began its anti-inflation policy. Because the Federal Reserve temporarily abandoned its tightening of policy in the spring and summer of 1980, it took longer than it might have to reverse the inflation scare in 1981.

An Alternative View

My alternative explanation for movements of interest rates in 1980 that focuses on the effects of the credit control policy, which was imposed in March 1980 and removed in July 1980.[1] This alternative explanation does not require assumptions about the Federal Reserve gaining and losing credibility for its

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1. For information on the credit control program and its implications for the conduct of monetary policy in 1980, see Gilbert and Trebing (1981).

anti-inflation policy over periods of a few months. This alternative explanation does not require labeling monetary policy as easing when the money stock was falling sharply and tightening and the money stock was rising rapidly.

Imposition of credit controls caused a sharp drop in the demand for credit, which caused the declines in short-term and long-term interest rates. This decline in the demand for credit was accompanied by a sharp decline in the money stock, especially in April 1980, because the operating procedure used at the time tended to be procyclical.[2] These declines in interest rates were reversed in the summer of 1980, when the credit controls were removed. Again, with a procyclical operating procedure, the money stock rose rapidly after credit controls were removed.

Using M1 as the indicator of monetary policy actions, there is a much shorter lag between the tightening of monetary policy and the peak of long-term interest rates in 1981. During much of the period from August 1980 through October 1981, M1 growth was rapid. The Federal Reserve did not consistently slow money growth until May 1981, and long-term interest rates peaked in October 1981.

It is difficult to determine the degree to which the decline in long-term interest rates that began in the fall of 1981 reflected lower expectations of long-run inflation. The economy was in a severe recession by the fall of 1981, and the decline in demand for credit must have depressed long-term rates to some extent.

CONCLUSIONS

I conclude my comments by considering their implication for interest rates as indicators of monetary policy. I find the the

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2. See Gilbert (1985) for a general description of the nonborrowed reserves operating procedure used from the fall of 1979 to the fall of 1982.

federal funds rate to be an unreliable indicator of monetary policy actions. In some cases the federal funds rate rose (fell) while the money stock rose rapidly (declined sharply). When money growth is included as an indicator of monetary policy, there is a shorter lag between the tightening of monetary policy and the following peaks of long-term interest rates. Finally, changes in long-term interest reflect forces in addition to changes in the credibility of Federal Reserve anti-inflationary monetary policy, including credit controls and recessions.

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1. Indicators of Monetary Policy, 1983-84

	Month	Federal funds rate	30-year government bond rate	Annual growth rate of M1
1983	January	8.68%	10.63%	8.94%
	February	8.51	10.88	14.15
	March	8.77	10.63	16.53
	April	8.80	10.48	11.34
	May	8.63	10.53	14.21
	June	8.98	10.93	9.78
	July	9.37	11.40	12.59
	August	9.56	11.82	6.31
	September	9.45	11.63	6.28
	October	9.48	11.58	12.59
	November	9.34	11.75	3.29
	December	9.47	11.88	3.28
1984	January	9.56	11.75	9.35
	February	9.59	11.95	3.72
	March	9.91	12.38	8.76
	April	10.29	12.65	8.45
	May	10.32	13.43	5.29
	June	11.06	13.44	9.08
	July	11.23	13.21	1.57
	August	11.64	12.54	0.44
	September	11.30	12.29	8.04
	October	9.99	11.98	-1.10
	November	9.43	11.56	8.00
	December	8.38	11.52	10.80

2. Indicators of Monetary Policy, 1979-81

	Month	Federal funds rate	30-year government bond rate	Annual growth rate of M1
1979	January	10.07%	8.94%	1.69%
	February	10.06	9.00	4.09
	March	10.09	9.03	9.38
	April	10.01	9.08	18.62
	May	10.24	9.19	0.00
	June	10.29	8.92	16.83
	July	10.47	8.93	12.94
	August	10.94	8.98	7.24
	September	11.43	9.17	7.87
	October	13.77	9.85	2.55
	November	13.18	10.30	0.31
	December	13.78	10.12	1.90
1980	January	13.82	10.60	11.20
	February	14.13	12.13	12.13
	March	17.19	12.34	-1.83
	April	17.61	11.40	-15.70
	May	10.98	10.36	-1.86
	June	9.47	9.81	17.92
	July	9.03	10.24	14.82
	August	9.61	11.00	24.72
	September	10.87	11.34	18.15
	October	12.81	11.59	14.48
	November	15.85	12.37	8.50
	December	18.90	12.40	-12.06
1981	January	19.08	12.14	8.85
	February	15.93	12.80	8.16
	March	14.70	12.69	14.16
	April	15.72	13.20	26.54
	May	18.52	13.60	-8.88
	June	19.10	12.96	0.28
	July	19.04	13.59	5.81
	August	17.82	14.17	4.89
	September	15.87	14.67	1.70
	October	15.08	14.68	3.70
	November	13.31	13.35	9.01
	December	12.37	13.45	10.76

INTEREST RATE OPERATING PROCEDURES OF FOREIGN CENTRAL BANKS

John Morton and Paul Wood[1]

The interest rate operating procedures employed by central banks in the major industrial countries in implementing monetary policy over the past decade have varied considerably. This variation has not only been among countries at any moment in time, but also often within countries over time. The main aim of this paper is to investigate the experience of these countries with various interest rate operating procedures, both descriptively and in terms of statistical measures, in light of their stated intentions and goals in terms of monetary policy implementation. The first section of the paper lays out some possible criteria for selection of an interest rate operating procedure, and some of the implications of choosing different monetary policy targets. The second section describes in more detail the recent experiences of six industrial countries (Japan, Germany, France, the United Kingdom, Switzerland, and Canada) with respect to interest rate operating procedures. The third section presents and discusses some statistical measures of this experience.

INTEREST RATE OPERATING PROCEDURES

Questions regarding the desirable properties, characteristics, and criteria of selection of an interest rate operating procedure can be usefully divided into two broad categories. The first category involves the choice of target variable, or variables, at which interest rate policy is aimed. These targets could be either ultimate macroeconomic targets, such as output, unemployment, or inflation, or intermediate targets, such as growth of one or more monetary aggregates or exchange rates. The second general category of factors involves the choice of a

1. Division of International Finance, Board of Governors of the Federal Reserve System. We would like to thank Karen Johnson and Ralph Smith for useful comments, and James Heil for research assistance.

particular interest rate operating procedure, given the selection of a particular target. In practice, of course, both categories are interrelated.

The choice of a policy target, which then becomes the focus of the interest rate operating procedure, can depend on a variety of factors. On a theoretical level, these would include prominently the likely source of economic disturbances, focussing on whether disturbances originate mainly from real or monetary factors, or from domestic or foreign sources. The possible choice of a monetary target would additionally depend importantly on the stability of monetary relations, in particular the demand for money. Political or institutional constraints can also be important in deciding on an exchange rate target, the most prominent recent example being possible membership in the European Monetary System (EMS).

The individual country experiences described in the next section, while exhibiting substantial variations, do appear to show some general trends with regard to choice of policy targets. Over the past decade there appears to have been a general, though not universal, movement away from monetary targets and, for some countries, a movement towards exchange rate targets. This trend is most evident, of course, among EMS members, other than Germany. There also appears to have been a general tendency to adopt a more flexible, ad hoc approach to targets, with a variety of targets having shifting relative weights under different circumstances.

The likely relationship between choice of a particular policy target and the variability of interest rates used to achieve that target is unclear. The outcome would depend on such factors as the main source of economic disturbances and the strictness with which policy targets are adhered to. In general, an intermediate target, such as monetary aggregate growth, might be more strictly followed, in the sense of a change in the target variable triggering a prompt and at times large change in interest rates. In this case, adoption of such a procedure might be expected to result in a more variable interest rate path. However, such a procedure might, over time, bring greater stability, eliminating possible discretionary swings in policy, and reducing interest rate variability.

Given the choice of a particular target, the question arises as to the interest rate procedures used to achieve that target. Assuming that at any moment a particular interest rate level could best achieve some desired level of the target, an interest rate implementation procedure would seem to be desirable if it could achieve that interest rate level, and undesirable if it could not. Thus, it would appear desirable to have an interest rate procedure that was "flexible," in the sense of allowing prompt and, if needed, large changes in interest rates. Conversely, an "inflexible" system, which somehow hindered interest rate changes, would appear undesirable.

As demonstrated in more detail in the next section, several countries have, over the past decade, moved to more flexible--in the sense defined above--interest rate operating procedures. These changes have sometimes been confined to the interest rate operating procedures themselves (Germany and the United Kingdom) or have taken place as part of a wider change to a more market-oriented monetary policy framework (Japan and France). Movement to a more flexible interest rate operating procedure may involve moving to less of a reliance on the discount rate, since discount rate changes may be hindered by concerns over announcement effects. Despite the seeming general desirability of a "flexible" interest rate operating procedure, monetary authorities may at times be reluctant to adopt procedures which are seen to lead to "unstable," or overly volatile interest rates, showing a preference for a more stable interest rate path.

INDIVIDUAL COUNTRY EXPERIENCES

Japan

The Japanese financial system has traditionally been characterized by a high degree of government control and restrictions. In terms of monetary policy, authorities have relied heavily on discount rate changes and quantitative controls. Over the past decade, this system has undergone substantial liberalization, featuring new financial instruments, more international openness, interest rate decontrol, and less reliance on the discount rate and more reliance on open market operations.

A variety of pressures have encouraged the move to financial liberalization. An increase in government deficits starting in the mid-1970s eventually led to the breakup of the system whereby banks were forced to accept government debt at below-market rates. The first real open market to emerge in the 1970s was the gensaki market, a repurchase market for government bonds. Market pressures to break down restrictions in domestic financial markets also came from abroad, particularly the United States. Various foreign exchange restrictions were reduced starting in 1980, and the Euroyen market grew rapidly in subsequent years.

The process of financial liberalization, which started later in Japan than in any other of the major industrial countries, with the possible exception of France, gained real momentum after the mid-1980s. Banks had been permitted to issue negotiable certificates of deposit in 1979. In 1985, money market certificates, yen-denominated bankers acceptances, and large denomination time deposits were introduced. Treasury bills first appeared in 1986, and commercial paper in 1987.

At the beginning of the 1980s, the Bank of Japan relied heavily on the discount mechanism to regulate credit conditions. Most interest rates were tied, formally or informally, to the discount rate. The Bank supplied credit to the market almost exclusively through changes in discount window lending. The discount rate was kept well below market interest rates, meaning that there was always an excess demand for discount borrowing. The Bank of Japan decided each day how much discount lending to make, both in total and to individual banks, effectively rationing credit. The Bank also imposed ceilings on the growth in bank lending. However, as more and more financial transactions took place at market-determined interest rates, and non-bank sources of credit grew in importance, this system became increasingly less efficient.[2] In response, starting about 1988, Japanese authorities adopted a policy of relying increasingly on open market operations and less on discount window lending as a way of supplying reserves to the banking system. They also looked to day-to-day control of the overnight rate as the main interest rate control mechanism, giving less importance to the discount rate. These shifts in operating procedure are still incomplete and ongoing.[3]

The Bank of Japan appears to have maintained an interest rate target rather than a monetary aggregate target over the past decade, i.e., monetary authorities appear to have varied interest rates in response to changes in macroeconomic targets, such as output and inflation, rather than money supply growth. The Bank of Japan announces "forecasts" for M2+CD growth, but does not appear to treat these as targets. For one thing, the forecast is for four-quarter growth rates but is only announced at the beginning of the end-point quarter, meaning that much of the forecast is already history. Also, in recent years, as money growth has fluctuated sharply, M2+CD forecasts have been varied in line with actual data, rather than changing more slowly, as would more likely be the case were they treated as targets.

Germany

Entering the 1980s, the Bundesbank relied primarily on the Lombard window to extend credit to banks. Borrowing at the Lombard window is done at the initiative of banks. The rate on those loans, the Lombard rate, is a rate set by the Bundesbank and adjusted infrequently, often in conjunction with an equal movement in the discount rate. During the first half of the decade, the call money rate tended to be near the Lombard rate. When bank reliance on Lombard borrowing became too heavy, the Bundesbank would attempt to gain control over Lombard borrowing by

2. By the end of 1991, over 60 percent of city bank deposits carried market rates of interest.

3. The Bank of Japan still relies mainly on varying the amount of discount window lending, rather than open market operations, for daily adjustments of credit availability.

putting quantitative limits on what banks could borrow at the Lombard window or by suspending the Lombard rate and substituting a special Lombard rate that could be changed daily. The Bundesbank began to use repurchase agreements (RPs) in the early 1980s and increasingly met bank liquidity needs with RPs beginning in 1983. The rates on RPs generally exceeded the Lombard rate during this time.

In 1985, in response to excessive use of the Lombard window, the Bundesbank raised the Lombard rate above the RP rate to make the Lombard window the borrowing source of last resort for banks. Since 1985, the call money rate has tended to track the RP rate, somewhere between the discount rate and the Lombard rate. The RP rate has been moved around more than the Lombard rate, which is only adjusted a few times a year. The Bundesbank effectively targets the call money rate. Funds are injected into and withdrawn from the market through weekly auctions at which RPs are tendered with a maturity of approximately one month, with two-month RPs also offered on occasion. Sometimes RP funds are offered at a fixed rate announced in advance. More commonly, the funds are auctioned at a rate sufficient to clear the market. The Bundesbank sets the quantity tendered after it observes the bids, so it has some control over the repurchase rate. The Bundesbank can also inject funds through emergency short-term RP tenders and by moving Treasury funds held at the Bundesbank into commercial banks.

Germany has had a monetary target continuously since 1975. For most of this period, the target was stated in terms of central bank money (CBM), a weighted sum of the components of M3. Starting in 1988, M3 itself became the targeted aggregate. In terms both of success in achieving targeted aggregate growth and the apparent importance attached to this goal, the Bundesbank seems to have been relatively committed to monetary aggregate growth as a policy goal. A complication to monetary targeting was introduced by the monetary union of eastern and western Germany in 1990. Since then, interpretation of monetary aggregate changes has become considerably more difficult and ambiguous.

France

More than any other major industrial country, with the possible exception of Japan, France had tightly regulated financial markets moving into the 1980s. There were extensive foreign exchange controls, a number of financial instruments were either officially or effectively prohibited, many interest rates (including bank deposit rates) were regulated, and monetary control was exerted largely through ceilings on bank credit growth.[4] Starting in the early 1980s, this highly regulated system began to be liberalized and deregulated. The liberalization process was prompted partly by market pressures, arising from financial innovations and foreign competition, and partly from a deliberate government policy aimed at increasing market efficiency. Major events in this liberalization process included the 1982 introduction of short-term bond mutual funds (SICAVs), which provided strong competition to regulated-rate bank deposits, the introduction of negotiable certificates of deposit and commercial paper in 1985, and opening of the short-term treasury bill market to non-financial corporations and individuals in 1986.

Although the process of financial liberalization has continued at various rates throughout the past decade, a key change in the procedures for implementing monetary policy took place in January 1987. The previous system of quantitative controls on bank asset growth was abolished, to be replaced by reserve requirements on liabilities, and the daily setting of the call-money market rate was also ended.[5]

The interest rate operating procedure established in 1987, which still in substance prevails, involves two key official interest rates. These are the intervention rate and the 5- to 10-day repurchase rate. Under normal circumstances, the interbank rate is between these two

4. The "encardrement du credit" credit ceiling system is described in Marc Quintyn, "From Direct to Indirect Monetary Policy Instruments: The French Experience Reconsidered," IMF Working Paper, March 1991, pp. 5-7.

5. Technically, credit growth ceilings were ended in 1985. However, they were replaced by a marginal reserve requirement system that in large part served as a functional equivalent. This system was abolished in January 1987.

rates, with the intervention rate acting as a lower bound and the repurchase rate an upper bound. The main instrument used to influence the interbank interest rate is the intervention rate (the rate at which repurchase funds are offered approximately once a week by the Bank of France). The Bank of France also controls the quantity of reserves allocated at the 5-10 day repurchase rate, though borrowing at that facility is done at the initiative of individual private banks.

French monetary authorities have maintained monetary targets continuously since 1977.[6] The strength of the French commitment to these targets appears to have varied over time, but in general has not been as strong as in some other countries, such as the United Kingdom. More important, especially in recent years, has been the French commitment to an exchange rate target, formally an EMS parity, in practice the mark. France joined the EMS in 1979, but devalued the franc within the EMS three times in the 1981-1983 period. A key event in France's commitment to an exchange rate target was the 1983 decision of the Mitterrand government, after much internal debate, to remain within the EMS. The last realignment of the franc within the EMS was in January 1987. Since then, maintaining a stable franc-mark exchange rate has clearly been the paramount goal of French monetary policy.

United Kingdom

Over the past decade, monetary policy operating procedures have varied in the United Kingdom. At times, authorities appear to have operated mainly with an interest rate target, varying interest rates in response to macroeconomic goals, such as output or inflation. At other times, monetary aggregate targeting has been given priority, and, more recently, an exchange rate target has been most important.

The Bank of England's interest rate operating procedures are conducted mainly through its money market dealing rates. These are the rates at which the Bank supplies liquidity daily to the market, primarily through open market transactions in commercial bills with the discount

6. The targeted aggregate has alternated between M2 to M3, with the aggregate undergoing a major redefinition in 1987.

houses. The Bank operates in four maturity bonds, ranging from 1-14 days to 64-91 days. In practice, the money market dealing rates operate much like discount rates in that they are set by the Bank and changed only infrequently.

It should be noted that in 1981, when the Bank instituted the system described above, "it was hoped that this mechanism would provide scope for a reasonable degree of flexibility in short-term interest rates."[7] Under the previous system, a Minimum Lending Rate, at which the Bank provided funds to the market, was officially set and remained unchanged for long periods of time. It was hoped that the new money market dealing rates would be partially set by market forces, and vary from day to day. Thus, the Bank's interest rate intentions would be revealed more indirectly, and the "announcement effect" of official lending rate changes would be lessened. As actual events unfolded, this goal could not be achieved.[8] The Bank remained the dominant force in the bill market, supplying significant funds each day, with its lending rates achieving a de facto discount rate status.

British monetary authorities first adopted a monetary target in 1976. The importance attached to this target increased sharply with the start of the Thatcher government in 1979. However, over time, various problems with monetary targeting--in particular financial innovations which seemed to distort monetary aggregate growth--led to a de-emphasis of monetary targets, although they still officially remain in place. Important stages in the process of moving away from monetary targets included the use of more than one monetary aggregate as a target (starting in February 1982), use of a M0 as a target, M0 consisting almost entirely of currency, and thus not under the active control of monetary authorities (starting in February 1984), and significant and persistent overshooting of the original M3 target (starting in March 1985).

7. A. L. Coleby, "Change in Money-Market Instruments and Procedures in the United Kingdom," in Changes in Money-Market Instruments and Procedures: Objectives and Implications, Bank for International Settlements, March 1986, p. 200.
8. For a description of this episode, see Coleby, pp. 201-204.

U.K. monetary authorities have also at various times used interest rate changes in order to achieve an exchange rate objective. In the late 1970s and early 1980s, the exchange rate of greatest interest to authorities was that of the pound against the U.S. dollar. However, increasingly, the exchange rate of the pound in terms of EMS currencies, and particularly the German mark, became the main objective. For a period in 1987-1988, British authorities maintained an unofficial but strong effort to keep the pound-mark exchange rate in a narrow range. In retrospect, this experiment was judged to have had an unfavorable outcome. Upward exchange market pressure on the pound against the mark led to an easing of monetary policy and reduction in interest rates that provided an undesirable inflationary stimulus to the domestic economy. Since October 1990, the pound has been an official member of the EMS's exchange rate mechanism. Experience in this later period has generally been more successful.

Switzerland

The Swiss National Bank's policy has been geared to two main objectives over the past decade, monetary targets and the exchange rate of the franc (mainly against the dollar early in the period, and against the mark in recent years). The relative importance of these two objectives appears to have varied over time. The Swiss have maintained monetary targets since 1975. The target has been stated in terms of adjusted central bank money (essentially the monetary base) since 1980. Between 1982 and 1987, Swiss monetary authorities came quite close to achieving their targeted monetary growth rate. However, both before and after this interval, substantial deviations from targets occurred.

In the 1978-1979 period, there developed a clear conflict between exchange rate and monetary target objectives. There was strong upward pressure of the franc (mainly against the dollar), which would have required a significant easing of monetary policy and lowering of interest rates to counter. However, such an easing was likely to lead to a significant overshooting of the monetary target. Swiss authorities chose to put greater weight on the exchange rate objective in this instance.

This resulted in a surge of money growth, a temporary abandonment of the monetary target in 1979, and a subsequent increase in inflation to what was, by Swiss standards, alarming levels. Analysis of this episode is complicated by several factors. In particular, the oil price shock of 1979, which contributed to inflationary pressures, and an upward shift in money demand, much of it coming from abroad. Nonetheless, Swiss authorities appear to have concluded that it was a mistake to allow an overshooting of the monetary target to the extent that took place.

The more recent period of substantial deviation from monetary targets was triggered by two changes introduced in 1988 which substantially shifted the demand for base money. First, a new electronic interbank payments system was established which sharply lowered commercial banks' need for clearing balances at the Swiss National Bank. Secondly, the authorities modified cash liquidity requirements, moving from an end-of-month to monthly average measure and lowering overall requirements. The net result of these changes was a substantial undershooting of the central bank money target over the 1988-1990 period, difficulty in interpreting the actual degree of ease or tightness of monetary policy, and an increase in inflationary pressures in 1991-1992. Despite this recent difficulty with monetary targeting, there remains a reluctance by some in Switzerland to move fully to an exchange rate target.[9] This decision is increasingly taking the form of possibly joining the EMS, effectively pegging the Swiss franc to the mark. This possibility appears strengthened by the recent referendum vote in favor of IMF membership, and the subsequent announcement by the Swiss government that it would apply for EC membership.

The Swiss National Bank has two means of affecting market liquidity. The first, and most important, involves foreign exchange swaps, usually of 1- to 3-month maturity. The second involves moving government balances into and out of the commercial banking system. The Swiss National Bank maintains both a discount rate, set at the Bank's

9. See, for example, G. Rich. "The Orientation of Monetary Policy and the Monetary Policy Decision-Making Process in Switzerland," Swiss National Bank, 1991.

discretion and changed only infrequently, and a Lombard rate which, since May 1989, has been computed daily by a formula which sets the rate 200 basis points (rounded to the nearest 1/8 percent) above a reference call money rate. This latter change appears to have been motivated by a desire to make the Lombard rate a penalty rate, and Lombard lending truly an exceptional source of bank liquidity, as well as avoiding announcement effects from Lombard rate changes.

Canada

Canadian monetary policy has been dominated over the past decade mainly by the important influence of, and need to respond to, conditions in the United States. Given the close integration of U.S. and Canadian financial markets, this has usually meant that Canadian short-term interest rate changes mirror those in the United States fairly closely. Unlike the situation of EMS members, however, there has never been a formal or official commitment to keep the Canadian dollar-U.S. dollar exchange within some specified narrow range. It has been a general policy of the Bank of Canada to pursue a "leaning against the wind" intervention policy, moderating but not totally resisting exchange rate movements. In addition, monetary authorities have explicitly recognized the trade-off between exchange rate and interest rate changes, with, for example, a potentially inflationary depreciation of the Canadian dollar's foreign exchange value leading to some compensating tightening of monetary policy through higher Canadian interest rates.

Canada first adopted an official monetary target in November 1975. However, various problems--including financial innovations which distorted monetary aggregates growth, and conflicts with other important targets, particularly the exchange rate--led to the abandonment of monetary targeting in November 1982. More recently, since 1990 targeting of another type has been introduced. Canadian financial authorities have announced a multi-year series of declining inflation targets. Although money aggregate growth (of M2) is to be used as one indicator guiding policy, it has been made clear that actual inflation is the main target.

In March 1980, the Bank of Canada adopted a formula for determining its discount rate. More specifically, the discount rate is determined by a pre-announced rule based on the outcome of the weekly 3-month Treasury bill auction. Since this procedure eliminates the "announcement effect" of discount rate changes, it provides the maximum degree of flexibility in implementing interest rate policy.

STATISTICAL MEASURES OF VOLATILITY

The preceding two sections suggest that, both in theory and in the views of central bank officials, a desirable property of an interest rate operating procedure is to be "flexible." Although it is difficult to arrive at a simple, unambiguous definition of this term, its core meaning appears to involve the ability to change interest rates promptly and fully when needed. This could involve both day-to-day changes, and cumulative adjustments over time. On the other hand, central bankers also may wish to have a relatively smooth path of key interest rates, either for political reasons or in order for policy to be more easily predicted by market participants. Therefore, it is ambiguous whether interest rate volatility is good or bad.

The discussion in the previous sections suggests several hypotheses as to the relative variability of interest rates under differing operating procedures and different policy regimes, although in some cases expected results are ambiguous. The switch to an interest rate operating procedure that is more market-oriented and less tied to official rates, such as that undertaken by Germany in 1985, might be expected to lead to a somewhat more variable interest rate path. Similarly, a general liberalization of financial market structure and monetary policy operating procedures, such as that which took place in Japan and France around the mid-1980s, might also be expected to increase interest rate variability. Adoption by Canada of a formula discount rate, where official interest rate changes are unhampered by announcement effects, might be expected to result, other things being equal, in relatively greater interest rate variability than in other countries.

The implications for interest rate variability of differing monetary policy target variables is a priori more uncertain. Thus, the expected relationship between interest rate variability in countries with a relatively strong commitment to a monetary aggregate target, such as Germany and Switzerland, and countries without monetary aggregate targets, such as Japan and Canada, is unclear, although there might be a weak presumption of somewhat greater interest rate variability in countries following a monetary aggregate target. There is a similar uncertainty about the role of exchange rate targets. Here, the main division would be between EMS members (France and, since 1990, the United Kingdom) and countries with no formal exchange rate commitment (Japan, Canada, and Switzerland). The situation here is further complicated by the fact that, even without a formal exchange rate arrangement, some countries still tie their monetary policies strongly at times to exchange rate targets (Canada to the U.S. dollar and Switzerland to the mark).

In tables 1, 2, and 3, we show measures of daily interest rate volatility for the six countries in our study. For five of the countries, we divided the sample where there was a significant change in the operation of monetary policy. (We did not find any break in policy for Canada). In Japan, the break we chose is at the beginning of 1985, which marked the approximate beginning of rapid financial liberalization. For Germany, the break is in February 1985, when the Bundesbank shifted to relying on RP agreements rather than the Lombard window as the primary source of liquidity for the banking system. In France, the break is at the beginning of 1987, when French financial markets were liberalized and the Bank of France switched from direct credit allocation to open market operations. In the United Kingdom, the break is in October 1990, when sterling entered the exchange rate mechanism of the EMS. For Switzerland, the break is in 1988, when Swiss cash liquidity requirements were changed to a monthly-average basis from a month-end basis.

The measure of daily volatility shown in Table 1 is the standard deviation of interest rates on a daily basis. For each of these countries, the interest rate path over time has either a substantial trend or prominent cycles, so that standard deviation measures over long periods are dominated by the large differences from mean, rather than day-to-day changes, and are thus relatively invariant for different frequencies. Because of this, we computed the standard deviation of daily data around the monthly mean for each month, then averaged the monthly standard deviations for each sub-period, and that is shown in Table 1. In Table 2, we show the standard deviation of daily changes in interest rates for each sub-period. The measure shown in Table 3 is the average absolute daily change in interest rates.

The first comparison we can make is between volatilities of overnight and three-month interest rates. For each of our measures and for every country and every time period, overnight interest rates are more volatile than three-month interest rates. That would be expected if overnight rates reflect temporary liquidity pressures in addition to changes in monetary policy. We also find that countries with the least volatility in overnight rates also tend to have the least volatility in three-month interest rates.

Comparing across countries, we find that Japanese interest rates have been less volatile at both the overnight and three-month maturities. German interest rates have generally been the next least volatile, followed closely by those of France, which has set its monetary policy to stabilize the franc-mark exchange rate especially in the more recent period. Interest rate volatility in the United Kingdom tends to be somewhere in the middle of this group of countries, while volatility has been the highest in Switzerland and Canada. We can thus find no clear division in interest rate volatility along the lines of countries that have monetary aggregate targets versus those that do not, because Japan and Canada (two countries without monetary targets) are on opposite ends of the volatility spectrum. Likewise, there is no clear division between EMS and non-EMS countries.

Comparing across time periods, we see that standard deviations around monthly means have declined for all the countries and all maturities except for the Japanese three-month interest rate. However, the three-month rate used here (the CD rate) is only available starting June 1984, so the first sub-period has only seven months of data for that rate. The standard deviation for the German overnight rate was almost unchanged. The most striking decline in interest rate volatility is also the most predictable. Swiss overnight interest rates became much less volatile after the switch to monthly-average liquidity requirements which reduced the sharp increases in overnight rates that tended to occur at the end of each month under the previous regime of month-end reserve requirements.

The measure of average absolute change shown in Table 3 shows declines in volatility in the latter sub-periods except for Germany and the United Kingdom. It is somewhat surprising that interest rate volatility has decreased in the more recent sub-periods for Japan and France, which moved to more flexible interest rate operating procedures. However, it is possible that the deepening of financial markets in the latter period of financial liberalization has contributed to lower interest rate volatility. In Germany, the move to a more flexible operating procedure in 1985 has been accompanied by slightly more volatility by the measure in Table 3.

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Data Series

Overnight

Germany: Frankfurt Interbank Call Money Rate

Japan: Tokyo Unconditional Lender Rate

France: Paris Day to Day Money Rate

United Kingdom: U.K. Call Money Rate

Canada: Canadian Day to Day Money Rate

Switzerland: Zurich Call Money Rate

Three-Month

Germany: Frankfurt Interbank Loan Rate

Japan: Rate on Certificates of Deposit (Secondary Market)

France: Paris Interbank Rate

United Kingdom: Interbank Sterling Interest Rate

Canada: Canadian Finance Company Paper

Switzerland: Swiss Interbank Rate

Table 1

Average of Standard Deviations of Daily Data Around Monthly Means

		Overnight rate	Three-month rate
Germany			
	1980-85	0.25	0.16
	1985-92	0.24	0.08
Japan			
	1980-84	0.18	0.01
	1985-92	0.13	0.07
France			
	1980-86	0.30	0.22
	1987-92	0.23	0.14
United Kingdom			
	1980-90	0.43	0.25
	1990-92	0.36	0.18
Canada			
	1980-92	0.58	0.23
Switzerland			
	1980-87	3.56	0.24
	1988-92	0.20	0.18

Table 2

Standard Deviations of Daily Changes in Interest Rates

	Overnight rate	Three-month rate
Germany		
1980-85	0.38	0.13
1985-91	0.32	0.06
Japan		
1980-84	0.13	0.00
1985-91	0.10	0.04
France		
1980-86	0.23	0.14
1987-91	0.20	0.09
United Kingdom		
1980-90	0.40	0.18
1990-91	0.35	0.11
Canada		
1980-91	0.58	0.16
Switzerland		
1980-87	6.98	0.20
1988-91	0.18	0.11

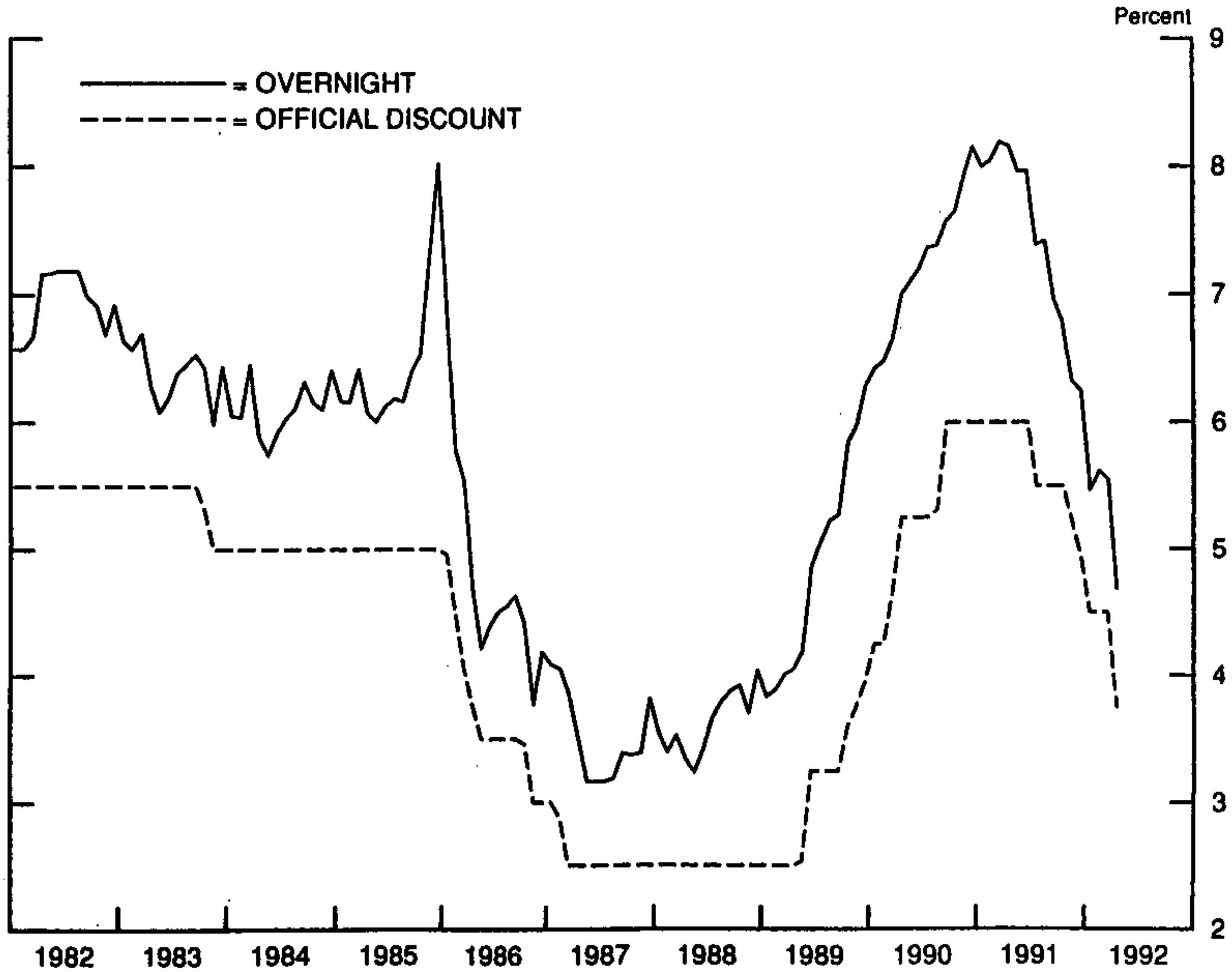
Table 3

Average Absolute Change of Interest Rates (Daily Data)

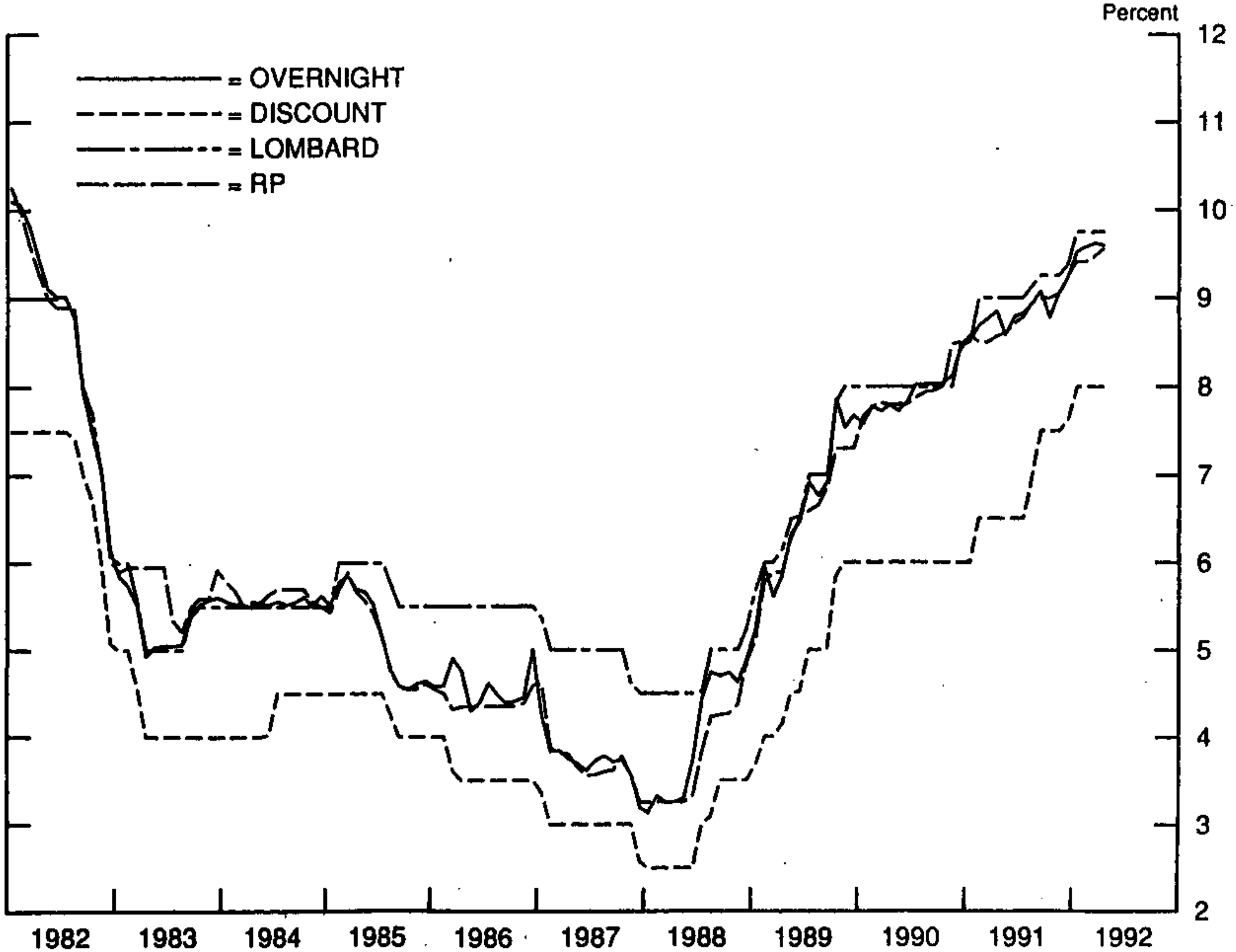
	Overnight rate	Three-month rate
Germany		
1980-85	0.110	0.063
1985-92	0.118	0.035
Japan		
1980-84	0.073	0.047
1985-92	0.063	0.018
France		
1980-87	0.121	0.063
1987-92	0.114	0.051
United Kingdom		
1980-90	0.226	0.093
1990-92	0.233	0.063
Canada		
1980-92	0.536	0.087
Switzerland		
1980-87	0.884	0.105
1988-92	0.375	0.059

Morton and Wood
Chart 1

Overnight and Official Discount Rates for Japan
(Monthly Average)



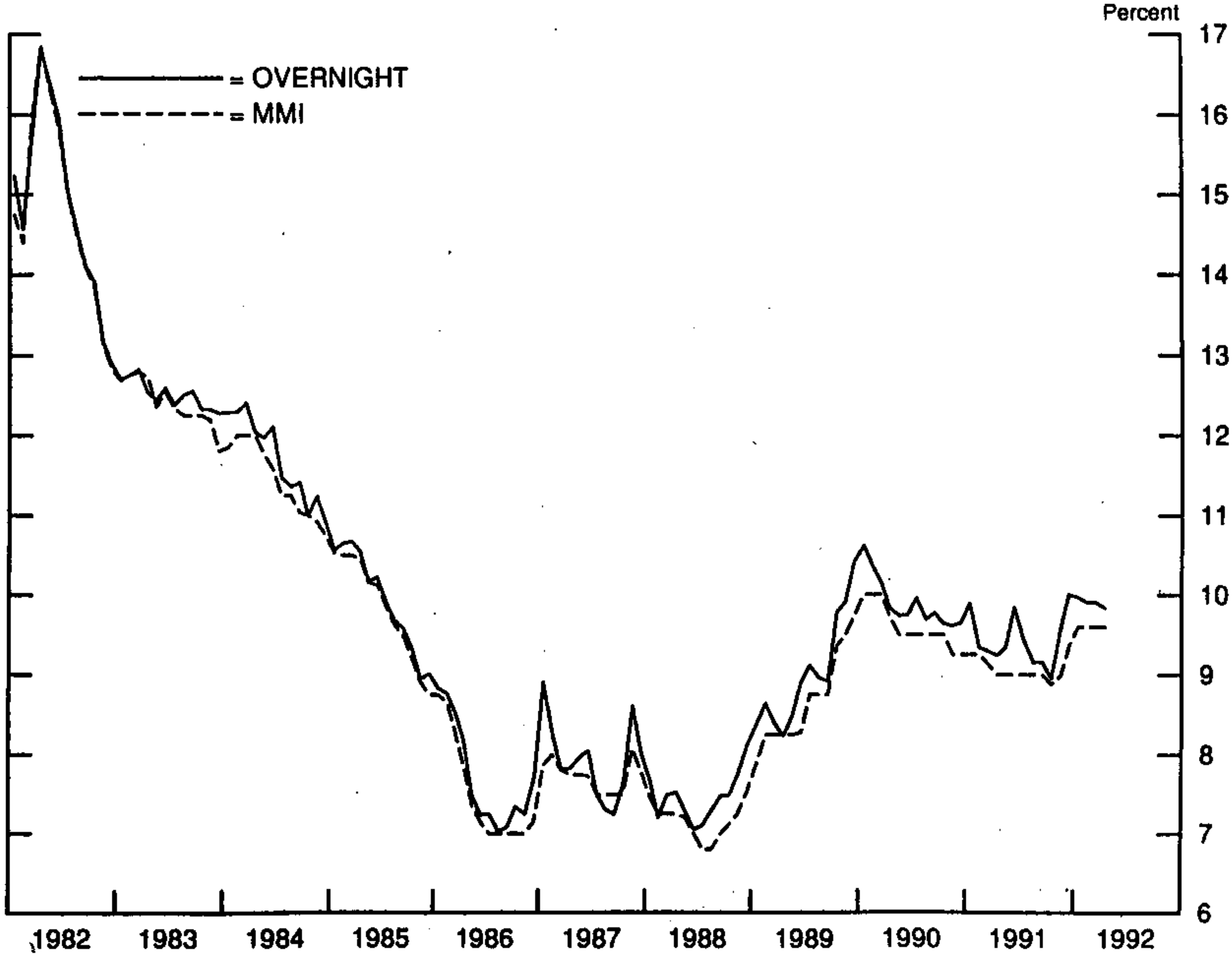
Overnight, Discount, Lombard, and RP Rates for Germany
(Monthly Average)



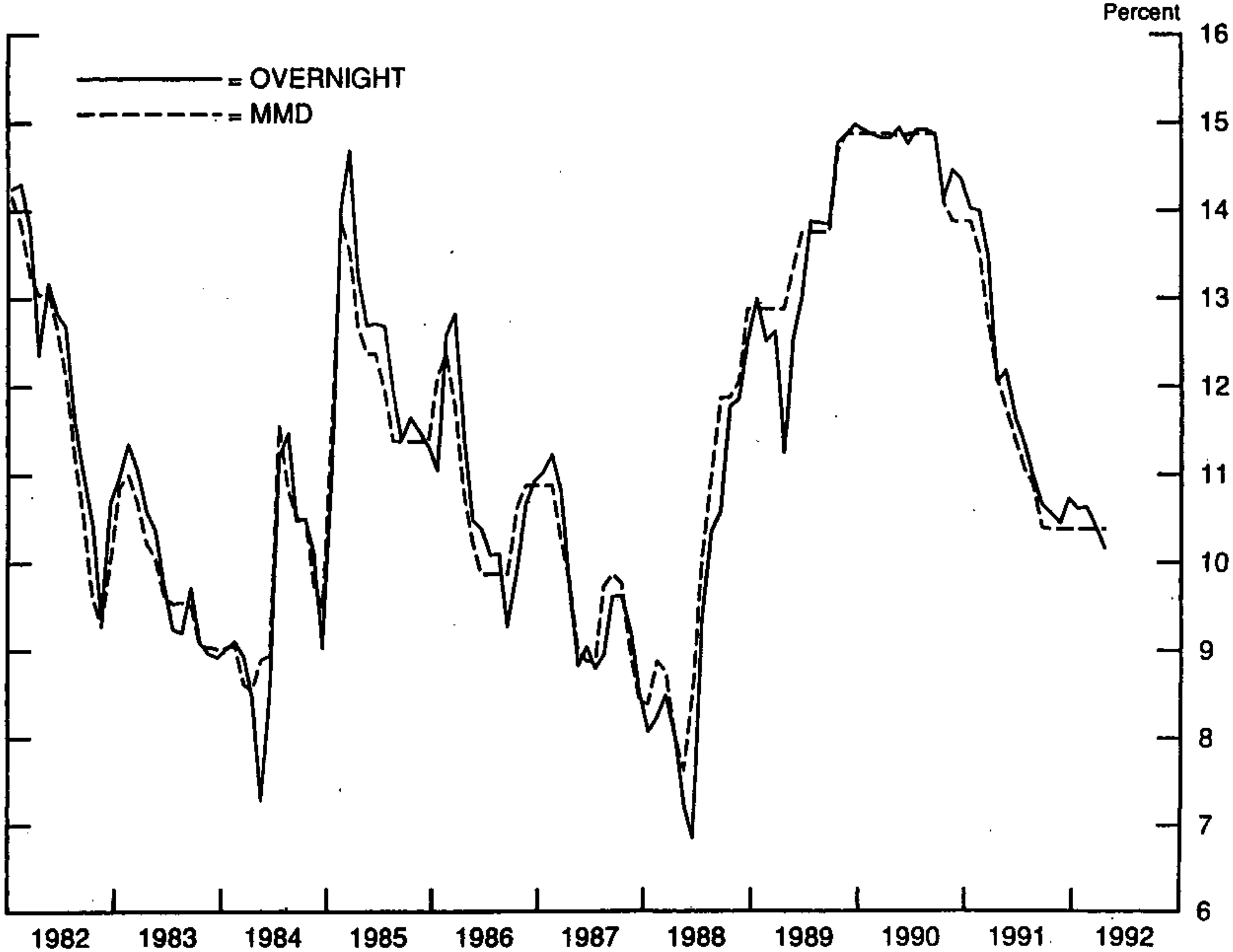
Morton and Wood
Chart 2

Overnight and Money Market Intervention Rates for France

(Monthly Average)

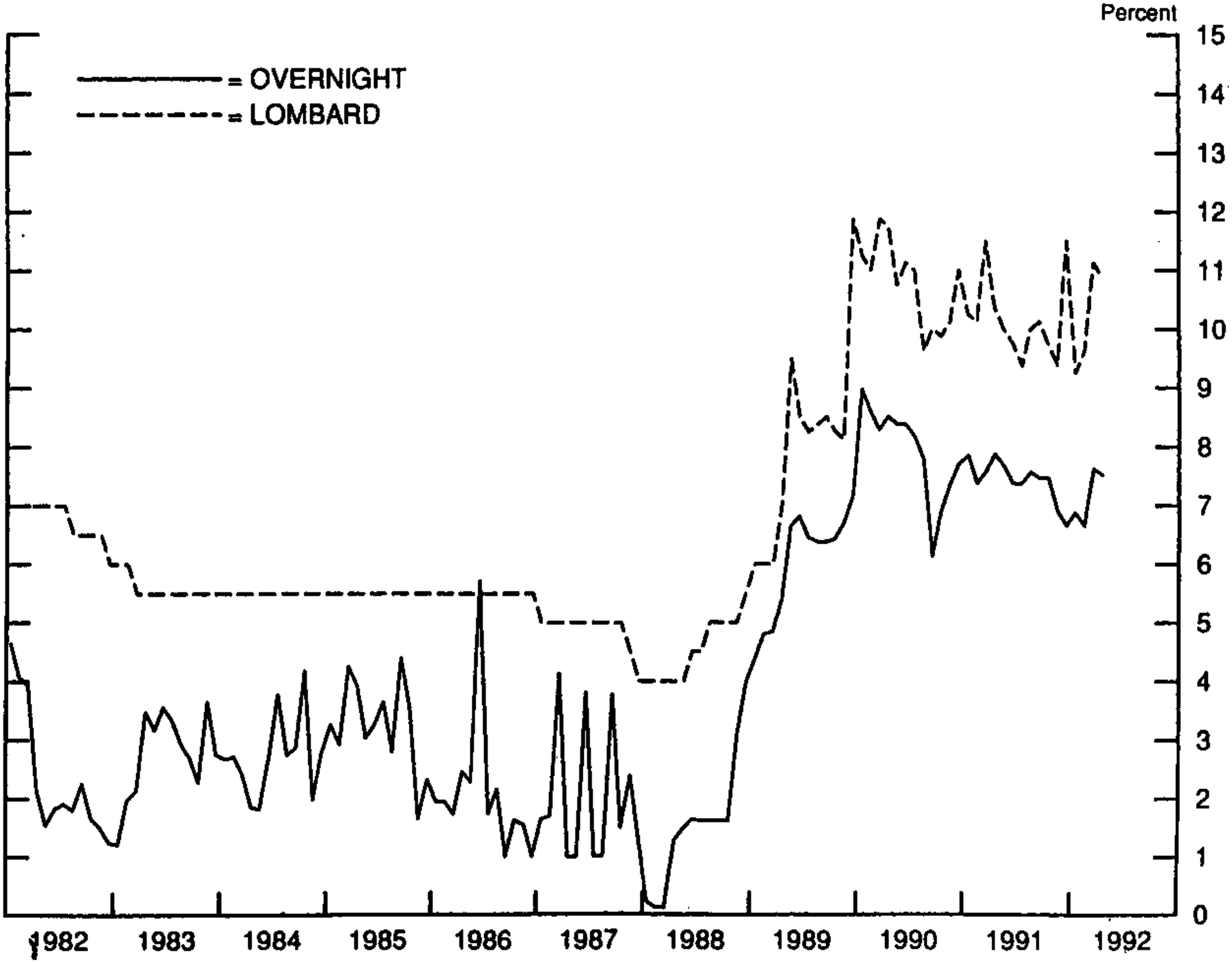


Overnight and Money Market Dealing Rates for the United Kingdom
(Monthly Average)



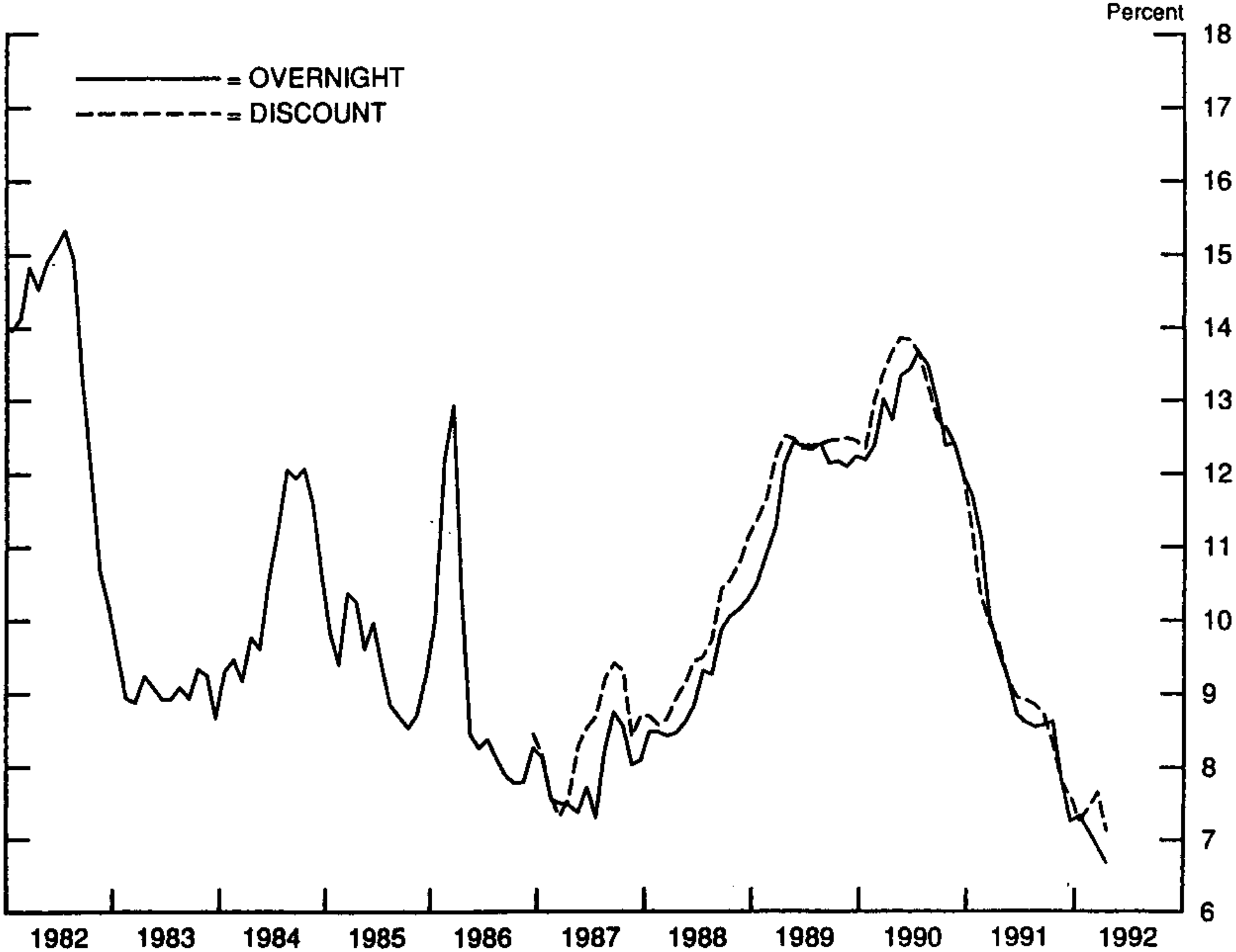
Morton and Wood
Chart 4

Overnight and Lombard Rates for Switzerland
(Monthly Average, Month End, Respectively)



Morton and Wood
Chart 5

Overnight and Discount Rates for Canada
(Monthly Average)



A COMPARISON OF MONETARY POLICY OPERATING PROCEDURES IN SIX INDUSTRIAL COUNTRIES

Bruce Kasman[1]

The institutional environments in which the central banks of the industrial world operate have changed substantially since the mid-1970s. Financial market liberalization, along with regulatory and technological change, has altered the relationships between central bank policy tools and objectives. Authorities have responded to these changes by revising the techniques and procedures they use to implement monetary policy. In Japan and France, where far-reaching reforms of the financial system have taken place, central bank operating procedures have been substantially transformed. In countries where well-developed capital markets existed earlier, the revisions in monetary policy operating procedures have been considerably less dramatic.

As financial liberalization and innovation proceed, the institutional settings of the central banks have become more uniform. Although arrangements still vary across countries, this convergence suggests that a comparison of central bank operating procedures is now likely to be of greater relevance to policy makers than at any time in the past.

An assessment of foreign practices may provide a particularly useful perspective on the changing conditions affecting the operations of the Federal Reserve's Open Market Desk. A noticeable increase in banks' reluctance to borrow at the Federal Reserve's discount window in recent years has at times contributed to large daily fluctuations in the Federal funds rate. Moreover, reductions in reserve requirements in 1990 and April of this year have led to occasional conflicts between the Desk's reserve management strategy and more volatile day-to-day conditions in the funds market. With other central banks offering a wide variety of alternative techniques for implementing policy

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1. Federal Reserve Bank of New York.
The author is grateful to Andre Bartholomae, Kevin Clinton, Spencer Dale, David Longworth, Ann-Marie Meulendyke, Michel Peytrignet and George Rich for providing useful comments and information. Valuable assistance in preparing this paper was provided by Matthew Maring.

and a number currently operating in an environment of low, nonbinding reserve requirements, an examination of operating procedures followed by foreign central banks seems timely.[2]

This article describes monetary policy operating procedures in six industrial countries -- the United States, Germany, Japan, the United Kingdom, Canada, and Switzerland. The object is to shed light on central bank strategies elsewhere in the industrial world and to compare them with the practices of the Federal Reserve. As part of this review, particular attention is given to the institutional environments in which central banks operate. The intermediate and ultimate objectives of a central bank, while important in an overall survey of monetary policy transmission, are not discussed in any detail.

Our review suggests that basic central bank intervention strategies are currently quite similar across the industrial world. Nearly all the central banks analyzed use interest rate operating objectives to guide their daily activities. In addition, although the central banks employ different instruments, they all implement policy principally through daily operations supplying or absorbing reserves at market-determined prices.

The Federal Reserve and several foreign central banks are also alike in having chosen to lower their reserve requirements in recent years. In most cases, the foreign monetary authorities have adjusted their operating procedures to accommodate this change. Specifically, they have provided a more elastic intraday supply of central bank reserves, largely through their credit facilities. In this way, they limit any tendency for reduced reserve margins to lead to higher day-to-day interest rate volatility.

Our analysis suggests that some of the practices observed abroad might be helpful in limiting the short-run volatility of the federal funds rate in the United States. However, our analysis also indicates that the volatility of the federal funds rate, although higher since the 1990 cut in reserve requirements,

2. A good discussion of Federal Reserve operating procedures following the reduction in reserve requirements can be found in "Monetary Policy and Open Market Operations during 1991." This Quarterly Review, Spring 1992, pp. 72-95.

remains low relative to that of comparable rates in most other countries. Moreover, we find no evidence that federal funds rate variability, within its current range, is transmitted to other money markets. Thus, the rise in interest variability that has accompanied the reduction in reserve requirements in the United States has probably not materially affected the monetary policy transmission mechanism.

COMPARING OPERATING PROCEDURES IN SIX INDUSTRIAL COUNTRIES

Key Features of Central Bank Operating Procedures

A central bank must choose implementation procedures that enable it to achieve its macroeconomic goals. Although the six central banks considered in this article have different objectives and operate under varied institutional environments, the key features of their implementation strategies are currently quite similar.

All six central banks implement policy by controlling the aggregate level of reserves available to the banking system. Although they are not in a position to control movements in all components of their balance sheets, particularly those related to their function as banker to the government and their holdings of foreign currency reserves, these banks currently have sufficient information and operational leeway to neutralize the effects of other activities and regulate the aggregate supply of reserves with a high degree of control.

In managing the reserve position of the banking system, central banks generally pursue short-run operating objectives. Operating objectives link reserve management activities to the intermediate and ultimate goals of policy and, in most countries, are also used to signal central bank policy intentions to market participants. Ideally, the authorities exert close control over operating objectives.

Bank reserves have served as an operating objective but the relationship between reserves and economic activity generally has been viewed as too volatile for reserves to function as an effective short-run guide to policy. Most of these central banks have instead geared their reserve management activities toward short-term interest rate objectives.[3] A wide variety of money market interest rates are employed as operating objectives. Nonetheless, influence over overnight interest rates is a goal common to the daily activities of all six of these central banks. Each of these countries has a well-functioning interbank money market where individual banks trade reserves on deposit at the central bank.[4] If the aggregate supply of banking system reserves does not correspond to demand, the cost of overnight funds in this market is immediately affected.

Although central banks' reserve management activities give them considerable control over short-term interbank rates, their influence on interest rates must extend to maturities well beyond overnight rates to affect economic activity. Central bank influence over longer term rates is indirect and principally determined by market forces. Through arbitrage, longer term rates reflect market expectations of future short-term rates. A central bank's leverage over longer term rates is obtained largely through its influence on these expectations. By taking steps to communicate credible intentions about the range in which overnight and other short-term interest rates should trade in the future, central banks can transmit their interest rate policies throughout the money market term structure and beyond.

To this end, most of these central banks limit themselves to infrequent adjustments in their operating objectives. Targeted interest rates are generally changed in small steps and only after

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3. The notable exception is the Swiss National Bank, which has maintained bank reserve operating targets for most of this period. In addition, the Federal Reserve experimented briefly with nonborrowed reserve objectives from 1979 to 1982. The choice of monetary policy operating targets has been the subject of considerable debate. William Poole provides the seminal discussion of these issues ("Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model," Quarterly Journal of Economics, vol. 84 (1970), pp. 197-216. For a recent discussion of interest rate operating objectives in the United States, see Marvin Goodfriend, "Interest Rates and the Conduct of Monetary Policy" and the accompanying comments by William Poole in Carnegie-Rochester Conference Series on Public Policy, no. 34 (1991), pp. 7-39.

4. In Japan and the United Kingdom, nonbank financial intermediaries participate in the interbank market. In Canada, an important overnight market in call loans, used by both banks and investment dealers, exists alongside the interbank market.

a sufficient amount of new information has accumulated to warrant a change in policy. By encouraging expectations of interest rate stability over a medium-term horizon, policy makers gain influence over rates throughout the term structure.

Although interest rate operating objectives have been prevalent among these central banks over the past two decades, the type of implementation strategy employed has, in many countries, evolved considerably.[5] During the 1970s, the central bank of Japan and several European central banks relied heavily on a system of administered interest rates to implement policy. Banks' marginal reserve demand in these countries was largely met through central bank credit facilities, often at below-market rates.[6] "Official" or tightly controlled money market rates served as anchors for regulated deposit and lending rates. Together with other controls over financial activity, official rate changes were transmitted largely through their direct effect on bank credit availability.

This approach came under pressure in the late 1970s. The delays by some central banks in adjusting interest rates to counter a buildup of inflation in the late 1970s raised concerns about the inflexibility of interest rate determination. Many observers believed that the use of highly visible official rates constrained banks from adjusting policy in a timely fashion. More important, however, rising inflation helped spur the liberalization of financial markets, which in turn substantially increased the importance of competitive forces in determining interest rates. Domestic financial markets also became more closely integrated with foreign markets. As a consequence, market-determined interest rates and exchange rates played an increasingly central role in private agents' expenditure decisions.[7]

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5. An excellent discussion of how monetary policy procedures have evolved can be found in J.T. Kneeshaw and P. Van den Bergh, "Changes in Central Bank Money Market Operating Procedures in the 1980s", BIS Economic Papers, no. 23, January 1989.

6. Reliance on subsidized central bank credit sources for bank reserve needs characterized German, Japanese, and Swiss monetary policy.

7. A detailed analysis of financial innovation and its effect on the monetary policy transmission mechanism can be found in Financial Innovation and Monetary Policy, Bank for International Settlements, (Basle, Switzerland 1984).

Although procedural changes have been greatest in those countries where financial change has been most significant, the central banks under review have in general moved towards market-oriented methods for implementing monetary policy. As noted earlier, authorities increasingly rely on market-determined interest rates both as operating objectives and as key elements in the transmission mechanism. At the same time, market operations, in which central banks intervene in financial markets at freely determined prices, have gradually replaced lending and regulatory controls as the principal instrument for altering reserve supplies in most countries.

The shift toward market-oriented interest rate objectives has helped the central banks to reduce the repercussions arising from changes in their policy stance. In addition, open market operations permit central banks to exercise considerable discretion in the day-to-day management of reserves. While relying on market forces to determine interest rates, central banks can intervene at select times to influence the range within which rates move. Furthermore, the wide variety of available domestic money market instruments (whose development was greatly encouraged by monetary authorities in most countries) allows the banks to construct intervention strategies that span the money market term structure.

In practice, central banks continue to severely limit the range in which short-term interest rates fluctuate. By fine-tuning their market operations, usually on a daily basis, these central banks alter reserves to accommodate variations in reserve demand.

This active effort to moderate even transitory interest rate fluctuations underscores central banks' desire to communicate their policy intentions clearly to market participants. In nearly all the countries under review, the stance of monetary policy is signaled through interest rates. Market interest rates respond to developments other than policy changes, however, and movements unrelated to policy must be filtered out before policy inferences can be drawn. By sharply limiting interest rate variations daily, central banks ensure that market participants can clearly identify interest rate targets and quickly ascertain changes in the monetary policy stance.

To implement an interest-rate-based operating policy through periodic open market operations, central banks must be able to predict the demand for bank reserves over some relevant horizon. Banks need reserves to meet reserve requirements and to make interbank payments. Central banks have considerable influence over reserve demand through their role in setting reserve requirements and interbank clearing rules. Specific rules (lagged reserve accounting, reserve averaging, and carryover provisions) and payment systems practices (timing of payments, overdraft provisions) have been designed, in part, to strengthen and stabilize the short-term demand for bank reserves. In general, the stability of reserve demand over a maintenance period has been a central element underlying central bank implementation procedures.

In the past, many central banks actively managed reserve demand by changing reserve requirements and applying other administrative controls to bank behavior. These practices have greatly diminished in recent years reflecting, in part, the general trend towards market-based policy strategies. At the same time, all six central banks have reduced reserve requirement ratios over the past decade in an attempt to lighten the burden they place on banks. In some countries the relaxation of restrictions on banks' reserve holdings has led to greater variability in reserve demand, compelling authorities to adjust their reserve management procedures.

Although this overview of the key features of central bank implementation strategies suggests broad similarities across countries, the specific techniques employed by individual central banks to implement monetary policy vary greatly. Central bank market operations span a wide spectrum of assets and maturities; the timing of operations and the frequency with which they are conducted also differ. Significant differences can be seen as well in the conditions determining access to central bank credit, the regulations setting required reserve levels, and the length of time granted depository institutions to meet their obligations.

In many cases, these differences are institutional in nature, reflecting the particular environments in which central banks operate. For example, in conducting open market operations, central banks must depend on the markets available to them. Where active secondary security markets are not developed, central banks may need to make special arrangements for implementing their reserve management policies.

The remainder of this section compares monetary policy implementation techniques across the six countries. By examining the particular institutional environment in which each central bank operates and by observing the interaction of the specific instruments central banks employ -- open market operations, central bank lending policy, and reserve requirements -- one can identify meaningful differences between Federal Reserve and foreign central bank operating procedures.

Operating Objectives and Procedures

All six central banks gear their short-term reserve management activities toward influencing interest rates, but specific interest rate strategies differ from bank to bank. The Federal Reserve in the United States limits its activities to influencing overnight interbank rates (the federal funds rate), allowing market forces to determine the transmission of policy to other financial markets. The Swiss National Bank also acts to smooth daily fluctuations in overnight interbank rates, but it is unique among these central banks in setting no explicit interest rate operating objective. Although the four other central banks also actively intervene to smooth fluctuations in overnight rates, they generally seek to influence money market rates of longer maturities as well. In Japan, overnight interbank rates remain the primary operating objective of the central bank, while in Canada, Germany, and the United Kingdom, rates of longer maturity, up to three months in some cases, are employed as the primary operating objective. A summary of the interest rates important to the banks' policy implementation is presented in Table 1. The primary interest rate operating objective for each country is highlighted.

Of the central banks considered, the Bank of England (BOE) is probably most active in its daily reserve management activities. Operating in an environment in which reserve requirements are low and banks each day try to maintain a specific daily level of operational balances at the BOE, the Bank has developed a strategy of frequent intraday interventions in money markets to achieve its interest rate objectives.[8]

Each morning at 9:45 a.m. the BOE announces its estimate of the net reserve position of the banking system for the day. Based largely on expected government transactions and the BOE's

8. To assist the BOE in its daily forecast of the reserve position of the banking system, each clearing bank is obliged to specify the size of reserve balances that it will try to maintain daily.

maturing stock of short-term bills, these estimates signal the amount of reserves that the BOE anticipates must be supplied to bring actual balances of clearing banks to the levels the banks are expected to maintain.[9]

Because the bulk of the BOE's assets are in short-term bills (commercial or Treasury) that mature in less than three months and that do not roll over automatically, the banking system will usually be projected to have a "cash shortage" at current interest rates. To meet this shortage, discount houses, which serve as intermediaries between the BOE and private banks, are invited to offer bills to the Bank for purchase, indicating the price at which they are willing to sell.[10] The BOE buys bills to meet the estimated shortage in four maturity bands: zero to fourteen days, fifteen to thirty-three days, thirty-four to sixty-three days and sixty-four to ninety-one days. It chooses the best prices offered but holds unchanged the minimum dealing rate (stop rate) on Band 1 bills maturing in up to fourteen days. As many as three rounds of these operations may take place in a day, enabling the BOE to respond to changing intraday market conditions. If late-day imbalances arise, they are met through credit facilities available to discount houses.

By purchasing bills across bands (maturities), the BOE attempts to extend its influence over interest rates throughout the money market. Variations in the amount of bills purchased in Band 4 (sixty-nine to ninety-one days), for example, tend to have a strong influence on three-month Treasury bill rates. The BOE also has the option of offering repurchase agreements to discount houses on its own terms if it does not wish to validate the rates being offered. Mindful of this option, the discount houses will generally offer prices embodying their expectation of the BOE's desired rate objectives.

The stop rate changes infrequently. Movements in this rate signal a shift in BOE policy and are usually reflected immediately

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9. The government holds most of its balances with the BOE. Because its daily transactions with the rest of the economy are large and fluctuate widely, the BOE's forecast of net government flows is both the key component of this estimate and the greatest source of uncertainty.

10. For more detailed information on the role of discount houses in the U.K. financial system and the BOE's money market operations more generally, see "Bank of England Operations in the Sterling Money Market", <u>Bank of England Quarterly</u>, October 1988.

throughout the interbank market and in commercial bank base lending rates (Chart 1). On occasion, the BOE will send a strong signal of its intention to shift policy by choosing not to accommodate a shortage in reserve needs during the day, thereby obliging discount houses to borrow from the BOE at terms determined by the Bank. Since the BOE has the flexibility to set this lending rate either above or below current stop rates, it can use this procedure to signal a tightening or an easing in policy.

Japanese monetary authorities followed a similar strategy of tight control over the key intervention rate until the early 1980s. Combining reserve management operations with administrative control over interbank market participants, the Bank of Japan (BOJ) was able to stabilize the call-money overnight interbank interest rate at the level desired for long periods. As part of a broader reform of financial markets over the past decade, the BOJ has actively promoted integration of the interbank with other financial markets and encouraged greater flexibility of interbank interest rates, particularly on an intraday basis.[11]

The overnight call rate remains the BOJ's key operating objective, and although it is subject to greater influence from market forces than in the past, the BOJ still actively strives to limit its fluctuations around the targeted level (Chart 2). The BOJ implements this policy through a variety of market operations, primarily transactions in commercial bills, and through its daily management of discount window credit. Control over the "reserve progress ratio," which measures reserves accumulated by banks relative to those required within a maintenance period, is a key element of this policy. Upward pressure on interest rates is effected by supplying fewer reserves than are necessary for the reserve progress ratio to rise at an average pace.

Banks have considerable leeway in managing their reserve positions because the reserve maintenance period is a full month in Japan. Nevertheless, changes in the reserve progress ratio clearly convey the BOJ intentions concerning future interest rates and, as a result, usually lead to a quick response in interbank interest rates.

11. For a detailed analysis of the evolution of Bank of Japan policy and references to the literature on financial market liberalization in Japan, see Bruce Kasman and Anthony P. Rodrigues "Financial Liberalization and Monetary Control in Japan" this Quarterly Review (Autumn 1991).

The evolution of BOJ policy over the past decade reflects a movement towards procedures long practiced by the Federal Reserve System. Indeed, the two central bank implementation strategies appear quite similar in their basic characteristics -- an overnight interbank market operating objective, the use of market operations and discretionary central bank lending facilities as policy instruments, and a focus on reserve management over a maintenance period.

Still, important differences remain between the operating strategies of the Bank of Japan and the Federal Reserve. While the Federal Reserve conducts most of its daily operations in the repurchase market for government securities, the BOJ relies on a variety of private market instruments, including commercial bills, commercial paper, and certificates of deposit. In part, the BOJ's reserve management activities reflect the limited development of a single short-term government securities market in Japan. However, the BOJ has also employed operations in different instruments to exert direct influence on money market interest rates. Up until 1988 interbank and other open markets were not fully integrated, and the BOJ intervened actively in longer term money markets, primarily to influence the three-month certificate of deposit rate.

Following a period in 1987 and 1988 in which open market rates moved well above comparable rates in the interbank market, the BOJ implemented a series of reforms to facilitate arbitrage across short-term money markets.[12] Since that time the BOJ has generally limited its efforts to influence direct influence over interest rates in the interbank market to instruments of seven days' maturity or less. Market operations in longer term money market instruments are now primarily designed to offset seasonal fluctuations in reserve demand.

The administration of discount window lending also differs considerably in the two countries. In the United States, banks initiate the decision to borrow at the Federal Reserve's discount window, and borrowing is rationed through a set of administrative guidelines. In Japan, the BOJ decides on the level of bank borrowing and the length of loans (a factor that determines the

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12. For a detailed discussion of money market reforms implemented since 1988, see Japan's Short-Term Money Market and Issues, Ministry of Finance and Bank of Japan, Money Market Study Group, August 1991.

effective cost of a loan). In administering the discount window lending, the BOJ actively manages loan provision on a daily basis to respond to intraday fluctuations in reserve positions. The BOJ is unique among the central banks surveyed in employing lending as a discretionary instrument of daily reserve management.

The institutional environment in which the Swiss National Bank (SNB) operates has undergone considerable change in recent years. From 1980 through 1988 the SNB guided its policy largely with short-term bank reserve targets. Although interbank interest rates fluctuated widely on a daily basis, the SNB was reasonably successful in achieving its primary policy objective of maintaining low rates of inflation.[13]

In 1988, the combined effects of implementing an electronic payment system for settling interbank cash balances (1987) and introducing new liquidity rules (January 1988) led to a sharp decline in reserve deposits held at the Bank (Chart 3).[14] The difficulties faced by the SNB in predicting the size of this decline led to an inopportune expansionary monetary policy in early 1988. In response, the SNB shifted its operating objectives away from reserves toward short-term interest rates and exchange rates.[15] Although the SNB has gradually moved back towards an implementation strategy based on operational targets for bank reserves, it has continued to emphasize interest rates in its daily operating procedures.

Each quarter the SNB signals its short-term policy intentions by announcing a forecast of the level of the monetary

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13. See Ben Bernanke and Frederic Mishkin ("Central Bank Behavior and the Strategy of Monetary Policy: Observations from Six Industrial Countries," unpublished paper) for a recent assessment of Swiss monetary policy in relation to other central bank practices over the past two decades.

14. The new liquidity rules lowered required reserves and shifted the maintenance period from the end of the month to a month average.

15. See Organization for Economic Cooperation and Development, OECD Economic Survey-Switzerland (Paris, 1989) for a discussion of Swiss monetary policy following these institutional changes.

base in the subsequent quarter.[16] Incorporated in this forecast is an unannounced operational target for the level of bank reserves held at the SNB. Although this target serves as a guide to policy operations over each month and each quarter, authorities have considerable discretion in deciding on their day-to-day activities. In implementing daily policy, the Bank largely seeks to smooth fluctuations in overnight interbank rates. Nonetheless, the interest rate policy of the SNB differs significantly from that of the other central banks under review. No operational targets are set for the level of interest rates, and the SNB does not employ interest rates to signal its stance to market participants.

The institutional changes that took place in Switzerland in the late 1980s have not led to substantial changes in the implementation procedures employed by the SNB. As before, market operations are generally conducted once each morning through foreign currency operations. These transactions, in the form of U.S. dollar-Swiss franc swaps, are conducted at rates close to those prevailing in Euromarkets and extend up to one year in maturity.

Earlier SNB restrictions, which placed limits on end-of-month Lombard lending and required banks to give advance notification of their credit needs, were removed when reserve requirements were reduced in 1988.[17] Nevertheless, in 1989 the Bank floated the Lombard rate 200 basis points above market rates, a move that has substantially limited recourse to this facility.

In Germany, interest rates on security repurchase agreements of one- to two-month maturities are the primary

16. The forecasts are designed to be consistent with medium-run growth targets for the monetary base. Since 1990, these medium-run targets have been defined as annual growth rates to be achieved over a period of three to five years. The targets thus give the SNB considerable flexibility in determining its quarterly forecasts.

17. Before January 1988, banks' reserve requirements were monitored only on the last day of a month. Banks' demand for reserves consequently soared at this time. With access to Lombard lending limited by these restrictions, short-term interest rates often rose very steeply at month's end.

operating objective of the Bundesbank.[18] These rates are determined at periodic tenders typically conducted once a week. The Bundesbank normally determines the amount of repurchase agreements offered at a tender by assessing market demand for reserves, and it chooses the best prices available. On occasion, it will fix the price (interest rate) at a tender to send a clear signal of its policy intentions to markets.[19]

Of the central banks considered, the Bundesbank is probably the least active in its daily reserve management activities. Repurchase agreement tenders generally provide the liquidity needed each day. Occasional "supportive" operations are undertaken to influence the day-to-day money rate through a number of reversible fine-tuning measures. Short-term interest rate smoothing, however, is largely obtained through means other than market operations, a system that reflects the limited development of domestic money markets in Germany. Specifically, official rate facilities on Lombard loans and the Bundesbank's Treasury bill selling rate bound the range within which money market rates can fluctuate (Chart 4). In addition, high reserve requirement ratios and long (one-month) maintenance periods provide banks with considerable flexibility to arbitrage away transitory shocks to their reserve positions.

For the Bank of Canada (BOC), the three-month Treasury bill tender rate is the primary operating objective. The BOC participates in the weekly auction and buys and sells bills in the market from time to time, both on an outright and on a buy-back basis. But the BOC implements policy mainly through daily transfers of government demand deposits between the BOC and private banks.[20] These transfers are decided late in the day, by which time the BOC has information on government transactions and other payment items that might affect bank reserves. Thus, the

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18. For a recent discussion of Bundesbank operating procedures, see Andre Bartholomae, "Some Operational and Instrumental Aspects of Monetary Targeting in Germany," Deutsche Bundesbank, unpublished paper, 1991.

19. For example, the Bundesbank employed "volume tenders" in which it set interest rates for several months following the October 1987 stock market crash.

20. A detailed description of these operations is found in Kevin Clinton, "Bank of Canada Cash Management: The Main Technique for Implementing Monetary Policy", <u>Bank of Canada Review</u>, January 1991.

BOC is able to determine end-of-day reserve positions with unusual precision, particularly because these "drawdowns" or "redeposits" of government balances occur too late for banks to make further adjustments to their balance sheets. These transfers have a direct effect on overnight rates in the call and interbank markets. Daily reserve management activities are geared, however, toward maintaining market conditions consistent with the BOC's weekly Treasury bill rate objective (Chart 5).

Key Instruments of Reserve Management

Intervention tools vary widely across the central banks surveyed. In part, these instruments reflect the differing financial environments facing authorities in the six countries. The choice of instruments is, however, also related to specific objectives of reserve management and the means chosen by the authorities to signal their policy intentions to financial market participants. A summary of the market operations employed by the six central banks is presented in Table 2.

The U.S. Federal Reserve operates mostly in the secondary market for government securities. The prototypical open market operation, the outright purchase or sale of government securities in the secondary market, has long been the major instrument for providing permanent bank reserves in the United States. The breadth and depth of this market allow the Federal Reserve to add or drain large amounts of reserves without significantly distorting yield structures.

Although outright purchases of securities provide the primary source of secular reserve creation, the Federal Reserve typically conducts less than ten outright purchases and sales in the market each year.[21] On a daily basis, policy is implemented primarily through repurchase agreements (which add reserves) or matched sale-purchase agreements (which drain reserves). These reversed security transactions involve lower transactions costs than outright transactions and provide a much more flexible instrument for the temporary adjustment of reserve positions. They are conducted through a large existing private market and may range up to fifteen days in maturity, although they usually mature in one or a few days. Although most of these transactions are

21. The Federal Reserve does take advantage of purchase or sale orders of foreign official accounts when these are consistent with reserve objectives.

designed to smooth temporary fluctuations in reserve markets, they are also employed by the Federal Reserve to implement a change in its policy stance.

In Japan, Canada, and the United Kingdom, as in the United States, outright purchases of securities are the main asset counterpart to the expansion in the monetary base over time. In Japan, the purchase of ten-year government bonds meets the secular demand for reserves but is not important in short-term reserve management. The BOJ conducts a variety of other operations to affect reserve positions on a temporary basis. Outright and reversed transactions in commercial bills and other money market instruments are designed to offset seasonal and other short-term fluctuations in reserve demand. The discount window lending activities remain the primary tool to smooth unexpected day-to-day fluctuations in reserve positions.

Canadian monetary authorities also employ a variety of instruments to achieve policy objectives. The BOC's weekly participation in the three-month Treasury bill tender and its purchases of long-term government bonds at issue are the principal asset counterparts of money base increases in Canada. On a day-to-day basis, the BOC's drawdown/redeposit mechanism, described earlier, is its primary instrument of reserve management. The distribution of drawdowns and redeposits among clearing banks is determined at twice-monthly auctions where banks bid competitively for allocation ratios of government demand deposits. Supplementing this mechanism are other market operations, including outright purchases of short-term government securities and repurchase agreements. All open market operations are, however, routinely neutralized by the BOC as part of its drawdown/redeposit activities. As a result, open market operations are geared toward directly influencing particular money market interest rates.

In the United Kingdom, BOE assets are held primarily in the form of short-term eligible bills. The BOE routinely purchases bills to roll over its maturing portfolio and to achieve its short-term reserve management objectives.[22]

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22. Eligible bills include Treasury bills and commercial bills carrying two established names, usually those of a British bank and a discount house. The BOE will buy or sell bills of up to three months' maturity and does conduct some reversed security transactions.

As noted earlier, BOE operations are designed to relieve daily money market shortages through the outright purchase of bills from discount houses. Although it typically maintains a fixed stop rate on Band 1 bills, the BOE generally does not relieve the entire shortage through Band 1 bill purchases. It conducts bill operations in maturities as long as three months, designing these operations to exert influence on rates throughout the money market term structure. In addition, the BOE can refuse to relieve shortages through bill purchases if it is unhappy with the rates being offered. In these circumstances, the BOE can offer repurchase agreements on its own terms or invite discount houses to use their borrowing facilities at 2:30 p.m. at a rate set at the BOE's discretion.[23]

Neither the Bundesbank nor the SNB holds significant portfolios of securities because well-developed short-term money markets do not exist outside the interbank market in Germany and Switzerland. In this environment, the Bundesbank uses central bank lending (mainly bills rediscounted) and bond repurchase operations as the major vehicles to augment the monetary base. The Bundesbank has established special provisions for reversed security transactions with banks; these transactions serve as the Bank's primary instrument of short-term reserve management. The Bundesbank conducts periodic tenders (usually weekly) for one- to two-month repurchase agreements. These repurchase agreements consist of a secular component and a component that makes temporary adjustments to reserve positions. Repurchase agreements have steadily increased as a share of Bundesbank assets since the mid-1980s, gradually supplanting discount window lending as the principal asset counterpart of the money base. Other instruments, such as foreign exchange swaps and the transfer of government deposits from the Bundesbank to banks, are employed when daily adjustments in reserve positions are deemed necessary.[24]

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23. The 2:30 borrowing differs from normal day-to-day late assistance in that the interest rates on loans are published and the amounts borrowed do not count against discount houses' borrowing facilities.

24. Foreign Exchange swaps are usually employed to neutralize an expansion in reserves resulting from international capital inflows. Transfers of government deposits between the Bundesbank and private banks are generally used to offset temporary reserve shortages associated with tax payments.

In Switzerland, the domestic securities market is extremely narrow. An active interbank swap market for major foreign currencies does exist, however, and the SNB employs currency swaps as the primary instrument of both permanent and temporary reserve operations. Conducted daily in the form of U.S. dollar-Swiss franc swaps with a small number of banks, these operations currently provide over 90 percent of the reserve creation for Swiss banks. Since the dollars purchased by the SNB in these transactions are covered forward, these transactions can be viewed equivalent to temporary operations in domestic securities. Because swaps are settled with a two-day lag, the SNB supplements these activities with same-day shifts of government deposits between its books and those of private banks.

Central Bank Credit Facilities

The monetary authorities in all six countries considered offer banks a facility for obtaining credit. The market operations described above, however, have largely replaced central bank credit as the major tool for short-term reserve management in these countries. At present, most central bank lending facilities are designed to meet unforeseen and temporary end-of-day liquidity shortages or to provide assistance for institutions in times of stress. Nonetheless, the role of lending in the six central banks' implementation strategies varies. A summary of key characteristics of central bank lending facilities is presented in Table 3.

In four of the countries considered (Germany, Japan, the United States, and Switzerland), a collateralized credit facility is made available to banks at below-market interest rates. In Germany, Japan, and Switzerland, discount window lending, determined by quotas, provides an ongoing source of subsidized funds to meet a portion of secular reserve demand. The Bundesbank's facility is particularly large, currently accounting for about one-quarter of total central bank assets (Table 4). The large volume of subsidized discount window lending in Germany is designed, in part, to offset the costs to banks of high levels of required reserves.

Because German and Swiss banks fully use their quotas most of the time, discount window lending does not accommodate banks' unanticipated reserve needs in these countries. Both the Bundesbank and the SNB provide an additional line of credit at a penal rate to meet unexpected short-term liquidity needs.[25] These facilities, called Lombard loans, effectively cap interest rate increases for short periods. Swiss Lombard rates float daily at two percentage points above the average of the previous two days' interbank call money rates. German Lombard rates, in contrast, are fixed by the Bundesbank and in recent years have generally remained no more than 100 basis points above the repurchase agreement rate.

Lombard lending by the Bundesbank has soared for brief periods on several occasions in recent years. These surges in lending reflect, in addition to market-related liquidity developments, a strategy of tightening policy: money market rates are increased first; once market pressures build, these increases are validated in official rates.[26]

In the other countries reviewed, the central bank has greater freedom to decide the terms on which lending is made available. In the United States, the Federal Reserve generally sets the discount rate below short-term market rates and rations access through administrative guidelines. Lending is designed to provide for unexpected liquidity needs, particularly at the end of reserve maintenance periods. For institutions that use the window frequently, however, future access is reduced, raising the implicit cost of borrowing. Furthermore, worries about potential adverse market reactions to discount window borrowing have developed in recent years as bank failures and earnings stress have risen. The use of the discount window has, consequently, been relatively limited.

Of the countries under review, only Japan makes lending an important instrument in short-term reserve management. Discount window lending makes up a substantial share of BOJ assets

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25. Both central banks impose quotas on access to Lombard facilities, but the quotas rarely present an effective constraint on borrowing.

26. The maturity of Lombard loans is determined by the remaining maturity of securities rediscounted. Generally the Bundesbank grants such loans with the expectation that borrowing should be repaid the following day. Nonetheless, there exists some incentive to borrow heavily through Lombard loans when repurchase interest rates are expected to increase above Lombard rates at the subsequent weekly repo tender.

(currently over 10 percent), and the Bank actively manages its lending policies on a daily basis. The BOJ can either increase or call discount window loans at its discretion, and typically uses this instrument to smooth daily fluctuations in bank reserve positions. In addition, with its "plus-one-day" pricing of loans, the BOJ's effective lending rate exceeds the discount rate and can become penal for very short-term loans.[27] Discount window lending thus gives the BOJ a highly flexible instrument for influencing daily conditions in interbank markets.

England's central bank also has discretion in providing credit. In its transactions with discount houses the BOE can decide whether to provide credit and what the price of that credit will be. Funds are made available for "late assistance" to meet interbank clearing needs, but the terms of this borrowing are determined by the BOE and are not disclosed publicly. Generally funds are lent at or above market rates, in a way that permits the discount house to predict the cost accurately. As noted earlier, the BOE occasionally uses its lending policies to signal changes in its policy stance, allowing discount houses to borrow at a publicly announced rate after it has refrained from accommodating reserve demand earlier in the day.

The central bank lending rate of the BOC (the Bank Rate) is adjusted weekly and set 1/4 percentage point above the previous Thursday's three-month Treasury bill tender. Until recently, banks were guaranteed recourse to this facility only once during a reserve maintenance period. The cost and availability of further borrowing were subject to the discretion of the BOC. Funds were provided, but at a rising cost for repeated use.

These restrictions on access to BOC credit were removed in November 1991. Banks can now borrow freely at the Bank Rate either as overnight overdrafts or to meet reserve deficiencies, a

27. The interest charged on discount window loans is calculated on the period of the loan (using the official discount rate) plus one day. Thus, the effective rate of interest rises as the BOJ reduces the length of time for which it is willing to lend.

change seen as a necessary prelude to the phased elimination of reserve requirements that began in June 1992.[28]

In addition to providing credit to meet short-term liquidity needs, most countries also offer a facility to absorb excess reserves so that short-term downward pressures on interest rates will be limited. In Japan, the BOJ has the option of withdrawing outstanding loans at will during banking hours. The Bundesbank's Treasury bill selling rate functions as an effective floor on call money rates in Germany, and in Canada, matched or outright sales of Treasury bills serve a similar purpose. In the United Kingdom, discount houses can offer to purchase securities from the BOE in the afternoon if surpluses emerge.

Reserve Requirements

Like central bank lending, required reserve ratios have diminished sharply in recent years. Required reserve ratios in all these countries stand well below their levels of the early 1980s; in some countries, requirements no longer effectively constrain bank behavior. In addition, the once common practice of altering reserve requirements to adjust the monetary policy stance has largely been discontinued.

Nonetheless, most central banks still view reserve requirements as an important part of their implementation procedures. Requirements are seen as strengthening and stabilizing the short-run demand for reserves, thus enhancing central bank control over interest rates. A summary of important characteristics of reserve requirement regulations is presented in Table 5.

Required reserves in all six countries under review are determined by ratios linked to categories of bank liabilities.[29] In the United States and, until recently, in Canada, requirements have primarily been imposed on transactions deposits, a practice

28. Under the regulations in place since June 1992 a bank with a cumulative deficiency at the end of a reserve maintenance period may pay a fee, charged at the Bank rate in lieu of taking an end-of-period advance. In practice, banks have adopted the fee option so that end-of-period advances no longer appear on the BOC balance sheet.

29. In June 1992, Canada removed required reserve ratios as part of its phased elimination of reserve requirements.

that reflects earlier attempts to use reserve requirements to facilitate the targeting of M1 through operating objectives for bank reserves. Elsewhere, requirements are more broadly based. In the United Kingdom, Japan, and Switzerland, requirements are roughly similar across types of eligible liabilities.

In all these countries, the period in which liabilities are incurred (the accounting period) ends before the period in which required reserves are held (the maintenance period). These lagged or semilagged accounting mechanisms are operationally convenient and, where reserve requirements are binding, provide central banks with a relatively good estimate of reserve demand within a maintenance period. For all six central banks except the BOE, reserve projections at maintenance period horizons are a key element in determining policy operations.[30]

Although lagged reserve requirements predetermine the demand for reserves, they can also severely limit the interest sensitivity of reserve demand, particularly at the end of maintenance periods. Unforeseen shifts in either the demand for or the supply of reserves have often led to large fluctuations in interbank rates at the end of a maintenance period. To provide greater flexibility in reserve management, particularly in the early stages of a maintenance period, nearly all of these central banks allow required reserves to be met by average reserve holdings over a maintenance period.[31] Reserve averaging gives value to banks' excess reserve positions by enabling the banks to maintain offsetting deficiencies during other days within the period. As a result, banks have an incentive to arbitrage away the interest rate effects of temporary reserve shocks. Through this mechanism, required deposits at the central bank can function

30. As noted earlier, clearing banks in the United Kingdom provide the BOE with an estimate of the operational balances they wish to hold each day. The BOE uses these estimates as a guide in determining daily security operations.

31. Reserve averaging extends over one month in Germany, Japan, and Switzerland, and over two weeks in the United States. In Canada, reserve averaging extended over two half-month periods until June 1992, when it was extended to one month.

as an important aid to central banks in promoting interest rate stability.[32]

The extent to which bank reserves actually serve as a buffer stock is related to the level of reserve balances held at the central bank. Because overnight overdrafts are restricted in Switzerland, Japan, and Germany, and penalized in the United States, Canada, and the United Kingdom, the cost of running reserve deficiencies rises substantially when average reserve balances are low. In the United States and Canada particularly, concerns have arisen about the banking system's reduced ability to absorb reserve imbalances at low reserve levels. Reserve deposits held at the central banks of both countries have fallen sharply in recent years as a result of a secular increase in demand for vault cash to satisfy reserve requirements and, in the United States, a reduction in reserve requirements (Table 6).[33]

Reserve management strategy in the United States traditionally focused on the two-week average reserve levels held by banks over a maintenance period. Since the cut in reserve requirements in December 1990, however, the open market desk encountered increasing conflicts between this strategy and daily federal funds market conditions. Many banks have become less tolerant of excess reserve positions early in the maintenance period, a reaction that has often led to significant late-day downward pressure in federal funds rates. At the same time, the funds rate in the morning can be a misleading guide to reserve market conditions as banks sometimes hold on to reserves early in the day to guard against inadvertent overdrafts. When faced with these conflicts in conducting its operations, the Desk has chosen to pay greater attention to daily trading conditions in the federal funds markets to prevent misleading signals from being sent to markets.[34]

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32. A provision for the carryover of a portion of reserve surpluses (or shortages) allows for some additional flexibility in managing reserves across maintenance periods in the United States.

33. In both countries, holdings of vault cash over previous maintenance periods satisfy current reserve requirements. Increased demand for vault cash thus lowers required deposits even when reserve requirements are unchanged.

34. See "Monetary Policy and Open Market Operations" for further details.

In two countries, the United Kingdom and Switzerland, reserve requirements place no effective constraint on bank behavior. In the United Kingdom, banks must place small non-liquid deposits at the Bank of England for six months at a time. This requirement provides the BOE with operating income but is not intended to play a role in the BOE's monetary policy operating strategy.

Since effective requirements are lacking, demand for reserves (operational deposits) is determined entirely by daily clearing needs. In this environment, the BOE has developed an operating strategy involving a number of daily market operations to interest fluctuations and other intraday developments. In addition, banks' uncertainty over their end-of-day clearing needs is eased by the availability of BOE late-day lending facilities to discount houses. BOE policies serve to stabilize reserve demand and encourage banks to economize on reserve holdings (Table 6).

Since the decline in reserve requirements in Switzerland in 1988, the SNB has placed greater emphasis on smoothing daily fluctuations in interest rates in its daily activities. In addition, central bank lending facilities in the form of Lombard loans are available to banks without restriction to meet unexpected liquidity shortfalls. Nonetheless, the SNB is much less accommodative than other central banks in its approach to offsetting temporary reserve disturbances, prohibiting overnight overdrafts and setting a large spread (200 basis points) between market and Lombard lending rates. In this environment, Swiss banks have chosen to hold substantial reserve deposits in excess of those required by regulations.

RELEVANCE FOR FEDERAL RESERVE OPERATING PROCEDURES

The varied institutional and political environments facing these central banks make it difficult to assess whether practices followed in any one country would be useful to another. Nonetheless, the comparison of operating procedures presented above does provide interesting insights, some of which may be relevant to U.S. policy makers.

The similarities in operating strategy among these central banks dominate any existing differences. All six banks currently gear their daily policies toward influencing money market interest rates; all except the SNB use short-term interest rates as operating objectives to guide their reserve management activities.

Furthermore, none of the banks aims to control interest rates rigidly. Although the tolerance for interest rate divergences from objectives differs across banks, authorities generally allow market forces to determine interest rates and intervene only to limit short-term fluctuations or to alter rates when changing economic conditions warrant.

Since interest rate operating objectives are transmitted to economic activity largely through their linkage to longer term interest rates and other financial prices, central bank intervention strategies are designed to communicate information about current and future policy that strengthens this transmission. In most cases, interest rate objectives are changed in small steps to stabilize expectations across the term structure. In some countries, central banks intervene in assets of varying maturities to influence the money market term structure directly.

In addition, these central banks actively seek to limit the daily volatility of targeted interest rates in order to reduce uncertainty about the stance of policy. In some countries (Germany, the United Kingdom) intervention rates under the tight control of the central bank send a precise signal of central bank intentions. Elsewhere, although some interpretation of money market interest rate movements is necessary, the central banks stabilize their targeted rates sufficiently so that the basic thrust of their policies is clear.

Over the past decade, foreign central banks have increased the role of open market operations as a reserve management instrument, moving toward an approach long followed by the Federal Reserve in the United States. At present, each of the central banks reviewed employs some form of open market operation as an instrument for controlling reserves. Some foreign central banks conduct their operations through special arrangements with banks or other counterparties. But where these arrangements exist, they generally reflect the limited development of secondary security markets.

More meaningful differences among the six central banks emerge in the functioning of their credit facilities. To be sure, the monetary authorities in all six countries extend credit to banks with temporary clearing imbalances and to banks in financial stress. The foreign central banks, however, differ from U.S. practice by moving away from administrative controls on credit allocation.

In three countries -- Germany, Switzerland, and Canada -- banks are able to access an open-ended line of credit for temporary liquidity needs at their discretion. Borrowing rates are set above the prevailing market rates and, in Switzerland and Canada, rates adjust automatically to market rates. In Japan and the United Kingdom, access to the discount window remains at the discretion of the central bank. In practice, however, discount houses in the United Kingdom can count on the central bank to meet temporary liquidity needs at rates close to the Bank of England's prevailing intervention rates.

These facilities provide foreign central banks with a flexible instrument to contain interest rate pressures, particularly late in a trading day when other intervention instruments are unavailable. In addition, each of these foreign central banks offers a facility to absorb late-day reserve excesses and thereby moderate downward interest rate pressures.

The Federal Reserve's discount mechanism has considerably less value as a device for smoothing interest rates. U.S. discount window lending is provided at subsidized rates and in accordance with administrative discretion. Partly because of this subsidy, the Fed discourages frequent use of the window. In recent years, banks have shied away from approaching the window, fearing that the markets will perceive them to be dependent on discount window support. The unwillingness of banks to borrow at the discount window also reduces the ability of banks to shed excess reserves through their repayment of outstanding credit.

In an environment of high, binding reserve requirements, the methods employed by central banks to allocate credit might not significantly affect their ability to limit interest rate variability. With sufficient averaging provisions in place, banks can be expected to arbitrage away the interest rate effects of transitory shocks to their reserve positions within a maintenance period. Indeed, recourse to Lombard loans in Germany, the country that has the highest reserve requirements and longest maintenance period of the six countries considered, is quite small under normal market conditions.[35]

35. The Bundesbank estimates normal Lombard lending levels at DM 0.5 billion, a level representing less than 0.2 percent of total central bank assets. As noted earlier, Lombard lending has risen sharply during short periods in which the Bundesbank allows repurchase agreement rates to push up against Lombard rates before it tightens policy.

But in the United States, recent declines in reserve requirements, coupled with increased demand for vault cash, have sharply reduced reserve deposits at the Federal Reserve. In an environment where overnight overdrafts are costly, the ability of banks to take advantage of reserve averaging has become more limited as reserve deposits decline. These developments, coinciding with the deterioration in the functioning of the discount window, may have increased the sensitivity of the federal funds rate to reserve shocks.

The central banks examined here that have faced similar concerns about the effects of lower reserve requirements have tended to revise their procedures to allow for a more elastic late-day reserve supply. The BOE, operating for over a decade in an environment where banks are effectively free from reserve requirements, has developed a strategy combining the elastic provision of central bank credit for late-day reserve imbalances with frequent open market operations during the trading day. The SNB has placed greater emphasis on interest rate smoothing in daily operations since a reduction in reserve requirements in 1988. In addition, while maintaining a large spread between rates on its Lombard lending and overnight rates, the SNB has increased access to central bank lending facilities since the decline in required reserves. In Canada, restrictions on bank access to BOC credit have also recently been removed as part of the phased elimination of reserve requirements.

The example of other central banks, then, raises a question: Should the Federal Reserve consider revising its operating procedures to adapt to lower reserve requirements? It could be argued that some revision enabling the Federal Reserve to supply reserves more elastically outside of the time it conducts open market operations could help limit the variability of interest rates from objectives.

To resolve this issue, an assessment of federal funds rate variability and its effect on monetary policy transmission is essential. The Appendix sheds some light on the issue by presenting evidence on actual interest rate variability. The interday volatility of the federal funds rate does appear to have risen following the decline in reserve requirements in 1990. However, U.S. federal funds rate volatility remains low in comparison with the volatility observed in overnight interbank rates in other countries. More important, perhaps, the evidence indicates that increased federal funds rate volatility, within the range observed, has not diminished the response of three-month money market rates to changes in interest rate objectives. Thus, these results do not suggest that the reduction in reserve requirements has weakened the effectiveness of the Federal Reserve's policy transmission mechanisms.

CONCLUSION

Our analysis, while far from conclusive, provides insights that may be useful in assessing monetary policy operating procedures in the United States. Like the Federal Reserve in the United States, several foreign central banks have lowered their reserve requirements in recent years. Their experience indicates that interest-rate-oriented monetary policies can be carried out in an environment of low, nonbinding reserve requirements. Central banks operating in such an environment have been able to achieve their interest rate objectives using reserve management techniques quite similar to those employed by the Federal Reserve System in the United States.

Foreign central banks have, however, seen the need to develop mechanisms that provide a highly elastic supply of reserves to restrict the intraday fluctuation of overnight interest rates. In most countries, the authorities have designed their central bank lending facilities, with rates set at or above current market interest rates, to achieve this goal.

The empirical evidence presented in this article indicates that the recent decline in reserve requirements in the United States, combined with the increased reluctance of banks to approach the discount window, has been associated with greater variability in the federal funds rates. Nevertheless, the evidence suggests that this rise in variability has not diminished the effectiveness of U.S. monetary policy operating procedures. Within its current range, the variability of the federal funds rate remains low and does not appear to have affected the linkage between federal funds and other money market rates.

APPENDIX: OVERNIGHT INTEREST RATE VARIABILITY

The review of central bank operating procedures presented in the text suggests that foreign central banks, in contrast to the Federal Reserve, employ their reserve management instruments, particularly lending facilities, in a way that places strict limits on overnight interest rate variability. In assessing the relevance of such facilities for the Federal Reserve, it is useful to compare the variability of interest rates in the United States and the other five countries we considered.

Table A.1 presents two measures of overnight interest rate variability for the 1988-91 period. The first computes the average absolute deviation of overnight rates around a thirty-day centered moving average. The second measures the average absolute deviation of overnight rates around a mean adjusted for changes in policy stances. This second measure is constructed by identifying dates on which each central bank's interest rate operating objectives changed. The mean level of overnight rates under a particular policy objective is used to represent a central bank's policy stance, and variability is computed around this changing mean.[36]

In principle, this measure should provide a more accurate indication of how interest rates diverge from a central bank's objective. However, changes in policy stances cannot be identified precisely. Moreover, although most central banks try to smooth overnight rates, significant differences in the degree of their tolerance for overnight rate volatility are not accounted for in this analysis.

The two measures of interest rate variability present a very similar picture. Despite the limited instruments available to the Federal Reserve to offset late-day reserve market imbalances, a comparison with other countries indicates that U.S. overnight interest rate variability is relatively low. Federal funds rates have diverged, on average, about 14 basis points daily from mean levels over 1988-91, a deviation less than in any country except Japan. Note, however, that these measures do not

36. For the United States, dates on which the expected trading range for the federal funds rate changed were obtained from the Open Market Desk of the New York Federal Reserve Bank. Figures for 1990 and 1991 appear in "Monetary Policy Operations during 1991," this Quarterly Review, Spring 1992; and "Monetary Policy Operations during 1990," this Quarterly Review, Spring 1991. For countries with well-defined intervention rates that signal the monetary policy stance -- Canada, the United Kingdom and Germany -- discrete movements in rates were used to identify policy changes. For Japan, periods of discrete change in the range of the overnight call rate were inferred from the actual movements in rates. Since the SNB does not employ interest rate operating objectives, this measure of rate variability was not computed for Switzerland.

indicate the degree of intraday interest rate variability, an issue of some concern to U.S. policymakers.

The evidence also points to a relationship between required reserves and overnight interest rate variability. In the United Kingdom and Switzerland, the two countries operating with low, nonbinding reserve requirements, overnight rates are much more volatile than the rates elsewhere. In addition, in the United States and Canada, where reserve deposits held at the central bank have fallen in recent years, the decline in reserves has been accompanied by rising interest rate variability.

These findings support the view that central banks face greater difficulty in stabilizing interest rates around desired levels when reserve requirements are eased. Nevertheless, increased overnight interest rate volatility, per se, need not erode the effectiveness of monetary policy, particularly if fluctuations in overnight rates are transitory and do not reduce the ability of market participants to identify the authorities' policy intentions.

To assess whether overnight interest rate variability has influenced the monetary transmission mechanism, one must determine whether the overnight rate variability impacts on longer term market interest rates. Table A.2 presents regression results estimating the effect of overnight rate variability (MAD^{O}) on the measured volatility of three-month money market rates (MAD^{M}).[37] As the Table shows, overnight rate variability is not systematically related to three-month money market rate divergences in the United States. Indeed, of the countries surveyed, only Switzerland has large and statistically significant coefficient estimates for transmission.

Perhaps a more important issue is whether interbank rate volatility influences the transmission of changes in central bank operating objectives to money market rates. To resolve this issue in the case of the United States, one can test whether the federal funds rate variability measure affects the response of three-month

37. In Table A.2 the volatility of interbank (MAD^{O}) and three-month money market rates (MAD^{M}) are measured as the absolute deviation of rates adjusted for changes in the monetary policy stance. For Switzerland, however, deviations around a thirty-day centered moving average are used. Note that the results are qualitatively unchanged by the choice of volatility measures.

Treasury bill rates immediately after a change in the Open Market Desk's federal funds rate objective. In the regression

$$\Delta R_t = c + (b1 + b2\ MAD^o_{t-1})\Delta ff_t + \mu_t$$

ΔR_t is the change in the three-month Treasury bill rate; MAD^o_{t-1} is the average absolute deviation of the federal funds rate from the Desk's objective, measured over the preceding objective period; and Δff_t is the change in the Desk's federal fund objective.[38] The coefficient estimate for b2 provides an indication of how variability has affected the transmission of federal funds rate changes.

The regression results are presented in Table A.3. Estimates are given for the responsiveness of the three-month Treasury bill on both the day of the federal funds rate change and the five days following the change. As the Table shows, the three-month Treasury bill rates rose on average 22 basis points in response to a percentage point rise in the federal funds rate objective on the day the objective increased. This response increased to 26 basis points after five days. The variability of federal funds rates does not appear to have altered this response. In both regressions, the coefficient on variability is not significant and enters with the wrong sign. Taken together, the results suggest that federal funds rate variability, within the range observed has not altered monetary policy transmission in the United States.

38. This analysis closely follows earlier work by Timothy Cook and Thomas Khan, "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s," Journal Of Monetary Economics, vol. 24 (1989), pp. 331-51.

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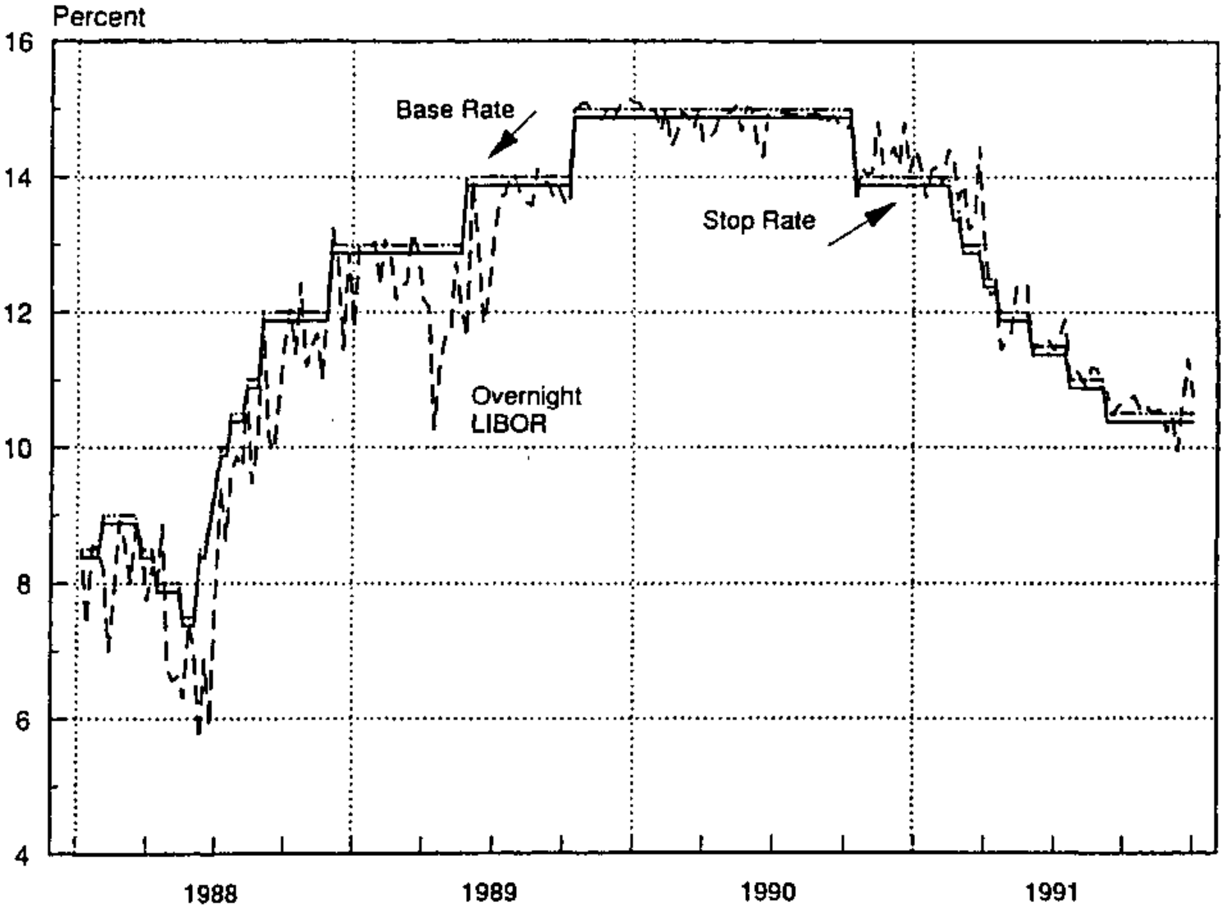
1. Structure of Short-Term Interest Rates

Country	Official Rates	Overnight Interest Rates	Other Key Interest Rates
United States	Discount rate	**Federal funds rate**	Treasury bill rate
Germany	Discount rate	Day-to-day money rate	**Repurchase agreement rate (one-to two-month)**
	Lombard rate		Three-month interbank loan rate
	Treasury bill selling rate		
Japan	Discount rate	**Interbank call money rate**	Certificate of deposit rate (three month)
			Bill discount rate
United Kingdom	No posted rate	Overnight interbank rate	**Bank of England dealing rate**
			Commercial bank base lending rate
			Three-month interbank loan rate
Canada	Bank Rate	Money market financing rate	**Three-month treasury bill tender rate**
			Ninety-day prime corporate paper rate
Switzerland[1]	Discount rate	Call money rate	Three-month Euro-franc deposit rate
	Lombard rate		

Note: Each central bank's primary interest rate objective appears in bold face type.

1. The Swiss National Bank does not employ interest rate operating objectives.

1. United Kingdom: Short-Term Interest Rates
Weekly Observations, Wednesdays



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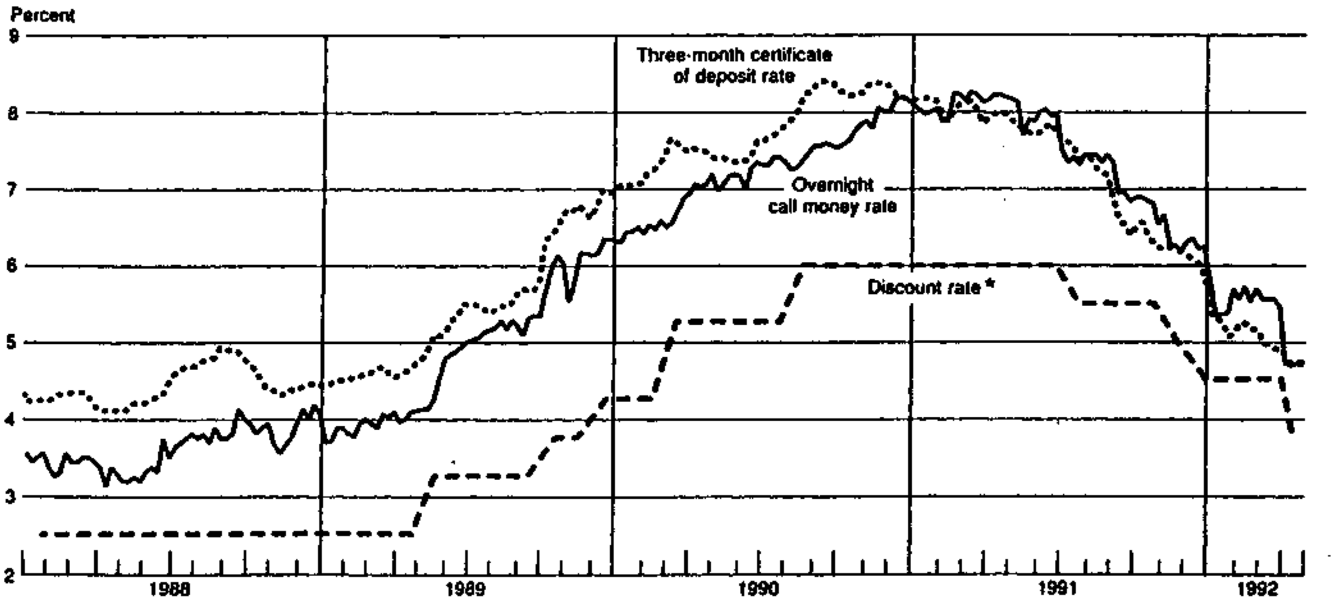
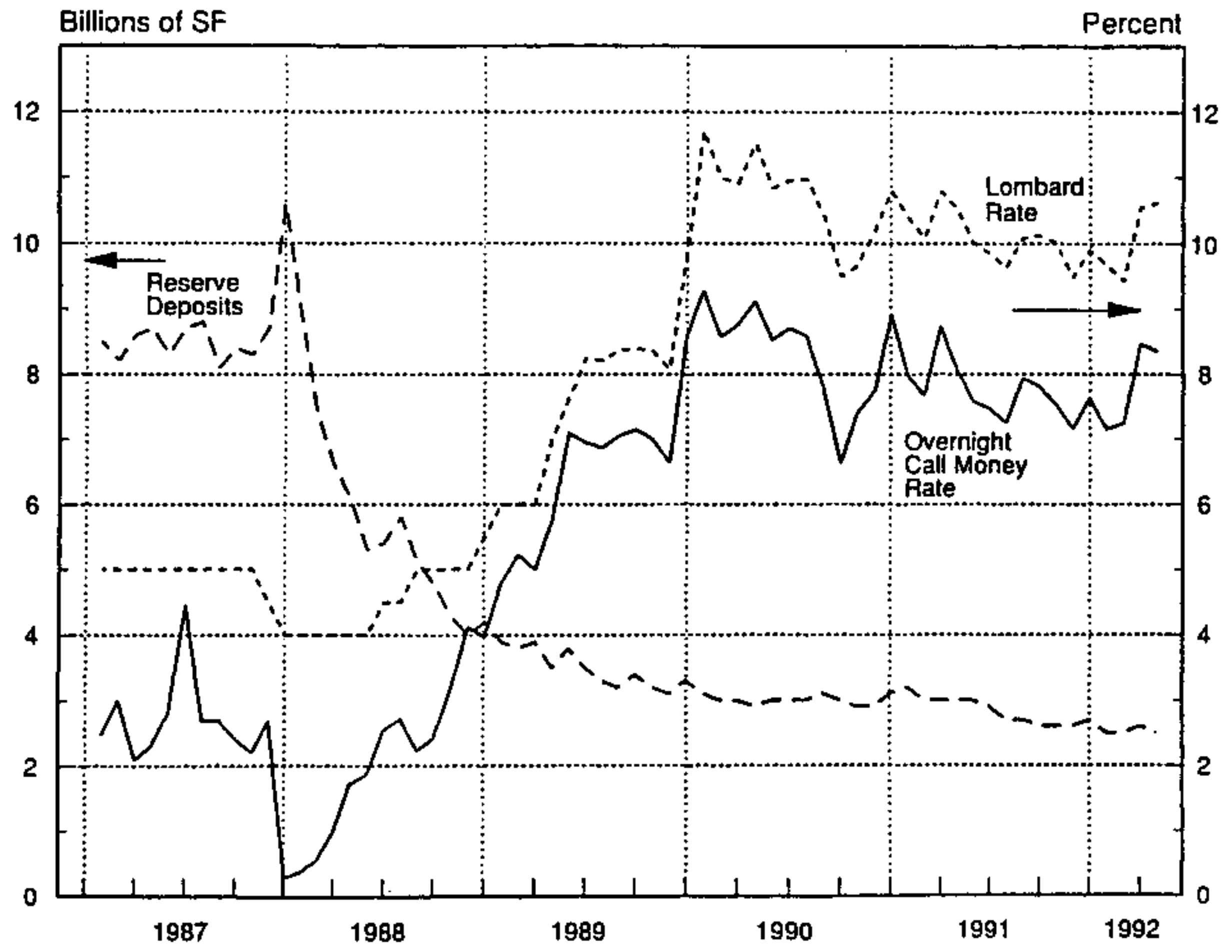
Kasman

2. Japan: Short-Term Interest Rates
Weekly Observations, Wednesdays

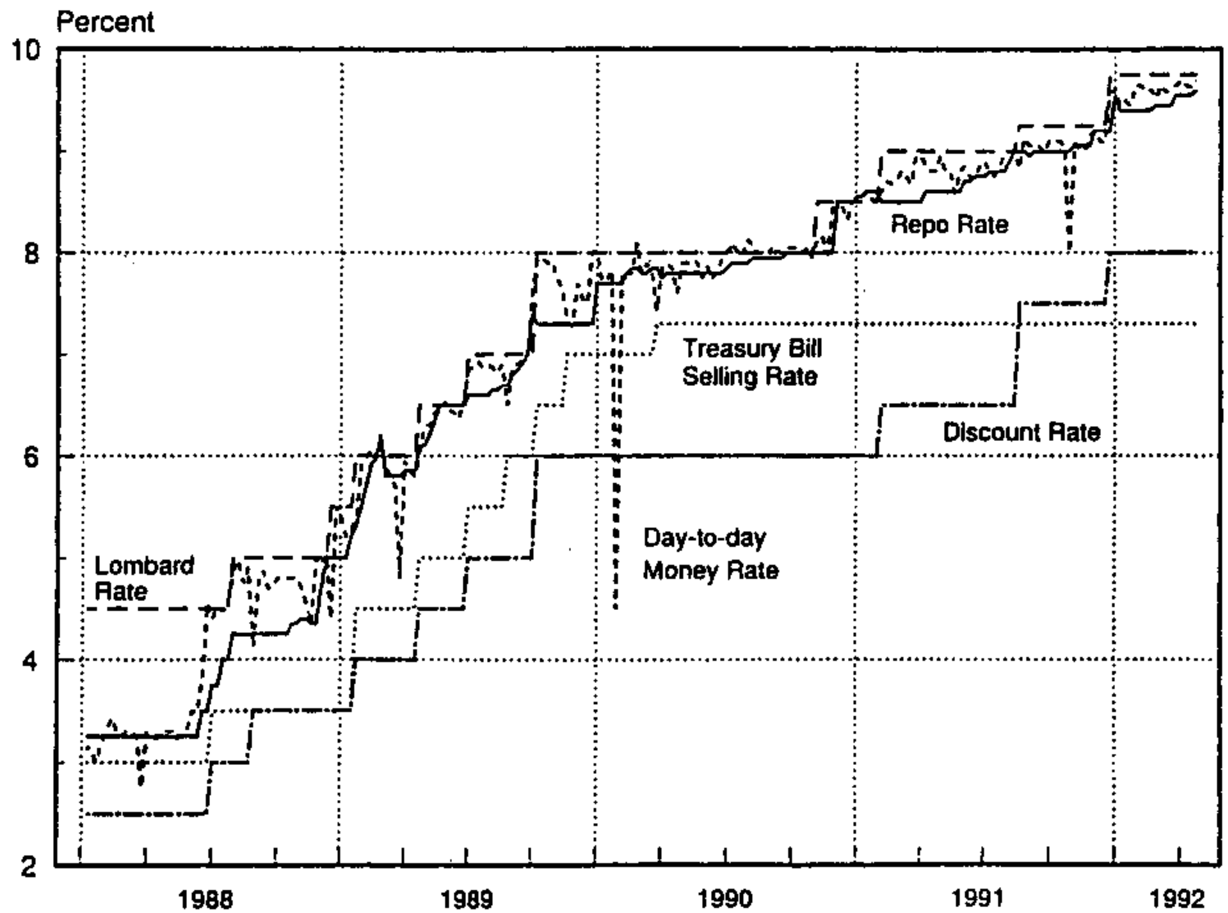


* Values are month-end observations.

3. Switzerland: Reserve Deposits and Interest Rates
Monthly Averages



4. Germany: Short-Term Interest Rates
Weekly Observations, Wednesdays



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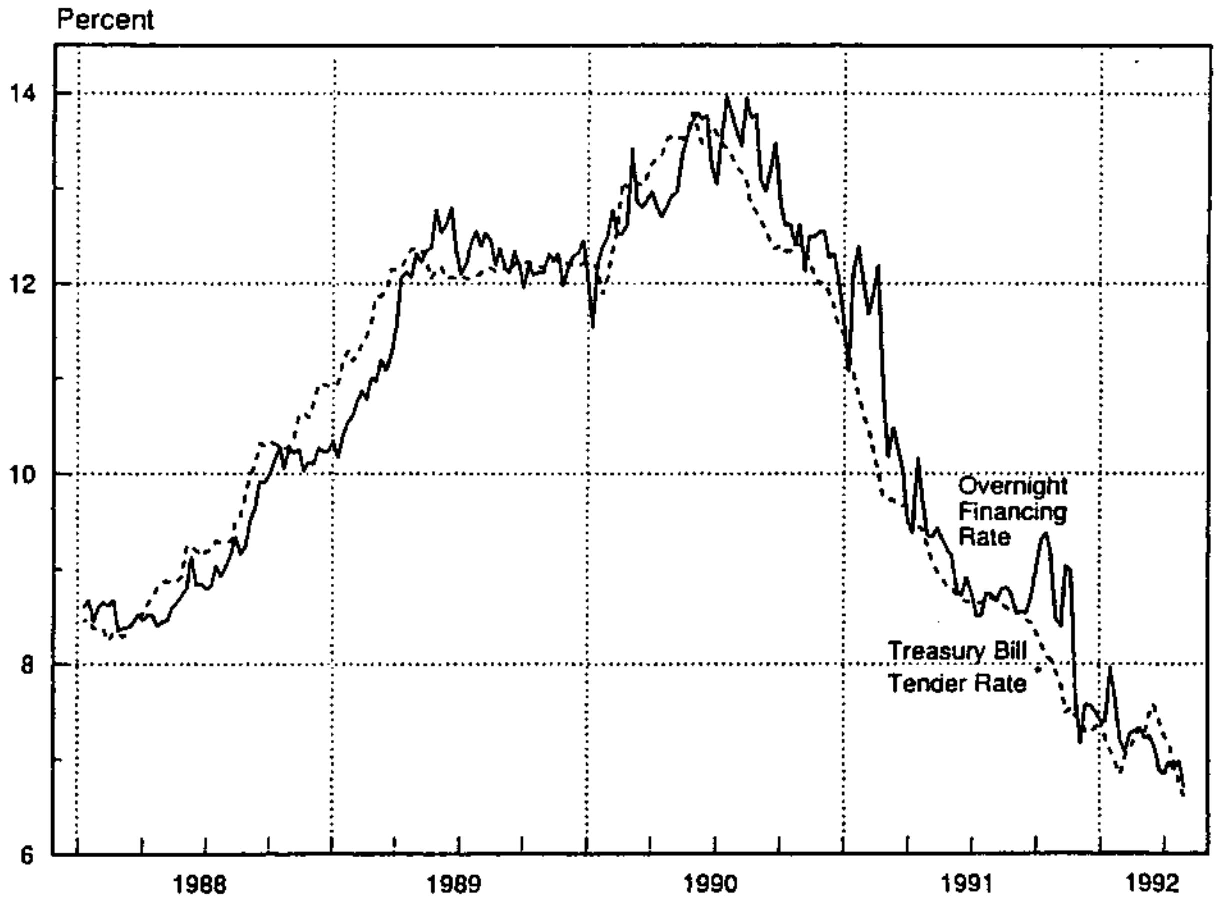
Kasman

5. Canada: Short-Term Interest Rates
Weekly Average



* At Thursday tender. The central bank lending rate (bank rate) is set 1/4 percentage point above this rate.

2. Instruments for Reserve Management

Country	Primary Short-Term Reserve Management Tool		Other Operations	
	Activity	Instrument	Activity	Instrument
United States	Repurchase agreement	Government security	Purchase or sale	Government security
	Matched purchase and sale	Government security		
Germany	Repurchase agreement	Government security	Purchase or sale	Government security
			Foreign exchange	Swap
Japan	Repurchase agreement	Commercial bills, government securities	Purchase or sale	Government security
	Discount window lending	----------	Repurchase agreement	Commercial paper
United Kingdom	Purchase or sale	Government security, commercial bills	Repurchase agreement	Government security
Canada	Drawdown/ redeposit	Government deposits	Purchase or sale or repurchase agreement	Government security
Switzerland	Foreign exchange	Swaps	Purchase or sale	Cantonal and bank bonds
			Drawdown/ redeposit	Government deposits

3. Central Bank Lending Facilities

	United States	Germany	Japan	United Kingdom	Canada	Switzerland
1) Credit available at below market rates	Yes	Yes	Yes	No	No	Yes
Access restricted by: Q = quotas, D = administrative discretion	Q,D	Q	Q,D	--	--	Q
Interest rate setting: P = posted rate D = set at discretion of central bank	P	P	P,D[1]	--	--	P
2) Other credit sources available	No	Yes	No	Yes	Yes	Yes
Access restricted by: Q = quotas, D = administrative discretion O = other	--	Q[2]	--	D	O[3]	Q[2]
Interest rate setting: F = Floats in relation to market rate P = Posted rate D = set at discretion of central bank	--	P	--	D	F	F

1. The Bank of Japan provides credit at the official discount rate. The Bank can add or call loans at will, however, and interest charged is calculated on the period of the loan plus one day. The effective cost of borrowing thus rises as the maturity of a loan is reduced.

2. Generally non-binding.

3. Bank of Canada advances are provided only for overdrafts to meet a deficiency of clearing balances or for an end-of-averaging period reserve deficiency.

4. Central Bank Lending as a Share of Central Bank Assets
(Annual Average of End-of-Month Observations)

	1985	1988	1991
United States	0.7	0.9	0.1
Japan	8.4	13.6	12.1
Germany	29.4	22.5	25.0
United Kingdom	1.8	1.8	3.0
Canada	7.4	2.2	2.0
Switzerland	9.9	0.9	1.2

5. Reserve Requirement Regulations

	United States	Japan	Germany	United Kingdom	Canada*	Switzerland
Length of reserve accounting period	14 days	1 month	1 month	6 months	1 month	3 months
Length of maintenance period	14 days	1 month	1 month	6 months	15 days	1 month
Interval from end of accounting period to end of maintenance period	2 days	15 days	15 days	180 days	30/45 days	50 days
Highest reserve ratio for demand deposits	10	1.3	12.1	0.5	10	2.5[1]
Highest reserve ratio for other deposits	0	1.2	4.95	0.5	3	0.5
Averaging provisions	Yes	Yes	Yes	No	Yes	Yes
Carryover provisions	Yes	No	No	No	No	No
Vault cash satisfies requirement	Yes	No	Up to 50 percent	No	Yes	Yes
Penalty for reserve deficiency (percentage above central bank lending rate)	2	3-5	3	0	0	0
Interest paid on reserves	No	No	No	No	No	No

1. Includes time deposits with a term to maturity up to three months.

* As of June 1992, reserve ratios were eliminated in Canada as part of a planned phaseout of required reserves. Currently required reserves are set at a predetermined amount; this amount will decline to zero in 1994. The maintenance period has been extended to one month. Banks incurring a reserve deficiency pay a penalty calculated at the Bank rate.

6. Reserve Deposits Held at Central Banks as a Share of Total Bank Liabilities (Year Average of End-Month Observations, in percent)

	1980	1985	1988	1991
United States	1.6	0.8	1.0	0.6
Japan	1.6	1.1	1.0	1.0
Germany	7.2	5.6	5.5	5.5
Switzerland	4.0	3.1	1.7	0.7
United Kingdom	0.3*	0.1	0.1	0.1
Canada	3.9	1.4	0.8	0.4

* Figure is for year-end 1981.

A.1. Overnight Interest Rate Variability
(Mean Absolute Deviation of Daily Observations, in Basis Points)

	Deviations from Thirty-day Centered Moving Average					Deviations from Mean Adjusted for Changes in Policy Stance[1]				
	1988	1989	1990	1991	Average 1988-91	1988	1989	1990	1991	Average 1988-91
United States	12.3	11.9	12.3	21.1	14.4	13.0	11.8	12.8	18.5	14.0
Japan	8.7	8.5	7.1	8.4	8.2	12.5	8.5	7.4	5.8	8.6
Germany	15.7	18.2	13.6	13.4	15.2	15.8	17.4	14.5	14.8	15.6
United Kingdom	50.4	32.9	14.8	25.3	30.9	52.5	39.7	14.2	25.0	32.9
Canada	9.7	13.4	21.3	28.7	18.3	11.0	15.7	21.3	28.8	19.2
Switzerland	--	33.8	34.8	37.8	35.5	--	--	--	--	--

Note: Overnight interest rates are the effective overnight Fed funds rate (the United States), overnight call rate (Japan), day-to-day money rate (Germany), London interbank offer rate (the United Kingdom), overnight money market financing rate (Canada), and overnight call rate (Switzerland).

1. Values are average absolute deviations of overnight rates from a mean that changes along with estimated shifts in central bank interest rate operating objectives.

A.2. The Transmission of Overnight Rate Variability to the Variability of Three-Month Money Market Rates (Based on Monthly Observations, 1988-1991)

$$MAD^{M}_{t} = C + B\ MAD^{O}_{t} + \mu_{t}$$

	C	B	$\bar{R}^2$	DW
United States	0.12 (4.79)	-0.16 (-0.95)	-0.01	2.23
Japan	0.04 (0.90)	0.22 (0.41)	-0.01	2.34
Germany	0.05 (1.46)	0.25 (1.28)	-0.02	1.92
United Kingdom	0.14 (7.14)	-0.01 (-.14)	-0.01	1.67
Canada	0.05 (3.71)	0.04 (0.58)	0.10	1.90
Switzerland[1]	-0.13 (-0.79)	0.70* (2.07)	0.23	2.32

Note: Equation is estimated using instrumental variables. Instruments include lagged MAD^{O} and lagged levels of interbank interest rates. Overnight interest rates are those described in Table A.1. Three month money market rates are the three-month Treasury bill rate (the United States and Canada), Gensaki rate (Japan), three-month interbank loan rate (Germany, Switzerland) and the three-month Sterling interbank deposit rate (the United Kingdom).

1. Sample covers June 1989-December 1991.

* Significant at 5 percent level.

A.3. Interest Rate Volatility and the Transmission of Changes in Federal Funds Rate Objectives: 1988-1991

$$\Delta R_t = C + (B_1 + B_2\ MAD^o_{t-1})\Delta ff_t + \mu_t$$

	C	B_1	B_2	$\bar{R}^2$	DW
Response of three-month Bill Rates (ΔR_t)					
Day of Federal Fund Objective Change	-0.02 (-1.51)	0.22** (4.03)	0.06 (0.22)	.51	1.86
Five Days Following Federal Fund Objective Change	-0.38 (-1.39)	0.26* (2.42)	0.58 (1.31)	.40	2.25

* Significant at the 5 percent level
** Significant at the 1 percent level

COMMENTS

Stephen A. Meyer[1]

The goal of these two papers is to develop an understanding of monetary policy operating procedures in countries other than the U.S. in the hope that we can learn something applicable to U.S. monetary policy. Potentially the most useful insights in these two papers come from examining operating procedures in those countries, such as Switzerland and the U.K., that have had low, non-binding reserve requirements. In those countries, low or nonexistent reserve requirements combine with tight restrictions on daylight overdrafts to create a situation in which required reserve balances are lower than the reserve deposits that banks need to hold to clear payments through the central bank. The U.S. is moving toward such a regime. Now that reserve requirements on transactions deposits have been lowered, we are likely to find ourselves in that situation during the early months of each year.

As Anne-Marie Meulendyke's paper for this conference notes, those responsible for implementing monetary policy in the U.S. are concerned that reserve requirements now are low enough that banks' reserve deposits sometimes will be lower than the operating balances they need to clear payments. Under current operating procedures, the Desk attempts to make the supply of non-borrowed reserves roughly equal to the forecasted demand each day. If the forecast is wrong, especially near the end of a reserve-maintenance period, the federal funds rate will deviate from its target. Non-binding reserve requirements, because they give rise

1. Vice President and Associate Director of Research, Federal Reserve Bank of Philadelphia, and Adjunct Professor of Finance, The Wharton School, University of Pennsylvania.

to larger errors in forecasting the demand for reserves, will generate more variability in the funds rate unless U.S. operating procedures are changed to compensate.

Most economists, including those in the Federal Reserve System, are not convinced that more variability in the funds rate would be harmful. But U.S. policymakers have revealed an aversion to funds rate volatility, at least in part out of concern that greater funds rate variability will reduce the Fed's ability to communicate the stance of monetary policy to the markets. Policymakers abroad share that aversion. Given policymakers' aversion to interest rate volatility, we would do well to learn whether other countries with low reserve requirements have designed operating procedures that yield less day-to-day interest rate volatility than does our current procedure. Or perhaps we can learn how to construct operating procedures that clearly communicate policymakers' intent to the markets despite volatility in short-term rates.

THE PAPERS

The papers by Kasman and by Morton and Wood treat operating procedures in major industrial countries, so they do overlap. Nonetheless, the papers neatly complement one another. Reading the two papers together, we learn about the evolution of operating procedures over time, including how central banks have adapted to changing financial conditions, and also about current practices for the day-to-day implementation of monetary policy. Both papers clearly indicate that operating procedures converged to a large extent during the 1980s, with central banks of all the countries examined now using a short-term interest rate as their operating instrument. Nonetheless, some important differences remain.

From Bruce Kasman's paper we learn about differences in the day-to-day operating procedures used to smooth short-term interest rates. Central banks rely mostly on open market operations in one or more financial assets, but non-market techniques such as direct lending to commercial banks (discount window lending, in U.S. parlance) or shifting government deposits between the central bank and commercial banks are used, too. From the paper by John Morton and Paul Wood we learn how the institutional context in which day-to-day operations take place has changed over time, and how monetary policy procedures have changed in response. While we learn a great deal from the papers, we learn less that I would like about the roles that the European Monetary System and international integration of money markets have played in the development of operating procedures. I suspect they have been important, but the papers do not tell us how important.

As the authors note, interest rate operating procedures are appropriate under some conditions. They were adopted or revived during the 1980s by all seven of the countries examined in these two papers as the seemingly robust empirical relationship between money, interest rates, and economic activity appeared to break down under the pressure of continuing deregulation of financial firms, spreading financial innovations, increasing international mobility of financial capital, and declining costs for financial transactions. The common movement toward interest-rate operating procedures was also driven, in part, by policymakers' perceptions that reserves or money supply targeting allowed too much interest rate volatility.

I do not have a comparative advantage in knowledge of the details of other countries operating procedures. Furthermore, reading some relevant literature and discussing the topic with a few participants in foreign financial markets reveals that the authors have done a generally good job of laying out those details. Thus I want to step back from the details and try to put the information presented in these two papers into perspective by discussing, at least in a general way, some analytic issues. I hope to focus the material in the papers on the search for alternative operating procedures before we turn to the lessons that we might draw from the experience of countries with non-binding reserve requirements.

INTEREST RATE OPERATING PROCEDURES

I turn first to a brief discussion of the objectives of interest rate operating procedures, and then to a broad-brush characterization of different ways to structure such procedures. I will focus on the implications of those structures for short-run variability in interbank interest rates. That will lead to some comments on the statistics presented in the two papers. Finally, I will offer comments on what we might adapt for use in the U.S.

The Objectives of Interest-Rate Operating Procedures

At the macroeconomic level, the objective of any monetary policy operating procedure is to achieve policymakers' desired outcomes for real GDP growth, inflation, or other macroeconomic variables. At the tactical level, we can identify at least four not-always-compatible objectives of day-to-day operating procedures: (1) to set the short-run operating instrument at a level believed consistent with policymakers' desired outcomes for intermediate targets such as money growth or the exchange rate, or for final goal variables; (2) to smooth day-to-day variability in short-term interest rates while nonetheless allowing the level of interest rates to move in response to "goods market" shocks; (3) to convey information about the stance of monetary policy to the markets -- sometimes clearly and sometimes not; and (4) to extract information about economic and financial shocks from the markets. Trade-offs among these objectives condition the design of interest-rate operating procedures.

The Design of Interest-Rate Operating Procedures.
As both papers note, an interest-rate operating procedure is, in practice, a set of techniques for managing the supply of bank reserves so as to keep the supply of reserves equal to the demand at the target interest rate. I will focus on market-related procedures.

The Simplest Procedure. Perhaps the simplest procedure is one in which the central bank creates a perfectly elastic supply schedule for reserves by posting an interest rate and announcing that it will supply any quantity of reserves that banks want to obtain at that rate. A central bank could implement such a procedure either by posting a rate at which it will freely lend to banks, or by posting a yield at which it will buy and sell some short-term financial instrument.

Clearly this simple procedure allows policymakers to set the operating instrument exactly at its target level. Changes in the target level are immediately observable, so this procedure provides full information about the stance of monetary policy to financial markets. Central banks in some of the countries considered in these two papers used to follow such a procedure, more or less, but no longer do so. The papers indicate that this procedure was dropped because it was perceived to slow the response of interest rates to shocks. That statement must be an argument about policymakers' willingness to change the target level of interest rates or about the need for political cover, rather than an argument that the simple fixed-interest-rate procedure does not extract information about shocks. The observed change in the quantity of reserves that results from a shock under a fixed-interest-rate procedure provides the same information about the economy as would the change in interest rates under a variable-interest-rate operating procedure, so long as we know the interest elasticity of the supply and demand for reserves. Evidently the simple fixed-rate operating procedure yields too little interest rate variability.

More Flexible Procedures. As an alternative, we can construct interest rate operating procedures that generate an inelastic or less-than-perfectly elastic supply of reserves over some range of interest rates, but that also keep rates from moving out of that range. Such procedures would allow shocks to immediately affect interest rates, and would also provide less information about policymakers intentions or targets by allowing some day-to-day interest rate variability.

One possibility is a two-tier lending mechanism, as in Germany. The central bank posts one interest rate at which banks can borrow up to a rationed amount, usually not quite enough to satisfy their total demand for reserves at that rate, and a second, higher interest rate at which banks can borrow freely. A second possibility uses a two tier intervention or repurchase rate to produce the same result, as in France. The central bank offers to buy government securities at a yield it chooses, up to some maximum quantity that is less than needed to satisfy banks' total demand for reserves at that yield. The central bank also offers to buy securities at banks' initiative, but at a higher yield. The central bank could either buy very short-term securities outright, or buy longer-term securities through repurchase agreements.

Both of these procedures would generate a supply schedule for bank reserves that is a step function. These two procedures would allow shocks to reserve demand to affect the level of interbank interest rates, at least within the range defined by the lower and upper discount or intervention rates. By choosing the spread between upper and lower rates, policymakers can control the maximum volatility in the targeted rate. By allowing the targeted interest rate to vary somewhat on a day-to-day basis, these procedures can maintain some flexibility or ambiguity about the central banks' exact target. And by announcing changes in the lower and upper rates, policymakers can make clear announcements about the stance of monetary policy when they need to do so.

Policymakers might feel that a vertical step in the supply schedule allows too much day-to-day variability in the targeted rate. In another variation on operating procedures, the central bank can manage the supply of reserves to get virtually any positive slope for the portion of the reserve supply schedule between the lower and upper intervention rates. By undertaking short-term repurchase agreements or foreign exchange swaps in response to forecasts of changes in the demand for reserves or to observed variations in interbank interest rates, or by shifting government deposits between commercial banks and the central bank, those responsible for implementing policy can generate an upward sloping supply schedule for bank reserves over a range of interest rates between the lower and upper lending or intervention rates.

Of course the upper and lower intervention rates can be used at the margin, rather than to provide the bulk of banks' reserves. The bulk of reserve deposits can be provided through outright purchases of securities, as in the U.S., Canada, and the U.K., or through long-term repurchase agreements as in Germany, or through foreign exchange swaps as in Switzerland. Thus the central bank can manage not only the slope of the upward-sloping portion of the reserve supply schedule but also its position. These mechanisms for providing the bulk of reserves can be biased toward keeping the banking system short of reserves on average, making it likely that interbank rates will trade near the top of the range defined by the upper and lower intervention rates. Or they can be biased toward keeping the banking system flush with reserves on average, so that interbank rates tend to trade near the bottom of the range.

Do Flexible Operating Procedures Meet the Stated Objectives? How does such an operating procedure stack up relative to the goals I discussed earlier? Such a mixed strategy can provide a well defined trading range for the targeted interest rate, thus limiting interest rate volatility. The targeted rate will respond to shocks in the demand for reserves, allowing policymakers to observe such shocks. The provision of reserves can be biased so as to keep the targeted rate near any desired level within the range, allowing policymakers not only to hit a specific interest rate target on average, but also giving them flexibility to make adjustments to their target without making explicit announcements of such changes. And changes in the top or bottom of the range can provide clear signals of changes in the stance of monetary policy.

Other Countries Use These Mixed Strategies. This mixed strategy of lower and upper discount or intervention rates with an upward sloping supply of reserves between them is a reasonably good characterization of operating procedures used in Germany and France. It is a less good, but still reasonable characterization of operating procedures in Canada and the U.K. In Germany the spread between the lower and upper lending rates is quite large, usually around 200 basis points. In the other countries the range is much narrower.

The U.S. Does Not. U.S. operating procedures, in contrast, generate no clearly identifiable minimum or maximum for the target interest rate. There is no minimum -- other than zero -- because discount window borrowing is so sharply restricted by administrative controls; there is no maximum because the Desk enters the markets at most once each day and there is no "Lombard facility." We can characterize the current U.S. operating procedure as one in which a nearly vertical supply curve for reserves is placed, daily, so that it intersects a forecast of that day's demand for reserves at the target federal funds rate. The reserves supply schedule is "nearly vertical," rather than vertical, for three reasons: (1) the Desk does shade its forecast of the demand for reserves up or down in response to movements in the funds rate; (2) dealers can and do withdraw from repurchase agreements with the Fed when market yields fall; and (3) discount window borrowing still responds a little to changes in the spread between the fed funds rate and the discount rate. With this nearly-vertical supply schedule, we sometimes see very large daily movements in the funds rate, particularly on the last day of reserve maintenance periods.

COMPARING OPERATING PROCEDURES AND INTEREST-RATE VOLATILITY

This discussion of operating procedures, along with the earlier discussion of the effects of non-binding reserve requirements, might lead us to expect that interbank interest rates in the U.S. would be more variable than those in other countries, except perhaps Switzerland and the U.K. That conclusion turns out to be half right, as the papers by Kasman and by Morton and Wood indicate. Interbank interest rates do seem to deviate more from their targets in Switzerland and the U.K. than in the U.S., but there is no apparent difference in the variability of U.S. interbank rates and those of the remaining countries.

Three cautionary notes on the interpretation of the statistics on interest rate variability presented in the papers are in order. First, as Kasman argues, we do not want to confuse changes in interest rate targets with the variability in interest rates that occurs around unchanged targets. Presumably it is only the latter kind of variability that policymakers find disturbing. As the charts presented in the two papers show, changes in target rates were quite frequent in some countries. For that reason I find it difficult to interpret the statistics presented by Morton and Wood; the average of standard deviations of daily interest rate changes around monthly means, for example, would correspond to unintended interest rate variability only if policymakers never changed interest rate targets except at the turn of the month. Second, as Kasman himself notes, his statistics for Switzerland and Japan are based on a less accurate identification of the central banks' target rates than is the case for other countries. Thus we should not be all that confident that the variability reported for Switzerland gives us an accurate measure of the effects of non-binding reserve requirements. Third, I suspect that the observed differences in interest rate variability reflect not only differences in operating procedures but also differences in policymakers' aversion to interest rate variability. Thus I am reluctant to draw strong conclusions about the effects of operating procedures on interest rate variability from the statistics presented in these two papers without knowing more about how much variability each country's policymakers find acceptable.

WHAT MIGHT THE U.S. ADAPT FROM OTHER'S OPERATING PROCEDURES?

I will conclude with a possibly provocative suggestion on what the Federal Reserve might adapt from other countries' operating procedures. I offer this suggestion in the hope that it will stimulate discussion and lead to wide-ranging consideration of alternatives. I should make clear that I have not worked out all necessary details, nor, I am sure, have I thought of all potential problems.

A Suggestion for U.S. Monetary Policy Operating Procedures

My suggestion is that the Federal Reserve augment its current operating procedures by setting up either a second discount rate -- a penalty discount rate modeled loosely on German practice -- or by setting up a penalty-rate repurchase facility modeled loosely on French practice. Adding either of these could serve as a first step in modifying U.S. operating procedures.

To set up a two tier discount rate, the Federal Reserve would establish the equivalent of a "Lombard rate" -- an additional, higher discount rate at which banks could borrow freely against eligible collateral. That second rate would be higher than the target federal funds rate and would exist alongside the current subsidy discount rate. Banks would be able to borrow at the lower, subsidy discount rate only in the event of truly unforseen reserve shortfalls due to events such as computer failures or wire transfer delays. But banks would have ready access to borrowing at the higher "Lombard rate."

To set up a penalty-rate repurchase facility, the Federal Reserve could announce that it stands ready to provide reserves to banks through short-term repurchase agreements arranged at banks' initiative, but at a rate that would be set above the target federal funds rate. Such a facility would require that banks have appropriate collateral; it also would require the Federal Reserve to put in place safeguards to limit counterparty risk.

Potential benefits of Modifying U.S. Operating Procedures.

Either of these facilities would provide a backup source of liquidity to the banking system when reserve deposits plus clearing balances fall short of balances needed for funds transfer purposes, or when the Desk underestimates the demand for reserves. Either facility could prevent spikes in the federal funds rate such as we have seen on some end-of-maintenance-period Wednesdays.

By establishing clear, although perhaps broad, limits on movements in the funds rate, either of these facilities might reduce policymakers' concerns that day-to-day movements in the federal funds rate could be misinterpreted as a change in monetary policy. That is particularly likely if market participants knew that significant changes in the stance of monetary policy would be signaled by changes in the penalty discount rate or repurchase rate, and perhaps also by changes in the subsidy discount rate. Seemingly paradoxically, a change in operating procedures that would prevent large movements in the federal funds rate could actually allow <u>more</u> day-to-day volatility by reducing markets' reliance on changes in the funds rate as an indicator of the stance of monetary policy.

In addition, the existence of a liquidity safety valve would reduce the Desk's need to match the supply of reserves to the predicted demand each day. The Desk might well be more able to focus on the reserve need for the maintenance period as a whole, and thus be free to conduct fewer daily open market operations aimed at smoothing the funds rate.

Finally, to the extent that the proposed changes allow greater day-to-day variability in the funds rate, they will enable market forces to move the average level of the funds rate more readily than is the case today. Those movements, in turn, might allow policymakers greater flexibility in making a series of small changes in their federal funds rate target, at least within the band defined by the subsidy discount rate and the penalty rate.

MONETARY TRANSMISSION CHANNELS IN MAJOR FOREIGN INDUSTRIAL COUNTRIES

Robert B. Kahn and Linda S. Kole[1]

The past two decades have witnessed far reaching transformations of financial markets in major foreign industrial countries. The process of financial liberalization that has taken place abroad in many ways parallels changes that have occurred in the United States. Although the specific circumstances of individual countries have differed, there have been important common elements, including the introduction of new financial assets and markets, fuller integration of domestic and international financial markets, greater reliance on market-determined interest rates, and significant structural change in banking systems. The changes in financial markets that occurred in most of the major industrial countries in part reflected the response to a common set of global economic forces. These changes, in turn, had an impact on the conduct of monetary policy and how monetary policy actions fed through to the real economy.

This paper characterizes the main financial channels through which monetary policy affects real economic activity in major industrial countries, and analyzes whether and how these transmission channels have changed during the past two decades. Because of the broad nature of the question, we have chosen to limit our country coverage. Our primary focus in this paper is on Japan, Germany, and the United Kingdom, three countries that have had a wide range of diverse experiences with financial deregulation and monetary control. We find evidence that in all three of these countries, wealth is crucial in the determination of money demand, the first link in the monetary transmission channel. Further the demand for broad money seems to have become more portfolio

1. Linda S. Kole is on the staff of the International Finance Division of the Federal Reserve Board. Robert B. Kahn, formerly a member of the staff of the International Finance Division of the Board, is now on the staff of the International Monetary Fund. We thank Hali Edison, Neil Ericsson, Mike Gavin, Craig Hakkio, Dale Henderson, Karen Johnson, Steve Kamin, Eric Leeper, Eileen Mauskopf, and Larry Promisel for their comments. Peter Fishman, John Maluccio, and Tina Sun provided exemplary research assistance.

based and interest sensitive in the past decade. We also find evidence that different monetary variables affect real economic activity differently across countries, but that the role of the term structure and the exchange rate seems to be increasing in the transmission channel.

The next section outlines reasons why monetary policy transmission mechanisms have changed in the past two decades. The third section then traces out a basic Keynesian model to illustrate the importance of asset prices in the monetary transmission process. Section 4 analyzes the relationship between money, interest rates, income, and wealth by estimating money demand functions and considering how they have changed over time. Section 5 then examines the links between various instruments of monetary policy and real variables. Finally, in the last section we summarize our results and explore possible extensions for future work.

MONETARY POLICY TRANSMISSION CHANNELS, 1970-1990

The reasons why monetary transmission mechanisms may have changed in the past two decades are well known. They include:

Financial liberalization and innovation. In the early 1970s, many foreign industrial countries had relatively underdeveloped financial systems that limited the channels through which monetary policy influenced economic activity. Subsequent changes in the transmission of monetary policy in these countries generally reflected governments' attempts to modernize and integrate their financial markets in a changing world economic environment. In Japan, financial markets were tightly controlled and segmented in the early 1970s. Major bank deposit rates were regulated while lending rates were closely linked to the Bank of Japan's discount rate. Bond markets were small and underdeveloped, and international transactions tightly controlled. Thus, credit was effectively rationed, and bank lending was the main channel through which monetary policy influenced the economy. Japan liberalized its capital markets later than many other industrialized countries. In the early 1980s, deregulation gradually gained momentum. Controls on domestic interest rates and on external capital flows were dismantled, and new financial products proliferated.

There was also substantial liberalization in the United Kingdom over the course of the 1970s and 1980s. Domestic financial markets were quite segmented (e.g. between the clearing banks and the building societies) in the early 1970s, restricting competition for both loans and deposits. In the 1970s, monetary policy mainly operated through restrictive guidance of bank and building society lending. Between 1973 and 1979, the "corset", in essence a tax on the expansion of U.K. banks' liabilities (and thus credit) was intermittently activated, although eventually it became ineffectual. When the Conservatives came to power in 1979, the new government recognized that the controls were increasingly ineffective and initiated major financial market reforms. Most of the restrictions on lending and exchange controls were abolished in 1979. The corset was scrapped in 1980, and reserve requirements were abolished in 1981. A series of other regulatory changes followed that culminated in the collapse of the building societies' cartel in 1983 and the Big Bang in 1986. Deregulation progressively put banks and building societies on a more even footing, broke down the separation of the mortgage market from other forms of personal credit, and freed consumer credit.

In contrast, German domestic financial market liberalization was already advanced by 1970, even though markets remain cartelized and underdeveloped. All interest rate controls were abolished in 1967. Exchange controls were removed in the 1950s. Such an environment might be expected to be one with particularly strong international linkages, and international financial innovation has made a mark on German capital markets, although relatively few new financial instruments have been introduced there. One special aspect of German financial markets has been their proximity to Luxembourg, a financial center that is considerably more developed than German markets. During the past two decades, Luxembourg has often served as an outlet for German portfolio shifts, providing Germans with the full array of instruments (offered by German banks) that their own market lacks. Without Luxembourg, German financial innovation would undoubtedly have proceeded at a faster pace. With the approach of a fully integrated European financial market, the process should accelerate.

It is often noted that one factor influencing liberalization of financial markets during the 1970s and 1980s was the sharp increase in industrial countries' interest rates and inflation rates after 1973.

Chart 1 depicts short-term interest rates and consumer price inflation from 1973 to the present in major foreign industrial economies. The increase in nominal and real interest rates created incentives for asset holders to reduce their balances bearing below-market interest rates. At the same time, the growth in government deficits in a number of countries contributed to the deepening of debt markets. Japan, France, and Sweden are countries where changes in heavily regulated bank systems were stimulated by the development of the bond market under the pressure of rising government budget deficits.[2]

Clearly other factors were also at work. Structural change in the banking system has contributed to a changing role for banks. And technological change, particularly in the advance of computer technology, altered the environment of financial markets, decreasing costs and increasing the speed with which financial transactions were transmitted between markets.

Most of the countries we examined responded to these changes by shifting monetary policy away from the use of credit constraints toward a greater reliance on market-determined interest rates. With the rapid development of financial markets, monetary aggregates became less stable and less subject to control by the monetary authorities. In general governments began to deemphasize monetary aggregates, by changing the method of targeting while paying more attention to short-term interest rates and their impact on the economy. For example, as the velocity of the broad aggregate £M3 became more unstable, the response of the U.K. government was to shift from targeting £M3 towards a narrower aggregate, M0. In the second half of the 1980s, British monetary policy became more interest-rate oriented, and at times, was used to pursue exchange rate targets as well.

In contrast, when German CBM became unstable and its targets were overshot in part as a result of volatility in currency flows, the Bundesbank shifted its focus to M3, an aggregate that puts less weight on currency. The Bundesbank was one of the first central banks to adopt (both informally and formally) monetary targets after the breakdown of the Bretton Woods system. Monetary policy relied heavily on interest

2. For a comprehensive discussion of these issues, see Germany and Morton (1985).

rates, supplemented by window guidance. Despite the uncertainties surrounding the unification of western and eastern Germany, the Bundesbank continues to put more weight on targeting broad money than do central banks in most other major industrialized countries.

Although the last two decades saw a gradual move towards more active use of short-term interest rates as instruments of monetary policy, evidence is generally inconclusive as to whether foreign authorities have acquired greater influence over long-term interest rates. Some have argued that financial innovation implies that short-term and long-term rates move more closely together than previously. However, as both government and corporate bond markets deepened, the ability of monetary authorities to influence long-term rates may have been reduced. Because long-term rates are more important in the determination of real economic variables, the nature of the relationship between monetary policy and the term structure is crucial.

Financial liberalization has had conflicting effects on the interest sensitivity of aggregate demand. In Europe and Japan, there have been significant structural changes that reduced liquidity constraints on consumers and rationing of loans by banks. To the extent that there is now less disintermediation from the banking system associated with a monetary contraction, interest rate changes will be measured to have a smaller impact on economic activity than previously. On the other hand, as discussed further below, individuals now carry more debt and their cash flow is more vulnerable to interest rate changes. In addition, households now have more assets whose return can be squeezed. In fact, one of the general conclusions that we suggest below is that wealth channels for the transmission of monetary policy now matter more.

Greater international openness and integration. Liberalization of domestic financial markets had its counterpart in greater economic integration of trade and financial relationships across countries. Part of this transformation reflected the continued liberalization of trade on a multilateral basis. Table 1 illustrates that, throughout the industrial countries, merchandise trade as a share of GDP/GNP rose between 1971-75 and 1987-91. Indexed by this measure, Germany, the United Kingdom, Canada and France appear to have been quite open by the late 1980s. In contrast, the external sector in Japan remains a smaller part of aggregate demand than is widely realized. Exchange rate considerations have figured prominently in Germany in part because of the relatively large size of the export sector (and because the Bundesbank has a statutory mandate to "safeguard the currency").

The greater openness of trade flows reflected a revolution in technology, which contributed to greater international integration of financial systems. Greater openness and financial market integration meant that governments increasingly had to respond to global economic disturbances. Spillover effects of one country's change in monetary policy could no longer be ignored. The growth of the tradable goods sector of these economies supports the common contention that monetary policy now has a greater impact on economic activity through the exchange rate channel than previously was the case. The usual argument is that a monetary-policy induced change in interest rates at home causes nominal interest differentials to change, leading to movements in nominal exchange rates. With the growth in the size of tradable goods sectors, movements in exchange rates will then have greater effects on aggregate economic activity. Mauskopf (1990) finds some evidence for an increase in the influence of the exchange rate on the volume of U.S. exports and imports using the Board's MPS model.

However, there are a number of reasons why we may not be able to observe this change clearly in the data. First, there is some evidence that long-term rates in the major industrial economies have moved more closely together in recent years than in the past. Whether this reflects greater financial integration or governments' policy responses to similar economic disturbances, the implication is that an interest rate innovation in one country may on average be associated with smaller movements in interest rate differentials and exchange rates than in the past. Further, changes in the passthrough of exchange rates to import prices (e.g., Hooper and Mann, 1989) will also affect the impact of monetary policy monetary policy through this channel.

The large movements in exchange rates of the major foreign industrial countries (especially against the dollar) during the 1980s also affected the monetary policy reaction function in some countries. The most obvious example was the creation of the EMS in 1979 and the gradual convergence of interest rates in member countries during the

1980s, which for all practical purposes devoted the conduct of monetary policy in France, Belgium, and the Netherlands to the goal of exchange rate stability against the mark. The progressive decline in the frequency of realignments in the EMS along with the move towards fuller EMU gradually enhanced the ERM's credibility and to some extent has made monetary targeting in separate nations obsolete.[3] Germany, arguably the most zealous G7 nation in terms of monetary targeting, occasionally subordinated its monetary objectives to external goals. For instance, after meeting its CBM targets each year between 1979 and 1985, the Bundesbank significantly overshot its target in 1986, when the mark appreciated 35 percent against the dollar and the current account reached a record level.[4] Japan also tolerated faster money growth at times due to exchange rate considerations. Occasionally, exchange rate targets have been inappropriate. For example, it is by now well recognized that the British experiment with shadowing the ERM at a rate of DM3 between 1987 and 1988 led to overly expansionary monetary growth, a boom, and excessive inflation.

The rise in consumer and business indebtedness. During the 1980s, the deregulation of financial markets and the provision of new financial instruments in many industrialized countries allowed both households and firms to accumulate more debt than ever before.[5] The removal of liquidity constraints for less well-off households and small firms and the wider selection of financing methods available to the private sector changed monetary transmission mechanisms in the following ways. Lower liquidity constraints allowed more consumers to smooth consumption and enabled them to react more to changes in permanent rather than current

3. It is interesting to note however that most of the ERM countries continue to target some aggregate, despite the essentially fixed nature of their exchange rates. One justification for the seeming inconsistency between exchange rate and monetary targets is that the anchor of the system, once the mark, has become less clear as Germany has had to adjust to the inflationary pressures of unification.

4. Note that domestic considerations were not in conflict with a monetary expansion, as consumer price inflation was negative for the first time since the 1950s.

5. In some countries a change in tax incentives contributed to the buildup of debt as well.

income.[6] Deregulation lowered the cost of financial intermediation, particularly for households, causing a shift towards borrowing. The larger proportion of households in debt meant that the private sector's sensitivity to interest rates might increase, thereby making monetary policy more potent. For example, empirical work by Dicks (1990) found that the interest elasticity of U.K. consumption increased during the 1980s, increasing the leverage of monetary policy.

Table 2 shows that the increase in debt of the household sector since the 1970s has been most dramatic in Japan and the United Kingdom. In both these countries, it could be argued that the conjunction of easy monetary policy and the rapid accumulation of mortgage debt fueled a real estate boom in the latter part of the 1980s. While land and equity prices were rising, the increase in consumers' liabilities seemed to be matched by the increase in their gross wealth. However, when tighter monetary policy finally burst the asset price bubbles in late 1989, both firms and households were left with an excessive stock of outstanding debt. After two years of recession, U.K. spending is still quite weak as firms and households continue to adjust their balance sheets. Debt overhang may have made U.K. consumers less responsive to monetary easing than previously was the case. For similar reasons growth in Japanese spending is now expected to be sluggish for some time. Note that these episodes have meant that asset prices, including those of tangible assets such as land, may be playing more of a role in the monetary transmission mechanism than previously.

The increase in household indebtedness has been more moderate in continental European countries such as Germany and France. The comparatively lower increase in the debt burden may mean that interest rate sensitivity has not changed as much in these countries. Also these countries did not experience the rapid asset price inflation seen in Japan and the United Kingdom in the late 1980s, so monetary policy may have worked less through the asset price channel.

6. Bayoumi (1990,1992) empirically documented this in his work on financial deregulation and consumption in the United Kingdom. He estimated that during the 1980s, the U.K. personal savings rate fell by 2-1/4 percent as a result of financial deregulation.

The cycle of debt growth and asset price inflation may have changed monetary reaction functions as well. In both the United Kingdom and Japan, the asset price inflation preceded periods of general consumer price inflation, giving monetary authorities an early warning that tightening would be a good idea.[7]

The responsiveness of firms to interest rates also was altered by the rise in business indebtedness, which again has been greatest in Japan and the United Kingdom as shown in the middle panel of table 2. Financial market deregulation expanded the access to credit and lowered the cost of borrowing for non-financial firms. With the development of corporate bond markets and innovations such as securitization, businesses have resorted increasingly to non-bank financing. However, as discussed with respect to the United States (in Bernanke and Blinder, for example) there are good reasons to believe that bank credit remains an important channel for monetary policy.

The switch to a less active stabilization policy in a lower inflation environment. In the 1980s, there appears to have been increased recognition on the part of foreign industrial governments that there are limits to what can be achieved through countercyclical fiscal policy and that monetary policy should be devoted more seriously to achieving price stability. As shown in the bottom panel of table 2, public sector debt as a share of GDP leveled off or declined in a number of countries between 1985 and 1990, although it probably has risen recently. Further, to some extent the drop in inflation and inflation expectations throughout the industrial world during the course of the 1980s can be credited to effective monetary policy. Lower inflation should have contributed to a decline in the velocity of various monetary aggregates and increased economic efficiency.

A CONVENTIONAL KEYNESIAN MODEL WITH WEALTH AND EXCHANGE RATE DYNAMICS

In light of our hypothesis that asset prices and wealth have become more important in the transmission of monetary policy, this section develops a

7. The Bank of Japan explicitly tightened policy in 1989 to quell asset price inflation. It appears that the U.K. government did not adjust monetary policy quickly enough in response to the asset price signal, leading to the boom and subsequent bust that occurred.

model of the open economy in which wealth plays a key role along with income in the determination of aggregate demand and prices. The model is Keynesian; the price level is sticky and output is demand determined in the short run. Wealth, modelled for simplicity as the value of the stock market, affects output directly through its effect on aggregate demand and is also a factor in determining money demand. Output, through both profitability and interest rate channels, in turn is a key determinant of asset prices. The model is a variant on Gavin (1989) who built on the closed economy analysis of Blanchard (1981).

Table 3 presents the equations of the model. The model is formulated so that all parameters in the structural equations are positive and all variables other than interest rates are in logs. In equations 1-2, real aggregate demand, D, depends on the real value of the stock market, q, real output, Y, the real exchange rate, E, and fiscal policy, G. Output then adjusts to the difference between aggregate demand and output, where the coefficient d is a measure of the speed of adjustment of Y to D.[8] Equation 3 can be interpreted as a liquidity formulation for money demand, solved for the nominal interest rate i, where the money supply is exogenously given. Money, income, prices, and wealth affect money demand. Alternatively, this equation could be thought of as a policy reaction function of the monetary authority. In this case, a positive coefficient on wealth would suggest that monetary authorities respond to asset price inflation by tightening policy. For simplicity, equation 4 defines the real interest rate as the nominal rate less the rate of change of home goods' prices; the real exchange rate does not enter. We also have assumed that perfect foresight prevails.

The dynamics of the price process are given in equations 5. The price adjustment parameter is simplistic, and abstracts from Phillips curve or staggered wage contracting considerations, but still allows for significant interactions in the results described below. The steady-state price level (equation 6) equilibrates the money market at the steady-state interest rate and the equilibrium level of output.

Asset market equilibrium is given in equations 7-9. In equation 7, the expected real return on a share of the stock market consists of

8. One could allow d to equal 1. in that case, Y jumps to its new equilibrium value.

both capital gains, $\dot{q}/q$, and the rate of profit, Z/q. This return must equal the real return on domestic bonds. Equation 8 is the open interest parity condition, where r^* is the foreign real interest rate and is exogenously given. Equation 9 specifies real profits as a function of real output and equation 10 gives the relationship between the long-run real interest rate and the short-run real interest rate.

Equations 1-9 can be solved for the steady state values of Y, q, E, and P, and the two negative roots that describe the adjustment of the economy after a shock. Chart 2 plots possible dynamic paths of these variables after a monetary shock occurs. Consider an unanticipated monetary expansion at time 0, with the economy initially at a steady state. The new steady state is identical to the old, except that the price level is increased by the amount of the monetary injection. As shown in chart 2, the simple price adjustment mechanism in this model ensures that prices adjust monotonically to their new equilibrium level.

The dynamic responses of output, interest rates, and the real exchange rate are more complicated. Output is "humpbacked", rising from the initial steady state to a point and then falling toward the unchanged steady state. Stock market wealth jumps up at the time of the monetary expansion to equilibrate expected stock market returns with returns in the bond markets, then gradually falls as interest rates and income adjust to the shock. In the left middle panel, the normal pattern of short- and long-term interest rates following the monetary expansion is shown. Interest rates initially fall following the monetary shock, then rise as output expands. Rates eventually rise above their baseline level before beginning to fall again as output returns to baseline. However, the introduction of stock market prices into the model creates the possibility that long-term interest rates could rise following the monetary expansion. Short-term interest rates always fall on impact of the monetary impulse, but rise as activity responds. If the monetary expansion has a strong effect on the stock market, and the increase in wealth in turn has a strong effect on activity, short term rates may respond quickly and soon rise above baseline. In this case, the long-term interest rate as the weighted average of current and future short-term rates might rise immediately, implying a stronger movement in the term structure.

Chart 2 also shows possible paths for the real exchange rate. The left and center bottom panels show the usual depreciation of the real exchange rate following a monetary expansion. As discussed by Gavin, the possibility exists in this model for the exchange rate to exhibit perverse behavior and appreciate following the monetary expansion. The logic is similar to the reason that long-term rates can rise following the innovation to money: If the stock market response is strong enough, the actual and expected increase in interest rates causes the exchange rate to appreciate. This model highlights the importance of wealth in the monetary transmission channel.

MONEY DEMAND IN JAPAN, GERMANY, AND THE UNITED KINGDOM

Although wealth plays a crucial role in the monetary transmission process, most of the vast literature on money demand in industrialized countries excludes this variable from the analysis. Especially when one considers the demand for broad aggregates, that are less oriented towards making transactions and have more of a role in portfolio management, the omission of some measure of wealth is likely to seriously bias one's results. M2+CDs, the aggregate most closely monitored by the Bank of Japan, and M3, the aggregate targeted by the Bundesbank, are both likely to be determined primarily by portfolio flows rather than fluctuations in the transactions demand for money. The same is true of British M4, which we chose to analyze here because of its closeness in definition to £M3, the aggregate targeted over most of the period.[9]

Corker (1989) noted the importance of including Japanese wealth in order to achieve a stable equation for the evolution of real M2+CDs and Hall, Henry, and Wilcox (1992) found personal sector wealth to be significant in the long-run determination of U.K. M4. In the spirit of these studies, we estimated money demand functions for broad monetary aggregates that allow wealth to play a role, both in short-run fluctuations of money demand and in a long-run (error-correction mechanism) context.

9. We chose not to model British M0, the aggregate targeted by the British government for the past few years. This aggregate, which includes notes, coin, and banks' operational deposits with the Bank of England, is extremely narrow and more of a coincident indicator of economic activity than a indicator of the government's monetary policy.

As we mentioned above, Japanese financial markets were deregulated later than those in Germany and the United Kingdom, and the process of removing interest rate regulations is still ongoing. As a consequence, among the three countries considered, Japan is the most likely candidate for instability in the demand for money. This is indeed what we find. In part, the problem in estimating a stable money demand function for the entire period between 1973 and 1991 is that different interest rates were probably relevant at different periods. The top panel of Chart 3 shows the relevant interest rates: the Gensaki rate was the most market-related rate in the 1970s whereas the own rate was very sticky and unrelated to market interest rates.[10] Both the own rate and the postal savings rate became more important over the course of the sample, while the Gensaki rate became progressively less significant. The chart also shows that the opportunity cost of M2+CDs, the gap between either outside rate and the own rate continued to narrow until quite recently.

Using quarterly data, we regressed the change in the log of M2+CDs deflated by the log GNP deflator, $\Delta(m-p)$, the change in log GNP (Δy), the rate of GNP price inflation (Δp), the growth in the log of real wealth, $\Delta(w-p)$, and the change in various interest rate measures: an own rate, i^{o}, the postal savings rates i^{PS}, the Gensaki rate, and the long rate, i^{L} as well as the error correction terms. We started with a specification that included 4 lags of each of the first-differenced variables, and gradually eliminated those variables that were not significant at the 10 percent level. The wealth variable used was an updated version of that used by Corker (1989), the total stock of assets held by the personal and corporate sector.[11] We originally started with error correction mechanisms similar to Corker's, $(m-w)_{t-1}$ and $(m-p-y)_{t-1}$, but found we were almost able to reject the implied restrictions, so we allowed the long run relationship between real money, real wealth and real output to be estimated freely.

10. We followed Corker (1989) in the construction of the own rate on M2+CDs as a weighted average of the interest rate on 3-month CDs and the average rate on savings deposits.

11. Unfortunately, this measure of wealth only includes financial wealth, not tangible wealth such as real estate.

The first column of table 4 presents the results. Note that the wealth variable, w-p, is quite significant, both in terms of its rate of change and in its lagged level. The rate of inflation, Δp, and its first lag, are strongly significant, and we were able to reject the hypothesis that the relevant demand is for nominal rather than real money. The rate of change of GDP, Δy, and its lags, did not add to the explanatory power of the equation, but y_{t-1} is significant. Both the postal savings rate, a rate on assets outside M2+CDs, and the own rate, a weighted-average rate on assets inside M2+CDs, have estimated coefficients that are significant and of the correct signs. Assuming price stability, the long-run money demand function implied by the error correction variables is:

$$m-p = .43y + .48(w-p) + 6.28i^{o} - 5.01i^{PS}$$

We then estimated the equation over two subperiods; 1973-1982 and 1983-1991. We broke the sample after 1982, before financial deregulation and innovation really started to take off in Japan.[12] The Fisher test indicates that one can reject the hypothesis that the demand for M2+CDs remained stable between these two periods at the 1 percent level of significance. Note that the dynamics have changed considerably between the two periods, and that during the first period this specification leads the errors to be serially correlated. There is some evidence that the lags were longer in the first period than in the second, perhaps indicating that money holders have become quicker to adjust their balances in response to changes in wealth, interest rates, and other explanatory variables.[13]

Turning to the estimated coefficients for the two subperiods, several points are worth noting. First, both the short-run and long-run interest rate elasticities are estimated with the wrong sign during the

12. Kasmin and Rodriques (1992) chose to break their sample in 1984.

13. We were able to find a stable money demand function between the 2 periods when we left many lags in the equation. These lags were more significant during the first period. Their addition however, did not improve the fit of the equation in the overall period, so they were discarded.

earlier period; with the change in the own rate significant, whereas in the later period all the estimated interest rate elasticities have the correct sign. Second, although the lagged wealth variable is significant in both periods, the long-run coefficients indicate that the proportion of an increase in wealth allocated to M2+CDs fell from 60 percent in the early period to about 50 percent in the later period, which seems consistent with the wider diversity of assets available outside the aggregate. Finally the higher significance of the lagged level of income in the earlier period is evidence that the transactions motive for holding money has become less important over time.

In contrast to the Japanese case, due to the lack of financial deregulation and the consistency of monetary policy, German money demand before 1990 was, a priori, the most likely to be stable among the countries we considered. The middle panel of chart 4 shows the interest rates relevant for German money demand. It is immediately apparent that they move together during the entire sample. Unlike Japanese savings instruments, German time deposits have had market-related interest rates for some time, reducing the incentive for financial innovations such as those which change the nature of the relationship between Japanese interest rates during the sample period.

We used the same estimation technique employed for Japanese money demand to determine the proper lag lengths of the included variables. Table 5 presents the results for the overall period and two subperiods: 1970-79 and 1980-89. The split in the sample is close to the creation of the EMS. We ended the sample in the fourth quarter of 1989 because of the possibility that the fall of the Berlin wall induced instability in the demand for M3.

The rate on public bonds was found to be more important than short-term rates as an opportunity cost of M3. This may be due to the fact that M3 contains assets of maturities of up to 4 years, so that the marginal investor might substitute into a longer-term asset such as public bonds. Although some studies of German money demand (see for example, von Hagen and Neumann (1988)) have included foreign interest rates and/or the exchange rate, (spot and forward), Frowen and Schlomann (1992) found them not to be very important for M3. The rate on public bonds is more important in the 1980s than it is in the 1970s, as is the own rate. Note that the coefficients on own rate and the public bonds rate are of equal and opposite sign in the later sample, indicating that an opportunity cost specification using the interest rate differential may be best for the period of the 1980s.

The wealth variable for Germany was constructed from flow-of-funds data of the household sector. Since data on households' net assets are available only on a biannual basis, we interpolated resulting in a smooth version of quarterly wealth. (This measurement error associated with interpolation and constructing stock data from flow data may account for the lower significance of wealth in German money demand, at least in comparison to Japan and the United Kingdom.) However, its significance increases between the two periods, indicating that portfolio management plays an increasing role in the determination of the demand for M3. The long-run solution implied by the error correction coefficients is:

$$m-p = .19y + .54(w-p) + 3.75i^{O} - 5.41i^{PB}$$

Finally, it is evident that the transactions demand for money has become less important as the lagged level of real GDP has become progressively less significant. The fit for the earlier period improves slightly if one adds in the change in GDP. None of these changes are statistically significant, however, as is indicated by the fact that the Fisher test does not reject the hypothesis that the two subsamples can be pooled. As we expected, and as others have found, it does not take much to arrive at a stable demand for German money in the pre-unification period.

It is difficult to say much about how the monetary transmission mechanisms have changed since the unification of east and west Germany. The lack of a sufficiently long data set post-unification rules out econometric analysis of the period. Nonetheless, a few preliminary judgments can be ventured. First, German money demand has become less certain following the 1990 currency conversion of Osmarks for Deutchmarks that added eastern German demand, and at times movements in interest rates and money growth have sent conflicting signals regarding the stance of policy.[14] In this environment, the Bundesbank has recognized that monetary policy changes will be at best a blunt instrument for influencing prices and activity.

Second, a case can be made that aggregate demand in Germany currently is less interest sensitive than before unification. Specifically, a significant portion of German domestic demand is associated with the surge in investment, and specifically construction, in the eastern portion of Germany. Much of this investment appears to be limited by capacity constraints, suggesting that changes in interest rates may have a limited effect on these flows in the near term. In addition, a substantial portion of this investment is publicly subsidized, and thus less responsive to monetary policy. Further, to the extent that investment in eastern Germany is subject to substantial systemic risks associated with the region's transition to a market economy, nominal interest rates will be a smaller part of the total perceived cost of investing than in western Germany.

Another argument that has been made is that with the completion of the internal market in the European community, barriers to entry into German banking markets have been reduced. New entrants, actual or potential, are expected to enhance competition in these markets and should lead to more competitive pricing of deposits. This may lead to less disintermediation associated with changes in Bundesbank policy, meaning that interest rate changes may have less effect on activity through the bank lending channel than previously.

Table 6 presents the results of estimating the demand for real U.K. M4. Here we adjusted the M4 data to account for a break in the fourth quarter of 1981 when the monetary sector replaced the banking sector and many new institutions such as the Trustee Savings Banks were for the first time included in the broad monetary aggregates. We tried a variety of interest rates including long-term rates, local-authority rates, and deposit rates, and found that over the entire sample, the rate on 3-month Treasury bills fit the best. From the bottom panel of chart

14. Some have argued that strong eastern German money demand suggests a combination of a high income elasticity and strong income growth due to large transfer payments from the government.

4, it appears that the opportunity cost of M4 has not varied substantially over the sample.

No interest rates seemed to matter in the rate of change form, and it was difficult to find specifications with the rate of change of GDP entering the equation significantly and with the correct sign. The change in real wealth (and its lags) also had nothing to add to the explanatory power of the other variables. Wealth is total wealth of the personal sector, including tangible assets. We also tried financial wealth, and it fit, but not as well, especially in the latter period.

The long-run money demand function implied by the error-correction terms is:

$$m-p = -.51y + 1.58(w-p) + 5.4i^{o} - 5.84i^{TB}$$

The estimated long-run elasticity of real M4 demand with respect to GDP is about -1/2. The equation can be rewritten in the following way:

$$m-p-y = 1.58(w-p-y) + .07y + 5.4i^{o} - 5.84i^{TB}$$

The inverse velocity of M4 is positively related to the wealth/GDP ratio and negatively related to the opportunity cost of money.

We chose as a sample breakpoint the end of exchange controls, and the beginning of the Thatcher government's reorientation of monetary policy from restrictive lending towards more market and monetarist goals. The equation passes the Fisher test for stability between the two periods at the 5 percent level of significance. It seems intuitively plausible that demand for U.K. M4 would be less stable than that for German M3, but more stable than the demand for Japanese M2+CDs. However, the dynamics seem to have changed between the two periods, as do the signs and significance of some of the coefficients.

The estimated coefficient on the growth of GDP (two quarters earlier) switches from positive to negative between the two periods.[15] It is interesting to note that the error correction mechanism implies the

15. Note that this result does not disappear if current and once-lagged GDP are included in the equation. The sum of the estimated coefficients still adds up to a negative number for the second period.

opposite change in sign between the two periods. The long-run elasticity of real M4 demand with respect to real GDP changes from an insignificant negative number to a significant positive 1.5. (Note that the negative long run income elasticity estimated for the full period seems to be coming from the 1970s rather than the 1980s.) The implication is that between the two periods the relationship between transitory changes in income and real M4 changed, but income became more important as a long-run determinant of money demand.

As in Japan, the long-run wealth elasticity declines between the two periods, from 1.4 in the 1970s subperiod to .5 in the latter period. It appears that in the earlier period, investors were moving into M4 on balance, while in the later period they were diversifying into assets outside M4.

The estimated coefficients for 3-month Treasury bill rate and the own rate decline in significance between the first and second period. This could be a result of other interest rates being more relevant. There is some indication that long-term rates seem to become more important between the two periods. This may be an indication that investors became more sophisticated as financial markets deepened.

To summarize our results thus far, we find evidence that wealth is a significant determinant of money demand in Japan, Germany, and the United Kingdom, and may have become more important than in the past. In all three countries, there seems to have been a shift from holding money for transactions purposes to holding it as part of a portfolio between the 1970s and 1980s. We find that the demand for broad money remained fairly stable in both Germany and the United Kingdom during the past two decades. However, in Japan, where financial deregulation was more gradual and is still ongoing, we find more instability.

THE RELATIONSHIP BETWEEN MONETARY AND REAL VARIABLES.

What is the relationship between monetary variables, be they monetary aggregates, interest rates, or exchange rates, and the real economy? This is an age-old question that has been analyzed most extensively for the United States without resulting in anything close to a consensus. We surveyed the evidence for Japan, Germany, and the United Kingdom. Some of the changes in the transmission mechanism discussed above could be expected to change the reduced form relationship between monetary variables and various activity variables. For example, if consumers have become more interest sensitive because of lower liquidity constraints, interest rates may be more related to real spending.

Estimation of the structural model laid out in section 3 is beyond the scope of this paper, but in this section we take a first pass at analyzing the relationship between monetary and real variables by looking at reduced-form results. Specifically, we ran a battery of regressions to assess the predictive power of monetary variables in the determination of real economic activity, over the 1973-91 period and two subperiods for Japan, Germany, and the United Kingdom. For the activity variables for which monthly data are available, industrial production (IP), retail sales (RS), the trade balance (TB), and the unemployment rate (U), we included six lags of the relevant variable, a trend, six lags of various price indices to proxy for supply shocks (and to stack the deck against us), and six lags of the three monetary indicators shown as column heading in tables 7-9.

The monetary indicators chosen were the major aggregates (in most cases the targeted ones), the 3-month interbank rate, and the term spread between a long-term rate and the 3-month rate. The latter variable has been shown by Stock and Watson (1989) and others to have remarkable explanatory power for U.S. output.[16] We also included the exchange rate as a monetary indicator, when the activity variable in question was an external balance.

Quarterly regressions were run with the following variables: real GNP or GDP, real consumption expenditures (C), real gross fixed investment (I), and real net exports (NX). These regressions included four lags of the activity variable, four lags of the monetary variable (on an average quarterly basis), and four lags of the GNP/GDP deflator, the CPI, the PPI, and the world commodity price index, respectively.

Because we were primarily interested in the cumulative impact of a given money or interest rate innovation, we tested whether the addition of the lags of the relevant monetary indicator variable summed to a

16. Our equations for industrial output are similar to those estimated for the United States by Stock and Watson (1989).

quantity significantly different from zero.[17] When we find the sum of the coefficients on a monetary variable to be significant, we can say that that variable helps predict the real variable. Table 7 presents the marginal significance levels for rejecting the hypothesis that the estimated coefficients on monetary indicator variables (in the columns) sum to zero in regressions where the activity variables (in the rows) are the dependent variables. A low marginal significance level means that it is easy to reject the null hypothesis that the 6 lags of a monetary variable sum to zero, i.e. low significance levels are associated with monetary variables adding to the predictability of real variables.

For Japan, it is evident that of the monetary variables considered, M2+CDs has the strongest relationship with real activity variables over the entire period in question. In addition, the additional explanatory power of M2+CDs (as well as bank credit) rose between the two periods, at least for retail sales, consumption, industrial production, and GNP. The 3-month rate is only a good additional predictor for industrial production and real GNP for the whole period, although it seems to be an important variable for investment in both of the subperiods, and for retail sales and net exports in the later period. The term spread is a good predictor of GNP, consumption and the trade balance, but only for investment in the earlier period. The fact that it increases in significance for several activity variables in the later period could mean that the sensitivity of activity variables (excluding investment) may have increased between the periods. The amount of financial deregulation and innovation in Japan during the past decade may have made the term structure relevant for the first time. As financial markets deepen, interest rates and term spreads may transmit a clearer signal of both monetary and real disturbances.

For Germany, the 3-month rate is the best indicator for the entire period, although M3 is a good indicator of industrial production, unemployment, GDP, and investment. The term spread is a good indicator for the trade balance, retail sales, GDP, and consumption. In the full

17. Note that this is a weaker test than Granger causality in that it does not require that each individual coefficient equal zero, but only that they sum to zero. However, we wanted to rule out cases where monetary variables entered significantly, but with equal and alternating signs.

sample, the regressions yield coefficients with the correct signs. One interesting finding is that money is negatively (and 3-month interest rates are positively) related to real net exports and the nominal trade balance. Not surprisingly, real net exports are also positively related to the DM/$ exchange rate especially in the case where the regressions are specified in terms of rates of change.

Comparing the two subperiods, it looks as if M3 and the exchange rate have somewhat more significance for real net exports in the later period, while the 3-month rate and the term structure have more significance for several real variables in the earlier period. It appears that interest rates were more important in the earlier period. Retail sales were much more related to monetary variables, including bank credit, in the earlier period indicating that they may have played more of a role in the monetary transmission mechanism. Overall, there are less differences to point to than in the case of Japan.

In the United Kingdom, interest rates are more strongly related to real activity variables than the two monetary aggregates we considered. The best overall indicator for the entire period seems to be the 3-month rate, although the term-spread is quite significant as a predictor of IP, GDP, investment and net exports. There is little evidence that consumption became more interest-sensitive over the two periods, and unfortunately, we only have retail sales data on the latter half. There is evidence that industrial production became more related to the 3-month rate, the term spread, and M4 while becoming less related to M0. The short rate and the term spread also have more impact on GDP and investment in the 1980s, i.e. the marginal significance levels decline between the two periods.

We also repeat these tests with first-differenced variables as well. These results were not as strong (not surprisingly), but there were a few points worth noting. In the case of Japan, the growth of M2+CDs is the best additional predictor of real economic growth, especially in the later period. There is again evidence that the term spread increased in importance between the two periods. The rate of change of the dollar exchange rate (the variable most likely to be non-stationary) has considerable significance for the rate of change of net exports for the full period and the early period, but not for the latter.

In contrast, the rate of DM depreciation against the dollar has more significance for German real net exports in the later period than in the earlier one, even though it its marginal significance level for the full sample is .0002. The 3-month rates still stands out as the best additional predictor for German economic activity. Finally, the result for the U.K. rate of change regressions were the worst of the three countries. The change in the dollar exchange rate did not add explanatory power in regressions involving the the trade balance or net exports, but both the change in the 3-month rate and the term spread were significant.

Next we considered the role of bank credit for each of the countries and the monthly regressions in tables 7-9. To summarize, bank credit did not play much of a role in predicting German activity variables, except retail sales. The marginal significance of bank credit was .0001 for retail sales in the earlier period. Bank credit appeared to matter for all the activity variables in Japan, primarily in the later period. For the United Kingdom, available data only allowed us to conduct the tests on the later period, and we found that bank credit did not have significant explanatory power for real activity in the 1980s.

To get at the issue of the change in international linkages, we decided to test whether a foreign monetary policy variable could add explanatory power to domestic monetary variables in Japan, Germany, or the United Kingdom. We reran all the regressions included in tables 7-9 adding 6 lags of the U.S. term spread to the monthly equations and 4 lags of the U.S. term spread to the quarterly equations and tested whether the U.S. term spread had additional predictive power for foreign real economic variables once their own monetary variables were accounted for.

For Japan, we found that the U.S. term structure was most significant as an additional explanatory variable for retail sales, the trade balance, the rate of change in unemployment, and GDP. In Germany, the U.S. term spread had additional explanatory power for GDP, consumption, net exports, and retail sales. The U.S. term spread is most significant in the U.K. regressions involving the trade balance, net exports, GDP, and investment.

One result we found across countries was that the U.S. term spread seemed to have more significance in the earlier period than in the later period. This could be evidence that international interest rates were less integrated in the earlier period, so that the U.S. term structure conveyed information lacking in domestic monetary variables. Another finding of note was that for most of the regressions involving net exports or the trade balance, the significance of the U.S. term spread substantially diminished when the exchange rate was chosen as the monetary variable, indicating that the U.S. term spread may be proxying for the exchange rate. In summary, the U.S. term spread had some additional explanatory power for foreign real variables, but nowhere near the power is seems to have for the U.S. real economy.

CONCLUDING REMARKS

This paper attempts to characterize the ways in which monetary transmission mechanisms abroad have changed in the past decades. We find that despite a major transformation in global financial markets, the demand for German M3 (pre-unification) and British M4 seems to be stable during the past two decades. Only in Japan, where financial deregulation was later and is still ongoing, do we fail to find a stable demand for broad money. We find some evidence that financial deregulation and innovation may have changed the interest rates relevant for money demand, and that the elasticity of money demand with respect to the opportunity cost of holding money has increased. There also seems to have been a shift from holding money for transactions purposes in the 1970s to holding it for portfolio motives in the 1980s.

We find that wealth plays an important role in the determination of money demand in each of the countries we considered. While this paper does not take the further step of empirically measuring the importance of wealth channels in the transmission of monetary policy to the real economy, we believe that more work on this area is crucial. Furthermore, our analysis suggests that a greater role for asset prices as indicators, instruments, or targets of central bank operating procedures.

The reduced form nature of our tests do not allow us to draw many conclusions about the transmission of monetary shocks to the real economy. However, we do find evidence that corroborates the view that the interest rate sensitivity of spending (especially that of consumption) has increased in the past decade. This is not surprising given the wider availability of consumer and mortgage credit for households and the development of new financing methods for firms. Further investigation into the impact of the debt buildup of the late 1980s on the monetary transmission mechanisms in Japan and the United Kingdom is clearly warranted.

We also find some evidence that the exchange rate is an important channel for monetary policy. In addition, the term structure of interest rates seems to be gaining significance as a predictor of real economic activity in Japan and the United Kingdom. However, the term spread is not found to be nearly as significant in Japan and Germany as it has been found to be as a predictor of U.S. real output, which raises the question of why such a difference has emerged.

Short of estimating a structural model across these foreign countries, there are several extensions to this paper that would be worthwhile. Estimating monetary reaction functions and attempting to pinpoint how they have changed over the past several years could give us valuable information on how money supply processes have evolved.

APPENDIX: Major Events or Policy Changes Affecting the Monetary Transmission Mechanism

G7

1973

- The Bretton Woods system of fixed exchange rates collapsed.

1979

- The exchange rate mechanism of the EMS began operation in March.

1985

- G7 Finance ministers met at the Plaza Hotel in New York in September and agreed on the Plaza Accord, that the dollar (which peaked in February 1985) was fundamentally overvalued and that a further fall in its value was warranted.

1987

- G6 Finance ministers met at the Louvre in February and decided to manage major exchange rates within unannounced target zones.

1989

- At the Madrid summit, EC governments agreed to start Stage One of European Economic and Monetary Union (EMU) on July 1, 1990.

1991

- At the Maastricht summit, EC governments agree to start Stage Two of EMU in 1994, and to begin full monetary union sometime between January 1997 and the end of 1999.

Japan

1974

- Following the oil price shock, inflation rose sharply and the government began to run substantial deficits that contributed to growth in the government securities (Gensaki) market. Also, interest rates on foreign currency deposits were liberalized.

1975

- Bank of Japan announced the "Money supply policy" in July acknowledging a shift in emphasis to focus on M2.

1978

- Bank of Japan began to present a public forecast of the money supply. At the beginning of each quarter, a forecast (not an official target) for the year-on-year growth rate of the monetary aggregate (initially M2) during the quarter was announced.

- The government began to issue, by public tender, 2-4 year medium-term bonds.

1979

- Bank of Japan shifted to announcing target for M2+CDs.
- Banks were allowed to issue Certificates of Deposit (CDs) worth at least ¥500 million.

1980

- "Chuki-Kokusai" funds (similar to money-market mutual funds) were introduced by securities firms.
- "Foreign Exchange and Foreign Trade Control Law" led to significant relaxation of capital controls.

1985

- Continued financial market reform occurred such as the introduction of money market certificates (MMC) for banks and credit associations, with minimum denominations (¥50 million) and maturity 1-6 months. Minimum denomination and maturity of CDs were shortened, and the ceiling on issue size was raised. Interest rates on deposits of ¥1 billion or more with maturity of 3-24 months were deregulated.

1986

- Interest rates on deposits of ¥300 million or more were decontrolled. Further liberalization on ceilings, size, and maturity of CD issues took place.

<u>Germany</u>

1972

- The annual report of the Council of Economic Experts advocated the control of the money stock to combat inflation.

1973

- The Bundesbank discarded its previous monetary indicator, "free liquid reserves" and replaced it with "central bank money" (CBM). In order to maximize control over CBM, it reduced to "practically zero" the formerly generous reserves that allowed banks easy access to CBM. The mark began to float.

1974

- The Bundesbank announced a target for CBM for the first time in December. The growth of CBM was to be held to 8 percent between December 1974 and December 1975.

1978

- As a result of a large appreciation of the mark and a substantial overshooting of its 8 percent CBM target for 1978, the Bundesbank announced that it would adopt a target range of 6-9 percent between the fourth quarters of 1978 and 1979.

1981

- The Bundesbank made Lombard credit available only under a Special Lombard Facility at a cost higher than the ordinary Lombard rate.

1985

- In January, the Bundesbank raised the Lombard rate to a level that applied in its temporary security operations and began to use market operations to supply reserves more liberally.

1986

- Reserve requirements were restructured to ensure that they covered liabilities in the form of bearer securities at up to two years, when German banks were authorized to issue CDs.

1987

- Minimum reserve ratios were increased for the first time since 1979, to offset the effect on bank reserves of large Bundesbank purchases of foreign exchange.
- After the substantially exceeding its CBM target, the Bundesbank decided to switch to an M3 target in December to decrease the influence of notes and coins on the aggregate.

1988

- A withholding tax on capital incomes to take effect the beginning of 1989 was passed and reportedly caused substantial capital outflows.

1989

- The withholding tax was withdrawn.
- The Berlin wall fell in November.

1990

- Monetary union, including the swaps of Osmarks for DM occurred in July and was followed by full unification of east and west Germany in October.

The United Kingdom

1972

- Sterling floated in June.

1973

- Supplementary Special Deposits scheme (better known as the "corset) was introduced, under which banks were required to place supplementary special deposits with the Bank of England if their interest bearing eligible liabilities grew faster than a specified rate (8 percent in the first 6 months). This scheme was suspended and reactivated intermittently throughout the rest of the decade.

1979

- The Conservative party came to power in May and essentially ended restrictive guidance on building society lending. In its first budget, the new government announced relaxation of exchange controls, continuation of the "corset", and a £M3 target range of 7-11 percent from mid-June 1979. Starting with the 1978-79 fiscal year it was announced that targets would be rebased every six months.

1980

- The green paper on Monetary Control was published in March, and in the medium term financial strategy (MTFS), the government announced a gradual reduction in money supply growth. The 1980-81 target for £M3 was to be 7-11 percent, and the range was to decrease by 1 percent each subsequent fiscal year to 4-8 percent in 1983-84. The "corset" was discontinued in June.

- In November, the government published a note on Methods of Monetary Control, in which it advocated phasing out the reserve assets ratio, under which banks had to hold at least 12.5 percent of their deposits in a specified range of liquid assets, and considering a cash ratio instead. The Bank of England was to change its money market intervention to emphasize open market operations rather than discount window lending, to try and keep very short-term interest rates within an unpublished band, and to gear daily operations primarily towards offsetting cash flows between the Bank and the money market.

1981

- In the MTFS, a new target range for £M3 was set at 6-10 percent for the 14 months starting in mid-February 1981. It was announced that the minimum reserve assets ratio would be abolished, and that all banks would be required to hold non-operational non-interest bearing deposits with the Bank of England. The new arrangements for monetary control took effect in August.

1983

- The conservative government of Margaret Thatcher was reelected. Nigel Lawson, new Chancellor of the Exchequer, reviewed monetary policy and stated that narrow measures of money were linked more closely to inflation.

- The building societies' cartel collapsed in October.

1984

- A target range for M0 was set for the first time, at 4-8 percent for the 14-month period beginning in mid-February 1984. The target range for £M3 was set at 6-10 percent.

1985

- Lawson suspended the 1985-86 £M3 target of 5-9 percent, because it had been set too low. Overfunding (the policy of issuing more government debt than required by the budget deficit which had started in 1981) was dropped and a full-funding policy was adopted in order to ease persistent shortages in the money market.

1986

- The Building Societies Act was passed and mortgage lending guidance was withdrawn. In October, financial reforms known as the "Big Bang" eased entry into dealing on the stock exchange and in the gilts market.

- A new target range for £M3 was set at 11-15 percent for the 1986-87 fiscal year, much higher than the 4-8 percent target range set out in the previous MTFS. The target range for M0 was set at 2-6 percent.

1987

- Target ranges for broad monetary aggregates were abandoned. The M0 target was set at 2-6 percent. The U.K. authorities begin to "shadow the ERM", by attempting to keep the value of the pound below DM3.

1988

- Sterling was allowed to appreciate above DM3 beginning in March. In the MTFS, M4 replaced £M3 as the main measure of broad money.

1989

- At the Madrid summit in June, Britain committed itself to becoming a member of the ERM by the end of Stage One of EMU.

1990

- In October, Britain joined the ERM at a central rate of DM2.95 and with 6 percent bands.

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TABLE 1

Measures of Openness
(Annual Average, in Percent)

	Exports + Imports / GDP		Exports / GDP	
	1971-75	1987-91	1971-75	1987-91
Japan	24	33	10	17
Germany	50	74	25	38
United Kingdom	47	67	23	32
France	38	51	18	24
Italy	10	12	4	6
Canada	40	58	21	28
United States	14	21	6	10

TABLE 2

Gross Debt as Percent of GNP/GDP

	1960-70	1970-80	1985	1990
		Households		
Japan	20.3	34.2	47.4	63.2
Germany	34.7	43.2	57.1	52.6
United Kingdom	31.0*	33.6	51.4	73.8
United States	48.0	50.3	59.0	71.7
Canada	43.9	53.2	50.2	63.2
France	34.0*	38.1	38.1	47.1
Italy	n.a.	6.5	6.9	9.8+
Sweden	46.0*	51.1	55.5	66.9
		Non-Financial Firms		
Japan	85.6	92.1	100.6	134.7
Germany	54.6	65.1	72.9	74.4
United Kingdom	44.3*	46.7	46.5	78.7
United States	35.6	35.6	40.7	48.9
Canada	62.0	65.8	69.6	76.4
France	63.6*	62.0	60.1	68.9
Italy	n.a.	48.9	57.2	60.9
Sweden	n.a.	59.9	68.1	99.6
		Public Sector		
Japan	22.5	45.8	88.9	75.7
Germany	20.3*	24.5	41.4	43.3
United Kingdom	87.1*	64.9	58.6	45.3+
United States	56.4	44.9	56.6	64.1
Canada	94.3	82.8	106.8	108.9
France	45.7	36.4	42.5	44.2
Italy	36.2	56.6	84.7	102.5
Sweden	n.a.	55.0	80.1	55.7

* Data for only part of period
\+ 1989
Source: BIS

TABLE 3

The Model

(1) $D = a_1q + a_2Y + a_3E + G$	D = aggregate demand
(2) $\dot{Y} = d(D-Y)$	q = value of stock market
(3) $i = gY - h(M-P) + jq$	Y = real output
(4) $r = i - \dot{P}$	E = real exchange rate
(5) $\dot{P} = -f(P-\bar{P})$	G = government spending
(6) $\bar{P} = M + (\bar{r} - g\bar{Y})/h$	i = nominal interest rate
(7) $\dot{q}/q + Z/q = r$	M = money stock
(8) $r = r^* + \dot{E}$	P = price level ($\bar{P}$ in equilibrium)
(9) $Z = b_1 + b_2Y$	r = real interest rate (in terms of home goods)
(10) $R = r + \dot{R}/R$	Z = profits
	r^* = foreign real interest rate
	R = long-term real interest rate
	$\dot{X}$ = $dx \vert dt$
	$\bar{X}$ = equilibrium value of X

TABLE 4: Estimates of Japanese Demand for Real M2+CDs, $\Delta(m-p)$

Variable	1973:IV - 1991:II	1973:IV - 1982:IV	1983:I - 1991:II
Intercept	1.005* (2.31)	.464 (.58)	.065 (.06)
$\Delta(m-p)_{t-1}$	.571** (5.07)	.328** (2.86)	.365* (2.04)
$\Delta(w-p)_t$	.150** (3.44)	.269** (3.92)	.196** (3.00)
$\Delta(w-p)_{t-1}$	.075* (2.04)	.001 (1.59)	.073 (1.53)
Δp_t	-.860** (-10.13)	-.552** (-7.32)	-.952** (-5.18)
Δp_{t-1}	.530** (3.44)	.089 (-.72)	.462 (1.54)
Δi^o_t	1.196* (2.10)	-1.292* (-2.33)	2.193* (2.20)
Δi^{PS}_t	-.988* (-2.11)	.486 (1.20)	-1.277 (-1.24)
$m_{t-1} - p_{t-1}$	-.253** (-4.84)	-.413** (-5.01)	-.311* (-2.28)
y_{t-1}	.103* (2.16)	.182** (2.98)	.179 (1.54)
$w_{t-1} - p_{t-1}$	.121** (4.88)	.252** (3.20)	.157** (2.72)
i^o_{t-1}	1.588** (4.80)	-1.271 (-1.79)	1.107 (.86)
i^{PS}_{t-1}	-1.268** (-4.81)	.651 (1.31)	-.907 (-.75)
Regression statistics			
$\bar{R}^2$	.895	.973	.850
Standard error	.00405	.00234	.00362
Sample size	71	37	34
Serial correlation (χ^2)			
lrst order	.070	9.493**	2.545
lrst-4th order	2.843	12.271*	6.547
Fisher test		$F_{13,45} = 4.62$**	

T statistics are in parentheses
*Significant at the 5 percent level
**Significant at the 1 percent level

TABLE 5: Estimates of German Demand for Real M3, $\Delta(m-p)$

Variable	1970:II - 1989:IV	1970:II - 1979:IV	1980:I - 1989:IV
Intercept	.331 (.88)	-1.610 (-1.49)	.381 (.94)
$\Delta(w-p)_t$	.456** (4.02)	.367* (2.19)	.708** (4.04)
$\Delta(w-p)_{t-1}$	.159 (1.69)	.244 (1.59)	-.060 (-.44)
Δy_t	.050 (.63)	.289 (1.97)	-.073 (-.73)
Δp_t	-.481** (-3.15)	-.509* (-2.60)	-.153 (-.47)
$m_{t-1} - p_{t-1}$	-.099 (-1.66)	-.327* (-2.31)	-.105 (-1.25)
y_{t-1}	.019 (.31)	.349 (1.95)	-.026 (-.40)
$w_{t-1} - p_{t-1}$	.054 (1.76)	.077 (1.35)	.102 (1.91)
i^o_{t-1}	.371* (2.04)	.072 (.23)	.586* (2.26)
i^{PB}_{t-1}	-.536** (-4.03)	-.484* (-2.41)	-.588** (-3.34)
Regression statistics			
$\bar{R}^2$	.594	.601	.554
Standard error	.00620	.00706	.00499
Sample size	79	39	40
Serial correlation (χ^2)			
lrst order	.044	.184	1.586
lrst-4th order	1.776	7.865	4.333
lrst-8th order	3.307	10.094	8.875
Fisher test		$F_{10,59} = 1.23$	

T statistics are in parentheses
*Significant at the 5 percent level
**Significant at the 1 percent level

TABLE 6: Estimates of U.K. Demand for Real M4, $\Delta(m-p)$

Variable	1970:I - 1991:II	1970:I - 1979:III	1979:IV - 1991:II
Intercept	-.147 (-1.08)	-.162 (-.36)	-2.583** (-2.94)
$\Delta(m-p)_{t-1}$	.337** (4.01)	.278 (1.78)	.057 (.36)
Δy_{t-2}	.182** (2.74)	.265* (2.45)	-2.87* (-2.08)
Δp_t	-.944** (-13.67)	-.972** (-8.79)	-1.116** (-8.26)
Δp_{t-1}	.315** (3.00)	.285 (1.41)	.091 (.52)
Δp_{t-2}	.190** (2.66)	.128 (1.21)	-.314 (-1.97)
$m_{t-1}-p_{t-1}$	-.055** (-3.44)	-.058 (-1.67)	-.187** (-4.68)
y_{t-1}	-.028 (-1.45)	-.019 (-.72)	.282* (2.52)
$w_{t-1}-p_{t-1}$	.087** (4.71)	.082* (2.15)	.094* (2.53)
i^{o}_{t-1}	.297* (2.49)	.696 (1.61)	.087 (.42)
i^{TB}_{t-1}	-.321** (-3.80)	-.553** (-3.14)	-.013 (-.10)
Regression statistics			
$\bar{R}^2$	.881	.906	.805
Standard error	.00663	.00726	.00531
Sample size	86	39	47
Serial correlation (χ^2)			
lrst order	.920	2.437	2.065
lrst-4th order	2.329	3.957	10.802*
Fisher test		$F_{11,64} = 1.88$	

T statistics are in parentheses
*Significant at the 5 percent level
**Significant at the 1 percent level

TABLE 7: Marginal Significance Levels of Monetary Indicators for Forecasting Alternative Measures of Economic Activity: Japan

Activity Variables	M2+CDs	3-month Rate	Term Spread	Dollar Exchange Rate
1973:III-1992:I				
1) Industrial Production (IP)	.014	.086	.168	--
2) Retail Sales (RS)	.00003	.020	.771	--
3) Trade Balance (TB)	.144	.302	.064	.081
4) Unemployment (U)	.015	.303	.115	--
5) GNP	.001	.365	.023	--
6) Consumption (C)	.005	.304	.059	--
7) Investment (I)	.022	.395	.759	--
8) Net Exports (NX)	.286	.264	.273	.021
1973:III-1982:IV				
1) IP	.135	.380	.432	--
2) RS	.677	.189	.329	--
3) TB	.050	.875	.737	.499
4) U	.930	.959	.930	--
5) GNP	.253	.187	.604	--
6) C	.149	.298	.962	--
7) I	.912	.001	.003	--
8) NX	.191	.420	.594	.001
1983:I-1992:I				
1) IP	.033	.678	.069	--
2) RS	.007	.005	.006	--
3) TB	.005	.972	.003	.771
4) U	.095	.144	.232	--
5) GNP	.022	.302	.002	--
6) C	.0003	.491	.376	--
7) I	.660	.015	.200	--
8) NX	.522	.029	.484	.040

For each activity variable, entries across the rows are the marginal significance levels for the F-test that the coefficients on 6 lags of the monetary indicators (columns) sum to zero in an unrestricted OLS prediction equation that also included a constant, trend, 6 lags of the forecast variable, and 6 lags of a price variable. The price variables used were the PPI in regressions including IP or U, the CPI in regressions with RS, and a world commodity price index in regressions with TB. Data are monthly and all variables but interest rates, the trade balance, and net exports are log levels. The term spread is the 10-year rate less the 3-month rate. Quarterly data include real GNP, consumption, investment, and net exports and are in 1985 yen.

TABLE 8: Marginal Significance Levels of Monetary Indicators for Forecasting Alternative Measures of Economic Activity: Germany

Activity Variables	M3	3-Month Rate	Term Spread	Dollar Exchange Rate
1973:III-1989:IV				
1) Industrial Production (IP)	.036	.080	.405	--
2) Retail Sales (RS)	.035	.005	.006	--
3) Trade Balance (TB)	.913	.048	.039	.164
4) Unemployment (U)	.056	.006	.442	--
5) GDP	.010	.004	.013	--
6) Consumption (C)	.681	.00002	.002	--
7) Investment (I)	.001	.016	.106	--
8) Net Exports (NX)	.341	.008	.103	.007
1973:III-1980:IV				
1) IP	.779	.770	.995	--
2) RS	.018	.0004	.006	--
3) TB	.585	.720	.077	.542
4) U	.131*	.00008*	.035*	--
5) GDP	.072	.460	.071	--
6) C	.949	.041	.509	--
7) I	.611	.044	.517	--
8) NX	.647	.375	.019	.231
1981:I-1989:IV				
1) IP	.084	.667	.623	--
2) RS	.018	.429	.833	--
3) TB	.514	.605	.475	.209
4) U	.415*	.219*	.153*	--
5) GDP	.404	.189	.064	--
6) C	.690	.612	.555	--
7) I	.530	.272	.588	--
8) NX	.021	.276	.299	.019

For each activity variable, entries across the rows are the marginal significance levels for the F-test that the coefficients on 6 lags of the monetary indicators (columns) from an sum to zero in an unrestricted OLS prediction equation that also included a constant, trend, 6 lags of the forecast variable, and 6 lags of the PPI. Data are monthly and all variables but interest rates, trade balance, and net exports are log levels. The term spread is the rate on 5-7 year public bonds less the 3-month rate. Quarterly data include real GDP, consumption, investment, and net exports and are in 1985 DM. * 12 lags used for unemployment, PPI, and monetary variable.

TABLE 9: Marginal Significance Levels of Monetary Indicators for Forecasting Alternative Measures of Economic Activity: United Kingdom

Activity Variables	M0	M4	3-Month Rate	Term Spread	Dollar Exchange Rate
1974:I-1991:II					
1) IP	.186	.023	.0002	.003	--
2) RS	--	--	--	--	--
3) TB	.016	--	.065	.149	.068
4) U	.291	--	.028	.105	--
5) GDP	.658	.049	.042	.053	--
6) C	.182	.130	.372	.750	--
7) I	.307	.145	.011	.074	--
8) NX	.109	.299	.051	.053	.101
1974:I-1979:III					
1) IP	.015	.660	641	.796	--
2) RS	--	--	--	--	--
3) TB	.875	--	.022	.545	.747
4) U	.016	--	.961	.252	--
5) GDP	.687	.191	.434	.466	--
6) C	.070	.065	.628	.197	--
7) I	.886	.317	.056	.092	--
8) NX	.021	.071	.328	.640	.123
1979:IV-1991:III					
1) IP	.336	.046	.0001	.009	--
2) RS	.0008	.209	.016	.136	--
3) TB	.336	.013	.190	.213	.131
4) U	.009	.603	.561	.411	--
5) GDP	.407	.256	.131	.442	--
6) C	.768	.910	.424	.545	--
7) I	.546	.530	.016	.018	--
8) NX	.360	.669	.842	.063	.751

For each activity variable, entries across the rows are the marginal significance levels for the F-test that the coefficients on 6 lags of the monetary indicators (columns) from an sum to zero in an unrestricted OLS prediction equation that also included a constant, trend, 6 lags of the forecast variable, and 6 lags of the PPI. Data are monthly and all variables but interest rates, trade balance, and net exports are log levels. The term spread is the 10-year rate less the 3-month rate. Quarterly data include real GDP, consumption, investment, and net exports and are in 1985 pounds.

Chart 1

INTEREST RATES AND INFLATION IN SELECTED G-10 COUNTRIES

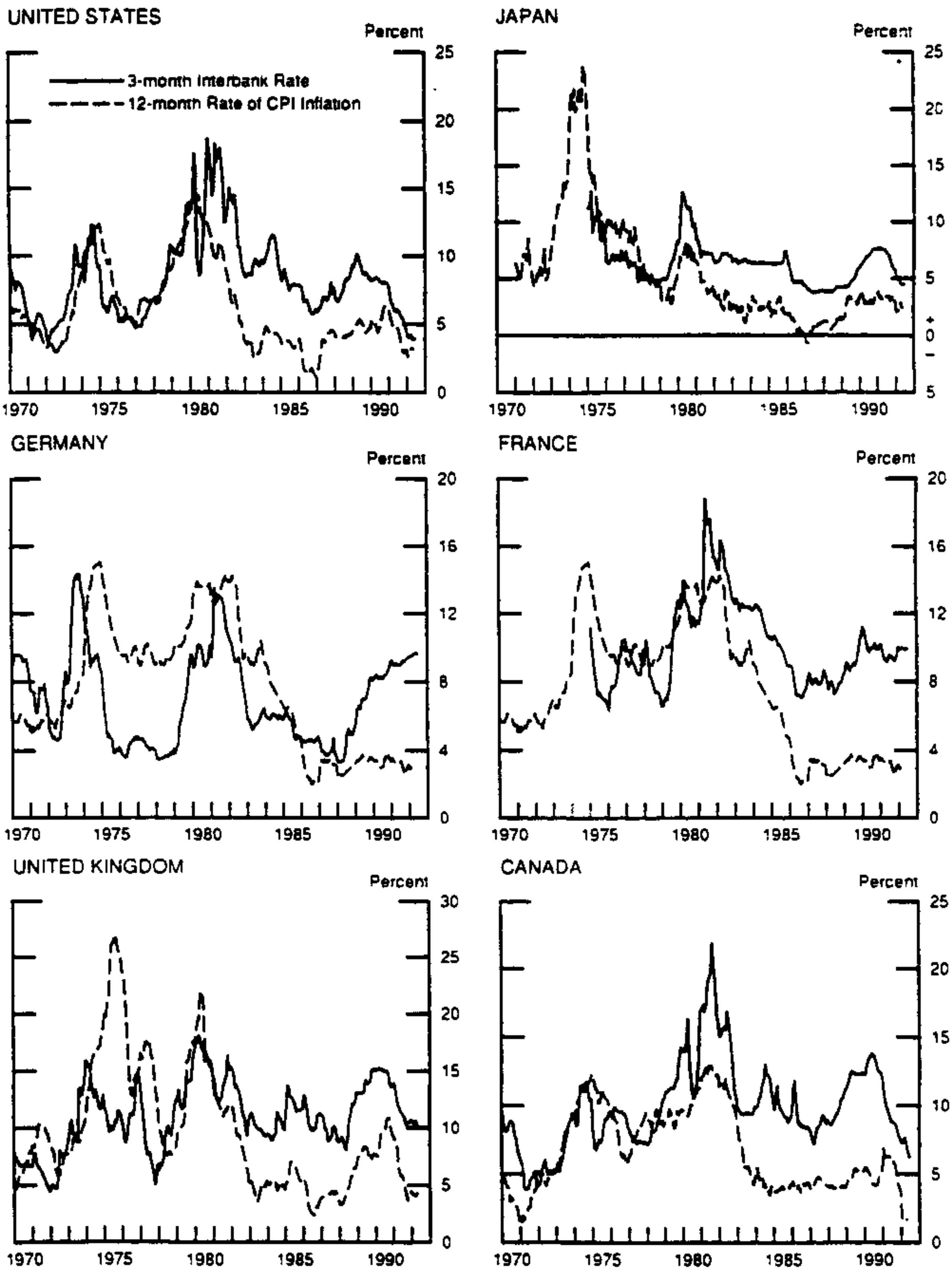
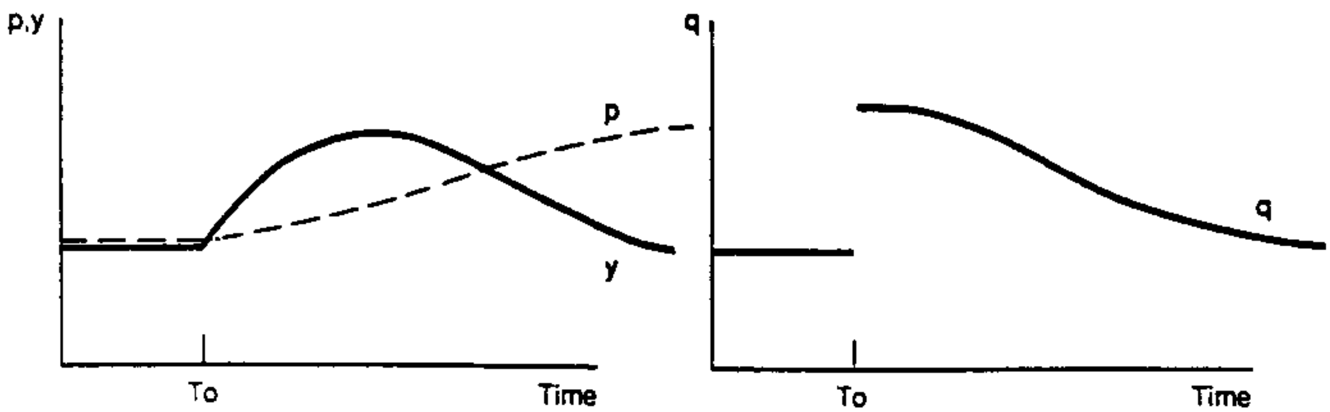
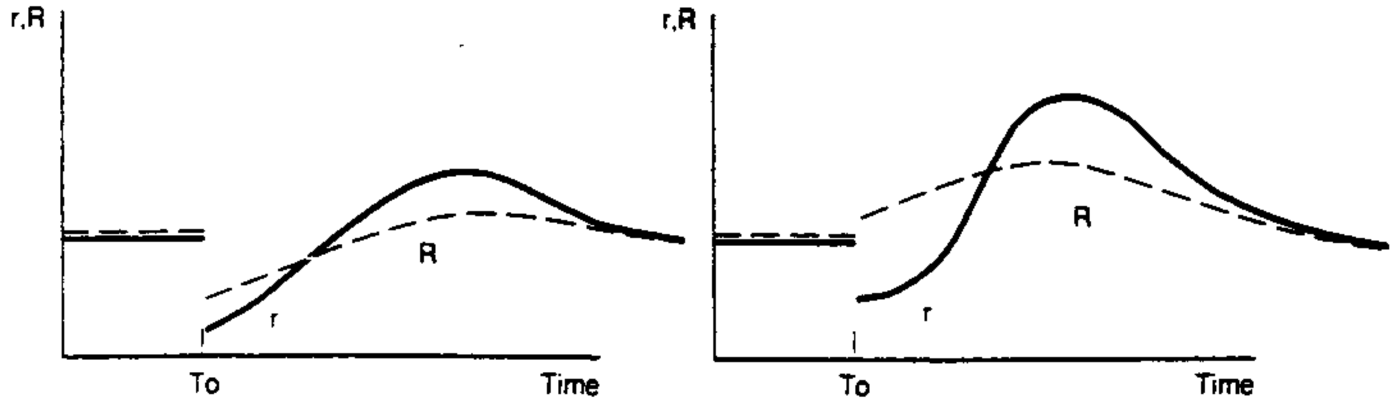


Chart 2: Model Dynamics

An Unanticipated Monetary Expansion



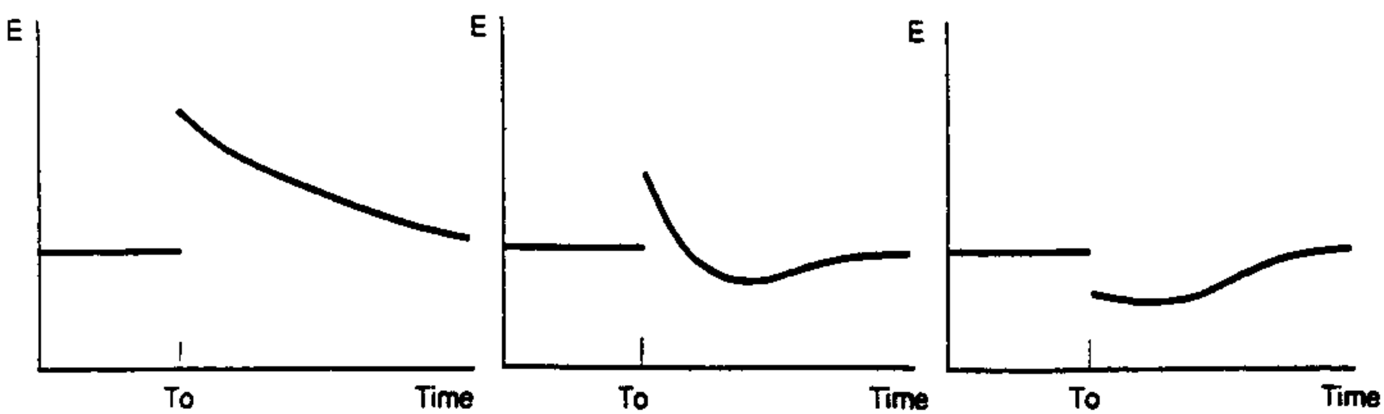
Interest Rates



Case a. "bad news" (normal case)

Case b: "good news"

Possible Exchange Rate Paths (E↑ = depreciation)



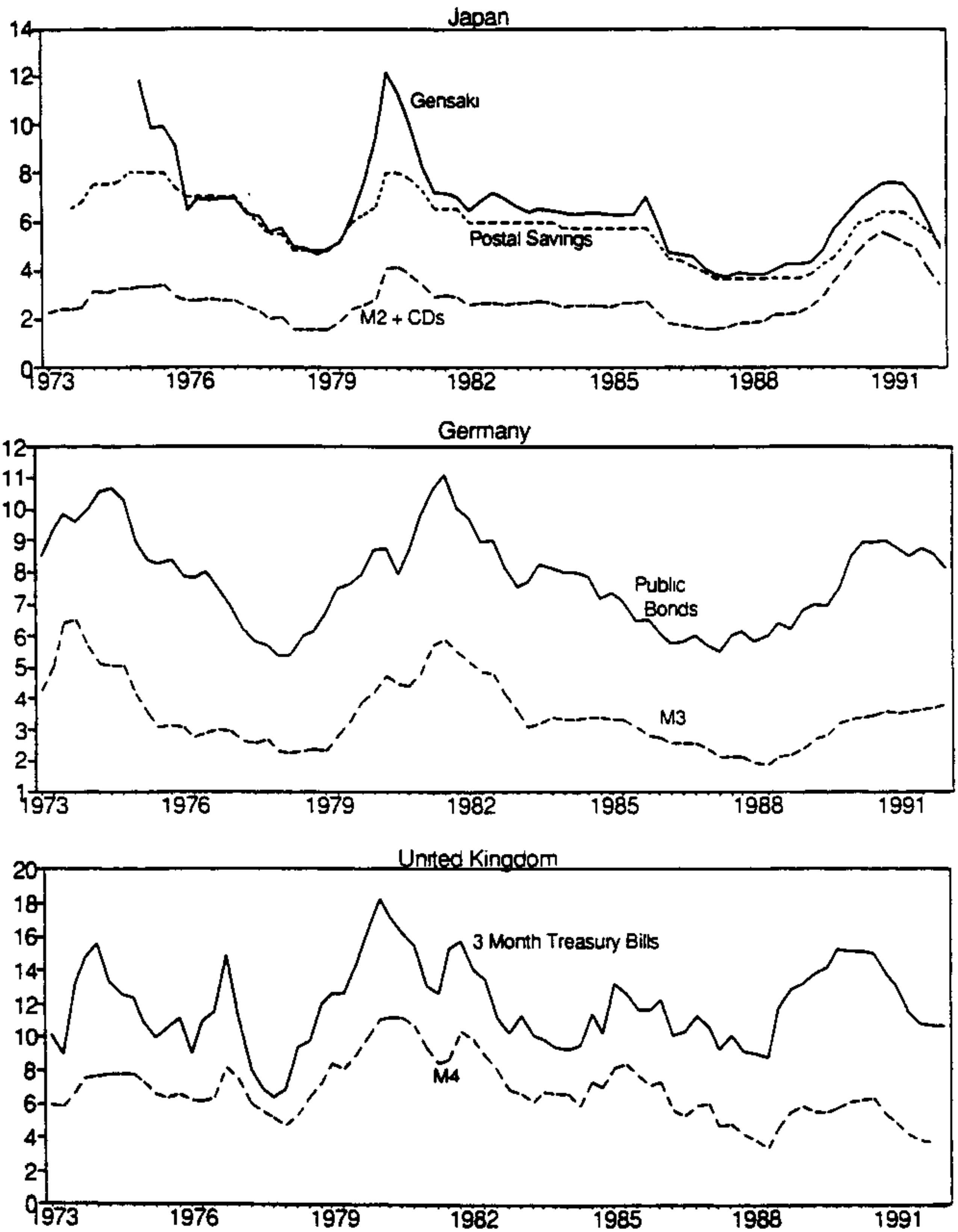
Case a: normal case initial depreciation, then gradual return to baseline

Case b: initial depreciation, then overshoot

Case c: initial appreciation

Chart 3

Market Interest Rates and Own Rates of Return On Broad Money



MONETARY TRANSMISSION CHANNELS IN MAJOR FOREIGN INDUSTRIAL COUNTRIES: A COMMENT

Craig S. Hakkio[1]

In "Monetary Transmission Channels in Major Foreign Industrial Countries," Robert Kahn and Linda Kole address "whether and how these [monetary] transmission channels have changed during the past two decades." In studying the U.S. economy, Friedman (1989, p. 96) finds that changes in the U.S. economy have "led to major changes in standard reduced-form relationships of the kind that often stand behind quantitative analysis of monetary policy at either formal or informal levels." Kahn and Kole have the more difficult challenge of finding whether the transmission channels have changed in Japan, Germany, and the United Kingdom.

In the first part of their paper, Kahn and Kole discuss why the channels of monetary policy may have changed. They then present a stylized Keynesian model that supposedly "captures the basic relationships that [the authors] hope to capture in the empirical work." However, the changes that occurred during the last two decades are probably more complex than what can be captured in a simple Keynesian model. In these comments, I will not discuss either of the first two sections. Instead, I will discuss the empirical results--presented in sections 4 and 5.

The evidence presented in "Monetary Transmission Channels in Major Foreign Industrial Countries" suggests that the

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transmission channel may, or may not, have changed. The authors estimate money demand functions for Japan, Germany, and the U.K. for the whole period and two subperiods. They find that money demand functions are stable in Germany and the United Kingdom, but unstable in Japan. The authors then estimate reduced form equations for 8 activity variables, using 3 measures of monetary policy, for the whole period and two subperiods. They "find evidence that corroborates the view that the interest rate sensitivity of spending has increased over the past decade."

In these comments, I will first make some specific comments on the paper by Kahn and Kole. Then, I will extend their results by looking at whether financial markets have become more integrated. Finally, I will test whether their results are sensitive to specification problems.

SOME SPECIFIC COMMENTS ON THE KAHN-KOLE PAPER

The authors' finding that "the interest sensitivity of spending (especially that of consumption) has increased in the past decade" is surprising. In studying the U.S. economy, George Kahn (1989, p. 30) states: "Empirical evidence suggests a reduction in the economy's overall interest sensitivity. This reduction in interest sensitivity is not spread equally across all sectors of the economy, however." In particular, Kahn finds that consumption is less interest sensitive, not more interest sensitive as found by Kahn-Kole. Benjamin Friedman (1989, p. 97) reports similar findings.

In discussing their results, Kahn-Kole seem to argue that a smaller marginal significance level means that the effectiveness of monetary policy is larger.[2] This is not necessarily true. The effectiveness of monetary policy depends on the size of the coefficient, in addition to its significance. And the marginal significance level says nothing about the size of the effect; rather it says something about the size of the coefficient relative to its standard error. If the coefficient falls and the standard error falls more, the marginal significance level will rise even though monetary policy has become less effective.

HAVE MARKETS BECOME MORE INTEGRATED?

Kahn and Kole argue that the transmission channels of monetary policy have changed due to financial liberalization and greater international openness. Since financial liberalization often took the form of opening financial markets to international competition, I will consider these two explanations as one. With more integrated financial markets, interest rates are determined in a single world capital market. Therefore, we would expect German interest rate changes to be highly correlated with U.S., Japanese, and U.K. interest rate changes. In addition, we would

2. The authors recognize this problem when they state: "The fact that it increases in significance for several activity variables in the later period could mean that the sensitivity of activity variables (excluding investment) may have increased between the periods."

expect monetary policy would be less able to influence interest rates.

Therefore, instead of determining whether money demand functions have shifted, or the sum of lag coefficients have changed, we can look directly at whether changes in interest rates have become more or less correlated over time. If markets are more integrated, then we would expect interest rate changes to be more highly correlated.

To test this hypothesis, I collected daily interbank bid rates from FAME for Japan, Germany, the U.K., and the United States. The interbank rate is a short-term interest rate. Since the timing may be important, the June 24 interest rate quote is at 10:00 am (local time) in Germany and the U.K., and at closing (local time) in Japan; in the United States, the interest rate is the effective federal funds rate. I then calculated the Spearman rank correlation coefficient between changes in interest rates and between the level of interest rates. The Spearman rank correlation coefficient is a robust measure of association between two variables; it is simply the correlation between the ranks, as opposed to between the actual values. I did not include exchange rates in calculating a covered interest rate because the results would be dominated by the exchange rate.

Table 1 gives the Spearman rank correlation coefficients. The top half of the table gives the correlation coefficient for the first difference in short-term interest rates, while the bottom half gives the correlation coefficient for the level of short-term interest rates. The first number in the cell is for the whole period, while the other two numbers are for the 2 subperiods. The subperiods are chosen to match those used in the Kahn-Kole paper. The breakponts are: Germany, December 31, 1979; Japan, December 31, 1982; and the United Kingdom, September 28, 1979.

The table shows that the rank correlation is about zero for the first difference and between 1/3 and 3/4 for the level. For example, the correlation between German and Japanese interest rate changes, for the whole sample, is -0.001; the correlation between the level of German and Japanese interest rates is 0.77.

There is little evidence that the correlations are bigger in the second subperiod. For example, for the first differences, 3 correlations become bigger in absolute value, 2 becomes smaller, and 4 remain the same. For the levels, 5 become bigger and 4 become smaller. Of course, without standard errors we cannot determine whether the changes are significant.[3]

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3. The marginal significance levels for the correlation coefficients equal 0.00 for the correlation of the levels, and are generally greater than 0.30 for the first differences. The only exceptions for the first differences are: Germany and Japan in the first subperiod (correlation = 0.07, msl = 0.10); Germany and the U.S. in the whole period (correlation = 0.03, msl = 0.09), and in the second subperiod (correlation = 0.03, msl = 0.08); the U.K. and the U.S. in the whole period (correlation = 0.05, msl = 0.00), in the second subperiod (correlation = 0.05, msl = 0.01).

Another way to test for changes in the extent of financial market integration is to calculate whether big changes in short-term interest rates are independent. Define "big" to mean a change in the upper or lower 5 percent tail of the distribution. With this definition, 10 percent of interest rate changes are "big." Table 2 shows the results for changes in U.S. and German interest rates. Table 2 is a two-way classification of interest rate changes. The table shows that of 3978 observations, 56 (or 1.4 percent) had a big change in U.S. interest rates and a big change in German interest rates. Given the definition of "big," we would expect 1 percent of the observations to fall in the BIG-BIG cell if big changes in U.S. interest rates were independent of big changes in German interest rates.[4] Fisher's exact test is a test of independence. According to the table, big changes are correlated with big changes.

Table 3 reports similar results for all countries and for 2 subperiods. The periods were chosen to match those used in the Kahn-Kole paper. The table reports the marginal significance level of Fisher's exact test statistic for independence. A small marginal significance level means you can reject the hypothesis that big changes are independent of big changes; less precisely,

4. Actually, we would expect 0.95 percent of the observations to fall in the BIG-BIG cell. Since there are missing observations for each variable and the table is constructed for non-missing observations for both variables, the BIG row and column sums do not equal 10 percent. As a result, if the changes are independent, we expect to find 0.107*0.089 = 0.0095 = 0.95 percent of the observations in the BIG-BIG cell.

a small marginal significance level means that big changes are correlated with big changes.

The results in Table 3 suggest that financial markets did become more correlated in the second subperiod. In most cases, the marginal significance level fell in the second subperiod. The two exceptions were (1) Germany and the U.S., where the marginal significance level rose from 0.00 to 0.01, and (2) the U.K. and Japan, where the marginal significance level rose from 0.46 to 0.49. Also, in many cases the marginal significance levels are less than 10 percent in the second subperiod. For example, we can reject the hypothesis that big changes in German interest rates are independent of big changes in Japanese and U.S. interest rates.

To summarize, the results in this section complement the results in the Kahn-Kole paper. There is some weak evidence that financial markets have become more integrated. As a result, we would expect that monetary policy transmission channels would change. However, since the evidence on greater integration is weak, the change in transmission channels is probably also weak.

WHY ARE THE RESULTS WEAK?

The inconclusive or weak results could truely reflect little or no change in the transmission channels, or they could reflect statistical problems. If we can minimize the chance of statistical problems, then we can be more confident that the results really reflect little or no change in the transmission channels. Therefore, this section looks at some potential statistical problems.

Are the Results Sensitive to Outliers?

The presence of outliers could produce the inconclusive results reported by Kahn-Kole. To check for outliers, I first estimate a reduced form equation for industrial production. The general form of the equation is similar to that used by the authors:

$$\log(\mathit{ind\ prod})_t = \alpha_0 + \alpha_1 \mathit{TIME}_t + \sum_{i=1}^{K} \beta_i (\mathit{monetary\ policy})_{t-i} + \sum_{i=1}^{K} \gamma_i \log(\mathit{ind\ prod})_{t-i} + \epsilon_t$$

$$\beta = \sum_{i=1}^{K} \beta_i$$

Monetary policy is measured by a monetary aggregate and by short-term interest rates. The lag length, K, is determined from Akaike's Information Criterion and Amemiya's Prediction Criterion.[5] I search for influential observations in this regression in several ways.

An influential observation, or a small influential subset of data, is one which "can have a disproportionate influence on the estimated parameters or predictions" of a regression equation

5. Generally, 2 to 4 lags were required, fewer than used by the authors.

(Belsley, Kuh, and Welsch (1980), p. 6). An observation may have a big influence on the fitted values of a regression, on the variance-covariance matrix of the coefficients, or on the sum of lag coefficients. Accordingly, three statistics are used in this paper to detect influential observations.[6] The first, Cook's distance, measures the influence of the t-th observation on the fitted values from a regression. The second, COVRATIO (Belsley, Kuh, and Welsch), measures the influence of the t-th observation on the variance-covariance matrix of the coefficients. The last, a variant of DFBETA (Belsley, Kuh, and Welsch), measures the influence of the t-th observation on the sum of the lag coefficients of the regression. Critical values are given for each statistic. In the results presented below, I focus on only the largest value of the statistic (which is also greater than the critical value).

To find an influential observation, the regression is estimated with all observations and with all but the t-th observation. Then, a normalized difference in some statistic is calculated with and without the t-th observation. Finally, the normalized difference is compared to a critical value. A large normalized difference means the observation is influential.

As an example, consider the variant of the DFBETA statistic.

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6. See Chatterjee and Hadi for a discussion of influential observations in linear regressions. They state that these three measures "seem sufficient for detecting influential observations" (p. 387).

I calculated a time series of sum of lag coefficients obtained from omitting one observation at a time. More specifically, $DFBETA_t = (\beta - \beta_t)/\sigma_{\beta(t)}$, where β is the sum of the lag coefficients, β_t is the sum of the lag coefficients obtained from omitting the t-th observation, and $\sigma_{\beta(t)}$ is the standard error of the sum of lag coefficients.[7] In other words, $DFBETA_t$ is like a t-statistic: it equals the difference in coefficient estimates divided by the standard error. If results are sensitive to an outlier at observation t, then $DFBETA_t$ will be "large."

Table 4 shows the dates of the influential observations in a reduced form with monetary policy measured as money and short-term interest rates. Each cell in the table gives the date of the most influential observation, the fraction of observations that are influential (the number to the left of /), and the size of the largest statistic relative relative to the critical value (the number to the right of /).

As expected, the different statistics find different influential observations. The fraction of influential observations ranges from 1 percent to 10 percent; and the size of the largest statistic ranged from 1.3 times the critical value to 31.8 times the critical value.

Unfortunately, no simple conclusions can be drawn from the table. While no simple conclusions can be drawn, it is clear

7. See Belsley, Kuh, and Welsch (1980) for an extended discussion of the DFBETA statistic.

that with so many influential observations, some of which are very "large," the results may be due to influential observations. Influential observations can be due to improperly recorded data. Alternatively, they can be legitimately extreme observations that contain valuable information about the parameter estimates. However, even in this situation it is important to identify the observations and determine the extent to which they are responsible for the results. That is, we want to know whether the results are due to this one observation, rather than the entire dataset. Unfortunately, such an analysis is beyond the scope of these comments.

Are the results sensitive to choice of subperiods?

The results could also be inconclusive because the authors split the sample at the wrong place. As a result, estimating a reduced form equation over two subperiods may miss the change. In addition, while it may be reasonable to think the change occurred at a single point in time, it is probably more likely that there have been several changes or that the changes occur gradually over time. If the effectiveness of monetary policy is changing gradually or has changed more than once, then estimating a reduced form over two sample periods may again miss the change.

To allow the change in monetary policy to occur over time, I estimated a series of rolling regressions. I estimate the same reduced form as in the previous section. Monetary policy is measured as either a monetary aggregate or the short term interest rate. The sample period is a fixed 20 percent of the observations. Charts 1-3 plot the sum of the lag coefficients with a 2 standard deviation confidence band. The top panel is the sum of money lag coefficients and the bottom panel is the sum of short-term interest rate lag coefficients.

In Japan, the sum of money lag coefficients changed from negative in the first part of the sample period to positive in the second part. Furthermore, the standard errors have become smaller over time. The sum of interest rate lag coefficients has changed over time, but there is no pattern. Except for two episodes, the sum was about 0 for most of the 1980s; the sum then turned positive in the 1990s.

There is little evidence of a change in the effectiveness of German monetary policy. The sum of both money and interest rate lag coefficients has fluctuated around 0 for most of the sample period.

In the United Kingdom, monetary policy seems to have become less effective. The sum of money coefficients was positive in the early part of the sample, and has been zero since then. However, the sum of interest rate coefficients has fluctuated around zero for most of the sample period.

To summarize, while the sum of lag coefficients have changed over time, the changes may not have been significant. Therefore, the weak results reported are probably not due to the authors' choice of subperiods.

CONCLUSIONS

The authors present a comprehensive study of changes in the monetary policy transmission mechanism in Japan, Germany, and the United Kingdom. The find weak evidence that there has been a change. In looking at different data and techniques, I have confirmed their results.

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1. Correlation of Short-term Interest Rates
(Spearman rank correlation matrix of first differences and levles)

	Germany	Japan	United Kingdom	U.S.
First difference of short-term interest rates				
Germany	*	-0.00 -0.01 0.00	0.01 -0.02 0.03	0.03 -0.02 0.06
Japan	-0.00 -0.01 0.01	*	0.01 0.01 0.01	-0.01 0.01 -0.01
United Kingdom	0.01 0.01 0.02	0.01 0.03 0.00	*	0.05 0.05 0.05
Levels of short-term interest rates				
Germany	*	0.77 0.74 0.73	0.61 0.42 0.59	0.47 0.13 0.42
Japan	0.77 0.72 0.66	*	0.63 0.73 0.49	0.43 0.61 0.12
United Kingdom	0.61 0.34 0.59	0.63 0.33 0.64	*	0.45 0.10 0.40

Note:

Each number is a rank correlation coefficient. The numbers are for different subsamples:

- row 1 whole subsample
- row 2 first subsample, determined by row variable
- row 3 second subsample, determined by row variable

The German/Japan correlation does not equal the Japan/German correlation in rows 2 and 3 because the breakpoints for the subsamples are different.

2. Normal and Big Changes in German and U.S. Short-term Interest Rates

		Change in U.S. interest rates		
Change in German interest rate		normal change	BIG change	row sums
	normal change	3253 81.8 %	300 7.5 %	3553 89.3 %
	BIG change	369 9.3 %	56 1.4 %	425 10.7 %
	column sums	3662 91.0 %	356 8.9 %	3978 100 %

Test of independence of row and column variables:

Fisher's marginal significance level = 0.002

3. Normal and Big Changes in Short-term Interest Rates
Two-way Table of Frequency Counts

	Germany	Japan	U.K.	U.S.
Germany 1/1/80	*	0.00 0.50 0.00	0.26 0.67 0.26	0.00 0.00 0.01
Japan 1/3/83	0.00 0.29 0.00	*	0.69 0.11 0.10	0.37 1.00 0.06
U.K. 10/1/79	0.26 0.66 0.17	0.77 0.46 0.49	*	0.03 0.41 0.08

Note:

A big change is defined as a change in the top or bottom 5 percent of changes. Therefore, 10 percent of the changes are big.

The number in the cell is the marginal significance level of the Pearson χ^2 test of independence between the row and column variable. Each cell has 3 numbers, corresponding to different sample periods:

row 1 whole subsample
row 2 first subsample, determined by row variable
row 3 second subsample, determined by row variable

Note, the German/Japan pair does not equal the Japan/German pair in rows 2 and 3 because the breakpoints for the subsamples are different. The first observation of the second subsample is given below the country name; the date corresponds to the breakpoint used in Kahn-Kole.

4. Detecting Influential Observations in a Reduced Form of Industrial Production

Statistic:		Germany	Japan	United Kingdom
Cook's distance	money	Feb 1991 5% / 20.4	May 1991 7% / 2.8	June 1985 10% / 3.2
	interest rates	July 1984 4% / 15.6	Feb 1976 6% / 6.0	Jan 1974 6% / 12.3
COVRATIO	money	March 1991 6% / 31.8	June 1989 11% / 4.3	May 1990 7% / 5.3
	interest rates	May 1981 8% / 9.5	June 1975 10% / 8.0	Sept 1973 6% / 11.6
DFBETA	money	June 1984 4% / 2.4	Oct 1982 3% / 1.3	Sept 1985 5% / 2.1
	interest rates	April 1979 1% / 1.6	April 1989 3% / 1.8	Jan 1974 3% / 4.7

Note: The first number in each cell is the date of the largest statistic. The pair of numbers on the second line give the fraction of observations greater than the critical value (the number to the left of /) and the size of the statistic relative to the critical value (the number to the right of /).

Chart 1
Sum of Lag Coefficients – Japan

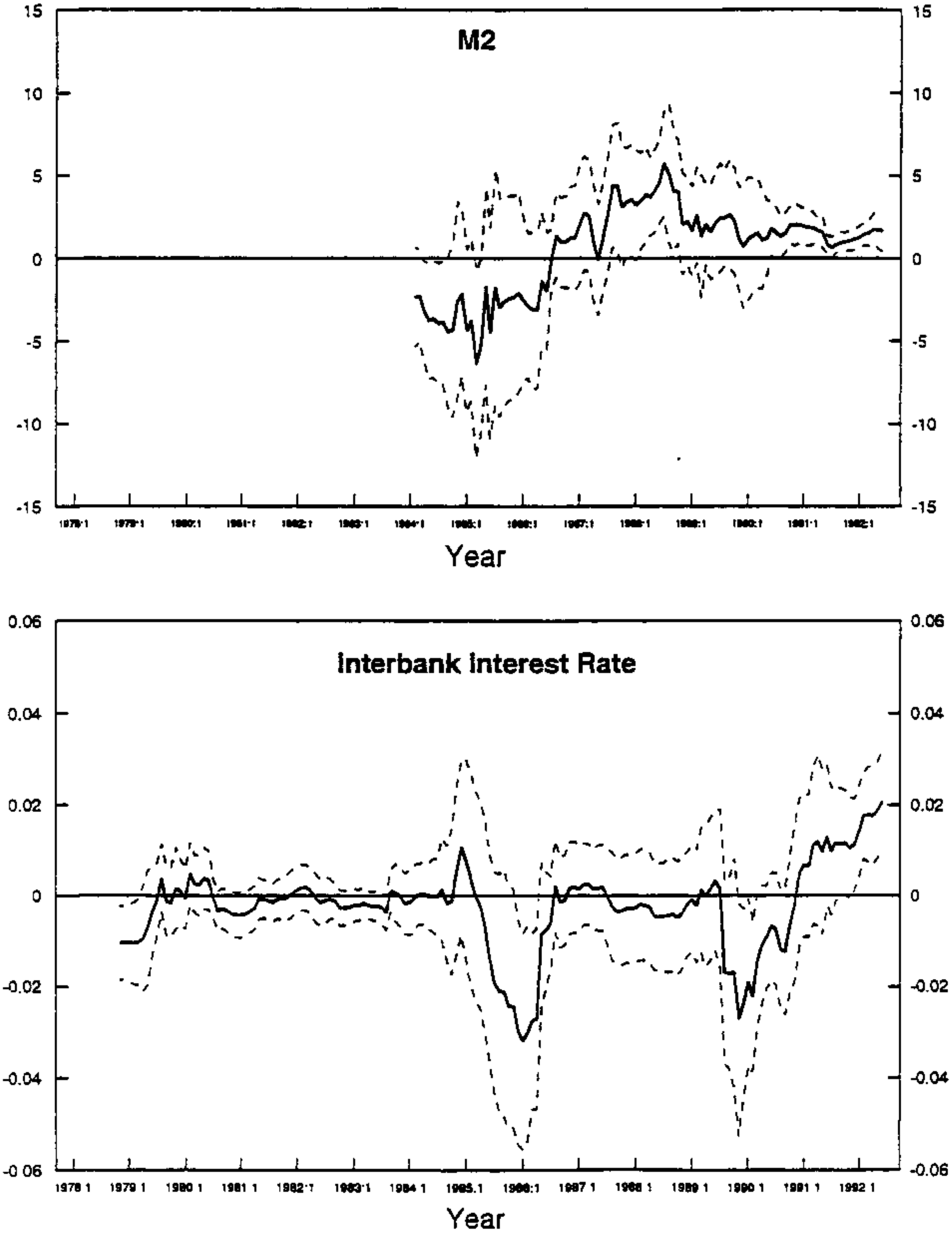
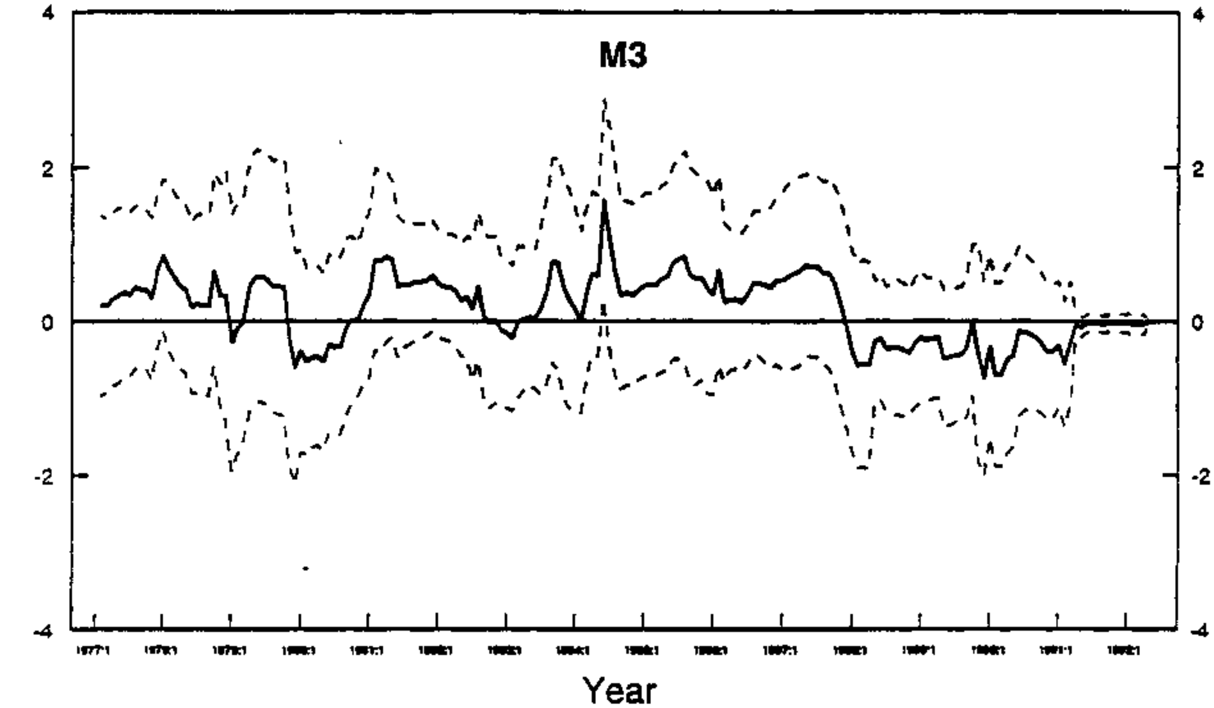


Chart 2
Sum of Lag Coefficients -- Germany



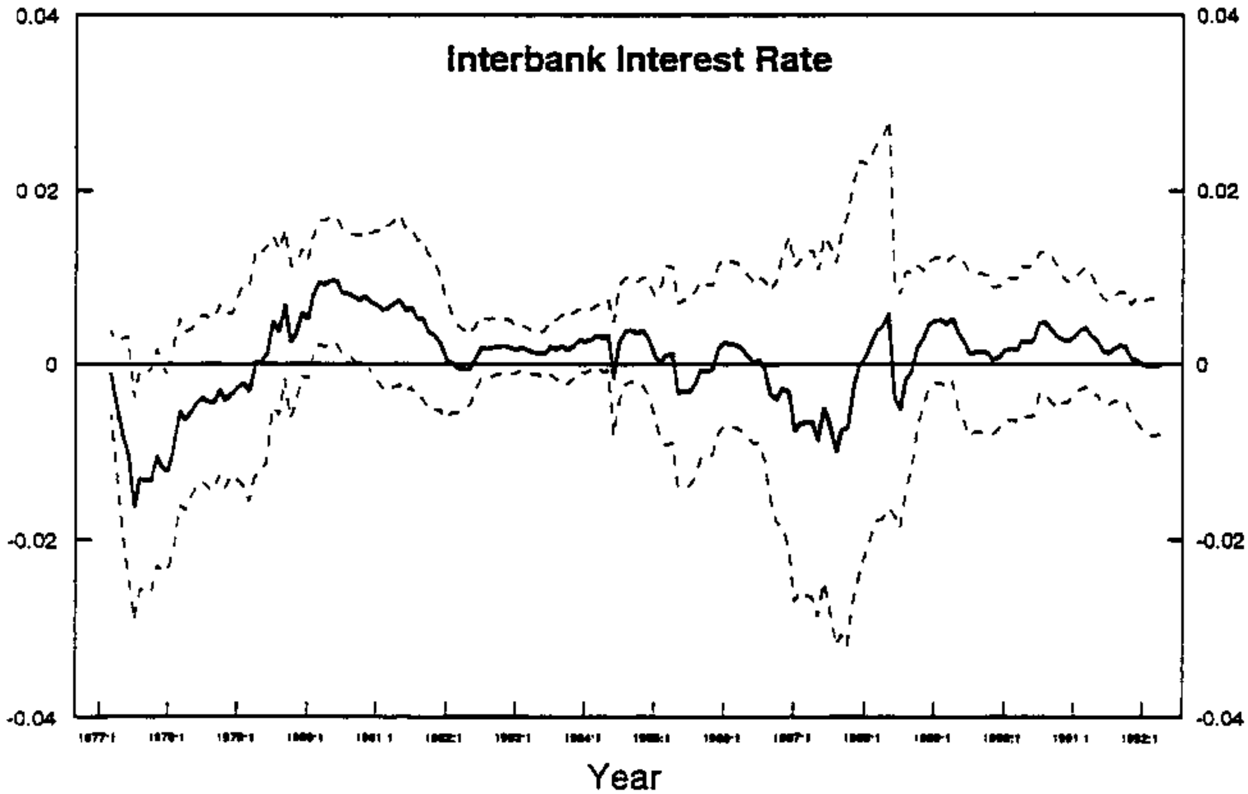
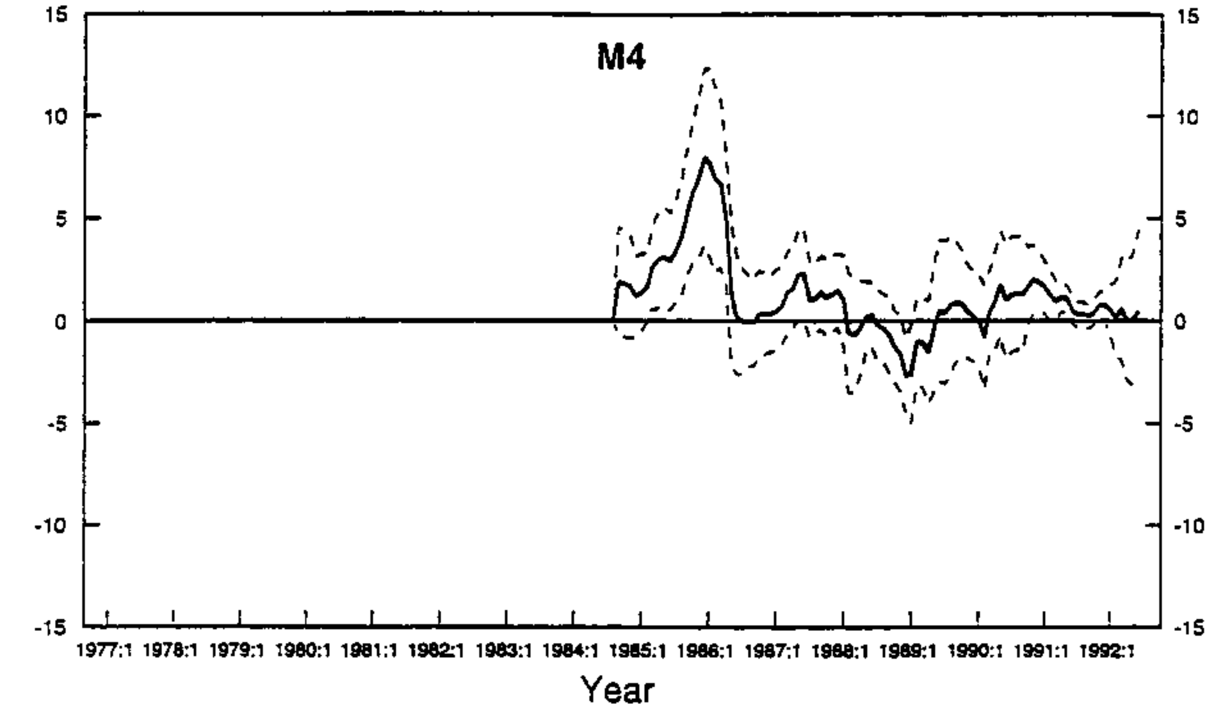
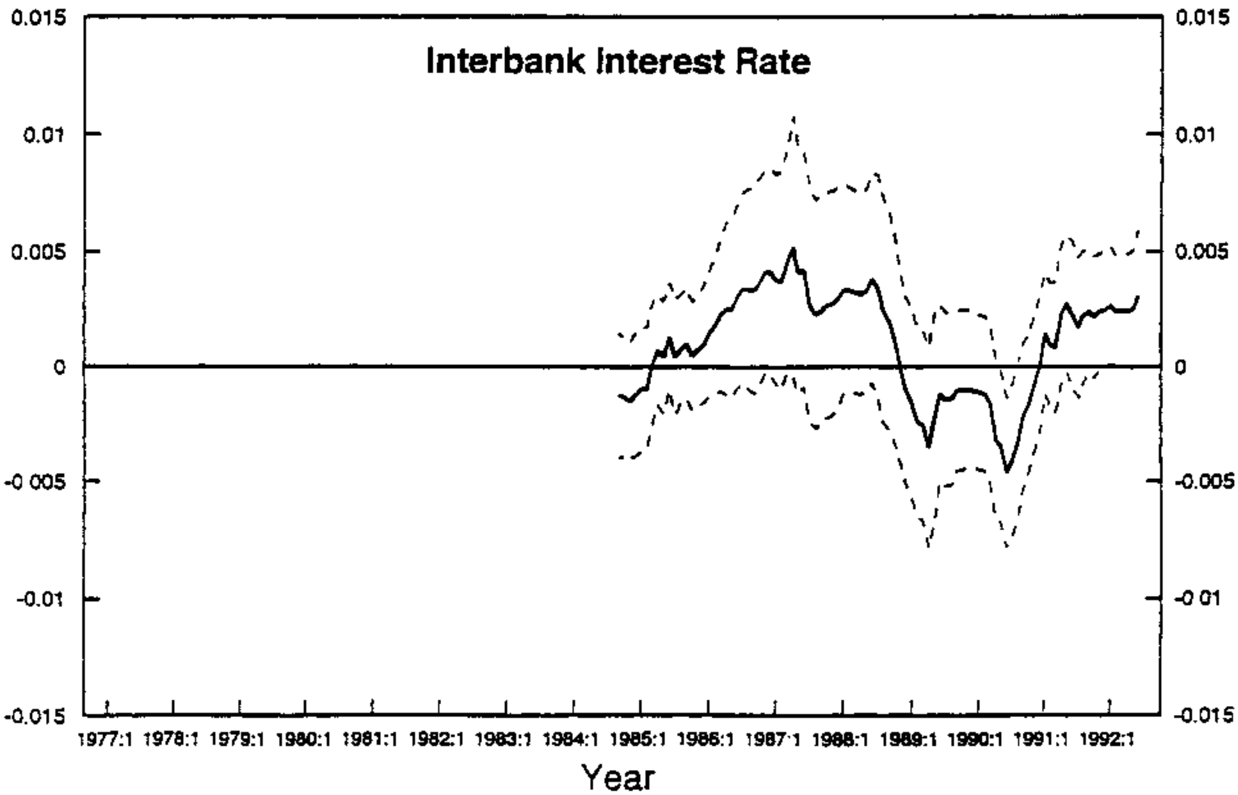


Chart 3
Sum of Lag Coefficients – The United Kingdom





ANOTHER HOLE IN THE OZONE LAYER: CHANGES IN FOMC OPERATING PROCEDURE AND THE TERM STRUCTURE

William Roberds, David Runkle, and Charles H. Whiteman[1]

To economists schooled in the Walrasian tradition, there could be no more enigmatic ritual than the practice of central banking. The classical models of this tradition show how Pareto-optimal allocations can be realized in competitive equilibrium, in which prices reflect the fundamentals of tastes, technology, and endowments. In response to changes in these fundamentals, prices must also change if competitive allocations are to remain optimal. By contrast, since 1914 the unifying theme of real-world monetary policy has been the elimination of short-run movements in short-term interest rates, typically via open market operations in government securities. The obvious implication of this practice, which has become known as interest-rate "smoothing," is that central banks (and their sponsoring governments) find such fluctuations in the time price of money to be inherently undesirable.

This apparent contradiction between high theory and everyday practice has hardly gone unnoticed by the economics profession. In fact, this contradiction has formed one of the traditional jumping-off points for much of the monetarist and neoclassical criticism of the policies of the Fed and other central banks. Yet the constant criticism of interest-rate "smoothing" from this quarter seems to have had almost no effect on the practice of monetary policy. A recent survey of operating procedures in five major industrialized countries (Batten et al., 1990) found that short-term control of interest rates was tightened in virtually all of these countries during the 1980s.

Perhaps in response to the continued popularity of interest-rate smoothing, a number of papers have appeared in the macroeconomics literature, in which economists working in the Walrasian tradition have taken a more benign view of interest-rate smoothing. These papers run the gamut from Sargent and Wallace (1982), which presents a model where

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We thank David Stowe for help in data collection. This paper was written while Whiteman was a visiting scholar at the Federal Reserve Bank of Atlanta; it reflects only the views of the authors, and not the Federal Reserve Banks of Atlanta and Minneapolis or the Federal Reserve System.

the best monetary policy is an interest rate peg, to Poole (1991), which suggests that the practice of interest-rate smoothing could in some instances serve as a potentially useful method for communicating a central bank's intentions to the public. While these papers have offered a number of insightful explanations for the smoothing phenomenon, it is fair to say that none of the explanations has been widely accepted within the economics profession. Instead, various factions within the profession have supported disparate views of smoothing, reflecting the more general professional quandary over the proper role for money in macroeconomic models.[2]

At the same time, there has been some acceptance on the part of the Federal Reserve System of the idea that it is possible to be too aggressive in the smoothing of short-term interest rates. In particular, the operating procedure of the late 1970s, which was almost completely focused on smoothing the Federal Funds rate, is typically viewed as a mistake. In an article in the Federal Reserve Bulletin, Heller (1988, p.425) notes that the emphasis on the funds rate contributed to a loss of control over the growth of the monetary aggregates. Essentially identical sentiments are voiced in a later issue of the Bulletin, in an article by Donald Kohn (1990, pp. 4-5). In a New York Fed-sponsored survey of various Fed approaches to open market operations, Meulendyke (1990) observes that during the late 1970s, "[Fed funds] rate moves during the week were so limited that they provided little or no information about reserve availability or market forces."

This combination of a desire on the part of policymakers to avoid past mistakes, together with the ongoing professional impasse over the conduct of monetary policy appears to have led to an "eclectic" or "compromise" approach to the day-to-day conduct of open market operations. The essence of this approach is perhaps best summarized in the survey of Batten et al. (1990, pp.30-32). Describing the general approach adopted during the 1980s, Batten et al. note that

"operating procedures in [the U.S. and other major industrialized countries] generally allow short-term rates to be primarily market-determined, while at the same time, permit monetary authorities to limit the range within which these rates fluctuate. Each monetary authority sees the need for interest rates to adjust expeditiously to reflect new economic developments but also recognizes the importance of maintaining

2. See Goodfriend (1991) for a survey.

some discretionary control over interest rate movements to avoid excessive volatility." [pp. 30-31]

An inherent limitation of this approach is that, lacking any real theoretical guidance, it provides no specific definition as to what level of interest rate volatility is "excessive." Without some specific criteria that define a well-functioning credit market, the "avoidance of excessive volatility" in short-term interest rates cannot be construed as a meaningful objective for monetary policy.

One reasonably objective and recently popular metric for evaluating the impact of interest-rate smoothing on the bond markets has been to compare the information content of the term structure, particularly at horizons of less than a year, across periods of time associated with different regimes for monetary policy. The intuition behind the use of the term structure for this purpose is fairly simple. If interest rates are to "adjust expeditiously to reflect new economic developments," then the spreads between long and short rates should contain some useful information about the future course of interest rates. This is because interest rates represent intertemporal prices, prices one would expect to be affected by news about the likely future course of the economy. One of the most widely cited papers in this area is by Mankiw and Miron (1986), who consider the performance of the short end (less than one year) of the term structure over various periods ranging from 1890 to 1979. They find that the term structure was more informative prior to the founding of the Fed. They hypothesize that this result is due to interest-rate smoothing activities on the part of the Fed after 1914. The salient claim of their paper is that there exists a tradeoff between the desire to smooth interest rates on the one hand, and the informativeness of the term structure on the other. Other papers in this tradition include Cook and Hahn (1990), Hardouvelis (1988), Mankiw, Miron, and Weil (1987), and Simon (1990).

In what follows, we seek to apply the term structure yardstick to the Fed operating procedure that has been in place since early 1984, technically known as borrowed-reserves targeting with contemporaneous reserve accounting. Specifically, we are interested in the ability of the term structure in the Fed funds market to predict subsequent moves in Fed funds rates, at horizons ranging from one to six months. We also try to measure the information content of the spreads between Fed funds rates and closely related rates on Treasury bills and repurchase agreements (repos). We are especially interested in comparing the term structure during the current operating procedure to the term structure under other recent operating procedures. Our results should be of interest to policymakers, given the widespread acceptance of the idea that successful monetary policy should not incorporate interest-rate smoothing to the same extent as was the case during the late 1970s. Our results should also be of interest to monetary theorists, as the set of stylized facts presented below presents a challenge to any theory that would attempt to explain the interaction between a central bank's open market operations and the information contained in the term structure.

Our study differs from previous studies in this area primarily in that we make use of daily data on yields for Fed funds and related markets. Previous studies that have attempted to measure the impact of interest-rate smoothing on the term structure have made use of weekly or lower frequency data. Since a major emphasis of the Fed's open market operations has traditionally been the smoothing of day-to-day interest rate changes, the use of daily data is necessary to fully capture the dynamics of the yield curve.

INSTITUTIONAL BACKGROUND

Although the smoothing of short-term interest rates has always been an important component of Federal Reserve policy, this practice reached a new stage during the 1970s. The development of the overnight market for bank reserves, popularly known as "Fed funds" provided the Fed with an efficient vehicle for large, frequent, short-lived interventions in this market.[3] Particularly during the latter half of the 1970s, short-run Fed policy came to focus almost exclusively on the funds rate target.

From October 1979 through October 1982, nonborrowed reserves (bank reserves not borrowed from the Fed) replaced the funds rate as the official short-run operating target. This change in operating targets was accompanied by a marked increase in the volatility of the funds rate. As is discussed in further detail below, the standard deviation of daily changes in the funds rate increased roughly threefold. Despite this degree of volatility, however, it is doubtful that fluctuations in the funds rate were completely ignored during this time period. A recent study by Cook (1989), found that despite the nominal adoption of the nonborrowed reserves target, two-thirds of the variation in the funds rate during the October 1979-October 1982 period can be directly attributed to policy actions on the part of the Fed; that is, these

3. Goodfriend and Whelpley (1986) present a useful historical summary of the Federal funds market.

movements in the funds rate were not necessary to meet the nonborrowed reserves target.

In October 1982, the Fed's short-term operating target was changed from nonborrowed reserves to borrowed reserves. Despite the continued nominal use of a reserves target, this change has been widely perceived (e.g., by Friedman, 1988) as a retreat towards the funds rate-targeting of the 1970s. Statistical comparisons of the two periods are somewhat problematic due to a change in reserve accounting that was instituted by the Fed in early 1984. Under the pre-1984 accounting procedures (commonly referred to as "lagged reserves accounting") required reserves were computed over a week-long computation period, and had to be maintained with a two-week lag. Under the post-1983 accounting procedures (commonly known as "contemporaneous reserves accounting"), required reserves are computed over a two-week period, and must be maintained with a two-day lag. A characteristic feature of the new accounting procedure has been the introduction of an occasional spike in the overnight funds rate on alternate Wednesdays, i.e., the last day of the two-week reserve maintenance period.[4]

STATISTICAL FINDINGS

Data and Summary Statistics

In what follows, we use daily data on Fed funds, repo, and T-bill rates at maturities of one day, 30 days, 90 days, and 180 days to examine the predictions of yield spread about future movements in short term interest rates.[5] The sample starts in the fall of 1974 and runs until the summer of 1991. Within that sample, we examine three of the different operating regimes:[6] the Fed-funds targeting regime (using a sample from January 2, 1975 to October 3, 1979); the nonborrowed

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4. For a more detailed description of the mechanics and implications of the change in reserve accounting procedures, see Goodfriend (1984). Additional details concerning recent approaches to open market policy can be found in Meulendyke (1989,1990) and Heller (1988).

5. Repurchase agreements, or repos, are short-term loans collateralized by a fixed-income security. For more information on repos, see Lumpkin (1986) or Stigum (1989). One problem in comparing repo rates is that different rates can be quoted for repos using different types of collateral. To minimize this problem, we look at data specifically for repos that are collateralized by Treasury securities.

6. We exclude the borrowed reserves targeting-lagged reserves accounting regime (October 1982-January 1984) because there are too few observation to conduct meaningful inference about the term structure of interest rates.

reserves targeting regime (using a sample from October 11, 1979 to October 6, 1982); and the present regime-borrowed reserves targeting with contemporaneous reserve accounting (using a sample from February 2, 1984 to July 24, 1991.)

The overnight Federal funds rate we use is the effective Federal funds rate computed by the Federal Reserve Board, which is a transaction-weighted average. All other data for Federal funds rates and repurchase agreement rates represent the daily closing quotes from the Bank of America at 5:00 p.m. Eastern Time. The repurchase agreement quotes are for transactions collateralized by Treasury securities. Since both Fed funds and repo rates are originally stated on a 360-day basis, they are all converted to bond-equivalent yields for comparison with other data. Data for one-month, three-month, and six-month[7] Treasury bill rates come from the Federal Reserve Board. These data are stated as discounts for an average of bid quotations for the most recent issue, and are also converted to bond-equivalent yields. A brief description of our dataset is presented in Table 1.

Summary statistics for daily changes in the various interest rates during the four operating regimes are summarized in Tables 2 and 3, and Figures 1-5.[8] The results in Table 2 reveal four characteristics of fluctuations in the rates.

First, the sample standard deviations of daily changes in the rates document the well-known increased volatility in interest rates across all maturities during the nonborrowed reserves targeting period. For example, the standard deviation of the daily change in the effective Federal funds rate FFEY increased from 0.301 (30.1 basis points) during the funds targeting period to 0.823 during the nonborrowed reserves period. The volatility dropped markedly after 1982, to 0.316 in the borrowed reserves-lagged accounting period, and 0.378 during the most recent contemporaneous accounting period.

Second, the higher-order moments summarized in the skewness (Sk) and kurtosis (Ku) measures are consistent with the view that while volatility increased during the nonborrowed reserves period, outliers were less important. With few exceptions, Sk and Ku are smaller during

7. Since bills are auctioned only once weekly, their maturities fluctuate on a periodic basis. For example, a "91-Day" T-bill typically has a maturity of 91 days on its issue date (Thursday), a 90-day maturity on the following day, etc.

8. The complete set of tables of summary statistics (112 pages in 16.67 pitch type) is available from the first author for a nominal fee to cover reproduction and postage.

1979-82 than in the funds-rate targeting regime or the borrowed-reserve contemporaneous-reserve-accounting regime. The similarity between the higher moment measures pre-1979 and post-1984 provides further evidence that these periods were alike, and highlights the difference between the practice of permitting only infrequent changes in the Federal funds target during 1975-79 and post-1984 and the "practice" of permitting the Funds "target" to change daily during 1979-82.

Third, except for 1979-82, there is a tendency for the volatility in daily changes to fall with the maturity of the underlying contract. For example, in the 1984-91 period, the standard deviations of overnight, thirty-, sixty-, ninety-, and one hundred eighty-day Federal funds rates were 0.378, 0.151, 0.136, 0.151, and 0.16. During 1979-82, rates on daily contracts were more volatile than those on longer contracts, but otherwise the volatility-maturity relationship seems absent.

Fourth, the Federal funds rate tends to be more volatile than the repo rate at each maturity. An exception to this is the 1979-82 period, when the two rates were about equally volatile.

The composite statistics of Table 2 conceal large interday differences displayed in Tables 3 and 4. Table 3 presents statistics by day of the Federal Reserve maintenance period for overnight Federal funds, and shows characteristics shared by the other overnight rates and to a lesser extent by rates on weekly contracts; Table 4 presents statistics for 3-month T-bills, and shows the characteristic pattern of other medium-term rates.

Table 3 displays the striking effects on short-term rates of reserve requirements. Even during 1979-82, volatility in daily changes is noticeably higher on the first and last days of the settlement period. Before 1979 and after 1982, the differences are quite large: pre-1979, volatility increases by a more than factor of four from Monday (day 1 of the five-day settlement period) to settlement Wednesday. From 1988 on, volatility increases by a factor of greater than six between nonsettlement Wednesday (day 5) and settlement Wednesday (day 10) and the following Thursday (day 1).

Table 3 also hints that the large movements on Wednesdays and Thursdays tend to be offsetting. Skewness switches sign between these days, as does the midpoint between the minimum and maximum values.

The fat tails and otherwise odd features of the distribution of daily changes is apparent in Figures 1-5. Figure 1 displays the distributions of daily changes for the four operating regimes, and illustrates clearly the leptokurtic nature of the distribution of changes during the nonborrowed reserves period. The remaining figures illustrate the distributions by selected days of the settlement period, and indicate the generally fatter tails which occur on settlement day.

The results in Table 4 indicate that the interday pattern of daily rates does not extend to rates for longer horizons. Volatilities across days are quite similar, and the distributions more nearly symmetric. Furthermore, the results differ little across operating regimes--a characteristic not shared by the term structure restrictions investigated below.

Tests of the Term Structure Restrictions

The most direct method for testing the implications of the expectations theory of the term structure is the so-called VAR (vector autoregressive) approach.[9] While the results of the VAR tests are less easily interpreted than those of the other tests presented below, they do provide summary measures of the overall validity of the expectations model of the term structure over the various policy regimes. To describe these tests, let $R_{t,n}$ denote a longer-term, n-period rate of interest, and let $R_{t,m}$ denote a shorter, m-period rate of interest, where m divides n. The risk-adjusted expectations hypothesis then states that the n-period interest rate at time t, $R_{t,n}$ is the average of the current m-period interest rate $R_{t,m}$, and current expectations about future m-period rates, plus a time-invariant risk premium; i.e.,

(1) $$R_{t,n} = (1/k)\Sigma_{i=0}^{k-1}\, {}_tR_{t+mi,m} + c, \quad k = n/m,$$

where ${}_tR_{t+k,m}$ is the expectation at time t of the m-period interest rate starting in period t+k. In the textbook case, the $\{R_{t,n}\}$ and $\{R_{t,m}\}$ processes are jointly Gaussian and covariance stationary.[10] Then it is a straightforward, though some what tedious exercise to apply the standard techniques of rational expectations to derive the implications of equation (1) on the fundamental moving average representation for the $\{(R_{t,n}, R_{t,m})\}$ process.

9. The approach is discussed in more detail in Campbell and Shiller (1987,1991) and Hodrick (1991).

10. These processes must satisfy other technical requirements in order to apply standard rational expectations methodology. See Hansen and Sargent (1991) for a thorough discussion of the econometric issues associated with tests of the expectations model of the term structure.

We adopt a number of modifications on this basic strategy, following the approach taken by Campbell and Shiller (1987). First, equation (1) is approximated by assuming that n/m is large, and taking an infinite horizon counterpart, i.e.,

$$(2) \qquad R_{t,n} = (1-\delta)\ \Sigma_{i=0}^{\infty}\ \delta^{i}\ {}_{t}R_{t+mi,m} + c$$

where δ is a discount factor in (0,1). This modification allows the restrictions imposed by the expectations model to be expressed in a linear form, which reduces computational complexity. Second, in this application we assume $m=1$ day, that is, the short rate is taken to be an overnight rate. Third, due to evidence in favor of difference-stationarity of the various interest rate processes, it is advantageous to rewrite (2) as

$$(3) \qquad R_{t,n} - R_{t,m} \equiv S_{t}^{(n,m)} = \Sigma_{i=1}^{\infty}\ \delta^{i}\ ({}_{t}R_{t+mi,m} - {}_{t}R_{t+m(i-1),m}) + c$$

Equation (3) states that the spread between the long rate and the short rate, $S_{t}^{(n,m)}$ must equal a discounted sum of expected future changes in the short rate. The fourth and final modification is to assume that the bivariate, stationary process ($R_{t,n}-R_{t,1}$, $R_{t,1}-R_{t-1,1}$) has a VAR representation. Under these modifications, the implications of the expectations model of the term structure can be shown to be equivalent to a set of linear restrictions on the coefficients of the VAR for ($R_{t,n}-R_{t,1}$, $R_{t,1}-R_{t-1,1}$).[11]

Representative results for these tests are shown in Table 5. In these applications, the short interest rate was taken to be the effective overnight Fed funds rate, and the long rate was taken to be the 3-month Treasury bill rate. A VAR model was fit to daily observations on first differences in the overnight funds rate and the spread between the T-bill rate and the funds rate. Missing observations were filled in by repeating the previous day's values. Standard tests for lag length revealed that 21 lags were sufficient to capture the model dynamics after October 1979. For the funds rate targeting period, however, these tests were somewhat ambiguous. Hence, for this period, Table 4 presents results for a 42-lag VAR system as well as for a 21-lag system.

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11. See Campbell and Shiller (1987, pp. 1066-1068). Following Campbell and Shiller, the expectations-model restrictions are tested using a Wald test. The variance-covariance matrix of the coefficients is the heteroskedasticity-consistent estimator suggested by Hansen (1982).

The results in Table 5 show that the expectations model can be rejected at arbitrary significance levels for the funds rate targeting period. The expectations model cannot be rejected on the basis of the data from the 1979-82 period, although the smaller sample size associated with this period makes this finding somewhat less informative than might be the case otherwise. The test results for the post-1984 sample fall in an intermediate range: the expectations model can be rejected at the 5% but not at the 1% level of significance.

The VAR results accord with other studies of the short end of the term structure that report subsample results for different Fed operating procedures, e.g., Simon (1990) and Hardouvelis (1988). They indicate that the expectations model can be taken literally only over the relatively short subsample associated with nonborrowed reserves targeting, that it is unlikely that much information can be recovered from the short end of the yield curve during the late 1970s, and that some information may be present in the yield curve after 1984.

Information in Spreads

Although the testable implications of the expectations theory of the term structure are rejected for two of the subsamples by the using a VAR model, that rejection does not necessarily mean that there is no information in the term structure. The expectations theory implies that current spreads between interest rates at different maturities predict future interest rate changes. This implication of the expectations theory warrants separate examination.

Campbell and Shiller (1991) show how under the expectations hypothesis, yield spreads can be used to predict changes in both short- and long-term interest rates. To use the hypothesis to predict short rates, follow the approach of the previous section by subtracting $R_{t,m}$ from both sides of (1) and reverse sides, giving

$$(4) \qquad (1/k)\Sigma_{i=0}^{k-1} {}_{t}R_{t+mi,m} - R_{t,m} = R_{t,n} - R_{t,m} + c, \; k = n/m.$$

The right-hand side of (4) is just the current spread between n- and m-period interest rates. Equation (2) thus suggests that the difference between the average expected m-period rate and the current m-period rate is equal to the current spread between n- and m-period rates plus a risk premium.

Equation (4) can be tested by regressing the realized difference between average m-period rate and the current m-period rate, $(1/k)\Sigma_{i=0}^{k-1} R_{t+mi,m} - R_{t,m} \equiv S_t^{(n,m)*}$ on the current spread, $R_{t,n}-R_{t,m} = S_t^{(n,m)}$. The expectations theory implies that the coefficient on the current spread should be unity. Thus, the current spread should be a good predictor of the future average change in short-term rates.

Campbell and Shiller also consider the implications of equation (1) for changes in future long-term rates. They note that

$$(5) \qquad s_t^{(n,m)} \equiv (m/(n-m))S_t^{(n,m)} = {}_tR_{t+m,n-m} - R_{t,n}.$$

This implication of the expectations hypothesis can be tested by regressing the realized value $R_{t+m,n-m}-R_{t,n}$ on $s_t^{(n,m)}$. The expectations theory predicts that the estimated coefficient on $s_t^{(n,m)}$ will be unity. Thus, a known multiple of the current spread should be a good predictor of the future change in long-term rates.

Campbell and Shiller test both (4) and (5) using McCulloch's (1990) monthly data on U.S. Treasury bill, note, and bond prices from 1952:1 to 1987:2. Their analysis is especially complete: they look at all possible combinations of short and long maturities that are multiples of each other from one month to ten years. By conducting such an exhaustive analysis, Campbell and Shiller are able to pinpoint those maturity combinations for which the expectations theory of the term structure works well, as well as those combinations for which it works poorly.

One of the Campbell-Shiller findings is that for any two maturities, n and m, equation (5) performs abysmally. That is, the current spread between n- and m-period rates has no power in predicting the difference between the (n-m)-period rate m-periods from now and the current n-period rate. In fact, equation (5) performs so poorly that the coefficient on $s_t^{(n,m)}$ is usually negative, while the expectations theory predicts a value of one for that coefficient.

The Campbell-Shiller estimates of equation (4) are somewhat more promising for the expectations theory. For maturities beyond three or four years, they cannot reject the hypothesis that the coefficient on $S_t^{(n,m)}$ is unity. This means that the current spread between n- and m-period rates predicts how the average m-period rate will change over the next n-periods.[12] But for shorter maturities, especially those below one year, Campbell and Shiller's tests reject the hypothesis that the coefficient on $S_t^{(n,m)}$ is unity. Their results are consistent with

12. Or to be more precise, it says how the average m-period interest rate every m periods from the current period to the n-mth period will change from the current m-period interest rate.

earlier research by Shiller, Campbell, and Schoenholtz (1983), Fama (1984), and Mishkin (1988).

Although the Campbell-Shiller results are useful for analyzing the predictive power of the yield spread over the entire post-Treasury-accord period, they do not tell us much about how different Federal Reserve operating procedures have affected the term structure. There are two ways in which we believe the Campbell-Shiller results must be extended to understand the effect of different operating procedures. First, we must examine the predictive power of yield spreads during each different operating regime, since the amount of information contained in the spread could differ greatly across the different regimes. Second, we must examine the predictive power of yield spreads for each different day of the maintenance period for the different operating regimes, since operating procedures and volatilities vary greatly by day of the maintenance period.

Since the Campbell-Shiller results show that there is almost no hope for equation (5), we concentrate our efforts on equation (4). We want to see whether differences in operating procedures can explain the Campbell-Shiller finding that average future short-term interest rates do not change as much from the current short term rate as the current yield spread predicts that they will. To do this, we estimated ex post versions of equation (4) using data consolidated according to operating regime, as well as broken out by day of the settlement period within each regime.[13]

Results for term Fed funds rates under the non-borrowed and borrowed reserves operating regimes are presented in Table 6. In the table, three characteristics of the term structure emerge. First, under the current operating regime, the short end of the term structure displays the characteristic pattern found by Campbell-Shiller for intra-year rates: the bias of the term structure forecast increases with the maturity of both the long and short term rates. Second, under the nonborrowed reserves targeting regime, the short end of the term structure was substantially more informative about movements in future

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13. Because we use daily data, the errors in our term-structure regressions are serially correlated, for reasons noted by Hansen and Hodrick (1980). We correct for both serial correlation and conditional heteroskedasticity using the methods suggested by Hansen (1982). Missing observations are dealt with in the following manner. We repeat missing observations in order to calculate the forward averages on the LHS of (4). However, these repeated observations are <u>not</u> used to calculate the regression results in Tables 6-10. This procedure de facto extends the maturity of pre-holiday short rates by one day.

short rates. With the exception of the overnight--30-day connection, each of the slope coefficients in the nonborrowed reserves table is within one standard error of unity, the value predicted by the expectations hypothesis. Third, the fraction of the variation in the spread between average future short rates and the current short rate which can be explained by the current long-short spread is much lower at the shortest end of the term structure during the nonborrowed reserves period. For example, the R^2 in the spread regression using the overnight--60-day spread was 0.45 after 1984, but only 0.16 between 1979 and 1982. However, this deterioration in quality of fit does not characterize the longer end of the term structure--primarily because so little of the variation is explained even in the best cases.

For the borrowed-reserves/contemporaneous-reserves accounting regime, the results for estimating (4) using data on repo rates are very similar to those using Fed funds data, as can be seen in Table 7. There are only two important differences between the repo results and those for Fed funds: First, the slope coefficients are somewhat higher using repo data if the long-rate maturity is 90 days or less. Second, the slope coefficients are actually negative if the long-rate maturity is 180 days and the short-rate maturity is 30 days or more.

For the results for estimating (4) using repo data are very different from those using Fed funds data for the nonborrowed-reserve targeting regime, as can be seen in Table 7. As noted above, the slope coefficients in the Fed funds regressions were all within one standard error of unity, except with a short-rate maturity of one day and a long-rate maturity of 30 days. With the repo data, only two of the slope coefficients are within two standard errors of unity.

The relatively poor performance of the term-structure regressions on repo data in the nonborrowed-reserve targeting period may well be explained by institutional factors affecting the repo market during this time. Before the fall of 1982, the repo market was quite immature and contained many legal uncertainties. One indication of the repo market's immaturity is the fact that most trades during this period were done at 1/4 percentage point increments. Fed funds were trading on 1/16 or finer percentage point increments. Because Fed funds rates had a higher resolution than repo rates, the term structure of repo rates could not contain as much information as the term structure of Fed funds.

Other institutional issues besides market immaturity may also explain the poor performance of these regressions. Until 1982, courts did not decide who actually owned the pledged securities if a broker went bankrupt. Also, pricing by dealers was not uniform until October 1982, when the New York Fed required repo pricing to be based on accrued interest on the pledged securities. This ruling came after abuses of alternative pricing mechanisms lead to nearly $300 million in losses to Chase Manhattan when Drysdale Government Securities collapsed.

Since term Fed funds data are not available for the funds-rate targeting period, Table 8 replicates some of the results in Table 6, using observations on the overnight funds rate and the 1, 3, and 6-month T-bill rates. The Table 8 results for the nonborrowed and borrowed reserves regimes are generally not as favorable to the expectations hypothesis as the analogous results in Table 6. We speculate that this deterioration in the fit of the expectations model is driven by the existence of a secondary market for T-bills that does not exist for term Fed funds. The existence of a secondary market implies that the price of T-bills should reflect the value of this "put-option" feature. It also seems likely that the value of this feature of T-bills would incorporate factors other than the conditional first moment of the short-term interest rate.

The Table 8 results also differ from the analogous figures in Table 6 in terms of the patterns displayed by some of the statistics over the various maturities. For both the borrowed and nonborrowed reserves subsamples, the bias of the term structure is less at 91 days than at 28 or 182 days. However, the two subsamples still differ substantially in terms of the bias and fit of the term structure equations. The results for the nonborrowed reserves subsample still dominate those for the borrowed reserves subsample in terms of bias, i.e., the slope coefficients are closer to unity. At a horizon of 182 days, the R^2 statistics are still larger for the nonborrowed reserves period. At the shorter horizons, the R^2 statistics are roughly the same for both periods.

Results for the funds-rate targeting period are also shown in Table 8. For the funds-rate targeting regime, the information content of interest-rate spreads appears to be uniformly low, as evidenced by the very low R^2's obtained for equation (4). The slope coefficients are also generally quite small, and in most cases are within a standard error of zero. The exception is the slope coefficient on the 6-month/3-month T-bill spread, which is greater than the analogous estimates for the borrowed- and nonborrowed-reserves regimes, though it still falls well within two standard errors of zero.

Periodicity and Information

As noted above, since 1984 the overnight funds rate has displayed a marked periodic pattern over the two-week reserve maintenance period, while these same periodic patterns are absent for term Fed funds rates. To investigate the effect of this periodicity on estimates of equation (4), we estimated versions of equation (4) over subsamples that consist of observations on particular days of the reserve maintenance period. Representative results from this exercise are displayed in Tables 9 and 10.

Table 9 shows that the choice of subsample makes a tremendous difference in the fit of equation (4), when the short rate is the overnight funds rate and the time period considered is the post-1984 borrowed-reserves/contemporaneous-reserve accounting regime. In these cases, i.e., in the first column of Table 9, the results for settlement Wednesdays display markedly higher values for both the estimate of the slope coefficient and for R^2. This "settlement-day" effect is more muted or virtually nonexistent for short rates having a maturity of 30 days or more. It is also much harder to detect for the 1979-82 period, in that the results for Wednesdays (which were all settlement days) are extremely close to the results for the period as a whole (cf. Tables 6 and 9).

Table 10 replicates the results of Table 9 for the repo market. The post-1984 results follow essentially the same pattern as for Fed funds, i.e., of better fits for the overnight rates on settlement Wednesdays, worse fits on non-settlement days, and few differences otherwise. Note that all of the slope coefficients when comparing overnight repos to longer-maturity repos are within two standard errors of unity. The 1979-82 results for Wednesdays differ little from the results over the entire 1979-82 sample (cf. Table 7).

INTERPRETATIONS AND FINDINGS

The results reported in Tables 1-10 are entirely consistent with the idea advanced by Mankiw and Miron (1986) that the information content of the term structure is strongly linked to the volatility of short-term interest rates. This effect shows up in two ways in our results. First, the estimates of the slope coefficient for equation (4) in Tables 6-10 are generally larger for the volatile 1979-82 period than is the case for the other subsamples. Second, both higher slope coefficient estimates and better fits are obtained for the relatively volatile subsample of settlement Wednesdays during the post-1984 period. The first of these two observations should be uncontroversial, as it has already been reported by earlier studies, notably Hardouvelis (1988) and Simon (1990). To our knowledge, the second observation is unique to the present paper and thus merits additional discussion.

From the standpoint of policy and evaluation of the current Fed operating procedure, the key question is "does the current operating procedure allow some information about short-term interest rates to be reflected in the term structure?" The answer to this question provided by Tables 5-10 is an unambiguous "yes, but ... ." The post-1984 results for equation (4) are certainly more favorable than the available 1975-79 results to the idea that rate spreads contain information about the future course of short-term rates. The down side of this generalization is that much of this information is of a limited, short-term nature. Tables 9 and 10 indicate that after 1984, equation (4) fits best for a particularly volatile subsample of our dataset, i.e., on settlement Wednesdays when the short rate is an overnight rate.[14] This pattern of results is consistent with the widely held notion that while the Fed may loosen its grip on the overnight funds rate on settlement Wednesdays, the day following settlement will generally see the return of the overnight funds rate to previous target value. Our settlement-day results might be considered encouraging in the sense that it shows that the markets are not "spooked" by settlement-day pressures in the overnight Fed funds market. On the other hand, the value of this type of information is likely to be nil at other than very short horizons.

Inspection of various entries of Tables 6-10 shows that such is in fact the case. For example, the second column of Tables 6,7,9, and 10 shows that in the post-1984 period, the 30-day/60-day and 30-day/90-day spreads do contain some information for future movements in 30-day rates. However, the 30-day/180-day spreads on Fed funds and repos do not have any forecasting power for future movements in 30-day rates. Similarly, the 60-day/180-day spreads on Fed funds and repos never provide information on the future course of 60-day rates. The same is true for the 90-day/180-day spreads on Fed funds and T-bills. In the case of repos, the 90-day/180-day spread does provide some information on future 90-day repo rates, but the sign of the slope

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14. Since 1984, the overnight funds rate has also tended to be quite volatile around year-end, due to holiday cash demand and "window-dressing" pressures. Point estimates very similar to those obtained for settlement Wednesdays were obtained for a post-1984 subsample consisting of the two-week periods beginning on a Thursday and spanning the Christmas and New Year's holidays.

coefficient is the opposite of that predicted by the expectations hypothesis and the amount of variation explained is quite small.

These last results suggest that despite the nominal distinctions between the post-1984 operating procedure and the funds-rate targeting regime of the late 1970s, relatively little information is being captured at the short end of the term structure. We find that what information available in the short end of the term structure vanishes at a horizon somewhere between 90 and 180 days, a finding consistent with the results of Hardouvelis (1988), whose data set extended only to 1985. That is, the net position of the markets, as reflected by the term structure, cannot be interpreted as having any predictive power beyond a horizon of roughly 90 days.

To obtain a better idea of how this finding impacts on the market's expectations of monetary policy, we make use of an idea suggested by Simon (1991). Using 1983-88 data on 30- and 60-day term Fed funds rates, Simon (1991, p.334) finds that a version of equation (4) fits particularly well during the days immediately preceding and following FOMC meetings. Simon interprets this finding as supporting the notion that the policy intentions of the FOMC are quickly transmitted to financial markets. To implement this idea for our data set, we fit equation (4) to both Fed funds and repo data after 1984, restricting ourselves to the days immediately following FOMC meetings (or the second day of the meeting for 2-day meetings). These results are displayed in Tables 11 and 12, along with the analogous results for the 1979-82 period.

In general the post-1984 results in Tables 11 and 12 do not differ radically from those reported in Tables 6 and 7. This is particularly true for the Fed funds market (cf. Tables 6 and 11). For repos, there is a somewhat better fit immediately post-FOMC for versions of equation (4) where the short rate is the overnight rate, or where the long rate has a horizon of 30, 60, or 90 days (cf. Tables 7 and 12). At a horizon of 180 days, there is no improvement in fit for the equations with a short rate having terms of 30, 60, or 90 days. These results suggest that interest rate spreads directly attributable to policy actions are not likely to be more informative than is usually the case, especially at horizons beyond 90 days.

To summarize, our results indicate that in the current (post-1984) policy environment the information implied by the short end of the term structure vanishes at horizons beyond 90 days. This result is consistent with the Mankiw-Miron hypothesis in the sense that the available evidence from the 1979-82 period (which is necessarily limited because of the short duration of the nonborrowed-reserves operating procedure) suggests that this was likely not the case when the Fed was less aggressively smoothing the funds rate. The fact that some information is contained in the post-1984 term structure for the very short term is consistent with the Mankiw-Miron hypothesis, in contrast to conjecture of Hardouvelis (1988, p.355). As is documented above, the volatility of the overnight funds rate on reserve settlement days is accompanied by an increase in the informativeness of the term structure. Since longer-term Fed funds and repo rates are generally not subject to the settlement day volatility, the Mankiw-Miron hypothesis would predict that the fit of equation (4) would fall with the maturity of the short rate. This is exactly what happens in the post-1984 sample.

Our results are also complementary to those obtained by Campbell and Shiller (1991). Recall that Campbell and Shiller are unable to reject the expectations hypothesis restriction on equation (4) (i.e., that the slope coefficient equals one) when the long rate has a maturity greater than three years. For the post-1984 Fed funds and repo markets, our results imply that interest rate spreads are quite informative at very short horizons, although we can still formally reject the expectations hypothesis, excepting the repo market on settlement Wednesdays. Campbell and Shiller (1991, p.507) also note that for the Treasury market, the forecasting ability of equation (4) falls with the length of the forecasting horizon (the long rate maturity) at horizons of less than one year. We document a similar effect in the post-1984 Fed funds and repo markets. The information content of the yield curve in these markets begins to decline at a horizon of no more than two months, and vanishes at six months.

CONCLUDING REMARKS

The results discussed above, together with the term structure results obtained by Campbell and Shiller (1991), Fama (1984), and related papers, point to a remarkable empirical regularity associated with the recent U.S. term structure. In terms of the ability of the term structure to predict subsequent movements in short rates via equation (4), there is an "ozone hole" in the term structure beginning at a horizon of roughly six months and extending out to a horizon of two or three years. That is, the ability of the implicit forward rates to anticipate the future course of interest rates is severely curtailed at horizons between 3-6 months and 2-3 years. Our conjecture is that the cause of the "ozone hole" is the Fed's historically accommodative stance towards seasonal fluctuations in the demand for credit. At a horizon of roughly six months, a policy incorporating seasonal accommodation has to come into conflict with the market-determination of short-term rates. Put another way, no one has yet invented a seasonally adjusted credit market.

Without a well-specified model, it is not possible to analyze welfare implications of the results presented above. However, the operating procedure in place since 1984 has been only partially successful in terms of providing information to credit market participants concerning the future course of short-term interest rates. Further, the greatest amount of yield-curve information has been available during episodes associated with higher volatility of the overnight Fed funds rate. Finally, we conjecture that the Fed's historical policy of seasonal accommodation poses an inherent limitation, for better or for worse, on the ability of implicit forward rates to forecast future interest rates at horizons close to one year.

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1. Data Series

Abbreviation	Series	Availability
FFEY	Overnight Effective Federal Funds Rate	75: 1: 2 - 91: 7:24
FF30Y	30-Day Fed Funds Rate	79:11:13 - 91: 7:24
FF60Y	60-Day Fed Funds Rate	79:11:13 - 91: 7:24
FF90Y	90-Day Fed Funds Rate	79:11:13 - 91: 7:24
FF180Y	180-Day Fed Funds Rate	79:11:13 - 91: 7:24
RPY	Overnight Repo Rate	75: 1: 2 - 91: 7:24
RP30Y	30-Day Repo Rate	79: 8:27 - 91: 7:24
RP60Y	60-Day Repo Rate	79: 8:27 - 91: 7:24
RP90Y	90-Day Repo Rate	79: 8:27 - 91: 7:24
RP180Y	180-Day Repo Rate	79:11:13 - 91: 7:24
TB1	One-month (28 Day)* T-bill Rate	75: 1: 2 - 91: 7:24
TB3	Three-month (91 Day)* T-bill Rate	75: 1: 2 - 91: 7:24
TB6	Six-month (182 Day)* T-bill Rate	75: 1: 2 - 91: 7:24

*Maturities of T-bills will fluctuate between auctions. Maturities above are for Thursdays.

2. Daily Changes in Selected Interest Rates

Variable	period	Mean	Std	Skewness	Kurtosis	Minimum	Maximum	Obs.
FFEY	75-79	0.000	0.301	-1.089	31.104	-3.427	2.352	1165
RPY	75-75	0.000	0.160	-0.529	6.506	-1.014	0.887	1157
TB3	75-79	0.002	0.087	0.714	9.775	-0.600	0.650	1165
TB6	75-79	0.003	0.072	0.461	4.102	-0.291	0.462	1132
FFEY	79-82	-0.003	0.823	0.27	2.427	-2.991	3.934	731
RPY	79-82	-0.006	0.774	0.034	2.089	-3.549	3.549	723
FF30Y	79-82	-0.001	0.351	-0.39	3.382	-2.155	1.267	697
RP30Y	79-82	-0.004	0.332	-0.106	3.529	-1.698	1.521	721
FF60Y	79-82	-0.003	0.338	-0.549	4.727	-2.281	1.267	700
RP60Y	79-82	-0.003	0.321	-0.153	4.086	-1.521	1.521	721
FF90Y	79-82	-0.002	0.351	-0.452	4.139	-2.281	1.521	700
RP90Y	79-82	-0.002	0.341	-0.26	4.986	-1.901	1.521	721
TB3	79-82	-0.007	0.309	0.274	2.809	-1.4	1.5	731
FF180Y	79-82	-0.001	0.359	-0.249	2.047	-1.521	1.267	680
RP180Y	79-82	-0.027	0.355	-0.028	4.744	-1.648	1.648	446
TB6	79-82	0.009	0.252	0.343	4.334	-1.307	1.266	690
FFEY	82-84	-0.003	0.316	-0.262	13.74	-2.038	1.663	304
RPY	82-84	0.009	0.314	-2	33.775	-3.042	1.521	296
FF30Y	82-84	-0.002	0.128	0.02	2.25	-0.507	0.507	298
RP30Y	82-84	0.001	0.093	0.253	1.531	-0.304	0.304	296
FF60Y	82-84	-0.002	0.123	0.212	0.977	-0.38	0.38	298
RP60Y	82-84	0.001	0.086	-0.007	1.586	-0.304	0.38	296
FF90Y	82-84	-0.001	0.133	0.075	0.637	-0.38	0.38	298
RP90Y	82-84	0.001	0.094	0.228	3.643	-0.355	0.507	296
TB3	82-84	0.002	0.085	0.248	2.378	-0.34	0.35	304
FF180Y	82-84	-0.002	0.131	-0.061	0.933	-0.507	0.38	298
RP180Y	82-84	0	0.129	0.231	4.687	-0.477	0.558	296
TB6	82-84	-0.015	0.241	0.31	4.004	-0.751	1.355	289
FFEY	84-91	-0.004	0.378	6.095	121.82	-2.737	7.898	1809
RPY	84-91	0.003	0.298	4.372	72.524	-1.673	5.323	1791
FF30Y	84-91	-0.002	0.151	-0.021	25.911	-1.394	1.457	1795
RP30Y	84-91	-0.002	0.101	-1.991	48.725	-1.673	1.014	1791
FF60Y	84-91	-0.002	0.136	-0.358	18.288	-1.077	1.077	1801
RP60Y	84-91	-0.002	0.095	0.07	13.935	-0.862	0.862	1793
FF90Y	84-91	-0.001	0.151	-0.258	18.698	-1.204	1.077	1801
RP90Y	84-91	-0.002	0.095	0.179	8.26	-0.71	0.71	1793
TB3	84-91	-0.002	0.077	-0.266	6.709	-0.56	0.47	1809
FF180Y	84-91	-0.003	0.16	-0.632	16.914	-1.331	1.141	1801
RP180Y	84-91	-0.002	0.114	0.499	8.264	-0.684	0.887	1793
TB6	84-91	-0.002	0.082	-0.791	8.838	-0.848	0.344	1697

Note: All rates converted to 365-day basis. Each period begins on a Thursday immediately following a settlement Wednesday. The periods are: 75-79: 1/2/1975-10/3/79; 79-82: 10/11/1979-10/6/1982; 82-84: 11/4/1982-2/1/1984; 84-91: 2/2/1984-7/24/1991. Skewness and Kurtosis are defined as follows: let T = number of observations, s^2 = the unbiased estimate of the variance, and m_r = the rth sample moment about the mean; then

$$\text{Skewness (Sk)} = [T^2/(T-1)(T-2)] \times m_3/s$$

$$\text{kurtosis (Ku)} = [T^2/(T-1)(T-2)(T-3)] \times [(T+1)m_4 - 3(T-1)m_2^2]/s^4.$$

For a normal distribution, Sk = Ku = 0. See Kendall and Stuart (1958).

3. Daily Changes in the Federal Funds Rate
By Day of the Reserve Maintenance Period
(Settlement on Last Day)

75: 1: 2 to 79:10: 3

variable	day	mean	std dev	skew	kurt	min	max	nobs
FFEY	1.	0.105	0.406	1.998	10.281	-1.501	2.352	238.
FFEY	2.	-0.009	0.096	-1.981	17.485	-0.740	0.365	238.
FFEY	3.	0.056	0.122	-0.562	11.463	-0.649	0.730	223.
FFEY	4.	-0.058	0.126	-1.067	9.725	-0.720	0.588	222.
FFEY	5.	-0.094	0.458	-2.706	15.696	-3.427	1.592	244.

79:10:11 to 82:10: 6

variable	day	mean	std dev	skew	kurt	min	max	nobs
FFEY	1.	0.404	0.887	0.644	2.193	-2.342	3.934	150.
FFEY	2.	-0.094	0.523	0.289	0.614	-1.419	1.511	148.
FFEY	3.	0.052	0.670	0.070	2.276	-2.048	2.565	140.
FFEY	4.	-0.158	0.659	0.498	3.812	-2.028	3.001	140.
FFEY	5.	-0.222	1.078	0.048	0.557	-2.991	2.717	153.

82:11: 4 to 84: 2: 1

variable	day	mean	std dev	skew	kurt	min	max	nobs
FFEY	1.	0.065	0.402	2.625	8.072	-0.548	1.663	62.
FFEY	2.	-0.136	0.306	-1.819	13.210	-1.713	0.923	62.
FFEY	3.	0.006	0.336	-4.549	25.497	-2.038	0.345	57.
FFEY	4.	-0.024	0.160	-0.031	-0.096	-0.446	0.294	58.
FFEY	5.	0.069	0.283	-0.688	2.336	-1.024	0.649	65.

84: 2: 2 to 91: 7:24

variable	day	mean	std dev	skew	kurt	min	max	nobs
FFEY	1.	-0.007	0.506	-0.413	5.373	-2.737	1.734	189.
FFEY	2.	-0.100	0.209	-2.109	14.963	-1.501	0.842	190.
FFEY	3.	0.071	0.242	-3.610	36.489	-2.038	0.963	165.
FFEY	4.	-0.058	0.150	1.175	11.017	-0.588	0.882	163.
FFEY	5.	-0.075	0.146	-1.223	7.246	-0.923	0.487	188.
FFEY	6.	0.010	0.191	1.502	11.989	-0.679	1.237	184.
FFEY	7.	-0.096	0.228	-3.478	23.314	-1.906	0.639	185.
FFEY	8.	0.093	0.284	2.324	14.847	-0.781	1.987	177.
FFEY	9.	-0.015	0.724	8.789	89.136	-0.913	7.898	177.
FFEY	10.	0.139	0.517	0.492	5.766	-1.845	2.869	191.

88: 1:14 to 91: 7:24

variable	day	mean	std dev	skew	kurt	min	max	nobs
FFEY	1.	-0.082	0.525	-1.605	6.938	-2.737	0.973	91.
FFEY	2.	-0.074	0.237	-2.949	19.847	-1.501	0.842	92.
FFEY	3.	0.008	0.246	-7.298	60.988	-2.038	0.274	82.
FFEY	4.	-0.053	0.088	-1.483	6.930	-0.456	0.203	80.
FFEY	5.	-0.045	0.082	-0.304	1.572	-0.324	0.142	89.
FFEY	6.	0.024	0.195	2.837	20.493	-0.679	1.237	87.
FFEY	7.	-0.098	0.249	-5.067	32.845	-1.906	0.152	87.
FFEY	8.	0.043	0.184	1.449	11.095	-0.618	0.963	77.
FFEY	9.	-0.064	0.144	-1.857	4.484	-0.618	0.172	77.
FFEY	10.	0.205	0.534	1.708	6.919	-1.085	2.869	91.

4. Daily Changes in the 91-Day T-Bill Rate, By Day
By Day of the Reserve Maintenance Period
(Settlement on Last Day)

75: 1: 2 to 79:10: 3

variable	day	mean	std dev	skew	kurt	min	max	nobs
TB3	1.	-0.011	0.075	-2.047	17.242	-0.600	0.230	238.
TB3	2.	0.004	0.099	1.023	6.486	-0.330	0.550	238.
TB3	3.	0.010	0.091	1.416	9.541	-0.290	0.580	223.
TB3	4.	0.021	0.093	1.173	10.150	-0.330	0.650	222.
TB3	5.	-0.013	0.072	0.119	5.159	-0.290	0.350	244.

79:10:11 to 82:10: 6

variable	day	mean	std dev	skew	kurt	min	max	nobs
TB3	1.	-0.043	0.272	-0.289	1.358	-0.890	0.830	150.
TB3	2.	-0.029	0.311	-0.269	2.613	-1.400	1.070	148.
TB3	3.	0.080	0.439	0.207	1.174	-1.230	1.500	140.
TB3	4.	0.001	0.251	-0.064	1.111	-0.740	0.850	140.
TB3	5.	-0.039	0.222	0.694	2.682	-0.600	1.000	153.

82:11: 4 to 84: 2: 1

variable	day	mean	std dev	skew	kurt	min	max	nobs
TB3	1.	-0.009	0.072	-0.023	2.314	-0.250	0.210	62.
TB3	2.	0.001	0.092	0.012	0.888	-0.220	0.260	62.
TB3	3.	0.023	0.113	0.543	0.611	-0.220	0.350	57.
TB3	4.	0.014	0.083	-0.922	5.459	-0.340	0.240	58.
TB3	5.	-0.014	0.053	-0.427	0.075	-0.150	0.090	65.

84: 2: 2 to 91: 7:24

variable	day	mean	std dev	skew	kurt	min	max	nobs
TB3	1.	-0.003	0.072	0.316	2.618	-0.250	0.260	189.
TB3	2.	-0.001	0.080	0.007	2.595	-0.330	0.280	190.
TB3	3.	0.021	0.063	1.563	8.241	-0.130	0.410	165.
TB3	4.	-0.012	0.065	0.118	1.234	-0.210	0.200	163.
TB3	5.	-0.023	0.076	0.691	11.407	-0.390	0.470	188.
TB3	6.	-0.007	0.066	0.181	0.993	-0.190	0.210	184.
TB3	7.	-0.002	0.083	-0.016	1.573	-0.290	0.250	185.
TB3	8.	0.003	0.094	-1.701	10.699	-0.560	0.370	177.
TB3	9.	0.013	0.090	-0.642	10.627	-0.560	0.360	177.
TB3	10.	-0.012	0.067	-1.261	4.983	-0.330	0.150	191.

88: 1:14 to 91: 7:24

variable	day	mean	std dev	skew	kurt	min	max	nobs
TB3	1.	-0.005	0.052	0.664	3.191	-0.140	0.220	91.
TB3	2.	-0.008	0.070	-0.197	2.540	-0.270	0.230	92.
TB3	3.	0.012	0.047	-0.441	-0.107	-0.110	0.110	82.
TB3	4.	-0.013	0.060	0.227	1.944	-0.180	0.200	80.
TB3	5.	-0.017	0.050	0.074	0.470	-0.150	0.120	89.
TB3	6.	-0.005	0.053	0.401	1.042	-0.130	0.170	87.
TB3	7.	-0.005	0.078	0.214	1.441	-0.230	0.240	87.
TB3	8.	0.018	0.058	0.677	2.931	-0.170	0.230	77.
TB3	9.	0.018	0.069	0.455	1.835	-0.190	0.230	77.
TB3	10.	-0.006	0.054	-0.365	2.113	-0.200	0.150	91.

5. VAR Tests of Expectations Model of the Term Structure

Data Sample	Long Rate	Short Rate	No. of Lags(L)	Wald Test of Expectations Model [$\sim\chi^2(2L)$] (P-value)
75-79	TB3	FFEY	21	76.1 (0.001)
75-79	TB3	FFEY	42	158.0 (0.00)
79-82	TB3	FFEY	21	48.6 (.224)
84-91	TB3	FFEY	21	65.0 (.0129)

6. **Slope Coefficients in Term Structure Regressions, Fed Funds Market**
Data Sample: 84: 2: 2 - 91: 7:24

m[15]=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.71084 (0.87272E-01) [0.43868715]			
60-Day	0.69768 (0.68365E-01) [0.45445806]	0.59242 (0.98340E-01) [0.15240927]		
90-Day	0.63523 (0.83047E-01) [0.35558630]	0.39346 (0.14370) [0.065956]		
180-Day	0.53355 (0.13379) [0.19241131]	0.21209 (0.28217) [0.01516]	0.10545 (0.30458) [0.00284]	-0.14113 (0.60790) [0.00159]

Data Sample: 79:10:11 - 82:10: 6

m=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.66258 (0.13481) [0.18600642]			
60-Day	0.80027 (0.24702) [0.15789838]	0.69623 (0.53894) [0.02302]		
90-Day	0.88427 (0.25799) [0.15622411]	0.77503 (0.59434) [0.03277]		
180-Day	0.87620 (0.19714) [0.15993267]	0.98028 (0.24848) [0.10281]	0.97080 (0.33589) [0.08755]	1.3203 (0.26700) [0.08581]

15. Note: m=Short Rate Maturity, n=Long Rate Maturity. Standard errors of slope coefficients in parentheses. R^2's in brackets.

7. Slope Coefficients in Term Structure Regressions, Repo Market
Data Sample: 84: 2: 2 - 91: 7:24

n=	m= Overnight	30-Day	60-Day	90-Day
30-Day	0.81293 (0.76210E-01) [0.47094]			
60-Day	0.80306 (0.83843E-01) [0.51417]	0.63056 (0.10172) [0.15022]		
90-Day	0.74918 (0.10663) [0.42462]	0.58669 (0.13858) [0.11086]		
180-Day	0.53700 (0.22351) [0.16325]	-0.31357E-01 (0.34781) [0.23165E-03]	-0.37417 (0.31626) [0.25596E-01]	-1.2195 (0.44449) [0.11419]

Data Sample: 79:10:11 - 82:10: 6

n=	m= Overnight	30-Day	60-Day	90-Day
30-Day	0.73162 (0.76086E-01) [0.20980]			
60-Day	0.55037 (0.10406) [0.90085E-01]	0.34580 (0.37397) [0.79651E-02]		
90-Day	0.41506 (0.19693) [0.44481E-01]	0.33395 (0.48853) [0.59293E-02]		
180-Day	0.15139 (0.29643) [0.62615E-02]	0.34026 (0.24751) [0.13233E-01]	0.44142 (0.26959) [0.18373E-01]	0.56562 (0.22936) [0.16460E-01]

8. Slope Coefficients in Term Structure Regressions, T-Bill Market
Data Sample: 84: 2: 2 - 91: 7:24

n=	m= Overnight (SR=Fedfunds)	91-Day
28-Day	0.37178 (0.11692) [0.25126]	
91-Day	0.67718 (0.13641) [0.35458]	
182-Day	0.47338E-01 (0.66608E-01) [0.01087173]	-0.83553E-02 (0.28326E-01) [0.00135683]

Data Sample: 79:10:11 - 82:10: 6

n=	m= Overnight (SR=Fedfunds)	91-Day
28-Day	0.54902 (0.84179E-01) [0.29063]	
91-Day	1.2083 (0.24637) [0.41399]	
182-Day	0.57291 (0.17944) [0.56781]	0.18989 (0.11866) [0.16096]

8. Continued

Data Sample: 75: 1: 2 - 79:10: 3

m=

n=	Overnight (SR=Fedfunds)	91-Day
28-Day	.22336 (.65927E-01) [.97948E-01]	
91-Day	.39235E-01 (.21011) [.015899E-02]	
182-Day	-.74599E-01 (.38467) [.26626E-02]	.43495 (.37102) [.049477E-01]

9. **Slope Coefficients in Term Structure Regressions, Fed Funds Market**
Data Sample: 84: 2: 2 - 91: 7:24, Settlement Wednesdays

n=	m= Overnight	30-Day	60-Day	90-Day
30-Day	0.85147 (0.36168E-01) [0.87987]			
60-Day	0.84914 (0.51974E-01) [0.81514]	0.75958 (0.13590) [0.17065]		
90-Day	0.81140 (0.64996E-01) [0.73914]	0.29532 (0.13990) [0.32129E-01]		
180-Day	0.79142 (0.69310E-01) [0.57071]	0.15565 (0.18608) [0.82124E-02]	0.13821 (0.20262) [0.54109E-02]	-0.29710 (0.36759) [0.64982E-02]

Data Sample: 84: 2: 2 - 91: 7:24, Wednesdays before Settlement

n=	m= Overnight	30-Day	60-Day	90-Day
30-Day	0.43032 (0.86797E-01) [0.16910]			
60-Day	0.43615 (0.11433) [0.10329]	0.56261 (0.70605E-01) [0.16686]		
90-Day	0.31526 (0.10734) [0.51279E-01]	0.41008 (0.93854E-01) [0.79219E-01]		
180-Day	0.17994 (0.12682) [0.15009E-01]	0.12697 (0.17736) [0.51560E-02]	0.10924 (0.21018) [0.31432E-02]	-0.16026 (0.45797) [0.20927E-02]

9. Continued

Data Sample: 79:10:11 - 82:10: 6, Wednesdays

m=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.73740 (0.76320E-01) [0.39902]			
60-Day	0.79166 (0.12191) [0.25797]	1.1530 (0.40904) [0.70105E-01]		
90-Day	0.86129 (0.13293) [0.23771]	0.85878 (0.49648) [0.45068E-01]		
180-Day	0.93573 (0.20738) [0.23866]	0.98905 (0.41132) [0.10274]	1.0780 (0.41318) [0.10083]	1.4088 (0.53714) [0.87880E-01]

10. Slope Coefficients in Term Structure Regressions, Repo Market
Data Sample: 84: 2: 2 - 91: 7:24, Settlement Wednesdays

m=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.88000 (0.41332E-01) [0.91237]			
60-Day	0.89058 (0.59263E-01) [0.86838]	0.81124 (0.14040) [0.17430]		
90-Day	0.86816 (0.73338E-01) [0.80642]	0.63977 (0.12307) [0.11341]		
180-Day	0.82090 (0.99945E-01) [0.59916]	-0.39116E-03 (0.30401) [0.31330E-07]	-0.35666 (0.35431) [0.22184E-01]	-1.1811 (0.42519) [0.10827]

Data Sample: 84: 2: 2 - 91: 7:24, Wednesdays before Settlement

m=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.57175 (0.90018E-01) [0.22958]			
60-Day	0.57329 (0.12672) [0.16959]	0.94002 (0.10909) [0.17167]		
90-Day	0.52235 (0.11224) [0.13487]	0.59400 (0.10046) [0.14026]		
180-Day	0.19879 (0.16344) [0.17115E-01]	0.56861E-01 (0.24290) [0.85628E-03]	-0.27002 (0.29575) [0.13148E-01]	-1.1915 (0.42815) [0.98355E-01]

10. Continued

Data Sample: 79:10:11 - 82:10: 6, Wednesdays

m=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.77928 (0.88908E-01) [0.27686]			
60-Day	0.54894 (0.17192) [0.99390E-01]	0.36621 (0.46336) [0.69809E-02]		
90-Day	0.48640 (0.24359) [0.64508E-01]	0.53541 (0.57689) [0.15607E-01]		
180-Day	0.28259 (0.29999) [0.24219E-01]	0.24637 (0.44599) [0.73326E-02]	0.32061 (0.45207) [0.10550E-01]	

11. Slope Coefficients in Term Structure Regressions, Fed Funds Market
Data Sample: 84: 2: 2 - 91: 7:24, Day after FOMC meetings

m=

n=	Overnight	30-Day	60-Day	90-Day
30-Day	0.74509 (0.83258E-01) [0.55146]			
60-Day	0.71413 (0.10129) [0.53943]	0.71192 (0.17200) [0.28684]		
90-Day	0.72288 (0.10569) [0.46611]	0.41039 (0.16886) [0.76046E-01]		
180-Day	0.70486 (0.14008) [0.30932]	0.86951E-01 (0.18779) [0.29287E-02]	-0.20294E-01 (0.27085) [0.10258E-03]	-0.31490 (0.45530) [0.77648E-02]

Data Sample: 79:10:11 - 82:10: 6, Day after FOMC meetings

m=

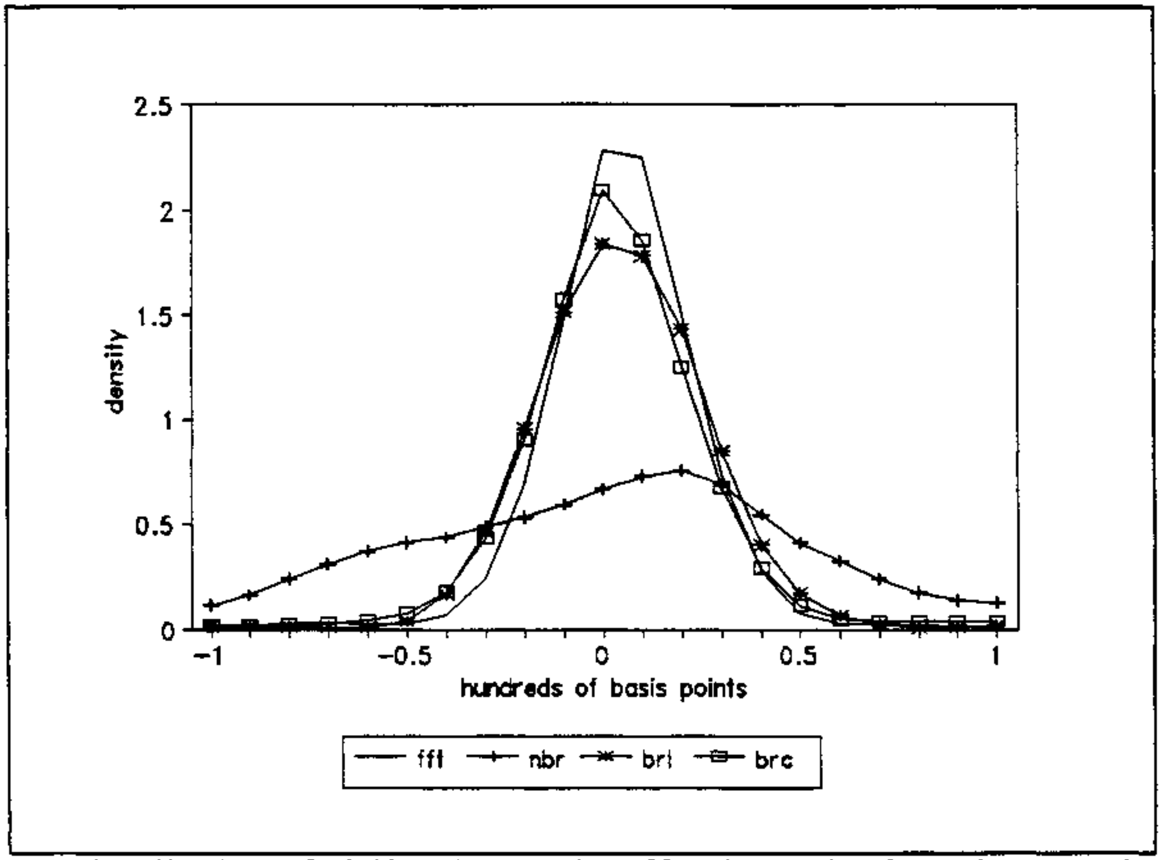
n=	Overnight	30-Day	60-Day	90-Day
30-Day	1.1375 (0.12522) [0.55483]			
60-Day	1.1084 (0.28921) [0.32927]	0.42279 (0.74265) [0.73300E-02]		
90-Day	1.0367 (0.31461) [0.27301]	0.60534 (0.89888) [0.16951E-01]		
180-Day	0.94613 (0.26896) [0.28244]	1.0098 (0.41959) [0.12071]	1.0853 (0.29268) [0.18424]	1.2601 (0.48919) [0.10950]

12. Slope Coefficients in Term Structure Regressions, Repo Market
Data Sample: 84: 2: 2 - 91: 7:24, Day after FOMC meetings

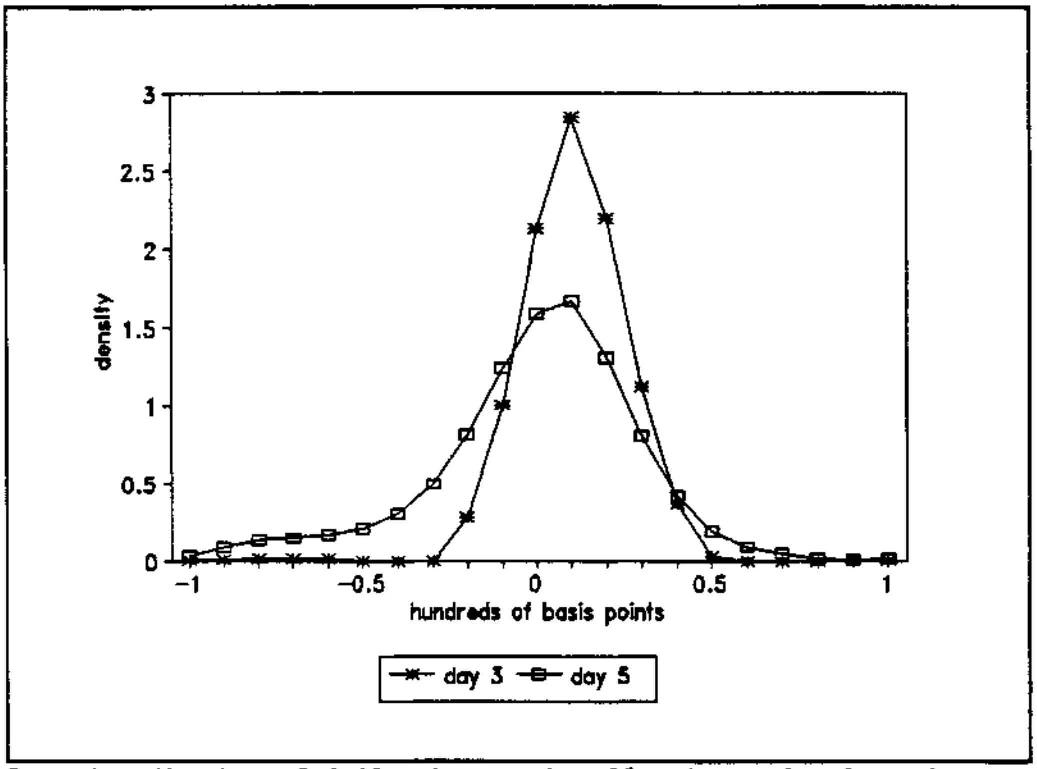
n=	m= Overnight	30-Day	60-Day	90-Day
30-Day	0.58366 (0.10163) [0.32624]			
60-Day	0.69122 (0.90822E-01) [0.47256]	0.94945 (0.15035) [0.33104]		
90-Day	0.69851 (0.10085) [0.40754]	0.81131 (0.15859) [0.19485]		
180-Day	0.60386 (0.14340) [0.19960]	0.46057E-01 (0.32509) [0.47395E-03]	-0.44065 (0.38018) [0.31240E-01]	-1.4686 (0.47491) [0.14990]

Data Sample: 79:10:11 - 82:10: 6, Day after FOMC meetings

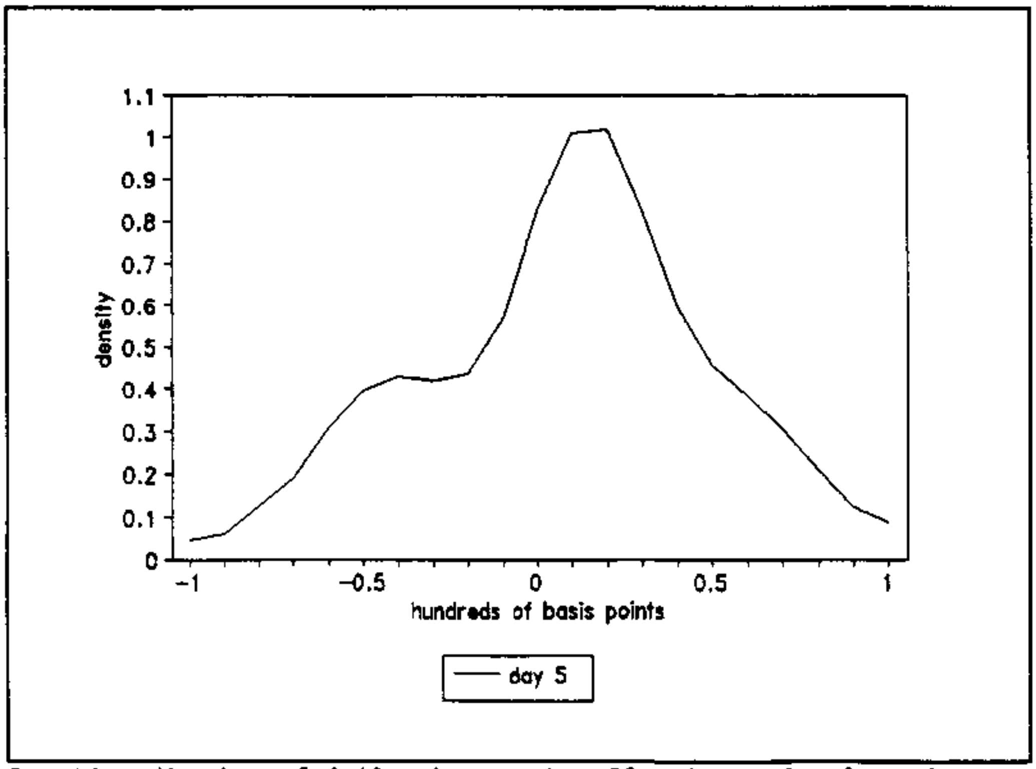
n=	m= Overnight	30-Day	60-Day	90-Day
30-Day	1.1657 (0.19487) [0.56774]			
60-Day	0.84924 (0.32370) [0.24901]	0.31677 (0.72952) [0.49330E-02]		
90-Day	0.75639 (0.38906) [0.17021]	0.38240 (0.91514) [0.61153E-02]		
180-Day	0.39520 (0.41207) [0.58096E-01]	0.38272 (0.52590) [0.15331E-01]	0.35125 (0.62701) [0.96151E-02]	0.66613 (0.36359) [0.36161E-01]



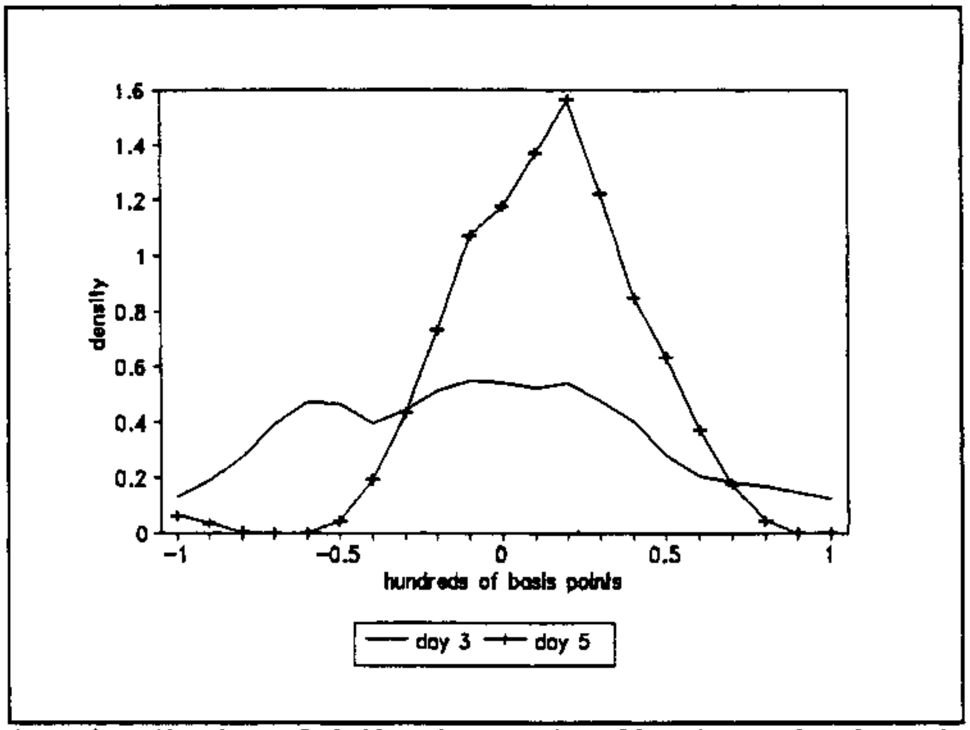
1. Distribution of daily changes in effective Federal Funds rate, by operating regime.



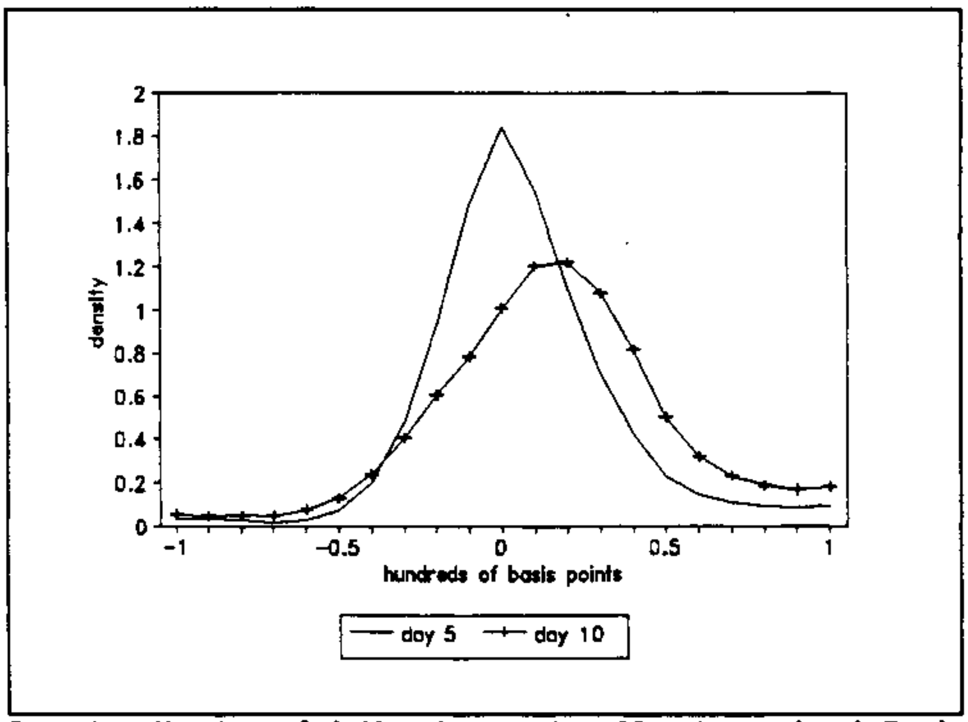
2. Distribution of daily changes in effective Federal Funds rate during the Fed Funds targeting period, by day of the settlement period (settlement day = day 5.)



3. Distribution of daily changes in effective Federal Funds rate on settlement day during the nonborrowed reserves targeting period.



4. Distribution of daily changes in effective Federal Funds rate during the borrowed reserves--lagged accounting regime, by day of the settlement period (settlement day = day 5.)



5. Distribution of daily changes in effective Federal Funds rate during the borrowed reserves--contemporaneous accounting regime, by day of the settlement period (settlement day = day 10.)

FOMC OPERATING PROCEDURES AND THE TERM STRUCTURE: SOME COMMENTS

Glenn D. Rudebusch[1]

This discussion is divided into two parts. The first describes some recent empirical results regarding the amount of information in the yield curve for forecasting future changes in short rates. My goal is to highlight several of the results of Roberts, Runkle, and Whiteman (1992) (henceforth RRW) and to compare their research to work done by previous authors. The second section contains an interpretation of this entire body of evidence in light of several characteristics of the Federal Reserve's monetary policy operating procedure.[2]

FACTS

RRW provide a careful study of the Rational Expectations Hypothesis (REH) of the term structure using data at the short end of the maturity spectrum. Their paper contains much fascinating empirical detail, but this note focuses on a single issue: the predictive power of the term structure for future movements in interest rates.

The REH of the term structure implies that the current spread between a long rate and a short rate should predict future changes in that short rate. I consider two special cases of such term structure predictions. First, I examine pairs of securities in which the maturity of the long-term debt instrument is twice that of the short-term debt instrument. Second, I consider the ability of the spread between the overnight rate and the one-month rate to predict future changes in the overnight rate.

Let $r(1)_t$ be the yield on a one-period bond, and let $r(2)_t$ be the yield on a two-period bond. Then, the expectations hypothesis implies that

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2. In addition, in a separate appendix written after the conference, I provide a formal model of the propagation of changes in the federal funds rate out the yield curve in order to address some of the comments and questions that were generated by the results in RRW and several of the other conference papers.

(1) $r(2)_t = 1/2[r(1)_t + E_t r(1)_{t+1}] + \tau;$

that is, the current two-period yield equals the average of the actual and expected one-period yields in sequence plus a term premium τ. Assuming rational expectations,

(2) $r(1)_{t+1} = E_t r(1)_{t+1} + u_{t+1}$,

where u_{t+1} is a forecast error orthogonal to information available at time t. Substituting (2) into (1) and rearranging provides a simple testable equation of the REH of the term structure:[3]

(3) $1/2[r(1)_{t+1} - r(1)_t] = \alpha + \beta[r(2)_t - r(1)_t] + \varepsilon_{t+1}$.

Under the REH null hypothesis, $\beta = 1$ and $\alpha = -\tau$; that is, after taking expectations of both sides of (3), one-half the optimal forecast of the change in the short rate should equal the spread between the long rate and short rate (minus a term premium). In addition, the error term is orthogonal to the right-hand side regressors, so ordinary least squares provides consistent coefficient estimates.

Studies that have tested the REH using equation 3 have obtained a wide variety of estimates of β. These $\hat{\beta}$'s are often significantly less than one; of particular note, however, is the dependence of the estimates on the maturity of the debt instruments being examined. Figure 1 provides estimates of β from eight studies prior to RRW that use data on yields of U.S. Treasury debt. The point estimates are arrayed as a function of the short (one-period) bond maturity, which ranges from two weeks to five years.[4] Each observation is numbered according to its source. For example, the "1"'s in figure 1 are taken from Campbell and Shiller (1991), who

3. This corresponds to equation 4 in RRW with n = 2m.

4. For example, the $\hat{\beta}$'s shown at the three-month maturity are obtained from a regression of the change in the yield of the three-month bill on the yield spread between the six-month and three-month bills. Although equation (3) is a convenient form for expressing results across a range of maturities, it does not describe the frequency of observation. Typically, empirical studies have used overlapping observations that are more frequent than those separated by the maturity of the short bond.

provide a careful, exhaustive study spanning a large range of maturities. Based on this collection of point estimates from previous researchers, the shaded band in figure 1 provides an informal summary of the relationship between the $\hat{\beta}$'s and the maturity of the short bond. Apparently, the forecast power of the term structure for changes in short rates is quite high for forecast horizons (i.e., shorter bond maturities) no longer than one month. As the horizon increases, forecast power initially disappears, as estimates of β fall essentially to zero over the range from three months to one year; however, with horizons longer than one year, forecast power starts to improve. The result is, according to Campbell and Shiller (1991), a "U-shaped" pattern of coefficients.

The evidence of RRW is consistent with this U-shaped pattern[5] for the short maturities that they investigate. For example, in their table 8, based on the spread between 3-month and 6-month Treasury bills, the estimates of β are not significantly different from zero. Also, based on the spread between the 30-day and 60-day term federal funds rates, RRW (table 6) report estimates of β equal to about 0.6 at the one-month horizon. Again, the predictive content of the yield curve, while substantial at very short maturities, appears to vanish at a forecast horizon of about three months.

RRW also analyze the forecasting ability of yield spreads that involve the overnight federal funds rate. As above, the basic insight of the REH is that if the yield curve is steeply sloped, future short rates should on average be above the current short rate. Let the length of a period be a day, so $r(1)_t$ is the overnight federal funds rate and $r(30)_t$ is the yield on a 30-day bill; then the expectations hypothesis implies that

$$(4) \qquad r(30)_t = 1/30[r(1)_t + E_t \sum_{i=1}^{29} r(1)_{t+i}] + \tau.$$

Assuming rational expectations, the analog to equation 3 is

5. Or, in their words, consistent with this "hole in the ozone layer," a metaphor that carries the gratuitous connotation of welfare loss.

$$(5)\qquad 1/30[\sum_{i=0}^{29} r(1)_{t+i}] - r(1)_t = \alpha + \beta[r(30)_t - r(1)_t] + \sum_{i=1}^{29} \varepsilon_{t+i}.$$

Under the REH null hypothesis, $\beta = 1$; that is, the deviation of today's federal funds rate from its expected average level over the next month should equal the spread between the current 30-day and one-day rates (minus a term premium). RRW find $\hat{\beta}$ to be fairly close to one. In their table 6, for example, using term federal funds data, they estimate β to be around 0.7. This high predictive power at short horizons generalizes to spreads between the overnight rate and the 60-day and 180-day bill yields and is broadly consistent with earlier work by Simon (1990).

In summary, I characterize the evidence on the forecasting ability of the yield spread with four propositions:[6]

S1. Spreads between the overnight federal funds rate and one-month, two-month, and three-month yields are very good predictors of the change from the current daily rate to the average daily rate that prevails over the relevant time period.

S2. Spreads between short-term bills--for example, 30-day and 60-day Treasury bills--are good predictors of the change in the short bill yield.

S3. Spreads involving longer bill rates, say, the 3-month, 6-month, and 12-month yields, have essentially no predictive content for future changes in these bill rates.

S4. Spreads involving medium and long maturity bonds--specifically, for maturities longer than two years--do appear to have some predictive content for movements in future interest rates.

INTERPRETATION

Simply put, propositions S1 through S4 indicate that the yield curve is useful for forecasting future interest rates, but only at certain maturities. Recently, several authors have linked this finding to the behavior of the Federal Reserve.[7] Specifically, they have asserted that the procedure by which the Fed controls the federal

6. RRW provide evidence consistent with the first three of these propositions.

7. See Mankiw and Miron (1986), Cook and Hahn (1989, 1991), and Goodfriend (1991).

funds rate is responsible for the varying predictive power of the yield curve. This section clarifies and extends this argument.

First, it is useful to describe the attributes of the Fed's operating procedure that are crucial for understanding the above results regarding the yield curve. Although the Fed's operating procedure has changed greatly over the past two decades--from direct federal funds rate targeting in the 1970s to indirect targeting through reserves in the 1980s--following Cook (1989) and Goodfriend (1991), I take as given that over this period the Fed has always taken an active interest in controlling the federal funds rate. Although the exact mechanism has changed over time, the following three attributes have characterized the Fed's underlying procedure for controlling interest rates:

F1. Transitory deviations from target are allowed on a daily basis. That is, the federal funds rate is not pegged to a target on an hourly or even a daily basis. Indeed, the Fed generally enters the federal funds market only once each day, in the late morning; thus, the intraday spot federal funds rate can display wide fluctuations. Furthermore, historically there has often been a target band for the federal funds rate rather than a single target value; using a band also allows transitory deviations from a mean value (usually the target band midpoint).

F2. Targets are adjusted not continuously but in limited amounts at discrete intervals. Rather than immediately adjusting the target in response to each new piece of information, the Fed behaves as if it has a threshold whereby only after sufficient information has accumulated will a target change be triggered. Also, targets are usually adjusted by only 25 to 50 basis points at a time; thus, when new information requires a larger change, the Fed implements a series of smaller target adjustments that are separated by several days to a couple of weeks.

F3. Except when a quick succession of target changes is needed to make a large adjustment (as noted in F2), the target is set at a level the Fed expects to be able to maintain.

These three attributes are apparent in figure 2, which shows federal funds rate targets from an illustrative episode of direct interest rate targeting. The targets are shown as a solid line; the actual daily effective federal funds rate appears as a dashed line.[8] Attribute F1 is apparent in the large but temporary deviations of the daily rate from the target. F2 is reflected in the "step-function" appearance of the target. Finally, the infrequent occurrence of target changes, shown by long steps or treads of many months duration, provides support for F3.

The three attributes of the Fed's "interest rate smoothing" operating procedure can explain the term structure results S1 through S3. First, the transitory daily deviations described by F1, coupled with the target persistence of F3, imply substantial predictable variation in the overnight rate. If today's rate is unusually high, perhaps because the day is a settlement Wednesday with strong reserve pressures, tomorrow's rate (and future daily rates) will likely return to the target level. This occurrence explains why the spread between the 30-day term federal funds rate (which should be close to the current target rate) and the 1-day rate (which is transitorily high) moves with the spread between the average 1-day rate that will prevail over the next month (which is also close to the target rate) and the current 1-day rate. RRW provide confirming evidence for this interpretation: Their table 3 indicates that large changes on Wednesdays tend to be reversed on Thursdays, and their tables 9 and 10 indicate that S1 holds best for these volatile settlement Wednesdays.[9]

The predictive information described by S2, which is available at the very short end of the term structure, can be explained by the discrete nature of policy changes, attribute F2. Let us suppose that a significant piece of new information arrives--say, in the form of news about some macroeconomic variable--that clearly requires a major policy change. If the Fed accomplishes this policy change by a series of moderate target adjustments conducted, say, over a three-week span, then the gap between the time that new information influencing policy was released and the time that the full policy action is finished generates predictable

8. The target series was obtained by linking the expected federal funds rates given in the Federal Reserve Bank of New York's weekly "Report of Open Market Operations and Money Market Conditions" during the period.

9. Cook and Hahn (1989, footnote 6) also describe similar evidence.

changes in interest rates at horizons of less than one month.[10]

The lack of predictive information in the 3-month to 1-year maturity range of the term structure, noted in S3, reflects attribute F3. As Mankiw and Miron (1986) argued, if market participants (rationally) expect the Fed to maintain the current federal funds rate target, then current spreads will have no predictive power for actual future changes in interest rates.[11]

Thus, attributes F1 through F3 of the Fed's operating procedure appear to be responsible for yield spread results S1 through S3. Further support for the reasoning linking F2 with S2 and F3 with S3 is provided by the analysis of Cook and Hahn (1989). They found that the 3-month, 6-month, and 12-month bill rates all moved on average about 50 basis points in response to a change of 1 percentage point in the federal funds rate target during 1974-79. That bill rates move by only about half of the target change suggests that target changes are forecastable to some extent (as implied by F2). However, that all three bill rates move by about the same amount means that new information about the federal funds target has little effect on the slope of the yield curve from 3 months to 12 months. This finding confirms the notion that the new federal funds rate target is expected to be maintained over that period.

Finally, for completeness, let me examine S4, the proposition that spreads between long rates contain forecasting power. Since Fama and Bliss (1987), this proposition has been reduced to the issue of whether interest rates display a slow

10. Cook and Hahn (1990) stress a different, but related, aspect of F2 as an explanation of S2. They note that the information threshold required for a target change implies that news that suggests an imminent policy action is often available to the market. For example, if weak employment data that suggest the need for a policy easing are released, the Fed may wait a week for another reading on inflation before acting. This gap could also generate predictable target changes over a very short period.

11. Cook and Hahn (1989) show that this same reasoning holds if the funds target is expected to change in the near future (consistent with A2) and then to persist at its new level. Strictly speaking, if one assumes a constant term premium along with the persistence of targets, the spread would be constant and the standard error of $\hat{\beta}$ would be infinite. However, as shown in Mankiw and Miron (1986), with a time-varying term premium, the $\hat{\beta}$ is biased toward zero.

reversion to mean at long horizons. The subsequent debate is summarized in Shea (1992). My own view on such issues, expressed in Rudebusch (1992, 1993), is that conclusions about the stationarity or nonstationarity of yields are very tenuous given the size of the available samples. However, although such deep conclusions cannot be made with any degree of certainty, at a practical level, S4 probably reflects the fact that over the sample period under consideration, markets have correctly anticipated that the Fed would be able to restrain inflation to moderate levels at business-cycle frequencies.[12] Coupled with a stationary real rate, the Fed's containment of inflation has probably generated the predictive power contained in long-maturity nominal interest rate spreads.

CONCLUSION

The explanation that RRW propose for linking Fed operating procedure to the empirical results on the predictive power of the term structure hinges on the Fed's elimination of seasonal fluctuations in interest rates, which would be predictable and which presumably would be reflected in spreads (see Hardouvelis (1988)). This interpretation appears flawed. The Fed's elimination of weekly, monthly, quarterly, and half-yearly seasonals would imply that figure 1 was a step function, displaying no predictive power up to six months and significant predictive power from twelve months and beyond. This implication does not accord with the U-shaped curve from the empirical evidence.

Instead, I have provided an interpretation of the term structure results that relies on characteristics of the Fed's interest rate targeting operating procedure. A consideration of the normative value of this procedure would also be of interest. Goodfriend (1991) conjectures that the smoothing characteristics of the operating procedure facilitate the communication of Fed intentions to financial markets. Further research on this issue would be illuminating.

12. Again, the evidence in Cook and Hahn (1989) is instructive. They find that the 20-year bond yield responds by only about 10 basis points to a 1 percentage point change in the federal funds target. This is consistent with slow mean reversion at long horizons.

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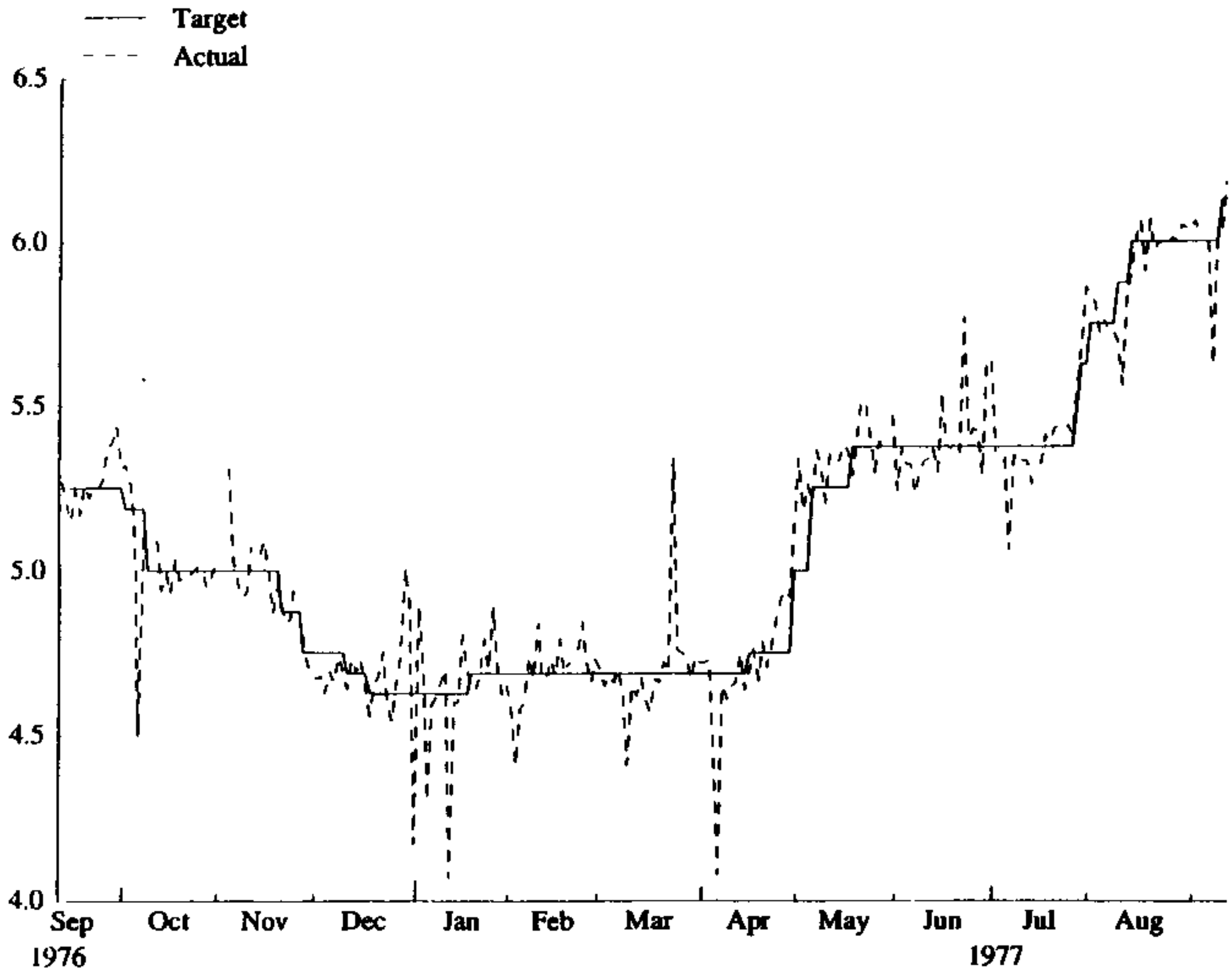
Figure 2
Federal Funds Rate



APPENDIX

PROPAGATION OF FEDERAL FUNDS RATE CHANGES TO LONGER-TERM RATES UNDER ALTERNATIVE POLICY REGIMES

Glenn D. Rudebusch[1]

My comments above on Roberds, Runkle, and Whiteman (1992, henceforth RRW) focused on the relationship between FOMC operating procedures and the amount of information in the yield curve for forecasting future changes in short rates. However, several papers at the conference, including RRW, touched on the general issue of the propagation of changes in the short rate out the yield curve: most notably, Gagnon and Tryon (1992), Goodfriend (1992), Hess, Small, Brayton (1992), and Kasman (1992). Discussions both at the conference and subsequently tried to discern from this array of evidence whether adopting an alternative operating procedure that changed the variability of the funds rate might also affect the variability of long rates. In this appendix, I develop a model that links movements in long rates to policy and non-policy federal funds rate shocks in order to interpret some of the findings in earlier papers.

In particular, my analysis clarifies the information content of RRW's evidence on the nature of the linkage between short and long rates. I show that the degree to which changes in the funds rate are transmitted to changes in long rates is unrelated to the predictive power of the yield spread. The model also provides a clear interpretation of changes in measures of interest rate volatility and correlation. Such changes are evident in the narrative history of Goodfriend (1992) as well as in the earlier evidence of Johnson (1981).

A MODEL OF SHORT AND LONG RATES

This section describes a simple theoretical structure that links Federal Reserve actions to movements in the funds rate and in longer rates. There are two crucial elements of the model: First,

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from equation 1. Substituting the first result into the second and taking expectations yields[4]

$$E_t r_{t+k} = E_t(\bar{r}_t + \sum_{i=1}^{k} u_{t+i} + \varepsilon_{t+k})$$

$$= \bar{r}_t. \tag{4}$$

That is, the expected funds rate at any point in the future is equal to today's target. This result can be used in equation 3 to solve for the current long rate

$$R_t = (1/\tau)\bar{r}_t + (1/\tau)\varepsilon_t + (1/\tau)\sum_{i=1}^{\tau-1}\bar{r}_t + \theta_t$$

$$= \bar{r}_t + (1/\tau)\varepsilon_t + \theta_t. \tag{5}$$

The current long rate is thus equal to the current target plus a small fraction $1/\tau$ of the current transitory funds rate shock plus a term premium.

To express the long rate in terms of the shocks affecting the short rate, equation 5 can be rewritten as

$$R_t = \bar{r}_{t-1} + u_t + (1/\tau)\varepsilon_t + \theta_t.$$

It is the policy shocks (u_t) affecting r_t that will be reflected in R_t because the term $(1/\tau)\varepsilon_t$ is negligible and the term premium θ_t is unrelated to r_t. Accordingly, the amount of short-rate variation that is transmitted to the long rate will depend crucially on the size of σ_u^2.

4. This expression assumes that financial market participants can discern the current target rate on any given day; that is, they know ε_t and u_t at time t. Thus, in this model, there is no avenue for misperceptions of monetary policy, arising, say, from the adoption of new operating procedures, to affect the relationship between the funds rate and longer rates. A useful extension to the model would be to re-examine the results assuming market participants had difficulty distinguishing transitory daily fluctuations in the funds rate from true policy shifts.

INTERPRETING RRW'S HISTORICAL EVIDENCE

The results of RRW indicated a clear difference across the pre-1979 and the 1979-1982 periods in the ability of the bill-funds yield spread to predict future changes in the funds rate. Their historical evidence was obtained by regressing actual changes in future short rates on the current spread between the funds rate and longer rates. In terms of the model outlined above, RRW's key regression can be obtained by subtracting r_t from both sides of (3), which after rearrangement gives

$$(6) \qquad (1/\tau)\sum_{i=1}^{\tau-1} E_t r_{t+i} - ((\tau-1)/\tau)r_t = (R_t - r_t) - \theta_t.$$

Under the assumption of rational expectations,

$$(7) \qquad E_t r_{t+i} = r_{t+i} + v_{t+i},$$

where v_{t+i} is a forecast error orthogonal to information at time t. Then (6) can be rewritten as the regression[5]

$$(8) \qquad (1/\tau)\sum_{i=1}^{\tau-1} r_{t+i} - ((\tau-1)/\tau)r_t = \beta(R_t - r_t) + e_t.$$

The dependent variable on the left-hand side requires the construction of $(1/\tau)\sum_{i=1}^{\tau-1} r_{t+i}$, which is simply the average of funds rates observed after time t, and the use of (7) implies that β equals one.

The regression error, $e_t = -\theta_t - \sum_{i=1}^{\tau-1} v_{t+i}$, is correlated with R_t through the common term premium but is not correlated with r_t. Because of the correlation between the regression error and the regressor, the OLS estimate of β, denoted $\hat{\beta}$, will be biased downward from one. Still, the size of $\hat{\beta}$ has been interpreted, as in RRW, as measuring the ability of long rates to forecast future movements in short rates.

Given the model for the funds rate, the value of $\hat{\beta}$ (in the population) can be easily determined. By definition,

5. This regression is essentially equation 4 in RRW.

$$\hat{\beta} = \mathrm{Cov}[(1/\tau)\sum_{i=1}^{\tau-1} r_{t+i} - ((\tau-1)/\tau)r_t,\ R_t - r_t]/\mathrm{Var}(R_t - r_t).$$

The numerator of this term can be rewritten as

$$\mathrm{Cov}[(1/\tau)\sum_{i=1}^{\tau-1}(\sum_{k=1}^{i} u_{t+i} + \varepsilon_{t+i}) - ((\tau-1)/\tau)\varepsilon_t,\ \theta_t - ((\tau-1)/\tau)\varepsilon_t]$$

$$= ((\tau-1)/\tau)^2\sigma_\varepsilon^2,$$

while the denominator can be rewritten as

$$\mathrm{Var}[\bar{r}_t + (1/\tau)\varepsilon_t + \theta_t - \bar{r}_t - \varepsilon_t] = \sigma_\theta^2 - ((\tau-1)/\tau)^2\sigma_\varepsilon^2.$$

Thus, the population value of $\hat{\beta}$ is given by

$$\mathrm{plim}\ \hat{\beta} = ((\tau-1)/\tau)^2\sigma_\varepsilon^2/[\sigma_\theta^2 - ((\tau-1)/\tau)^2\sigma_\varepsilon^2].$$

$$(9) \qquad = 1\ /\ [\lambda(\tau/(\tau-1))^2 - 1],$$

where $\lambda \equiv \sigma_\theta^2/\sigma_\varepsilon^2$, the ratio of the variance of the term premium to the variance of the transitory shock.

As can be seen from (9), the estimate of β varies inversely with λ. Thus, increases in σ_ε^2 are reflected in a higher $\hat{\beta}$. Intuitively, increased transitory deviations of today's funds rate from the target provide more predictable future variation in the funds rate because today's deviation will be eliminated, on average, the next day through reversion to target. This predictable future reversion to target is incorporated in the long rate, which boosts the value of $\hat{\beta}$. In contrast, increases in σ_θ^2 simply increase the noise in the long rate and lower $\hat{\beta}$. Most importantly, however, the crucial feature of (9) to note is that $\hat{\beta}$ does not depend on the variance of the policy shocks (σ_u^2). Intuitively, this results because such shocks do not affect either side of the regression (8): the shocks are reflected completely in both r_t and R_t and so do not change the yield spread, and they are permanent and so do not show up in the difference between future and current funds rates. Thus, evidence on the size of $\hat{\beta}$ places no restriction on the size of policy shocks to the funds rate and hence has nothing to say about the extent to which the variability of the funds rate is reflected in long rates.

The actual estimates of β from RRW during the 1975-1979 and 1979-1982 periods (with standard errors in parentheses) are[6]

$$\text{(Fact 1)} \qquad \hat{\beta}^{*} = \underset{(.21)}{0.04} \qquad \text{and} \qquad \hat{\beta}^{**} = \underset{(.25)}{1.21}\,.$$

where a single asterisk denotes the period before October 1979 and a double asterisk denotes the 1979-1982 period. The finding that $\hat{\beta}^{*}$ is less than $\hat{\beta}^{**}$ implies that in terms of the model variances

$$(10) \qquad \lambda^{*} > \lambda^{**} \qquad \text{(that is, } \sigma_{\theta}^{2*}/\sigma_{\varepsilon}^{2*} > \sigma_{\theta}^{2**}/\sigma_{\varepsilon}^{2**}\text{)}.$$

As we shall see below this evidence places no restriction on the volatility of long rates or on the correlation of movements in the long rates with movements in the funds rate.

INTERPRETING JOHNSON'S HISTORICAL EVIDENCE

In this section, I use the model of the funds rate (equations 1 and 2) and of the long rate (equation 5) to analyze the historical evidence provided in Johnson (1981) regarding changes in the behavior of interest rates after 1979. In particular, the next two subsections focus, in turn, on changes in (1) the volatility of the funds rate and longer-term rates and (2) the correlations between movements in the funds rate and in longer rates.

The Volatility of the Funds Rate and Longer-Term Rates

First, let us compute the volatility of the funds rate and of the long rate in terms of the parameters of the model. The variance of the change in the funds rate, denoted $\Delta r_t = r_t - r_{t-1}$, is given by

$$\begin{aligned}\sigma_{\Delta r}^{2} &\equiv \mathrm{Var}(\Delta r_t) \\ &= \mathrm{Var}(\bar{r}_t - \bar{r}_{t-1} + \varepsilon_t - \varepsilon_{t-1}) \\ &= \mathrm{Var}(u_t + \varepsilon_t - \varepsilon_{t-1})\end{aligned}$$

6. These estimates are based on the spread between the three-month Treasury bill and the funds rate and are taken from table 8 in RRW.

$$(11) \qquad = \sigma_u^2 + 2\sigma_\varepsilon^2.$$

Similarly, the variance of the change in the long rate is given by

$$\sigma_{\Delta R}^2 \equiv \mathrm{Var}(\Delta R_t)$$

$$= \mathrm{Var}[\tilde{r}_t - \tilde{r}_{t-1} + (1/\tau)(\varepsilon_t - \varepsilon_{t-1}) + \theta_t - \theta_{t-1}]$$

$$(12) \qquad = \sigma_u^2 + 2(1/\tau)^2\sigma_\varepsilon^2 + 2\sigma_\theta^2.$$

Thus, the volatility of the *funds rate* depends on both the variance of the permanent policy shock, σ_u^2, and the variance of the temporary shock, σ_ε^2. The volatility of the *long rate* depends primarily on the variance of permanent policy shocks and the variance of the term premium, σ_θ^2; the variance of the transitory shock is negligible because its weight, $2(1/\tau)^2$, is so small.

The historical standard deviations of changes in the funds rate and in a variety of longer rates during the 1975-1979 and 1979-1982 periods are shown in table 1.[7] Clearly, the volatility of all rates increased in the later period. Label this result as "fact 2"; that is,

$$\text{(Fact 2)} \qquad \sigma_{\Delta r}^{2*} < \sigma_{\Delta r}^{2**} \qquad \text{and} \qquad \sigma_{\Delta R}^{2*} < \sigma_{\Delta R}^{2**} ,$$

where again a single asterisk denotes the period before October 1979 and two asterisks denote the 1979-1982 period.

The historical evidence on volatility expressed by fact 2 could be reconciled with equations 11 and 12 in a number of ways. A plausible set of assumptions about the variances of the model's shocks that could explain fact 2 are:

$$(13) \qquad \sigma_\varepsilon^{2*} < \sigma_\varepsilon^{2**},$$

$$(14) \qquad \sigma_u^{2*} < \sigma_u^{2**},$$

$$(15) \qquad \sigma_\theta^{2*} < \sigma_\theta^{2**}.$$

7. This table extends some of the results in tables 4 and 9 of Johnson (1981) to daily data and a larger post-1979 sample.

Inequality 13 implies that the Federal Reserve allowed much larger temporary deviations from its implicit target rate in the 1979-1982 period than before. Inequality 14 implies that the Federal Reserve was much more aggressive in moving the target rate in the later period than before. The larger policy shocks reflected, in part the new emphasis on movements in M1 underlying Federal Reserve policy actions.[8] Finally, inequality 15 implies that the variance of the term premium also increased after 1979, which is consistent with the increase in interest rate risk implicit in fact 1.[9]

Thus, the greater volatility of the funds rate in the 1979-1982 period reflects both the looser control by the Federal Reserve over day-to-day movements in the funds rate (inequality 13) as well as larger permanent policy shifts (inequality 14). The greater volatility of longer rates reflects the greater policy shocks as well as the increase in the volatility of the term premium.

The Correlation of Movements in the Funds Rate and Longer Rates

How does the correlation between changes in the funds rate and the long rate depend on the model parameters? This correlation is given by[10]

$$\begin{aligned}\rho &\equiv \mathrm{Corr}(\Delta r_t, \Delta R_t) \\ &= \mathrm{Cov}(\Delta r_t, \Delta R_t)/\sqrt{\mathrm{Var}(\Delta R_t)\mathrm{Var}(\Delta r_t)} \\ &= (\kappa + 2/\tau)/\sqrt{(\kappa + 2)(\kappa + 2\lambda + 2/\tau^2)}\ . \qquad (16)\end{aligned}$$

here $\kappa \equiv \sigma_u^2/\sigma_\varepsilon^2$, the ratio of the variances of the policy and transitory shocks, and where, as before, $\lambda \equiv \sigma_\theta^2/\sigma_\varepsilon^2$. The correlation

8. Both (13) and (14) are consistent with evidence presented in Balduzzi, Bertola, and Foresi (1992).

9. Inequality 15 is consistent with the evidence in Cook and Hahn (1990); the various proxies for the (ex ante) term premium that they display show a clear increase in volatility during the 1979-1982 period.

10. Note that the covariance of the two rate changes is given by

$$\begin{aligned}\mathrm{Cov}(\Delta r_t, \Delta R_t) &= E_t[(\Delta r_t)(\Delta R_t)] \\ &= E_t[(u_t+\varepsilon_t-\varepsilon_{t-1})(u_t+(1/\tau)(\varepsilon_t-\varepsilon_{t-1})+\theta_t-\theta_{t-1})] \\ &= \sigma_u^2 + (2/\tau)\sigma_\varepsilon^2.\end{aligned}$$

ρ depends positively on κ: increases in σ_u^2 increase the covariance of Δr and ΔR proportionately more than their variances and hence boost ρ, while increases in σ_ε^2 increase the variances more than the covariance and hence diminish ρ. Intuitively, the long and short rates will be more closely correlated when the shocks that drive them both (the permanent u_t policy shocks to $\bar{r}_t$) are more important than the shocks that essentially drive only the short rate (the ε_t shocks of r_t about $\bar{r}_t$). The correlation also depends negatively on λ because increases in the variability of the term premium (relative to σ_ε^2) simply add noise to the long rate and leave the short rate unaffected.

The actual correlations of changes in the funds rate with a variety of longer rates are shown in table 2.[11] The correlations during the 1975-1979 period, ρ^*, are shown in the first column; the correlations during the 1979-1982 period, ρ^{**}, are shown in the second column. The correlations are all higher in the later period; that is,

(Fact 3) $\quad \rho^* < \rho^{**}$.

In terms of the model variances, fact 3 implies that

$$\kappa^* < \kappa^{**} \qquad (\text{that is, } \sigma_u^{2*}/\sigma_\varepsilon^{2*} < \sigma_u^{2**}/\sigma_\varepsilon^{2**}),$$

or

$$\lambda^* > \lambda^{**} \qquad (\text{that is, } \sigma_\theta^{2*}/\sigma_\varepsilon^{2*} > \sigma_\theta^{2**}/\sigma_\varepsilon^{2**}),$$

or, most likely, both.[12]

11. This extends some of the results in tables 10 through 13 in Johnson (1981) to daily data and a larger post-1979 sample.

12. One factor that has been ignored is duration (see Goodfriend, 1992). The results in table 2 at maturities greater than one year are obtained from *coupon* securities, while the model considers only *zero-coupon* securities. The yield on a coupon security would move a bit more in response to a transitory shock than the yield on a zero-coupon security, and the correlation between the funds rate and the bond rate would be slightly higher.

CONCLUSION

The change in Federal Reserve operating procedures in October 1979 ushered in, as had been expected, an era of increased funds rate volatility. At the time, many were surprised by how variable longer rates also became. In assessing whether a change in operating procedures will increase the variability of long rates, the key insight from the above model is that one must focus on the permanent policy shocks. Such a narrow focus is not surprising because only the long-lived shocks to the short rate will affect long rates under the rational expectations hypothesis of the term structure. Accordingly, whether future changes in the procedures governing the behavior of the funds rate will affect long rates depends in large part on whether the associated re-specified reaction function for policy has been linked to variables that are subject to more permanent shocks. More generally, in a world where the rational expectations hypothesis of the term structure may not hold, the variability of long rates depends on what market participants *believe* about changes in the size of the permanent shocks.

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Table 1

Standard Deviations of Changes in Federal Funds Rates
and in Rates on Various Treasury Securities
(Daily data; percentage points)

Type of security	Sample period 75-79	79-82
Federal funds	.32	.96
3-month bill	.09	.34
6-month bill	.07	.31
1-year bill	.08	.27
3-year note	.06	.21
5-year note	.05	.19
10-year note	.04	.17
20-year bond	.03	.16

The sample period "75-79" includes data from January 6, 1975 through September 28, 1979; the sample period "79-82" includes data from October 15, 1979 through October 1, 1982.

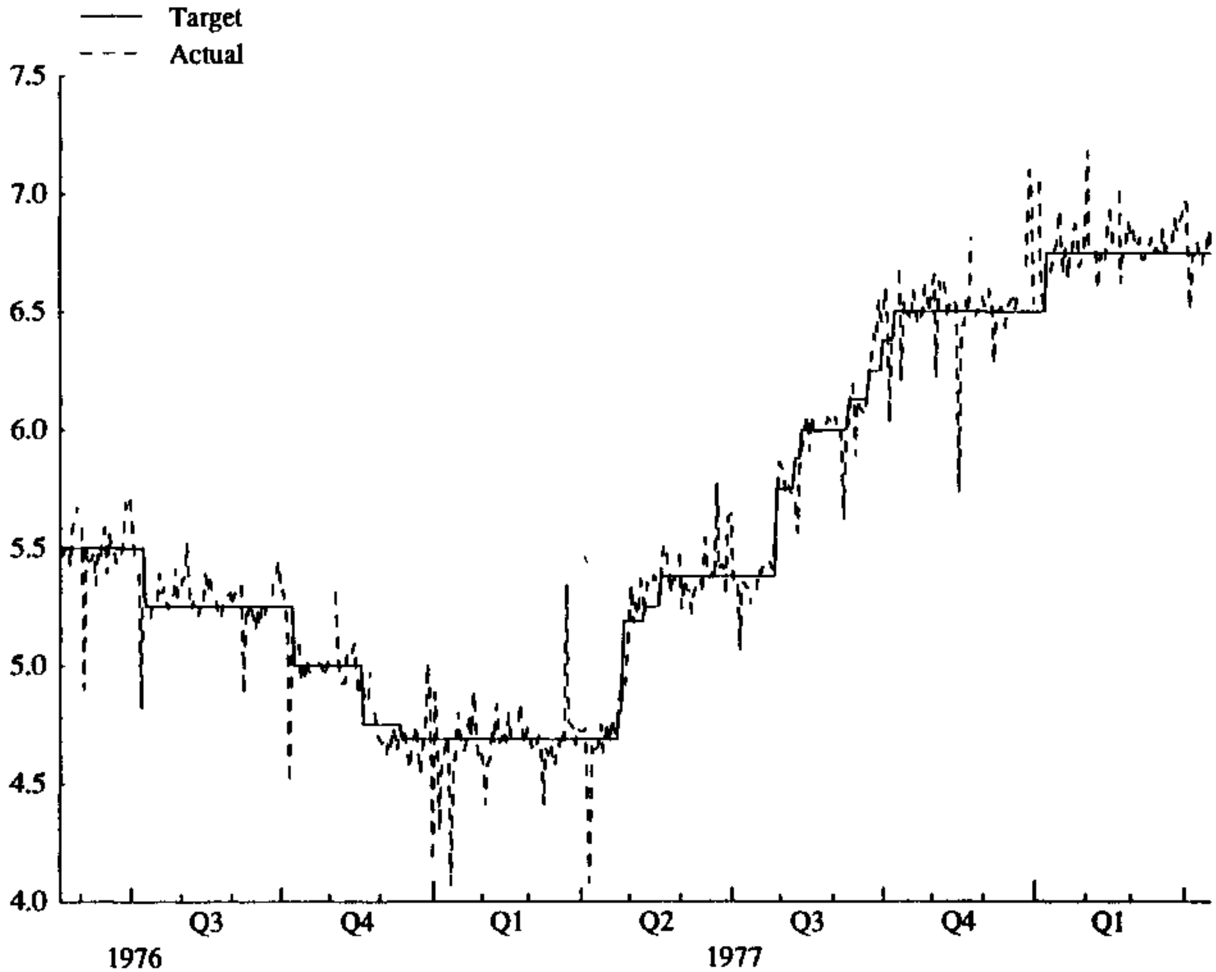
Table 2

Correlations of Changes in the Funds Rate with
Changes in Rates on Various Treasury Securities
(Daily data)

Type of security	Sample period 75-79	79-82
3-month bill	.07	.21
6-month bill	.05	.22
1-year bill	.10	.20
3-year note	.06	.19
5-year note	.05	.16
10-year note	.04	.15
20-year bond	.02	.15

The sample periods are the same as in table 1.

Figure 1
Federal Funds Rate



A POLICYMAKER'S GUIDE TO INDICATORS OF ECONOMIC ACTIVITY

Charles Evans, Steven Strongin, and Francesca Eugeni

The evaluation of economic indicators has often progressed with an odd independence for the way in which such indicators are actually used in practice in the economic policy process. The search is often for one "best" indicator, where "best" typically refers to winning in some narrowly defined contest of general purpose forecasting ability measured over some pre-selected time-span. The actuality of the policy process is far richer. Indicators are used in a kind of chaotic democracy, each indicator casting a vote based on its own forecast and the policymakers weighing each vote, based on their assessment of the current credibility of the indicator.

This is quite different from the standard academic formulation of economic policy where a "true" model is developed and then policy run in a way optimizes the performance of the model. Understanding this difference in approach leads to very different ways of evaluating indicators. It is not just enough to produce a "best" model; rather, it is important to understand what type of information is contained in a given indicator so that its message can be properly evaluated and also how much weight to give that message given what else is also known.

Indicators, like people, perform better or worse depending on the context in which they operate. Efficient usage requires matching indicators both with appropriate questions and with other complementary indicators. For instance, some indicators do far better at predicting short-run changes in activity, but do not do very well at pinning down the level of activity over longer time spans, while other indicators forecast short-run phenomena poorly, but do better at predicting average activity over longer time span. Also while some indicators have very close substitutes, such as the twenty or so short-term interest rates sometimes used in econometric studies, and thus provide little additional information beyond that already contained in other indicators, some indicators can provide substantial additional information, thus providing important confirming or contradicting information. The policymaker needs to know how to match questions with indicators depending on the current policy context. A swiss army knife is a fine general purpose tool, but it is hardly a substitute for a well-equipped workshop.

This paper seeks to develop and implement a set of techniques for evaluating indicators of economic activity that more closely match the actual use of such indicators in the day-to-day policy process. We see that process as primarily involving the re-assessment of short- to medium-term economic activity based on indicator by indicator analysis with the primary decision matrix being whether it is necessary to ease or tighten policy in order to realize appropriate levels of economic activity. We do not address the longer run issues of assessing appropriate levels of economic activity or other issues involving inflation or the value of the dollar nor do we address the question of how best to implements those decisions. Evaluating indicators in this context has four primary parts; ranking candidate indicators, characterizing the nature of the information in those indicators, assessing their usefulness in practice and determining what relative weight should be given to each indicator. The idea is to develop the information that a policymaker needs in order to interpret information as it comes in and to choose which indicators to watch depending on the questions being asked.

As policymakers typically use indicators one at a time, all of our analysis will be carried out on a bivariate basis. Multivariate regression models allow indicators to play off against one another so that if two indicators hold both common and independent information better statistical fits can usually be obtained by fitting one multivariate model rather than mixing 2 bivariate models. The advantage of using the mixing approach is that when one of the indicators begins to misbehave, which they do, you can, at least temporarily, just ignore that indicator. Second, by only using the primary information over-fitting is less of a worry. Third and most important, the mixing approach allows a much more precise assessment of exactly the type of information is contained in each indicator and thus allows policymakers to reoptimize their choice of indicator sets based on the type of question being asked.

Beyond the focus on bivariate models, there are a number of other differences between our work and normal econometric practice that are worth noting. First, as will be shown in the paper different indicators are useful at different forecast horizons, so that we will not be suggesting one best model, but rather we will be suggesting ways of combining indicators depending on the precise policy question being asked. Second, along these same lines as we are more concerned with the interpretation of each of the individual indicators rather than the construction of a structural model of the economy, we will pay much more attention to characterizing the type of information in each individual indicator than is normally the case. Also, since the forecasts derived from the indicators typically get averaged together either informally in the policymaker's mind or formally in the mixing models shown in the last section of this paper, we analyze the degree to which one indicator can be said to have information which is independent from another. Policymakers are often faced with a variety of indicators pointing one way and another group pointing a different way, in such cases it is not only useful to know what weight would have produced the best forecast historically, but the degree to which the indicators are independent bits of information or the same information being repeated over and over again in a variety of guises. Policymakers quite rightly give greater weight to information which they see as independent confirmation. It is useful in this light to more fully analysis the independence of information in various indicators. It is also helpful to know if the indicator in question usually contains the type of information being sought.

METHODOLOGY

As noted above, the primary focus of this paper is the examination of various data series as indicators of changes in real economic activity, which we measure alternately as annualized log change in real GDP, employment and industrial production. In most cases results are supplied for all three measures of economic activity.

The major focus will be on the forecasting real GDP, except in the sections of the paper which focus on issues of timing in which case employment will be used, since it is available at the monthly frequency allowing for more precise estimation of the pattern of impact over time.

Throughout the paper the indicators are used to produce forecasts of economic activity. The specific functional form of the forecasting equation is always the same. One year of data for the indicator and one year of lagged economic activity is included in the regression. Thus, the exercise is strictly equivalent to a bivariate VAR with one year of lags, 4 lags for the real GDP models and 12 lags for the employment and industrial production models. The models are estimated in log differences and rates of change are annualized. Interest rates and interest rate spreads are used in their level form. In many of the tables an additional forecast is provided with the label "NONE". In this case, the forecast is based solely on the past history of economic activity, a pure auto-regressive model with one year of lagged data. This pure auto-regressive forecast is referred to as the no-indicator forecast. When the horizon of forecast is varied, we simply change the dependent variable in the regression rather than dynamically iterate the one period ahead forecast. This optimizes the parameterization for the forecast horizon in question, rather than multiplicatively combining estimation errors forward. Symbolically the forecasting equation can be written:

$$Y_{t+k}-Y_t=A(L)\Delta Y_{t-1}+B(L)\ I_{t-1}+\omega_t$$

where Y_t it the log of economic activity at time t and I_t is the indicator at time t, k is the number of periods in the forecast horizon and A(L) and B(L) are polynomial in the lag operator L of order one year.

The indicators are split into four groups, which we call families. Each family is meant to represent a natural division of indicators into groups which are likely to share similar characteristics. For example, the first family we examine is interest rates, the second is money-based measures, the third is interest rate spreads and the fourth is composite indicators, such as the Department of Commerce Leading Indicators and the S&P 500. The fourth group also contains those series which do not fit neatly into the overall classification scheme.

The idea is to first examine the indicators within a family, finding out which indicators within each family produce the best forecasts and contain the most independent information and then taking these "best" indicators and examining what is to be gained by mixing the information from different families. This serves a number of purposes. First, by breaking the large list of potential indicators into smaller groups it makes each examination more manageable. Second, by using natural groupings it allows us to look at questions such as what is the best interest rate or the best money measure in a natural way. Third, one key issue for indicators is the degree to which they actually contain independent information. Focusing on groups which are already thought to have similar information provides a natural focus to learn if these preconceptions are accurate or if some of these groups contain more than one type of information. Lastly, by first selecting the best indicators at the family level and then mixing between families, we can produce a mixed forecast which, as noted above, closely approximates the way policy forecasting appears to be done in practice.

Each family of indicators is subjected to the same analysis. First, each family of indicators is described and a table is presented which lists the indicators examined and their means, standard deviations and their correlations with the measures of economic activity. Then each of the indicators is subjected to four evaluations, 1.) Classical goodness of fit rankings, 2.) Characterization of fit, 3.) Indicators performance in practice and 4.) Encompassing tests.

The classical goodness of fit rankings are based on simple full sample regressions estimated on data from the beginning of 1962 through the end of 1991. The results are presented in table two of each family analysis section. Table two shows the rankings for each indicators in the family based on the regression they produce. The idea is that the best indicators are the ones that produces the best fit where fit is measured by the R^2 of the regression or the standard deviation of the residual from the regression[1]. This closely approximates the oldest notions of evaluating the best indicators of economic activity for policy. It is also closely linked to the notion of Granger causality, which measures whether or not the indicators actually helps forecast economic activity. The p-value for this test is also included in the table.

The second evaluation seeks to characterize the type of information in the indicator. Typically the question can be thought of as if the indicator goes up today how does that change my expectations about economic activity in the future. This is analyzed by calculating the dynamic response path of employment for each of the indicator forecasting equations, which shows how a one standard deviation[2] increase in the indicator changes expectations about future growth rate of employment for each month for the next 36 months[3]. This allows us to characterize the information in the indicator based on how fast economic activity responds, how much it responds and how long the change in activity lasts. Figure 1 in each family section graphs the dynamic response path for each indicator in the family, as well as the 2 standard deviation bands on the estimates of the dynamic response paths to show the amount of uncertainty about the response path.

1. In the appendix tables which include sub-sample results are also presented.

2. The standard deviation measure used is the one from a bivariate VAR for the indicator and the measure of economic activity. this is used to approximate the average size of movement in the indicator series.

3. This is basically the same as an impulse response function except that the identifying assumption is not derived from a specific decomposition of the error matrix, but on the assumed path of the actual series, i.e. the indicator changes given the level of current activity. This is arithmetically equivalent to an impulse response function using a Choleski decomposition with the indicator ordered last.

Table 3 summarizes this information in terms of the maximum response for all three of the measures of economic activity, showing the timing, size and uncertainty of the maximum response of economic activity for each indicator in the family.

The third evaluation switches the focus to how well the indicators are likely to work in practice. To this end, goodness of fit is reinterpreted in a way closer to the way forecasts are actually used. First, table 4 shows the goodness of fit ranking recalculated for a series of forecast horizons, so that we can get a better feel for what these indicators are good at. First, the single period horizon used in the first evaluation and then a one-quarter horizon, a two-quarter horizon and a one-year horizon[4]. Table 5 in each section then repeats this analysis using forecasting equations which do not contain any prior information. Specifically, the forecasting equations are estimated sequentially using Kalman filtering techniques using only the sample information available prior to the period being forecast. This provides a more accurate assessment of how an indicator is likely to perform in practice. These forecasts are then ranked by the mean squared error (MSE) of the forecasts from 1972 onward. The R^2s are no longer well defined. This analysis is followed up by Figure 2 in each section which graphs the cumulative residuals for Kalman forecasts from 1972 onward. This allows us to examine if these forecasts tend to perform badly during recessions or if there was some particular point in the past where they did especially well or poorly. It also tells us if the forecasts have tended to miss in some systematic fashion over time. The residuals are measures as the actual growth in economic activity minus the forecasted growth. Thus, a downward trend in the cumulative residuals would indicate a prolonged period of over-

4. It should be noted that these are not iterated VAR forecasts, rather the forecast parameters are chosen to maximize performance at the forecast horizon specified. this can either be thought of as a state space estimation minimize the t+k forecast variance or as simple OLS with the dependent variable the t+k growth rate. This avoids any problem that might result from a indicator that performs poorly at high frequencies having that failure interfere with longer frequency forecasting.

predicting growth in activity.

The fourth evaluation switches the focus to independence of information. As noted above one of the most important factors to understand about indicators is whether of not they contain independent information relative to some other indicator. This allows a policymakers to assess whether a new piece of information actually contains any additional information or whether it is simply the same information with a different label. The way to evaluate this is through a set of techniques called encompassing tests. In the context of this paper, indicator A is said to *encompass* indicator B, if given the forecast implicit based on A there is no additional information in indicator B. Indicator A is said to *dominate* indicator B if A encompasses B and B does not encompass A. The simplest way to test this is to run a regression with economic activity as the dependent variable and the forecast of activity based on indicator A and the forecast of activity based on indicator B as the independent variables. Symbolically this can be written

$$\Delta GDP_t = \phi\, for(A)_t + (1-\phi)\, for(B)_t + \epsilon$$

Where $for(A)_t$ and $for(B)_t$ are the forecasts of GDP_t based on indicators A and B respectively and ϕ is relative weight OLS assigns to $for(A)_t$ and $for(B)_t$. If ϕ is significantly different from 0 then we can reject that for(A) is encompassed by for(B). Likewise if $1-\phi$ is significantly different from 0 then we can reject that *for*(B) is encompassed by *for*(A). If neither is encompassed then both indicators contain independent information and a better forecast can be obtained by mixing both sets of information with the relative weight given by ϕ. If only one is encompassed, then it is said to be dominated and only the other is necessary to produce an efficient forecast. If both are encompassed then either indicator alone can produce an efficient forecast, this occurs when there is a very high degree of collinearity and the standard error of the parameter estimate is large. In this case the indicator which has the best historical track record would likely be the superior choice. The generalization to longer horizons is straight forward, though the calculations of the standard errors is more complicated since the errors are no longer independent.

Table 6 in each family section contains the encompassing test. The table is read as follows. The indicators are listed both along the top and along the side. The numbers in the table refer to the test that the indicator listed along the side is encompassed by the indicator along the top. The test statistics are the significance levels for the test the indicator along the top does in fact contain all the information in the indicator along the side. For the sake of readability values below .05 are left blank.

The way to interpret these tables is that an indicator whose row is blank contains information that is independent of every other indicator in the family. An indictor whose column is full of high numbers is said to encompass those indicators. An indicator that did both would be said to dominate the family. In general, what we will search for is the set of indicators in each family which contain all the information in the family using as few indicators as possible. In general this will mean that the best variable from the previous tests will be included plus additional indicators which contain independent information i.e. the indicators that add the most. Formally this means that all indicators that are not encompassed by any other indicators in the family plus whatever additional indicators are necessary to fully encompasses or cover all the other indicators in the family. This is analogous to finding a set of minimum sufficient statistics.

The indicators that make it through this process will then be tested in the mixing model section of the paper in between-family encompassing tests, which examine whether or not there is independent information between families or not. Then a set of "best" indicators will be selected in order to develop a mixing models of indicators which contain independent information for each of the forecasting horizons. These models will contain estimates of the appropriate relative weights that should be applied to the individual indicator based forecasts. Completing the circle of policy forecasts, The mixing model will be time-varying to see if there is any gain from adjusting the weight applied to these individual forecasts based on recent performance.

INTEREST RATE LEVELS

Table 1.1 lists the nominal interest rates which were selected for investigation, along with some descriptive statistics. All of the rates are expressed at annual rates: the Federal Funds rate (FF), 3- and 6-month Treasury bill rates (TB03 and TB06), 1-, 3-, 5-, and 10-year constant maturity Treasury bond rates (CM01, CM03, CM05, and CM10), the 3-month Eurodollar rate (EUR03), the 6-month Commercial Paper rate (CP6), and the BAA bond rate (BAAS). Each of these interest rates is negatively correlated with the economic activity variables. The interest rates with the largest absolute correlation with real GDP are the Federal Funds rate, the 3-month Eurodollar rate, and the 6-month Commercial Paper rate.

Table 1.2 reports statistics for the one-period-ahead forecasting model. Notice that all of the interest rates provide significant predictive power for all three economic activities. The R^2 fall within fairly narrow bands indicating that the relative rankings are not particularly important--all of these indicators are useful at the one-month forecast horizon.

Figure 1.1 graphs the response of the employment growth forecast to a one-standard deviation change in information about last period's indicator. As with the F-tests in Table 1.2, the response paths are virtually identical across the interest rates considered: employment growth rises for three or four months and then falls, eventually asymptoting back to zero from below the axis. The confidence bounds on these responses are sufficiently wide that the initial response could be zero. For all of the interest rates, however, there is a point within the first year that employment growth is significantly negative: the largest such effects are for the 6-month Commercial Paper rate and the BAA bond rate. For all of the indicators across all of the activities, the maximum effect is negative and occurs within one year of the impulse.

Tables 1.4 and 1.5 rank the indicator forecasts for in-sample and out-of-sample forecasting behavior. Focusing on the out-of-sample results first, notice that for industrial production and employment at the one-month horizon, the no-indicator forecasts perform better than the interest rate forecasts. But for GDP all of the interest rate forecasts outperform the no-indicator forecasts at all horizons. Focusing on GDP, the Federal Funds rate is ranked first at the four-quarter growth horizon; but the 3-month Eurodollar rate is best at the one- and two-quarter horizons. The success of the Eurodollar rate is also evident for industrial production and employment at all horizons beyond one-month. The 6-month Commercial Paper rate improves in forecasting accuracy as the horizon increases; this is true for GDP, industrial production, and employment (placing no worse than third at the one-year horizon). In general, the shorter maturity bills perform better than the longer maturity bonds (3-, 5-, and 10-year Treasuries).

The in-sample results of Table 1.4 indicate that the Eurodollar rate increases in ranking due in part to its out-of-sample stability. In the out-of-sample rankings the Eurodollar rate is first for industrial production (3-, 6-, 12-months), employment (6- and 12-month), and GDP (one- and two-quarters). In 6 of these 7 instances, these represent an increase in ranking from the in-sample results. In contrast to this stability, the 6-month Commercial Paper rate does not fare as well. At the shorter forecast horizons, it goes from being ranked number 1 or 2 in-sample to either 6, 9, or 10 out-of-sample. For the industrial production and employment, the Federal Funds rate also experiences a substantial out-of-sample forecast deterioration at the shorter forecast horizons relative to the in-sample rankings.

The cumulated residuals from the Kalman forecasts in Figure 1.2 show that, overall, the indicators in our interest rate family consistently underforecasted real GDP between 1974 and 1982. The upward trend in the cumulated residuals during this period can be explained in part by an unprecedented increase in inflation, which caused interest rates to rise without the normally anticipated decline in output. On the other hand, between 1983 and 1989, the Federal Funds rate, the 6-month Commercial Paper rate, the Eurodollar rate, and all of the Treasury bill rates performed well, as shown by the flattening of their cumulated residuals slopes during this period. Between 1990 and 1991, however, the indicators performance deteriorated again, as all of the interest rates missed the 1990-91 recession and consistently overforecasted real GDP.

Table 1.6 reports the encompassing results for GDP. The simplest case is for the 4-quarter horizon: the Federal Funds rate dominates the other interest rates since it is unencompassed and it encompasses all other interest rates at this horizon. At the one- and two-quarter horizons, however, this domination does not hold; none of the interest rates are unencompassed at these horizons. Since all of the interest rates Granger-cause economic activity in Table 1.2, it is probably not surprising that each of the interest rates contains useful forecasting information. For example, at the one-quarter horizon the Federal Funds rate, the 3-month Eurodollar rate and the 6-month Commercial Paper rate all can be said to encompass each other, i.e. if you know one interest rate based forecast knowing another is not much help. Since all of these interest rate forecasts are encompassed by at least one other interest rate forecast, the next criterion for selection is to determine if any one of the interest rate forecasts can cover all of the other interest rate forecasts. In fact, at the one-quarter horizon, the Federal Funds rate, the 3-month Eurodollar rate, and the 6-month Commercial Paper rate all cover every other interest rate. The 3-month Eurodollar rate covers the Federal Funds rate and the 6-month Commercial Paper rate with higher levels of significance, and since, as noted above, the 3-month Eurodollar rate was the number one ranked indicator in the out-of-sample forecasts of GDP at the one-quarter horizon, the 3-month Eurodollar rate is selected as the best interest rate level indicator at the one-quarter horizon. Similar reasoning leads to the selection of the 3-month Eurodollar rate for the two-quarter horizon.

TABLE 1.1 - DESCRIPTIVE STATISTICS

	MONTHLY (Jan 62 - Feb 92)				QUARTERLY (Jan 62 - Dec 91)		
			Correlation with				Correlation with
Indicator	Mean	Std. Dev.	Industrial Production	Employment	Mean	Std. Dev.	Real GDP
FF	7.352	3.345	-0.230	-0.245	7.370	3.304	-0.353
TB03	6.605	2.715	-0.190	-0.222	6.620	2.686	-0.299
TB06	6.761	2.647	-0.186	-0.219	6.777	2.622	-0.295
CM01	7.265	2.872	-0.173	-0.215	7.282	2.849	-0.282
CM03	7.597	2.746	-0.162	-0.226	7.608	2.737	-0.257
CM05	7.736	2.708	-0.161	-0.231	7.744	2.705	-0.251
CM10	7.866	2.674	-0.154	-0.231	7.869	2.678	-0.237
EURO3	8.033	3.282	-0.224	-0.254	8.055	3.232	-0.352
CP6	7.341	2.879	-0.223	-0.252	7.359	2.844	-0.342
BAA	9.588	3.108	-0.188	-0.286	9.590	3.120	-0.269

TABLE 1.2 - CLASSICAL GOODNESS-OF-FIT STATISTICS

	MONTHLY (Jan 62 - Feb 92) INDUSTRIAL PRODUCTION					MONTHLY (Jan 62 - Feb 92) EMPLOYMENT					QUARTERLY (Jan 62 - Dec 91) GDP				
Indicator	R2	Change in R2	SEE	P-Value	Rank	R2	Change in R2	SEE	P-Value	Rank	R2	Change in R2	SEE	P-Value	Rank
FF	0.259	0.063	8.965	0.0057	10	0.423	0.050	2.303	0.0052	6	0.338	0.220	3.148	0.0000	3
TB03	0.263	0.067	8.940	0.0030	8	0.426	0.053	2.297	0.0028	5	0.293	0.176	3.252	0.0001	6
TB06	0.271	0.076	8.887	0.0007	5	0.429	0.055	2.291	0.0015	3	0.304	0.186	3.227	0.0000	5
CM01	0.273	0.078	8.875	0.0005	4	0.428	0.054	2.294	0.0020	4	0.309	0.191	3.216	0.0000	4
CM03	0.265	0.069	8.930	0.0022	7	0.421	0.047	2.307	0.0080	7	0.279	0.161	3.285	0.0002	7
CM05	0.263	0.067	8.941	0.0030	9	0.419	0.046	2.310	0.0109	8	0.268	0.150	3.310	0.0003	8
CM10	0.265	0.070	8.925	0.0020	6	0.417	0.043	2.315	0.0171	10	0.253	0.136	3.343	0.0009	10
EURO3	0.276	0.081	8.859	0.0003	3	0.431	0.057	2.287	0.0010	2	0.354	0.236	3.110	0.0000	1
CP6	0.286	0.091	8.797	0.0001	1	0.438	0.065	2.273	0.0002	1	0.348	0.231	3.123	0.0000	2
BAA	0.283	0.087	8.818	0.0001	2	0.419	0.045	2.312	0.0124	9	0.258	0.140	3.333	0.0007	9

TABLE 1.3 - MAXIMUM IMPACT OF DYNAMIC MULTIPLIERS

	MONTHLY (Jan 62 - Feb 92) INDUSTRIAL PRODUCTION			MONTHLY (Jan 62 - Feb 92) EMPLOYMENT			QUARTERLY (Jan 62 - Dec 91) GDP		
Indicator	Months to Max	Max Impact	Std. Dev. at Max	Months to Max	Max Impact	Std. Dev. at Max	Quarters to Max	Max Impact	Std. Dev. at Max
FF	7	-1.349	0 454	10	-0.406	0.129	3	-1.442	0 307
TB03	5	-1.577	0 499	9	-0.335	0 135	3	-1.250	0 280
TB06	5	-1.610	0.496	12	-0.365	0.130	3	-1.354	0 303
CM01	5	-1.655	0 468	12	-0 411	0.123	3	-1.443	0 308
CM03	5	-1.550	0.482	12	-0.414	0.146	3	-1.383	0 326
CM05	5	-1.446	0 480	10	-0.431	0 141	3	-1.367	0 303
CM10	12	-1.270	0.488	12	-0.382	0.145	3	-1.332	0 314
EURO3	5	-1.615	0.475	9	-0.494	0.124	3	-1 605	0.290
CP6	5	-1.793	0.484	9	-0.464	0.123	3	-1.502	0.282
BAA	5	-1.973	0 486	7	-0 395	0 138	3	-1.280	0 310

TABLE 1.4 - MULTIPERIOD FORECASTS (In-Sample)

	MONTHLY (Jan 62 - Feb 92)								MONTHLY (Jan 62 - Feb 92)								QUARTERLY (Jan 62 - Dec 91)					
	INDUSTRIAL PRODUCTION								EMPLOYMENT								GDP					
	1 MON		3 MOS		6 MOS		12 MOS		1 MON		3 MOS		6 MOS		12 MOS		1 QTR		2 QTRS		4 QTRS	
INDICATOR	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK
FF	0.258	10	0.351	3	0.400	3	0.530	2	0.423	6	0.576	3	0.571	3	0.581	2	0.338	3	0.463	3	0.530	1
TB03	0.263	8	0.333	7	0.337	6	0.477	5	0.426	5	0.564	7	0.543	6	0.529	4	0.293	6	0.402	5	0.496	3
TB06	0.271	5	0.346	5	0.353	4	0.483	4	0.429	3	0.570	5	0.550	4	0.528	5	0.304	5	0.406	4	0.487	5
CM01	0.273	4	0.341	6	0.350	5	0.455	6	0.428	4	0.567	6	0.547	5	0.509	6	0.309	4	0.397	6	0.443	6
CM03	0.264	7	0.325	8	0.329	8	0.410	7	0.421	7	0.561	8	0.540	8	0.486	7	0.279	7	0.350	7	0.377	7
CM05	0.263	9	0.318	9	0.314	9	0.386	8	0.419	8	0.560	9	0.536	9	0.474	8	0.268	8	0.332	8	0.346	8
CM10	0.265	6	0.307	10	0.280	10	0.346	10	0.417	10	0.550	10	0.514	10	0.442	10	0.253	10	0.296	10	0.307	10
EURO3	0.276	3	0.371	2	0.420	2	0.509	3	0.431	2	0.581	2	0.575	2	0.546	3	0.354	1	0.471	2	0.490	4
CP6	0.286	1	0.382	1	0.438	1	0.541	1	0.438	1	0.592	1	0.592	1	0.564	1	0.348	2	0.475	1	0.516	2
BAA	0.283	2	0.348	4	0.332	7	0.361	9	0.419	9	0.570	4	0.543	7	0.466	9	0.258	9	0.329	9	0.315	9
NONE	0.196	11	0.201	11	0.115	11	0.097	11	0.373	11	0.489	11	0.414	11	0.269	11	0.118	11	0.123	11	0.076	11

TABLE 1.5 - KALMAN MULTIPERIOD FORECASTS (Out of Sample)

MONTHLY (Jul 73 - Feb 92) — INDUSTRIAL PRODUCTION

INDICATOR	1 MON RMSE	1 MON RANK	3 MOS RMSE	3 MOS RANK	6 MOS RMSE	6 MOS RANK	12 MOS RMSE	12 MOS RANK
FF	11 232	11	8 845	11	7 141	8	4 778	3
TB03	11 168	9	8 601	10	7 353	11	4 993	6
TB06	10 735	8	8 301	7	7 076	7	4 847	4
CM01	10 664	7	8 198	5	6 898	4	4 882	5
CM03	10 577	4	8 154	3	6 897	3	5 029	7
CM05	10 609	5	8 229	6	6 973	5	5 131	8
CM10	10 629	6	8 349	8	7 172	10	5 354	9
EURO3	10 483	2	7 899	1	6 415	1	4 531	1
CP6	11 196	10	8 426	9	6 801	2	4 724	2
BAA	10 518	3	8 184	4	7 158	9	5 495	11
NONE	9 901	1	7 902	2	7 068	6	5 485	10

MONTHLY (Jul 73 - Feb 92) — EMPLOYMENT

INDICATOR	1 MON RMSE	1 MON RANK	3 MOS RMSE	3 MOS RANK	6 MOS RMSE	6 MOS RANK	12 MOS RMSE	12 MOS RANK
FF	2 761	11	2 182	11	1 988	10	1 864	2
TB03	2 707	9	2 129	10	2 031	11	1 728	6
TB06	2 644	7	2 074	8	1 974	9	1 702	4
CM01	2 630	5	2 042	7	1 932	5	1 706	5
CM03	2 604	3	2 011	5	1 913	2	1 732	7
CM05	2 599	2	2 010	4	1 920	4	1 757	8
CM10	2 625	4	2 036	6	1 969	8	1 826	10
EURO3	2 630	6	1 993	2	1 847	1	1 610	1
CP6	2 752	10	2 124	9	1 951	6	1 686	3
BAA	2 657	8	1 998	3	1 915	3	1 784	9
NONE	2 463	1	1 948	1	1 953	7	1 913	11

QUARTERLY (Jul 73 - Dec 91) — GDP

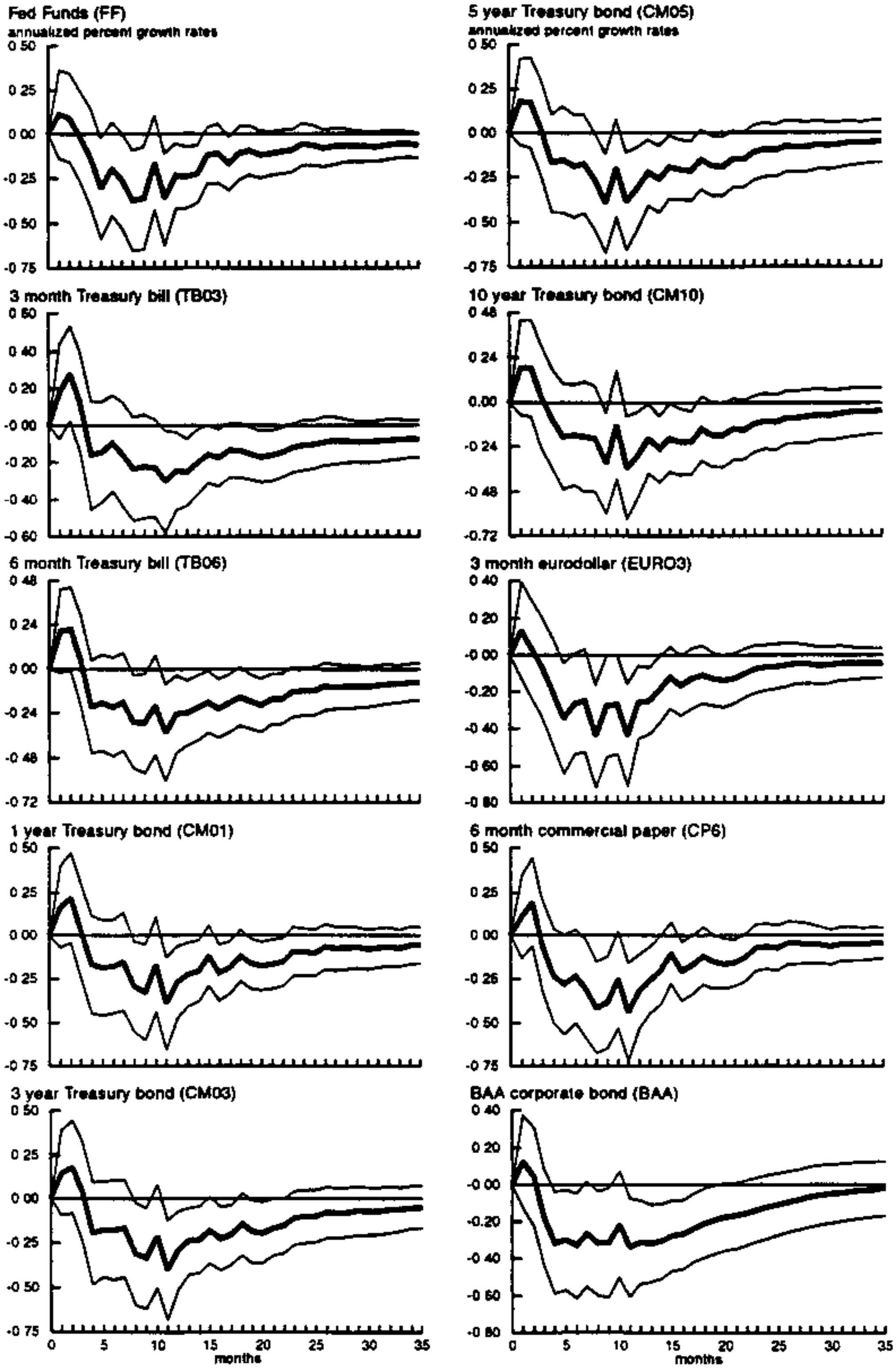
INDICATOR	1 QTR RMSE	1 QTR RANK	2 QTRS RMSE	2 QTRS RANK	4 QTRS RMSE	4 QTRS RANK
FF	3 793	2	2 859	3	2 160	1
TB03	3 969	9	3 075	6	2 260	5
TB06	3 862	4	3 000	5	2 251	4
CM01	3 828	3	2 996	4	2 356	6
CM03	3 876	5	3 094	7	2 483	7
CM05	3 936	7	3 144	8	2 552	8
CM10	3 949	8	3 249	10	2 683	9
EURO3	3 622	1	2 754	1	2 222	3
CP6	3 880	6	2 827	2	2 216	2
BAA	4 006	10	3 197	9	2 725	10
NONE	4 015	11	3 358	11	2 819	11

TABLE 1.6 - MULTIPERIOD ENCOMPASSING TESTS (Sample Period: Jan 62 - Dec 91)
Probability Value for Null Hypothesis: X is Encompassed by Y

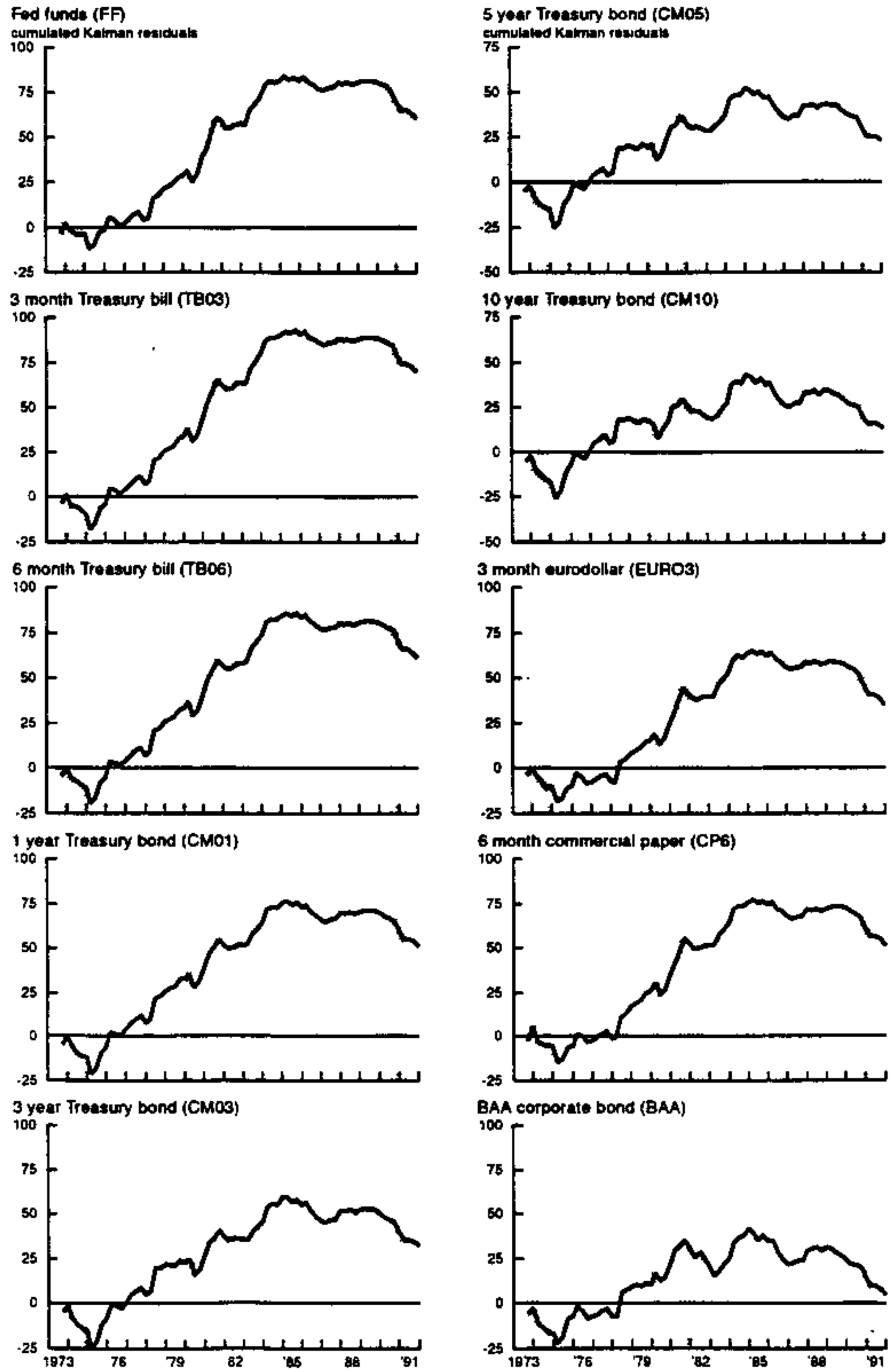
X \ Y	FF	TB03	TB06	CM01	CM03	CM05	CM10	EURO3	CP6	BAA	Maximum P Value
					GDP 1 qtr						
FF	n a	--	--	--	--	--	--	0.932	0.856	--	0.932
TB03	0.482	n a.	0.796	0.830	0.061	--	--	0.391	0.262	--	0.830
TB06	0.945	0.204	n a	0.947	--	--	--	0.403	0.241	--	0.947
CM01	0.677	0.103	0.342	n a	--	--	--	0.723	0.524	--	0.723
CM03	0.682	0.343	0.949	0.264	n a	0.065	--	0.803	0.601	0.053	0.949
CM05	0.637	0.375	0.910	0.412	0.251	n a	0.066	0.906	0.702	0.154	0.910
CM10	0.464	0.371	0.798	0.684	0.508	0.563	n a	0.818	0.976	0.380	0.976
EURO3	0.119	--	--	--	--	--	--	n a	0.240	--	0.240
CP6	0.272	--	--	--	--	--	--	0.659	n a	--	0.659
BAA	0.326	0.221	0.431	0.638	0.485	0.407	0.253	0.666	0.783	n a	0.783
					GDP 2 qtrs						
FF	n a	--	--	--	--	--	--	0.605	0.867	--	0.867
TB03	0.090	n a.	0.925	0.310	--	--	--	0.340	--	--	0.925
TB06	0.337	0.448	n a	0.220	--	--	--	0.250	--	--	0.448
CM01	0.582	0.515	0.864	n a	--	--	--	0.293	--	--	0.864
CM03	0.617	0.959	0.443	0.109	n a	--	--	0.360	0.107	--	0.959
CM05	0.694	0.975	0.520	0.191	0.132	n a	--	0.450	0.197	0.137	0.975
CM10	0.665	0.763	0.418	0.210	0.096	--	n a	0.491	0.263	0.794	0.794
EURO3	0.231	--	--	--	--	--	--	n a	0.598	--	0.598
CP6	0.214	--	--	--	--	--	--	0.340	n a	--	0.340
BAA	0.574	0.302	0.635	0.837	0.429	0.228	--	0.989	0.742	n a	0.989
					GDP 4 qtrs						
FF	n a	--	--	--	--	--	--	--	--	--	0.044
TB03	0.963	n a	0.152	--	--	--	--	0.139	0.661	--	0.963
TB06	0.920	0.910	n a	--	--	--	--	0.255	0.662	--	0.920
CM01	0.596	0.373	--	n a	--	--	--	0.980	0.157	--	0.980
CM03	0.593	0.363	--	--	n a	--	--	0.623	0.166	--	0.623
CM05	0.541	0.302	--	--	--	n a	--	0.506	0.140	--	0.541
CM10	0.588	0.362	0.130	0.074	--	0.072	n a	0.555	0.211	0.419	0.588
EURO3	0.539	0.263	0.173	--	--	--	--	n a	0.785	--	0.785
CP6	0.746	--	--	--	--	--	--	0.052	n.a	--	0.746
BAA	0.845	0.776	0.507	0.534	0.692	0.895	0.101	0.767	0.456	n a	0.895

NOTE Values less than or equal to 0.05 are marked with a dash

1.1. Dynamic Response of Employment to Interest Rate Levels



1.2. Interest Rate Levels: Cumulated Kalman Residuals in Forecasting Real GDP



THE MONETARY AGGREGATES

Table 2.1 lists the monetary indicators which were selected for investigation, along with some descriptive statistics. For this family of indicators all but one of the variables are expressed as (log) growth rates: the monetary base (Board of Governors (MB) and St. Louis (MBSTL) versions), M1, M2, M3, L, and long-term debt of nonfinancial institutions, as well as real M1 and real M2 (deflated by the consumer price index). The other monetary indicator is the ratio of nonborrowed reserves (this period) to total reserves (last period) (NBRX). Strongin (1991) has found that this normalized reserve aggregate contains much of the information about monetary policy actions which Sims (1991) attributes to innovations in the Federal Funds rate (orthogonalized relative to output and prices).

Two observations about the descriptive statistics seem to be in order. First, these aggregates are plausible choices as monetary indicators of economic activity. Focusing on GDP, the aggregates tend to be correlated with GDP, and the highest correlations are with the real aggregates M1 and M2. In fact, it appears to be roughly the case that as the endogenous component of the monetary aggregate increases, the contemporaneous correlation with economic activity increases. This is loosely the causation/reverse causation debate--do the larger monetary aggregates influence activity more than the narrower aggregates, or are they influenced more? Second, for most of the aggregates the standard deviations are about one-half or less than the average growth rates; however, for real M1 and M2, the standard deviations are 2 and 6 times greater than the average growth rate. In turns out below, that these two aggregates, nominal M2, and the NBR/TR ratio are the most useful indicators.

Table 2.2 reports statistics for the one-period-ahead forecasting model, an autoregression of the economic activity variable with lagged values of the indicator included. Focusing on GDP, notice that nominal M2, real M1, real M2, and the NBR/TR ratio provide significant predictive power for GDP beyond the information contained in past values of GDP. These three indicators consistently provide predictive power for industrial Production and employment as well. For GDP the lowest ranking indicators tend to be nonfinancial debt, the monetary base, and the broad aggregate L.

Figure 2.1 graphs the response of the employment growth forecast to a one-standard deviation change in information about last period's indicator. For all of the monetary indicators, a positive impulse eventually leads to a positive growth of employment. For most of these indicators, however, the imprecision of these forecasts is large enough so that the response is either not statistically significant for most of the response path (nominal M1, M3, L and nonfinancial debt) or entirely insignificant (both monetary bases). Real M1 and M2 all have similar response patterns: persistent and quick, with the M1 response being a bit earlier. The responses of nominal M2 and the NBR/TR ratio are also persistent with a bit more raggedness than the responses to the real aggregates. The NBR/TR ratio also has the longest significant response. For all of the indicators and economic activity variables, the maximum one-period impact occurs within one year (reported in Table 2.3).

Tables 2.4 and 2.5 rank the indicator forecasts for in-sample and out-of-sample forecasts at various horizons. Turning to Table 2.5 first, notice that for the one-month forecast horizon for both industrial production and employment, the best forecast is one without any monetary indicators. For GDP there are four indicators which consistently provide additional information for forecasts: real M2 (which is always first), the NBR/TR ratio (always second), nominal M2 and real M1. These indicators are also useful for industrial production and employment for six-month horizon and beyond. They are also the highest ranked indicators in Table 2.4 for the in-sample forecasts.

The monetary aggregates which consistently provide no additional predictive power beyond the no-indicator model in the out-of-sample rankings are the two monetary base measures, nominal M1, and L. They also do poorly in the in-sample rankings. This lack of information is stable across forecast horizons.

The cumulated residuals from the Kalman forecasts shown in Figure 2.2 provide another perspective of the out-of-sample performance of our family of money based measures. In our case, the best indicator is again real M2 as its cumulated residuals path clearly stays near zero values, except for isolated periods of large forecast errors in 1978 and 1981, when real M2 underforecasted economic activity. Real M2's performance was again noticeably good between 1990 and 1991, when most of the other money based indicators clearly failed to predict the recession. The NBR/TR ratio was relatively stable from 1973 to 1981, but has shown a consistent pattern of overforecasting output growth since 1982. This deterioration may be due to increasing reluctance on the part of banks to borrow from the discount window. The performance of other monetary aggregates is less reliable and clearly more volatile than the behavior of real M2 and the NBR/TR ratio. For example, the two measures of the monetary base and M1 consistently underforecasted real GDP between 1974 and 1977, as shown by their upward sloping paths. Overall, the path of nominal aggregates plunged during the credit control program of 1980, overpredicting output growth during the mild recession. From 1983 to 1988, these nominal aggregates performed fairly well, exhibiting uncharacteristic stability, except for M1 which did substantially worse between 1983 and 1984. Finally, between 1990 and 1991, there was a considerable deterioration in the performance of M1, L, and the two measures of the montary base, as they consistently overpredicted economic growth.

Table 2.6 reports the encompassing results for GDP. For each of the forecast horizons, we find that real M2 is not dominated by any of the other forecasts (reading across the real M2 row, the hypothesis is always rejected at low marginal significance levels). None of the other indicator forecasts can cover the information contained in real M2. Furthermore, the real M2 forecasts cover the information contained in all of the other indicator forecasts (reading down the real M2 column, the hypothesis that real M2 covers each forecast is not rejected).

Therefore, real M2 is a dominant indicator within the class of monetary indicators selected here for GDP.5

TABLE 2.1 - DESCRIPTIVE STATISTICS

Indicator	MONTHLY (Jan 62 - Feb 92) Mean	Std. Dev.	Correlation with Industrial Production	Correlation with Employment	QUARTERLY (Jan 62 - Dec 91) Mean	Std. Dev.	Correlation with Real GDP
MBSTL	6.785	3.617	-0.014	-0.058	6.784	2.195	0.034
MB	6.710	3.321	-0.021	-0.027	6.662	2.282	0.013
M1	6.160	5.864	0.005	-0.033	6.055	3.730	0.157
M2	7.750	4.082	0.119	0.013	7.769	3.292	0.236
M3	8.323	4.072	0.113	0.092	8.363	3.520	0.246
L	8.138	3.662	0.167	0.175	8.183	3.057	0.239
DBTNF	8.977	2.752	0.175	0.290	9.017	2.446	0.180
M1R	1.085	7.245	0.063	0.009	0.971	5.143	0.297
M2R	2.675	5.837	0.156	0.053	2.685	4.868	0.353
NBRX	0.976	0.027	0.059	-0.026	0.983	0.029	0.154

TABLE 2.2 - CLASSICAL GOODNESS-OF-FIT STATISTICS

	MONTHLY (Jan 62 - Feb 92)					MONTHLY (Jan 62 - Feb 92)					QUARTERLY (Jan 62 - Dec 91)				
	INDUSTRIAL PRODUCTION					EMPLOYMENT					GDP				
Indicator	R2	Change In R2	SEE	P-Value	Rank	R2	Change In R2	SEE	P-Value	Rank	R2	Change In R2	SEE	P-Value	Rank
MBSTL	0.225	0.029	9.169	0.3997	8	0.393	0.019	2.363	0.5618	9	0.166	0.049	3.532	0.1744	7
MB	0.222	0.027	9.182	0.4760	9	0.389	0.015	2.370	0.7445	10	0.145	0.027	3.577	0.4734	9
M1	0.221	0.026	9.188	0.5172	10	0.401	0.028	2.346	0.2192	8	0.172	0.055	3.519	0.1284	5
M2	0.252	0.057	9.003	0.0144	3	0.442	0.069	2.264	0.0001	2	0.219	0.101	3.419	0.0084	4
M3	0.229	0.033	9.144	0.2755	7	0.412	0.039	2.324	0.0383	5	0.169	0.052	3.525	0.1483	6
L	0.236	0.041	9.100	0.1246	5	0.404	0.030	2.341	0.1486	6	0.164	0.046	3.538	0.1993	8
DBTNF	0.231	0.036	9.128	0.2092	6	0.401	0.028	2.346	0.2156	7	0.124	0.006	3.620	0.9352	10
M1R	0.244	0.048	9.054	0.0477	4	0.418	0.044	2.314	0.0148	4	0.250	0.132	3.351	0.0012	2
M2R	0.284	0.089	8.808	0.0001	1	0.444	0.071	2.260	0.0001	1	0.346	0.228	3.128	0.0000	1
NBRX	0.277	0.081	8.854	0.0003	2	0.426	0.053	2.297	0.0028	3	0.249	0.131	3.352	0.0012	3

TABLE 2.3 - MAXIMUM IMPACT OF DYNAMIC MULTIPLIERS

	MONTHLY (Jan 62 - Feb 92) INDUSTRIAL PRODUCTION			MONTHLY (Jan 62 - Feb 92) EMPLOYMENT			QUARTERLY (Jan 62 - Dec 91) GDP		
Indicator	Months to Max	Max Impact	Std. Dev. at Max	Months to Max	Max Impact	Std. Dev. at Max	Quarters to Max	Max Impact	Std. Dev. at Max
MBSTL	4	1.054	0.489	8	0.221	0.148	2	0.787	0.323
MB	10	0.894	0.508	5	0.192	0.138	2	0.410	0.300
M1	7	1.145	0.515	3	0.370	0.126	2	0.671	0.328
M2	7	1.755	0.476	9	0.705	0.137	2	0.904	0.309
M3	7	1.393	0.538	9	0.500	0.149	3	0.787	0.344
L	7	1.655	0.507	9	0.458	0.143	3	0.739	0.333
DBTNF	2	1.214	0.447	5	0.332	0.126	4	0.113	0.301
M1R	7	1.371	0.513	5	0.485	0.124	2	1.011	0.321
M2R	7	1.567	0.464	5	0.568	0.128	2	1.069	0.289
NBRX	12	1.467	0.496	8	0.449	0.148	3	1.047	0.308

TABLE 2.4 - MULTIPERIOD FORECASTS (In-Sample)

	MONTHLY (Jan 62 - Feb 92)								MONTHLY (Jan 62 - Feb 92)								QUARTERLY (Jan 62 - Dec 91)					
	INDUSTRIAL PRODUCTION								EMPLOYMENT								GDP					
	1 MON		3 MOS		6 MOS		12 MOS		1 MON		3 MOS		6 MOS		12 MOS		1 QTR		2 QTRS		4 QTRS	
Indicator	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK
MBSTL	0.225	8	0.230	8	0.144	10	0.113	10	0.393	9	0.506	8	0.434	8	0.274	10	0.166	7	0.154	8	0.102	8
MB	0.222	9	0.226	9	0.145	8	0.135	8	0.389	10	0.499	9	0.424	9	0.276	9	0.145	9	0.144	9	0.121	5
M1	0.221	10	0.259	7	0.199	6	0.127	9	0.401	8	0.523	7	0.454	7	0.288	7	0.172	5	0.163	7	0.096	10
M2	0.252	3	0.335	3	0.333	3	0.268	4	0.442	2	0.581	2	0.540	2	0.394	4	0.219	4	0.249	4	0.186	4
M3	0.229	7	0.274	5	0.211	5	0.165	5	0.412	5	0.548	5	0.487	5	0.324	5	0.169	6	0.189	5	0.107	7
L	0.236	5	0.269	6	0.195	7	0.146	7	0.404	6	0.527	6	0.461	6	0.291	6	0.164	8	0.184	6	0.097	9
DBTNF	0.231	6	0.225	10	0.144	9	0.151	6	0.401	7	0.496	10	0.420	10	0.285	8	0.124	10	0.133	10	0.121	6
M1R	0.244	4	0.320	4	0.304	4	0.282	3	0.418	4	0.557	4	0.517	4	0.415	3	0.250	2	0.288	3	0.244	3
M2R	0.284	1	0.413	1	0.478	1	0.567	1	0.444	1	0.609	1	0.604	1	0.573	1	0.346	1	0.447	1	0.514	1
NBRX	0.277	2	0.365	2	0.386	2	0.417	2	0.426	3	0.562	3	0.525	3	0.446	2	0.249	3	0.327	2	0.292	2
NONE	0.198	11	0.201	11	0.115	11	0.097	11	0.373	11	0.489	11	0.414	11	0.289	11	0.118	11	0.123	11	0.076	11

TABLE 2.5 - KALMAN MULTIPERIOD FORECASTS (Out-of Sample)

MONTHLY (Jul 73 - Feb 92)

INDUSTRIAL PRODUCTION

Indicator	1 MON RMSE	1 MON RANK	3 MOS RMSE	3 MOS RANK	6 MOS RMSE	6 MOS RANK	12 MOS RMSE	12 MOS RANK
MBSTL	10 406	8	8 317	11	7 468	11	5 736	8
MB	10 275	5	8 142	5	7 244	6	5 594	7
M1	10 452	10	8 218	10	7 273	8	5 760	9
M2	10 368	6	7 780	3	6 648	3	5 425	4
M3	10 447	9	8 161	8	7 308	9	5 843	10
L	10 405	7	8 174	9	7 382	10	5 843	11
DBTNF	10 112	4	8 157	6	7 270	7	5 498	6
M1R	10 630	11	8 159	7	6 952	4	5 309	3
M2R	10 111	3	7 368	2	5 902	1	4 229	1
NBRX	9 947	2	7 362	1	6 096	2	4 594	2
NONE	9 890	1	7 894	4	7 064	5	5 485	5

MONTHLY (Jul 73 Feb 92)

EMPLOYMENT

Indicator	1 MON RMSE	1 MON RANK	3 MOS RMSE	3 MOS RANK	6 MOS RMSE	6 MOS RANK	12 MOS RMSE	12 MOS RANK
MBSTL	2 583	6	2 040	10	2 058	11	2 012	9
MB	2 553	5	2 011	6	2 023	7	1 986	7
M1	2 587	8	2 022	7	2 030	8	2 023	10
M2	2 585	7	1 931	3	1 896	3	1 894	3
M3	2 610	9	1 998	5	2 006	6	1 997	8
L	2 630	10	2 028	8	2 050	10	2 043	11
DBTNF	2 535	4	2 034	9	2 041	9	1 955	6
M1R	2 671	11	2 064	11	2 004	5	1 905	4
M2R	2 483	3	1 838	1	1 731	1	1 558	1
NBRX	2 477	2	1 903	2	1 828	2	1 711	2
NONE	2 463	1	1 948	4	1 953	4	1 913	5

QUARTERLY (Jul 73 - Dec 91)

GDP

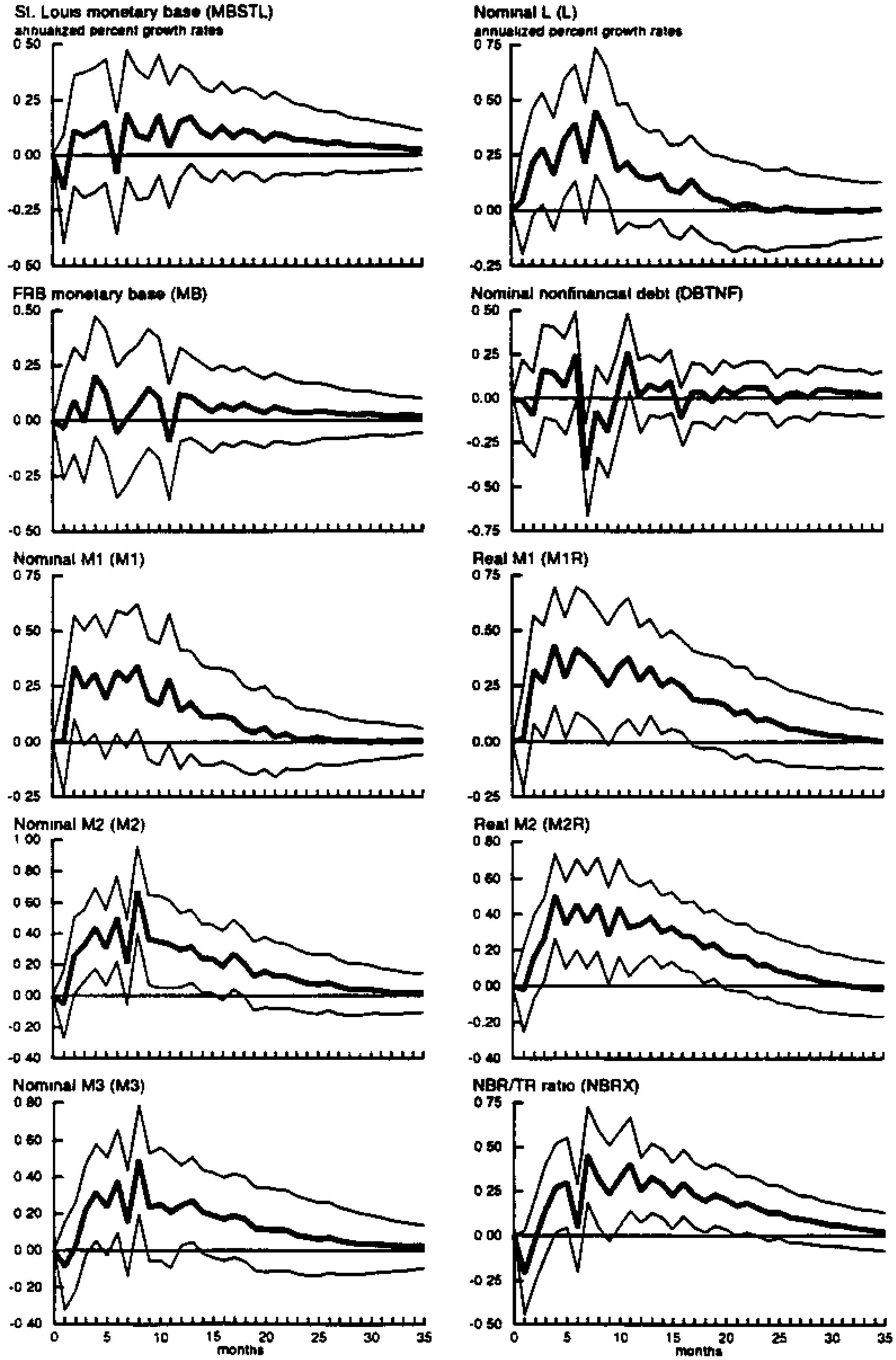
Indicator	1 QTR RMSE	1 QTR RANK	2 QTRS RMSE	2 QTRS RANK	4 QTRS RMSE	4 QTRS RANK
MBSTL	4 108	7	3 474	10	2 904	8
MB	4 114	8	3 426	7	2 840	7
M1	4 149	10	3 455	9	2 992	11
M2	3 944	3	3 252	3	2 809	4
M3	4 073	5	3 394	6	2 948	10
L	4 136	9	3 432	8	2 926	9
DBTNF	4 242	11	3 495	11	2 870	6
M1R	4 097	6	3 285	4	2 775	3
M2R	3 674	1	2 844	1	2 219	1
NBRX	3 799	2	3 003	2	2 550	2
NONE	4 015	4	3 358	5	2 819	5

TABLE 2 6 - MULTIPERIOD ENCOMPASSING TESTS (Sample Period. Jan 62 - Dec 91)
Probability Value for Null Hypothesis: X is Encompassed by Y

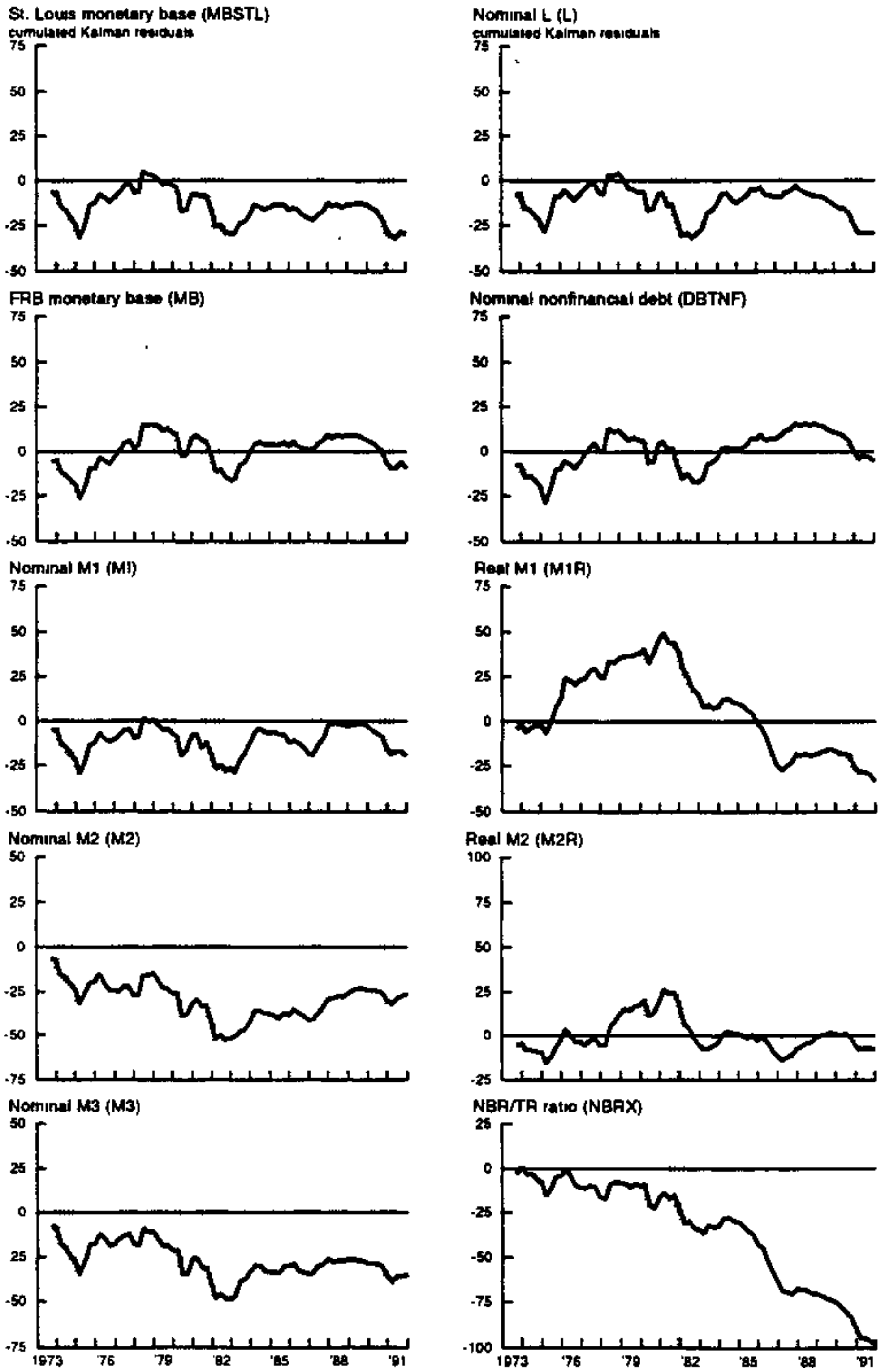
X \ Y	MBSTL	MB	M1	M2	M3	L	DBTNF	M1R	M2R	NBRX	Maximum P Value
					GDP 1 qtr						
MBSTL	n a	0 064	0 150	0 462	0 178	0 094	--	0 763	0 759	0 411	0 763
MB	0 726	n a	0 307	0 569	0 296	0 224	0 075	0 682	0 936	0 500	0 936
M1	0 055	--	n a	0 506	0 105	0 054	--	0 658	0 855	0 671	0 855
M2	--	--	--	n a	--	--	--	0 098	0 954	--	0 954
M3	0 138	--	0 135	0 733	n a	0 174	--	0 327	0 653	0 149	0 733
L	0 119	--	0 136	0 407	0 324	n a	--	0 322	0 449	0 286	0 449
DBTNF	0 694	0 755	0 669	0 771	0 716	0 825	n a	0 829	0 970	0 755	0 970
M1R	--	--	--	--	--	--	--	n a	0 924	--	0 924
M2R	--	--	--	--	--	--	--	--	n a	--	0 000
NBRX	--	--	--	--	--	--	--	--	0 286	n a	0 286
					GDP 2 qtrs						
MBSTL	n a	0 266	0 760	0 817	0 484	0 359	--	1 000	0 954	0 959	1 000
MB	0 595	n a	0 516	0 654	0 477	0 445	0 167	0 686	0 994	0 722	0 994
M1	--	--	n a	0 667	0 112	--	--	0 803	0 970	0 845	0 970
M2	--	--	--	n a	--	--	--	0 173	0 833	0 119	0 833
M3	--	--	0 064	0 603	n a	0 197	--	0 323	0 560	0 193	0 603
L	--	--	--	0 258	0 294	n a	--	0 274	0 284	0 333	0 333
DBTNF	0 490	0 715	0 604	0 691	0 533	0 697	n a	0 774	0 973	0 745	0 973
M1R	--	--	--	--	--	--	--	n a	0 752	0 101	0 752
M2R	--	--	--	--	--	--	--	--	n a	--	0 000
NBRX	--	--	--	--	--	--	--	--	0 133	n a	0 133
					GDP 4 qtrs						
MBSTL	n a	0 930	0 341	0 604	0 525	0 344	0 659	0 840	0 782	0 896	0 930
MB	0 336	n a	0 126	0 248	0 228	--	0 330	0 362	0 817	0 464	0 817
M1	0 658	0 693	n a	0 914	0 669	0 439	0 517	0 987	0 841	0 958	0 987
M2	--	--	--	n a	--	--	--	0.263	0 430	0 400	0 430
M3	0 452	0 392	0 424	0 612	n a	0 442	0 375	0 776	0 918	0 746	0 918
L	0 521	0 523	0 396	0 523	0 626	n a	0 652	0 802	0 824	0 975	0 975
DBTNF	0 196	0 331	0 072	0 230	0 209	0 089	n a	0 300	0 836	0 334	0 836
M1R	--	--	--	--	--	--	--	n a	0 257	0 305	0 305
M2R	--	--	--	--	--	--	--	--	n a	--	0 000
NBRX	--	--	--	--	--	--	--	--	0 473	n a	0 473

NOTE Values less than or equal to 0 05 are marked with a dash

2.1. Dynamic Response of Employment to Money Based Measures



2.2. Money Based Measures: Cumulated Kalman Residuals in Forecasting Real GDP



INTEREST RATE SPREADS

Recent research on financial market indicators of economic activity have brought renewed attention to interest rates spreads. Laurent (1988), Bernanke (1990), Estrella and Hardouvelis (1991), Friedman-Kuttner (1992), Kashyup-Stein-Wilcox (1991), and Stock-Watson (1989) have suggested and tested various interest rate spreads as predictors of economic activity with significant success. The idea behind most of these spreads is that the difference in yields between two different debt instruments provides information beyond that in the level of interest rates. The two primary types of interest rates spreads that have been used are risk-spreads which measure the difference in yield between a private debt instrument and the yield on a government bond of equivalent maturity and term-spreads which measure the difference in yield of government debt instruments of different maturities.

Typically, the motivation for the risk spreads is that the risk in the private debt instrument is a measure of the market's assessment of the near term risk in the relevant business environment and that high risk implies a tough time for business ahead. Friedman-Kuttner have argued that this interpretation is probably flawed since the spreads are typically too large to be explained by any reasonable estimate of the risk inherent in the private debt instruments and suggest that liquidity considerations play a significant role in the pricing of public-private spreads. Following their lead, we also will refer to these spreads as public-private spreads.

The term-spreads seek to measure the relative availability of credit through time. The convention is that the shorter maturity yield is subtracted from the longer. Thus, a positive spread would indicate that short term funding is available at a lower rate than longer term funding. The normal interpretation is that if short-term funds are especially cheap relative to long-term funds this will encourage borrowing and economic activity. An alternative explanation is that the higher long-term yields are signaling expectations of higher future credit demand resulting from increased economic activity. A third interpretation is that by taking the difference between a short- and long-term interest rate you are correcting the shorter term rate for changes in inflationary expectations and taxes, leaving a better measure of short-run credit conditions. In any case, all of these term-spread measures have the counter-intuitive implication that a rise in long-term interest rates is good for the near-term outlook of the economy. Estrella and Hardouvelis (1991) and Strongin (1990) attempt to reconcile the term-spread results with current theory with limited success.

We test 3 public-private spreads and 5 term-spreads[5]. The specific measures we use are the TED or Eurodollar spread which is the 3-month Eurodollar rate minus the 3-month Treasury bill rate. The Commercial Paper spread which is the 6-month Commercial Paper spread minus the 6-month Treasury bill rate, and the Baa spread which the Baa yield minus the 10-year Treasury bond rate[6]. The five term-spreads contain three spreads based on the Federal Funds Rate, a short, medium and long spread -- the short spread is the 3-month bill rate minus the Federal Funds rate -- the medium spread is the 12-month bill rate minus the Federal Funds rate -- the long spread is the 10-year bond rate minus the Federal Funds rate. There are two intermediate spreads as well the 12-month/3-month spread and the 10-year/1-year spread.

Table 3.1 shows that as expected the public-private spreads all show a strong negative correlation with economic activity and the term-spreads all show a positive correlation with activity: the shorter the term-spread, the higher the correlation.

Table 3.2 indicates that based on classical measures of fit

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5. These are the only commonly used spreads available for the entire data sample. Other spreads are examined in the appendix for shorter samples, but the results are no different and the public-private spreads presented either dominate or at least equal any of those presented in the appendix.

6. The 10-year rate is used because the 7-year which might be preferred is not available for a sufficient time span. The appendix also includes the Baa/7-year spread and spread's using the AA bond yield.

all of the spreads do fairly well in explaining all three measures of economic activity. The R^2s for industrial production range from .236 to .339; the range for employment growth is .416 to .459; and the range for GDP is from .234 to .339. With the exception of the 12-month/3-month term-spread, every spread Granger causes activity at a high level of significance. The only exception is the 12-month/3-month spread which fails to Granger cause industrial production. The public-private spreads do a better job of predicting employment and industrial production with the Commercial Paper spread and the Baa spread ranking 1 and 2. For GDP the results are more mixed with the Commercial Paper spread and 12-month/Federal fund spread coming in 2nd.

The dynamic response path graphs in Figure 3.1 shows substantial difference in the dynamic response of employment growth by type of spread. The response of employment to an increase in the Baa spread shows a quickly rise, peaking at only 3 months. The response then dies just as quickly. The response paths for the two shorter-term public-private spreads the Commercial Paper spread and the Eurodollar spread build rapidly then plateau for a number of months and then die quickly. The term-spread response paths, with exception of the 12-month/3-month spread, all build slowly, peak and then slowly die out. Only in the case of the Baa spread is there a well-defined peak in the response path, all of the other spreads show extended period of impact. This would suggest that the strength of the Baa spread will be in very short horizon forecasts, the strength of the Commercial Paper and Eurodollar spreads will be at short and middle horizons, while the strength of the term-spreads will be in longer term forecasts. Table 3.3 suggests similar conclusions with the Baa spread showing the quickest, largest and most tightly estimated peak for employment and industrial production. The longer horizon GDP results show the impact of the Baa spread falling off considerably though it is still very quick.

Tables 3.4 and 3.5 strongly re-enforce these conclusion and provide some startling evidence on the effect of forecast horizons on indicator performance. First, in table 4 it is clear that the performance of the Baa spread falls off dramatically as the forecast horizon is increased. Ranking 2nd for industrial production and employment at the one-month horizon, the rank drops to 6th and 7th for industrial production and employment respectively for the three-month horizon and is dead last by six months for all measures of activity. The Commercial Paper spread, on the other hand, does very well ranking 1st until the one-year horizon in both employment and industrial production, when it is superseded by a number of term-spreads. In forecasting GDP the Commercial Paper spread still does very well at the one-quarter horizon, but fades quickly falling to 4th at the six-month horizon and 6th at the one-year horizon. The Federal Funds rate based spreads do very well as the forecasting horizon lengthens. Starting out in the middle to back of the pack at the shortest horizons they rise to dominate the top of the ranking at the one-year horizon with the 12-month/Federal Funds spread rising to 1st for all three measure of activity. The intermediate spreads rarely do well.

Table 3.5, showing the out-of-sample results shows a very similar story in terms of rankings. The interesting additional fact is how well the spread models stand up to the no-indicator model. At every horizon except one-month the spread models strongly outperform the no-indicator model, though at the one-month horizon the no-indicator model does outperforms all of the spread models except the Baa spread, which is only good at short horizons. Clearly the forecast horizon is extremely important to the evaluation of interest rate spread models.

The cumulated residuals from the Kalman forecasts in Figure 3.2 show some striking similarities in the overall forecasting performance of our family of interest rate spreads. Except for the 3-, 6-, and 12-month/Federal Funds rate spreads, all of our spreads tend to overforecast real GDP, as shown by their consistently negative residuals. While the 3-, 6-, and 12-month/Federal Funds rate spreads performed fairly well from 1973 to 1980, they clearly failed during the last three recessions. In fact, they all underforecasted economic activity between 1980 and

1982, and then overpredicted real GDP between 1990 and 1991. Between 1982 and 1989, their path was conspicuously flat. This suggests that these spreads do well in forecasting normal periods of economic activity, but periodically fail in predicting recessions. Although the 5-year/ and 10-year/Federal Funds rate spreads follow a similar pattern between 1973 and 1981, after 1982 their cumulated residuals path never stabilized but plunged to persistently negative values. Our intermediate term spreads (12-month/3-month and 10-year/1-year spreads) failed during all of the recessions in our sample period (including the 1973-1975 recession), and developed a consistently negative bias after 1982, as they clearly overpredicted real GDP. All of the private/public spreads followed the same general pattern of mediocre performance from 1973 to 1981, and persistent overprediction of economic activity thereafter. In general, we conclude that, although a persistent bias in forecasting exists in all of the interest rate spreads we investigated, some of them did fairly well during most of our sample period, but failed during periods of large scale financial restructuring.

The encompassing tests in Table 3.6 are exactly what would be expected given the previous results. To fully encompass all of the information in the interest rate spreads it is usually necessary to include both a public-private spread and a term-spread. Also not surprisingly, the Commercial Paper spread and the 12-month/Federal Funds rate spreads dominate their respective groupings at the one- and two-quarter horizons. It is interesting to note that the Stock-Watson leading indicator index, which was designed to fit data at the six-month horizon, chose the Commercial Paper spread and the 10-year/1-year spread. For our sample period, the 12-month/Federal Funds spread narrowly dominates the 10-year/1-year spread. At the 4-quarter horizon the public-private spread no longer contains additional information beyond that contained in the 12-month/Federal Funds spread. The 12-month/Federal Funds spread, however, does not dominate since it fails to cover (only) the 10-year/1-year spread. We selected the 10-year/Federal Funds spread since it covers more spreads than the

10-year/1-year spread, covers the 10-year/1-year spread, and performs better out-of-sample. The selection of two term spreads is consistent with the previously noted results that the public-private spread do not contain as much long run information as the term-spreads. It is interesting to note that examination of the entire encompassing results indicate that the separation between the public-private spreads and the term-spreads is not very clear. At some horizons some term-spread encompass some public-private spreads while at other horizons the results reverse. This would seem to indicate that there are common multiple driving forces in the determination of these spreads and that those driver factors associated with longer horizon economic activity predominate in the term-spreads with the common factors that drive short-run performance dominate the public-private spreads.

TABLE 3.1 - DESCRIPTIVE STATISTICS

Indicator	MONTHLY (Jan 62 - Feb 92) Mean	Std. Dev.	Correlation with Industrial Production	Correlation with Employment	QUARTERLY (Jan 62 - Dec 91) Mean	Std. Dev.	Correlation with Real GDP
TB3FF	-0.747	0.864	0.291	0.252	-0.750	0.807	0.449
TB6FF	-0.591	0.948	0.292	0.255	-0.593	0.886	0.442
TB12FF	-0.577	1.149	0.291	0.254	-0.580	1.082	0.425
CM05FF	0.384	1.586	0.210	0.123	0.373	1.511	0.321
CM10FF	0.514	1.791	0.200	0.114	0.499	1.713	0.309
TB12TB3	0.170	0.468	0.177	0.158	0.170	0.434	0.225
CM10CM1	0.601	1.036	0.083	0.001	0.588	0.997	0.170
EUROTB3	1.428	0.931	-0.235	-0.248	1.434	0.885	-0.378
CP6TB6	0.579	0.489	-0.305	-0.297	0.582	0.461	-0.431
BAACM10	1.722	0.698	-0.248	-0.390	1.720	0.690	-0.297

TABLE 3.2 - CLASSICAL GOODNESS-OF-FIT STATISTICS

	MONTHLY (Jan 62 - Feb 92)					MONTHLY (Jan 62 - Feb 92)					QUARTERLY (Jan 62 - Dec 91)				
	INDUSTRIAL PRODUCTION					EMPLOYMENT					GDP				
Indicator	R2	Change In R2	SEE	P-Value	Rank	R2	Change In R2	SEE	P-Value	Rank	R2	Change In R2	SEE	P-Value	Rank
TB3FF	0.291	0.095	8.769	0.0000	3	0.435	0.062	2.278	0.0004	3	0.327	0.209	3.174	0.0000	3
TB6FF	0.280	0.085	8.834	0.0002	4	0.430	0.057	2.289	0.0012	5	0.321	0.204	3.187	0.0000	4
TB12FF	0.275	0.079	8.866	0.0004	5	0.429	0.055	2.291	0.0016	6	0.330	0.212	3.166	0.0000	2
CM05FF	0.256	0.061	8.981	0.0084	7	0.415	0.042	2.318	0.0224	10	0.302	0.185	3.231	0.0000	6
CM10FF	0.254	0.059	8.992	0.0111	8	0.416	0.043	2.316	0.0186	9	0.309	0.191	3.216	0.0000	5
TB12TB3	0.236	0.041	9.099	0.1224	10	0.424	0.050	2.302	0.0047	7	0.238	0.120	3.377	0.0026	9
CM10CM1	0.250	0.054	9.018	0.0207	9	0.417	0.044	2.315	0.0163	8	0.284	0.166	3.273	0.0001	8
EUROTB3	0.274	0.079	8.870	0.0004	6	0.431	0.058	2.286	0.0009	4	0.294	0.177	3.250	0.0001	7
CP6TB6	0.340	0.144	8.462	0.0000	1	0.459	0.086	2.229	0.0000	1	0.339	0.221	3.145	0.0000	1
BAACM10	0.303	0.108	8.691	0.0000	2	0.437	0.064	2.274	0.0002	2	0.234	0.116	3.386	0.0033	10

TABLE 3.3 - MAXIMUM IMPACT OF DYNAMIC MULTIPLIERS

	MONTHLY (Jan 62 - Feb 92)			MONTHLY (Jan 62 - Feb 92)			QUARTERLY (Jan 62 - Dec 91)		
	INDUSTRIAL PRODUCTION			EMPLOYMENT			GDP		
Indicator	Months to Max	Max Impact	Std. Dev. at Max	Months to Max	Max Impact	Std. Dev. at Max	Quarters to Max	Max Impact	Std. Dev. at Max
TB3FF	7	1.991	0.483	6	0.500	0.127	3	1.408	0.310
TB6FF	7	1.731	0.468	6	0.466	0.128	3	1.283	0.277
TB12FF	7	1.446	0.466	6	0.412	0.125	3	1.259	0.285
CM05FF	7	1.091	0.478	15	0.355	0.087	3	1.195	0.294
CM10FF	7	1.022	0.497	9	0.370	0.134	3	1.243	0.293
TB12TB3	14	1.375	0.382	14	0.534	0.111	5	0.879	0.282
CM10CM1	5	1.471	0.486	9	0.342	0.134	3	1.243	0.296
EUROTB3	7	-2.083	0.515	12	-0.553	0.146	3	-1.493	0.338
CP6TB6	9	-2.476	0.480	8	-0.711	0.136	3	-1.449	0.312
BAACM10	3	-2.645	0.473	3	-0.519	0.121	2	-0.833	0.312

TABLE 3.4 - MULTIPERIOD FORECASTS (In-Sample)

	MONTHLY (Jan 62 - Feb 92)								MONTHLY (Jan 62 - Feb 92)								QUARTERLY (Jan 62 - Dec 91)					
	INDUSTRIAL PRODUCTION								EMPLOYMENT								GDP					
	1 MON		3 MOS		6 MOS		12 MOS		1 MON		3 MOS		6 MOS		12 MOS		1 QTR		2 QTRS		4 QTRS	
Indicator	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK
TB3FF	0.291	3	0.402	2	0.477	2	0.524	3	0.435	3	0.591	3	0.585	4	0.549	6	0.327	3	0.446	3	0.437	5
TB6FF	0.280	4	0.382	3	0.456	3	0.547	2	0.430	5	0.590	4	0.595	3	0.605	2	0.321	4	0.459	2	0.490	4
TB12FF	0.275	5	0.369	5	0.438	4	0.555	1	0.429	6	0.593	2	0.604	2	0.626	1	0.330	2	0.470	1	0.518	1
CM05FF	0.256	7	0.334	7	0.381	7	0.488	4	0.415	10	0.569	7	0.569	6	0.585	4	0.302	6	0.428	6	0.498	2
CM10FF	0.254	8	0.337	6	0.385	6	0.484	5	0.416	9	0.572	5	0.574	5	0.587	3	0.309	5	0.435	4	0.491	3
TB12TB3	0.236	10	0.286	10	0.269	9	0.358	8	0.424	7	0.567	8	0.563	7	0.572	5	0.238	9	0.333	9	0.383	7
CM10CM1	0.250	9	0.305	9	0.296	8	0.361	7	0.417	8	0.552	10	0.526	9	0.489	8	0.284	8	0.374	7	0.396	6
EUROTB3	0.274	6	0.380	4	0.413	5	0.323	9	0.431	4	0.571	6	0.542	8	0.431	9	0.294	7	0.364	8	0.230	9
CP6TB6	0.340	1	0.500	1	0.559	1	0.426	6	0.459	1	0.634	1	0.623	1	0.506	7	0.339	1	0.429	5	0.289	8
BAACM10	0.303	2	0.324	8	0.218	10	0.168	10	0.437	2	0.553	9	0.461	10	0.293	10	0.234	10	0.175	10	0.138	10
NONE	0.198	11	0.201	11	0.115	11	0.097	11	0.373	11	0.489	11	0.414	11	0.269	11	0.118	11	0.123	11	0.076	11

TABLE 3.5 - KALMAN MULTIPERIOD FORECASTS (Out of Sample)

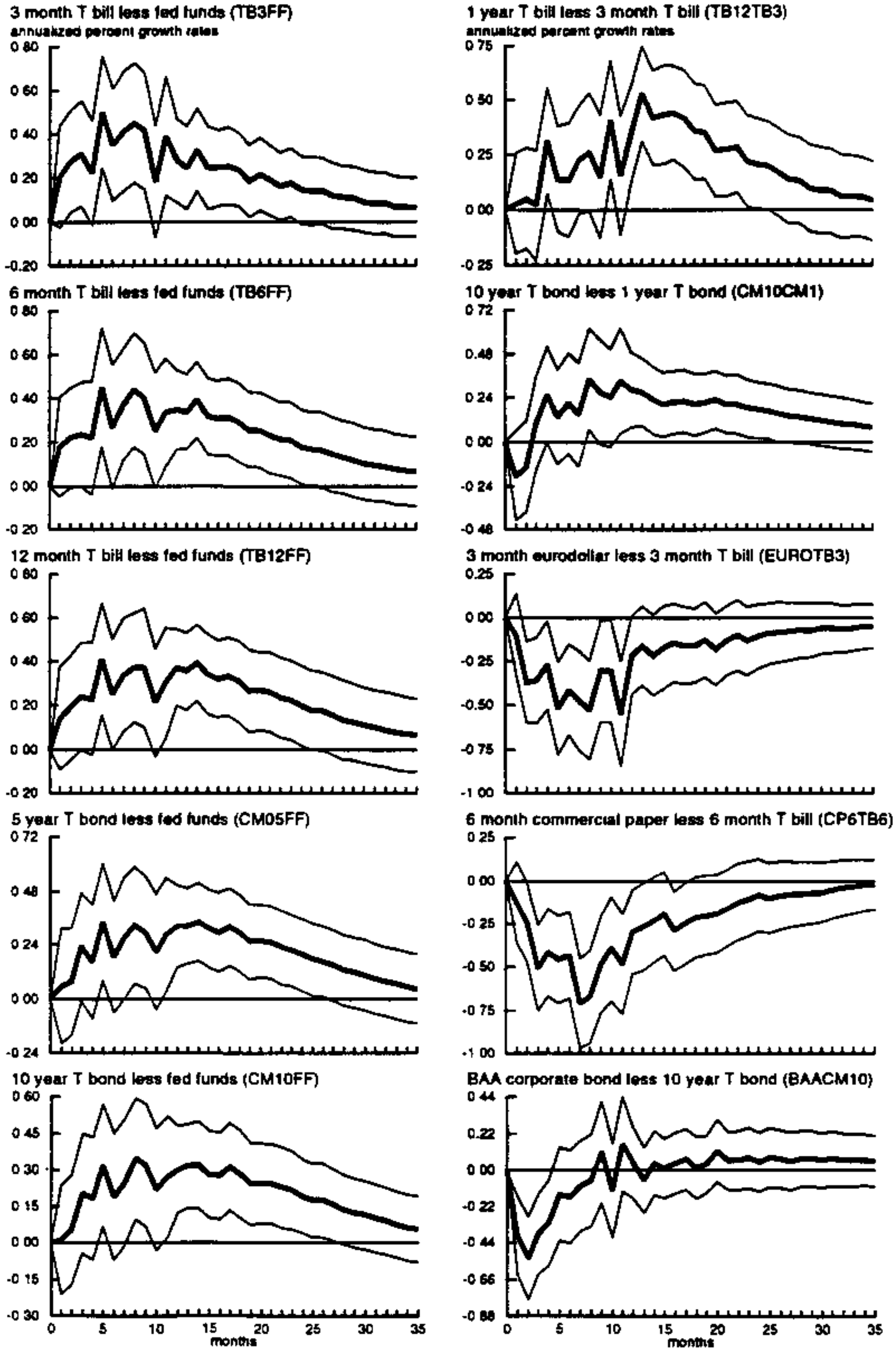
	MONTHLY (Jul 73 - Feb 92)								MONTHLY (Jul 73 - Feb 92)								QUARTERLY (Jul 73 - Dec 91)					
	INDUSTRIAL PRODUCTION								EMPLOYMENT								GDP					
	1 MON		3 MOS		6 MOS		12 MOS		1 MON		3 MOS		6 MOS		12 MOS		1 QTR		2 QTRS		4 QTRS	
Indicator	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK
TB3FF	10 161	5	7 421	3	5 763	2	4 209	3	2 581	5	1 937	4	1 785	3	1 599	6	3 809	1	2 674	1	2 253	5
TB6FF	10 371	6	7 768	4	6 075	4	4 081	1	2 624	7	1 960	6	1 775	2	1 492	3	3 691	3	2 691	2	2 091	2
TB12FF	10 582	8	8 164	8	6 539	5	4 207	2	2 658	9	1 986	7	1 791	4	1 435	1	3 753	6	2 754	3	2 015	1
CM05FF	10 931	9	8 386	9	6 742	7	4 517	4	2 708	10	2 055	9	1 866	8	1 504	5	3 745	5	2 811	6	2 111	3
CM10FF	10 970	10	8 390	10	6 656	6	4 542	5	2 740	11	2 063	11	1 853	6	1 495	4	3 763	7	2 785	5	2 161	4
TB12TB3	11 054	11	8 539	11	7 169	11	4 906	7	2 653	8	2 030	8	1 868	7	1 479	2	4 197	11	3 187	9	2 370	6
CM10CM1	10 572	7	8 149	7	6 891	8	5 053	9	2 622	6	2 055	10	1 937	9	1 674	7	3 857	8	2 970	8	2 389	7
EUROTB3	9 898	3	7 289	2	5 937	3	5 048	8	2 512	3	1 926	3	1 834	5	1 779	9	3 698	4	2 866	7	2 721	8
CP6TB6	9 900	4	6 703	1	4 922	1	4 806	6	2 543	4	1 790	1	1 632	1	1 710	8	3 656	2	2 760	4	2 744	9
BAACM10	9 858	1	7 785	5	7 025	9	5 575	11	2 446	1	1 913	2	1 972	11	1 998	11	3 983	9	3 485	11	2 846	11
NONE	9 890	2	7 894	6	7 064	10	5 485	10	2 463	2	1 948	5	1 953	10	1 913	10	4 015	10	3 358	10	2 819	10

TABLE 3.6 - MULTIPERIOD ENCOMPASSING TESTS (Sample Period: Jan 62 - Dec 91)
Probability Value for Null Hypothesis: X is Encompassed by Y

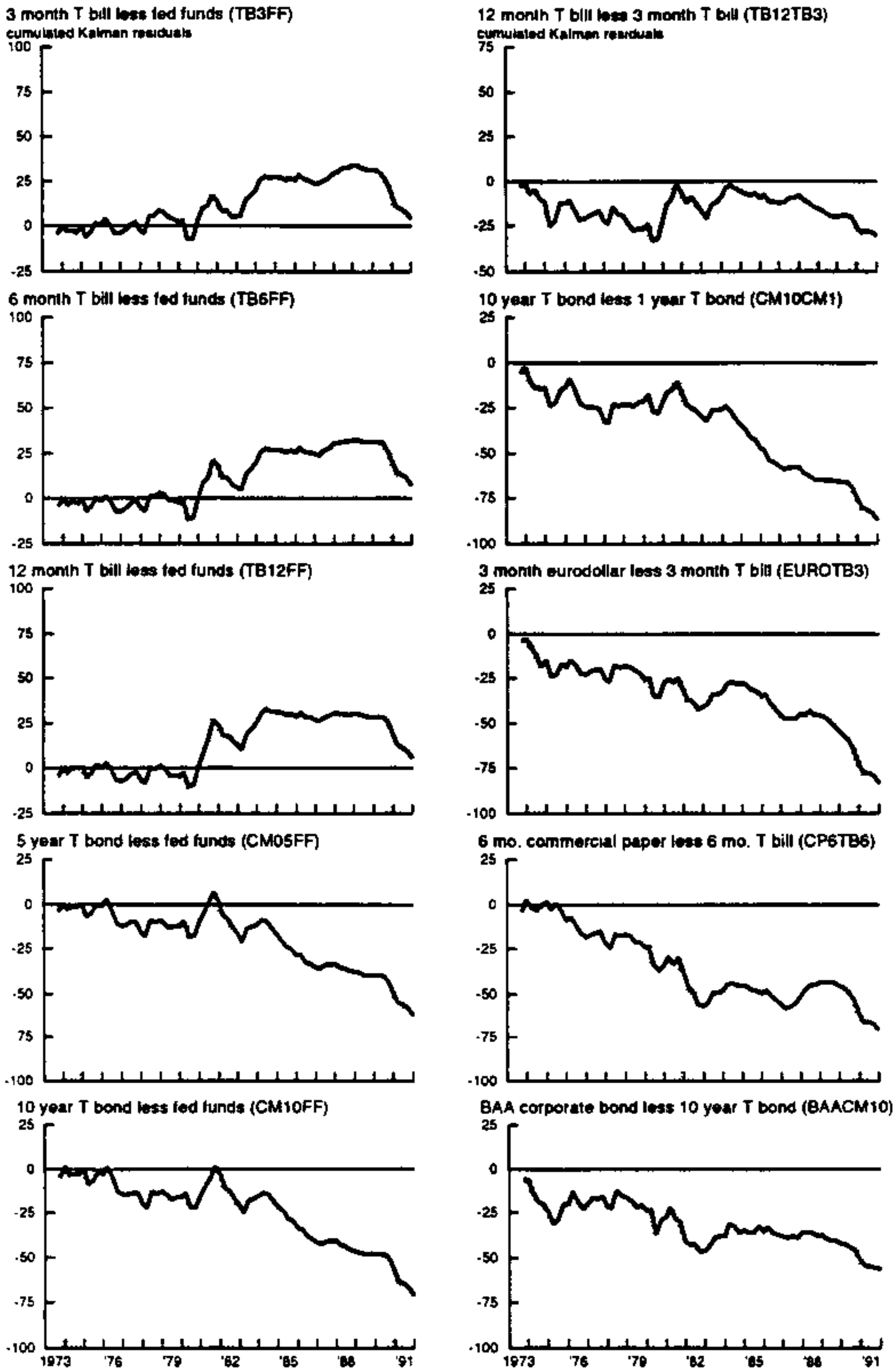
X \ Y	TB3FF	TB6FF	TB12FF	CM05FF	CM10FF	TB12TB3	CM10CM1	EUROTB3	CP6TB6	BAACM10	Maximum P Value
GDP 1 qtr											
TB3FF	n.a.	0.185	0.167	--	--	--	--	--	0.156	--	0.185
TB6FF	0.462	n.a.	0.999	--	--	--	--	--	0.109	--	0.999
TB12FF	0.105	0.227	n.a.	--	--	--	--	--	--	--	0.227
CM05FF	--	0.109	0.369	n.a.	0.540	--	0.098	--	0.053	--	0.540
CM10FF	--	0.062	0.231	0.215	n.a.	--	0.077	--	--	--	0.231
TB12TB3	0.093	0.333	0.797	0.430	0.413	n.a.	0.115	--	0.055	--	0.797
CM10CM1	--	--	0.106	0.454	0.699	--	n.a.	--	--	--	0.699
EUROTB3	0.125	--	--	--	--	--	--	n.a.	0.186	--	0.186
CP6TB6	0.066	--	--	--	--	--	--	--	n.a.	--	0.066
BAACM10	--	--	--	--	--	--	0.072	0.053	0.104	n.a.	0.104
GDP: 2 qtrs											
TB3FF	n.a.	0.569	0.467	--	--	--	--	--	--	--	0.569
TB6FF	0.070	n.a.	0.798	--	--	--	--	--	--	--	0.798
TB12FF	--	0.155	n.a.	--	--	--	--	--	--	--	0.155
CM05FF	--	0.092	0.337	n.a.	0.665	--	--	--	--	--	0.665
CM10FF	--	0.055	0.206	0.271	n.a.	--	--	--	--	--	0.271
TB12TB3	--	0.256	0.755	0.370	0.353	n.a.	0.071	--	--	--	0.755
CM10CM1	--	--	0.126	0.876	0.710	--	n.a.	--	--	--	0.876
EUROTB3	0.214	--	--	--	--	--	--	n.a.	0.222	--	0.222
CP6TB6	0.093	--	--	--	--	--	--	--	n.a.	--	0.093
BAACM10	0.545	0.459	0.580	0.908	0.991	0.436	0.935	0.807	0.936	n.a.	0.991
GDP 4 qtrs											
TB3FF	n.a.	0.322	0.548	0.131	0.092	--	--	--	--	--	0.548
TB6FF	--	n.a.	0.197	0.056	--	--	--	--	--	--	0.197
TB12FF	--	--	n.a.	--	--	--	--	--	--	--	0.027
CM05FF	--	--	0.176	n.a.	0.170	--	--	--	--	--	0.176
CM10FF	--	--	0.144	0.720	n.a.	--	--	--	--	--	0.720
TB12TB3	--	0.142	0.576	0.333	0.261	n.a.	--	--	--	--	0.576
CM10CM1	--	--	0.062	0.593	0.230	--	n.a.	--	--	--	0.593
EUROTB3	0.752	0.989	0.979	0.899	0.965	0.094	0.428	n.a.	0.560	--	0.989
CP6TB6	0.883	0.870	0.840	0.774	0.783	--	0.115	--	n.a.	--	0.883
BAACM10	0.500	0.392	0.442	0.863	0.930	0.111	0.973	0.569	0.575	n.a.	0.973

NOTE: Values less than or equal to 0.05 are marked with a dash

3.1. Dynamic Response of Employment to Interest Rate Spreads



3.2. Interest Rate Spreads: Cumulated Kalman Residuals in Forecasting Real GDP



COMPOSITE INDICATORS

The composite indicator family consists of the NBER experimental leading indicator series (XLI) and the NBER experimental non-financial recession index (XRI2) (which measures the probability of a recession), the Department of Commerce leading indicators (lead), the National Association of Purchasing Managers Index (PMI), the change in the S&P 500 (S&P), changes in sensitive materials prices (SMPS), and the Kashyap-Stein-Wilcox "mix" (KSWMIX), which is the ratio of bank lending to the sum of bank lending and commercial paper lending (see Kashyap et al. (1991)). It should be noted that the NBER experimental index includes the 10-year/1-year interest rate spread and the Commercial Paper spread and that the Department of Commerce leading indicator index includes real M2, which have been used in previous sections. All three leading indicator composites are designed to predict economic activity at a six-month horizon, though the optimization for the Department of Commerce index is not as specific as either of the NBER indices.

Table 4.1 shows that most of these series have the expected correlation with contemporaneous economic activity, except for the change in the S&P 500 which has small negative correlations with growth in industrial production and employment and only a small positive correlation with growth in real GNP. The KSWMIX variable is positively correlated with real GDP: one interpretation of this correlation is that increased (decreased) bank lending is associated with expansions (contractions).

Table 4.2 shows that all of these series perform very well in classical regression analysis. They all produce high R^2s. The R^2s for industrial production range from .289 to .391; the range for employment growth is .434 to .527; and the range for GDP is from .205 to .455. Further, each of these indicators Granger causes activity at a high level of significance. In terms of ranking, the Department of Commerce leading indicators and NBER experimental index are 1st and 2nd for all of the measures of economic activity, with the Department of Commerce leading indicators coming in 1st for industrial production and employment and the NBER experimental index coming in 1st for real GNP. The change in S&P 500 comes in last in every category and the change in sensitive materials prices comes in next to last in every category.

The dynamic response path graphs in Figure 4.1 show somewhat similar patterns.[7] For all three leading indicators series -- the NBER leading indicator, the NBER nonfinancial recession index and the Department of Commerce's leading indicators -- employment growth shows a rapid rise peaking at 5 months. From that peak all three graphs exhibit significantly different behavior. The NBER leading indicator graph plateaus for 4-5 months and then drops off before the end of the year. Employment's response to changes in the NBER nonfinancial recession index drops off steadily from the peak while the response to changes in the Department of Commerce's response path is in-between with a high initial peak followed by a stable period then a steady decline.

The response of employment to the changes in the purchasing managers index and the change in sensitive material prices both show dramatic jumps in forecasted employment growth peaking at 3 and 2 months, respectively. Employment growth then falls steadily in the Purchasing Managers Index graph while it plateaus in the sensitive material prices graph. The S&P 500 graph is similar, showing a leap up followed by a steady decline, except it has a small initial drop in the first month. It is interesting to note that all of these dynamic response paths are barely significant at the one year mark, despite showing fairly precisely estimated effects earlier. As a group these series seem to hold a lot of information about short-run changes in economic activity, with most of that information centered at the 3-9 month horizon.

Tables 4.4 and 4.5 which examine the forecasting ability of these indicators at different forecast horizons, in-sample and out-of-sample, show very stable rankings as the forecast horizon

7. The dynamic response of employment to the KSWMIX variable is not reported since it is only available on a quarterly basis.

changes. The leading indicators series do best, posting very similar performances. The other series do not do as well, though the Purchasing Manager's Index does well at the one-month horizon for industrial production. Placing 3rd in-sample and 2nd out-of-sample for the one-month horizon then falling off at longer horizons. Among the leading indicator series, the Department of Commerce series does best at horizons of less than six months, while the NBER index ranks first for horizons of 6 months and longer. For GDP, the NBER index always does better with the differential in performance increasing with horizon. The KSWMIX variable does reasonably well in-sample, but out-of-sample it performs worse than "NONE," the no-indicator forecast. The one anomaly in the tables is that the change in sensitive material prices does very well out-of-sample for GDP at the 4 quarter horizon, actually outperforming all of the other indicators except the NBER leading indicator series.

The cumulated Kalman residuals in Figure 4.2 show some striking similarities and some differences in actual performance across these indicators. Except for KSWMIX, all of our composite indicators have overforecasted real GDP over time, as their cumulated residuals are consistently negative. This bias is clearly evident during recessions and becomes more dramatic after 1980. After 1982, while the negative bias is exacerbated in the NBER leading indicator and S&P 500, the path becomes somewhat more stable for most of our indicators. The NBER nonfinancial recession index is our best performer during this period, which is not surprising since the index was originally developed in response to the failure of the NBER leading indicator index to forecast the 1990-1991 recession.

The encompassing results in Table 4.6 show that for horizons of two- and four-quarters the NBER index dominates this entire family of indicators, with the possible exception of the KSWMIX. At the one-quarter horizon both the Department of Commerce and NBER nonfinancial recession indices are not encompassed by any of the other forecasts. These results are not surprising in light of the ranking discussed earlier and the fact that the NBER leading indicator index was designed to provide a "best" forecast of economic activity at a six-month horizon, using virtually all of the macroeconomic data available. At the one- and two-quarter horizons, the KSWMIX is encompassed by the NBER index at the 5% significance level, but not the 10% level. We chose not to include the KSWMIX in the survivor list of indicators due to its poor out-of-sample performance in Table 4.5.

TABLE 4.1 - DESCRIPTIVE STATISTICS

Indicator	MONTHLY (Jan 63 - Feb 92) Mean	Std. Dev.	Correlation with Industrial Production	Correlation with Employment	QUARTERLY (Jan 63 - Dec 91) Mean	Std. Dev.	Correlation with Real GDP
XLI	3.070	4.162	0.439	0.429	3.039	4.067	0.547
XRI2	0.157	0.139	-0.556	-0.523	0.156	0.131	-0.649
LEAD	2.990	11.148	0.454	0.249	2.993	8.832	0.600
PMI	53.380	7.668	0.524	0.681	53.400	7.473	0.632
S&P	6.463	42.410	-0.028	-0.050	6.451	24.588	0.185
SMPS	0.319	0.930	0.325	0.444	0.322	0.912	0.278
KSWMIX					0.925	0.040	0.316

TABLE 4.2 - CLASSICAL GOODNESS-OF-FIT STATISTICS

	MONTHLY (Jan 63 - Feb 92) INDUSTRIAL PRODUCTION					MONTHLY (Jan 63 - Feb 92) EMPLOYMENT					QUARTERLY (Jan 63 - Dec 91) GDP				
Indicator	R2	Change In R2	SEE	P-Value	Rank	R2	Change In R2	SEE	P-Value	Rank	R2	Change In R2	SEE	P-Value	Rank
XLI	0.369	0.165	8.353	0.0000	2	0.484	0.104	2.198	0.0000	2	0.455	0.338	2.893	0.0000	1
XRI2	0.338	0.134	8.555	0.0000	4	0.483	0.102	2.200	0.0000	3	0.385	0.268	3.073	0.0000	3
LEAD	0.391	0.187	8.204	0.0000	1	0.527	0.146	2.104	0.0000	1	0.405	0.288	3.022	0.0000	2
PMI	0.355	0.152	8.439	0.0000	3	0.463	0.083	2.241	0.0000	4	0.265	0.148	3.359	0.0005	4
S&P	0.289	0.085	8.864	0.0002	6	0.434	0.054	2.301	0.0029	6	0.205	0.089	3.493	0.0222	7
SMPS	0.300	0.096	8.795	0.0000	5	0.436	0.056	2.297	0.0019	5	0.232	0.115	3.433	0.0045	6
KSWMIX	-	-	-	-	-	-	-	-	-	-	0.243	0.126	3.410	0.0023	5

TABLE 4.3 - MAXIMUM IMPACT OF DYNAMIC MULTIPLIERS

	MONTHLY (Jan 63 - Feb 92) INDUSTRIAL PRODUCTION			MONTHLY (Jan 63 - Feb 92) EMPLOYMENT			QUARTERLY (Jan 63 - Dec 91) GDP		
Indicator	Months to Max	Max Impact	Std. Dev. at Max	Months to Max	Max Impact	Std. Dev. at Max	Quarters to Max	Max Impact	Std. Dev. at Max
XLI	6	2.441	0.455	5	0.650	0.124	3	1.731	0.310
XRI2	3	-2.668	0.446	5	-0.811	0.137	2	-1.829	0.309
LEAD	5	2.475	0.453	5	0.766	0.132	2	1.851	0.274
PMI	2	2.655	0.454	3	0.617	0.124	2	1.223	0.314
S&P	5	2.310	0.487	7	0.596	0.145	2	0.935	0.322
SMPS	2	1.801	0.468	2	0.401	0.120	7	-0.679	0.246
KSWMIX	-	-	-	-	-	-	2	1.021	0.302

TABLE 4.4 - MULTIPERIOD FORECASTS (In-Sample)

	MONTHLY (Jan 63 - Feb 92)								MONTHLY (Jan 63 - Feb 92)								QUARTERLY (Jan 63 - Dec 91)					
	INDUSTRIAL PRODUCTION								EMPLOYMENT								GDP					
	1 MON		3 MOS		6 MOS		12 MOS		1 MON		3 MOS		6 MOS		12 MOS		1 QTR		2 QTRS		4 QTRS	
Indicator	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK	R2	RANK
XLI	0.369	2	0.555	2	0.638	1	0.510	1	0.484	2	0.675	2	0.694	1	0.608	1	0.455	1	0.568	1	0.401	1
XRI2	0.337	4	0.419	3	0.364	3	0.255	6	0.494	3	0.646	3	0.584	3	0.417	3	0.382	3	0.316	3	0.168	6
LEAD	0.391	1	0.569	1	0.606	2	0.460	2	0.527	1	0.705	1	0.656	2	0.500	2	0.405	2	0.341	2	0.247	2
PMI	0.355	3	0.389	4	0.356	4	0.255	5	0.463	4	0.580	4	0.483	5	0.325	6	0.265	4	0.203	7	0.173	5
S&P	0.289	6	0.364	5	0.349	5	0.269	4	0.434	6	0.572	5	0.530	4	0.381	4	0.205	7	0.216	5	0.152	7
SMPS	0.300	5	0.346	6	0.327	6	0.334	3	0.436	5	0.547	6	0.479	6	0.345	5	0.232	6	0.206	6	0.229	3
KSWMIX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.243	5	0.249	4	0.193	4
NONE	0.204	7	0.204	7	0.116	7	0.088	7	0.381	7	0.493	7	0.417	7	0.282	7	0.117	8	0.117	8	0.072	8

TABLE 4.5 - KALMAN MULTIPERIOD FORECASTS (Out-of-Sample)

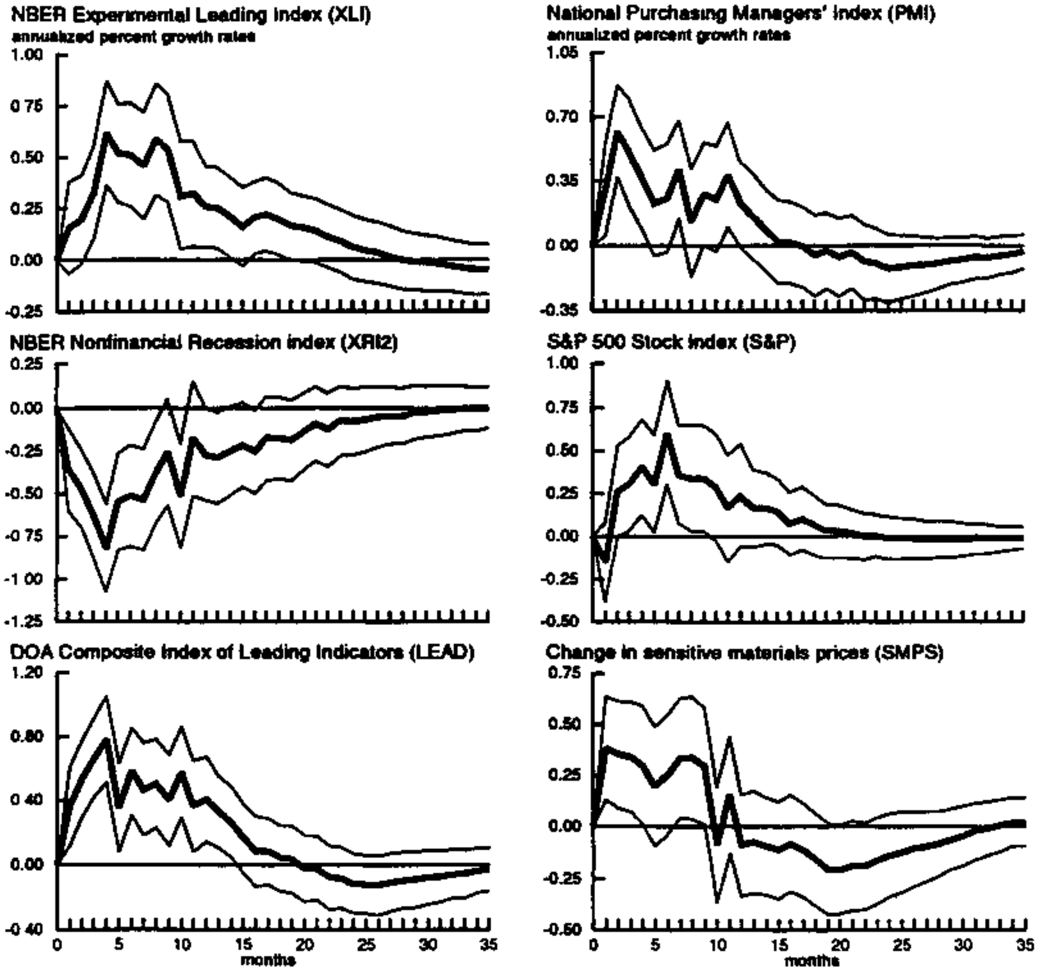
	MONTHLY (Jul 73 - Feb 92)								MONTHLY (Jul 73 - Feb 92)								QUARTERLY (Jul 73 - Dec 91)					
	INDUSTRIAL PRODUCTION								EMPLOYMENT								GDP					
	1 MON		3 MOS		6 MOS		12 MOS		1 MON		3 MOS		6 MOS		12 MOS		1 QTR		2 QTRS		4 QTRS	
Indicator	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK	RMSE	RANK
XLI	9 441	3	6 293	2	4 586	1	4 226	1	2 405	3	1 662	2	1 481	1	1 473	1	3 246	1	2 376	1	2 392	1
XRI2	9 589	4	7 353	4	6 604	6	5 444	6	2 439	4	1 801	3	1 839	3	1 897	4	3 427	3	3 026	3	2 758	5
LEAD	9 057	1	6 081	1	4 899	2	4 449	2	2 290	1	1 614	1	1 632	2	1 717	2	3 307	2	3 024	2	2 669	3
PMI	9 172	2	7.163	3	6 156	3	5 101	4	2 402	2	1 864	4	1 935	6	1 978	7	3 838	4	3 319	6	2 736	4
S&P	9 921	7	7.442	6	6 287	4	5 124	5	2 522	7	1 921	5	1 884	4	1 882	3	3 984	6	3 253	4	2 758	6
SMPS	9 685	5	7 391	5	6 291	5	4 779	3	2 495	6	1 944	6	1 926	5	1 915	5	3 914	5	3 306	5	2 612	2
KSWMIX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4 078	8	3 377	8	2 846	8
NONE	9 894	6	7 945	7	7 125	7	5 575	7	2 467	5	1 953	7	1 966	7	1 943	6	4 052	7	3 369	7	2 799	7

TABLE 4.6 - MULTIPERIOD ENCOMPASSING TESTS (Sample Period: Jan 63 - Dec 91)
Probability Value for Null Hypothesis: X is Encompassed by Y

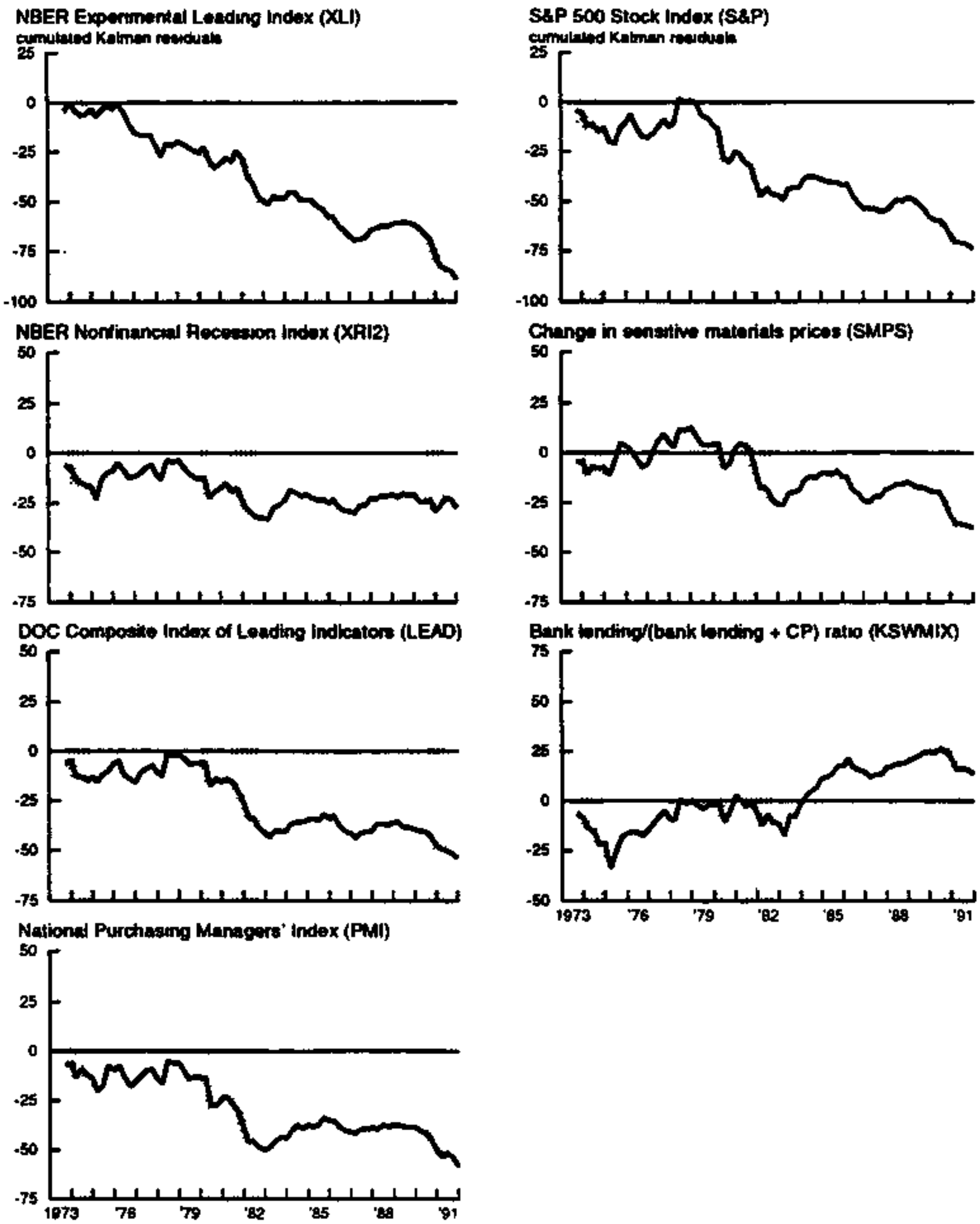
X \ Y	XLI	XRI2	LEAD	PMI	S&P	SMPS	KSWMIX	Maximum P Value
					GDP: 1 qtr			
XLI	n a	--	--	--	--	--	--	0.001
XRI2	--	n a	--	--	--	--	--	0 012
LEAD	--	--	n.a.	--	--	--	--	0 030
PMI	0.300	0 195	0.889	n.a.	--	--	--	0 889
S&P	0 754	0 334	0.619	0.100	n a.	0 090	--	0.754
SMPS	0 598	0.114	0.923	0.127	--	n a	--	0.923
KSWMIX	0 061	--	0.088	--	--	--	n.a.	0.088
					GDP: 2 qtrs			
XLI	n a	--	--	--	--	--	--	0.000
XRI2	0 370	n.a.	--	--	--	--	--	0.370
LEAD	0 761	--	n.a.	--	--	--	--	0 761
PMI	0 609	0 603	0.314	n a.	0.065	0.197	0.143	0 609
S&P	0 897	0.211	0.861	--	n.a.	0.097	0.064	0.897
SMPS	0 644	0 305	0 728	0.162	0.160	n.a	0.179	0.728
KSWMIX	0 087	--	0 060	--	--	--	n.a.	0 087
					GDP: 4 qtrs			
XLI	n a.	--	--	--	--	--	--	0.000
XRI2	0.939	n.a.	0.690	0.282	--	0.310	0.113	0.939
LEAD	0 420	--	n.a.	0.076	--	0.087	--	0.420
PMI	0.903	0.244	0.829	n.a.	0.121	0.636	0.181	0.903
S&P	0.616	0 104	0.748	0.303	n.a.	0.329	0.142	0.748
SMPS	0.377	0.055	0.153	--	--	n.a.	0.090	0 377
KSWMIX	0.166	0 056	0.056	0.113	--	0.196	n.a.	0.196

NOTE: Values less than or equal to 0 05 are marked with a dash.

4.1. Dynamic Response of Employment to Composite Indicators



4.2. Composite Indicators: Cumulated Kalman Residuals in Forecasting Real GDP



MIXING MODELS FOR REAL GDP

This section analyzes those indicators drawn from the previous sections that contain independent information and did well in the out-of-sample Kalman rankings. The indicators are subjected to another round of encompassing tests and rankings. Finally the usefulness of these final indicators are assessed in the context of a time-varying forecast-mixing model.

Table 5.1 presents the Kalman forecast RMSE for the one-, two-, and four-quarter horizon forecasts of real GDP. For the one-quarter horizon the best indicators are the NBER composite indicators (XLI and XRI2), and the Department of Commerce Leading Indicators Index (LEAD). The spreads and real M2 do the worst at this short horizon, but all of the remaining indicators do contribute information beyond the own past history of GDP (NONE). At the two-quarter horizon, the best indicator is the NBER leading indicator index with the 12-month/Federal Funds rate spread coming in a distant second: the NBER leading indicator index is 14% more accurate than the 12-month/Federal Funds rate spread. This is not surprising since the NBER leading indicator index was constructed by Stock and Watson to produce the "best" forecast of the growth in economic activity over the six-month horizon considered here. Turning to the four-quarter horizon, it seems surprising that the NBER leading indicator index comes in last after the 12-month/Federal Funds rate spread, the Federal Funds rate, the 10-year/Federal Funds spread, and real M2. This demonstrates again that the choice of economic indicators depends critically upon the horizon being forecast-- at the four-quarter growth horizon, a different collection of interest rate spreads than the ones selected by Stock and Watson are useful.

New encompassing results are displayed in Table 5.2. At this point, the purpose of these tests is to narrow the list of indicators in a structured manner. However, a rigid adherence to a statistical significance level is not maintained if an indicator is relatively useful and of independent interest. At the one-quarter horizon, the composite indicators the NBER leading indicator index, the NBER nonfinancial recession index, and the Department of Commerce leading indicators are each undominated and together sufficient. The two-quarter horizon is more interesting. Three indicators are clearly necessary. The NBER leading indicator index is undominated, and the 12-month/Federal Funds rate spread is undominated at the 10% level. The 3-month Eurodollar rate is not covered by these two indicators, and it is not dominated at the 11% significance level. Real M2 is also included in this final cut for two reasons: it is only covered by the NBER leading indicator index at the 14% significance level and it is of inherent interest as the best monetary aggregate considered here. Finally, notice that the 6-month Commercial paper spread (CP6TB6) did not make the final list at the two-quarter forecast horizon, but it is a component of the NBER leading indicator index.

At the four-quarter horizon, three indicators are undominated: the Federal Funds rate, real M2, and the 12-month/Federal Funds rate spread. The NBER leading indicator index does not contain independent information beyond these indicators. The 10-year/Federal Funds rate spread is included in the final list for three reasons: it is undominated at the 15% significance level, it covers the NBER leading indicators index better than the shorter end of the term structure (12-month/Federal Funds rate spread), and it is interesting to include a long spread at this horizon since Stock and Watson found a long spread useful at the two-quarter horizon.

The next step is to combine these forecasts into a forecasting model (for each horizon) which allows the weights on the indicators to vary over time depending upon their recent performance. Essentially we would like the model to take the following form:

$$F_t = \phi_{1t}\, for(A)_t + \phi_{2t}\, for(B)_t + \phi_{3t}\, for(C)_t$$

where $for(A)$ represents a forecast based upon indicator A and F_t is the combined forecast. The weights ϕ_{1t} should be non-negative and sum to one: in this case, the indicator's weight is a direct measure of its importance for the forecast. When the weights vary over time according to their forecast accuracy, the time path of the weights provide a direct measure of the indicators' reliability over time. We implement this model in the following way. Let ε_{it}^2 be the sum of (recent) squared forecast errors based upon indicator i's model. In this paper, we take "recent" to be one year of known forecast errors (4 quarters). Let $avg_t(\varepsilon_{it}^2)$ be the average of the ε_{it}^2s at time t and μ_i is the average of ε_{it}^2 - $avg_t(\varepsilon_{it}^2)$ over time. Then ϕ_{it} is defined to be:

$$\phi_{it} = \alpha_i - \beta_i \left(\varepsilon_{it}^2 - avg_t(\varepsilon_{it}^2) - \mu_i\right), \qquad \alpha_i, \beta_i \geq 0$$

where the parameters α and β can be estimated by a linear regression model if the non-negativity constraints are ignored, or nonlinear methods if the constraints are imposed.[8] Since ε_{it}^2 - $avg_t(\varepsilon_{it}^2) - \mu_i$ is mean zero by construction, the time-variation due to the β's nets out to zero over time. Consequently, the α estimates represent the average weight associated with each indicator forecast. However, over short periods of time when an indicator's forecast misbehaves, its errors ε_{it}^2 will be larger than the average errors; this will lead to the indicator's forecast receiving a temporarily smaller weight.

Table 5.3 displays the estimated α weights for these models. The one-quarter results indicate that the NBER leading indicator index is the most reliable, having an average weight of .533 in the combined forecast. The other indices (NBER Experimental Recession Index and the BEA Leading Indicators Index) received about equal shares of the remaining weight. The β's in this case are estimated to be zero; that is, there is no significant contribution to the forecast accuracy by allowing the weights to vary over time.

The two-quarter results are more interesting. As was

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8. The results in Table 5.3 were obtained by imposing the nonnegativity constraints. Initially, each of the β's was constrained to be positive. If the initial estimate was on the boundary (zero), its corresponding time-varying component was deleted from the estimation. The α's were constrained to be positive and sum to one.

expected from the encompassing results, the NBER leading indicator index receives the bulk of the weight in the final forecast (61%). This agrees with the analysis of Stock and Watson who constructed the NBER leading indicator index explicitly for its ability to forecast at this two-quarter ahead horizon. We do find that real M2 receives a substantial weight (19%), while the 12-month/Federal Funds rate spread is at 10% and the 3-month Eurodollar rate is 9%. Figure 5.1 graphs the time path of the ϕ weights for these four indicators, as well as the two-quarter GDP forecast and actual. Notice first that the NBER leading indicator index forecasts have been quite reliable, only once dropping below a 50% weight in the combined forecast. Real M2, however, has varied dramatically in its usefulness, going negative on two occasions: in 1976 and immediately following the 1981-82 recession. During that recession, real M2 did not forecast negative growth at any time (although it did in the 1980 recession), whereas the 3-month Eurodollar rate, the 12-month/Federal Funds rate spread, and the NBER leading indicators index did forecast negative growth during some portion of this recession.[9] This poor performance is captured in the time-varying model by decreasing the weight on the real M2 forecast temporarily until it begins to improve. On the other hand, during the most recent recession real M2 has gone above a 50% weight (keep in mind that the average weight for real M2 is .19). During this time, real M2 has grown only slowly and this lead to a forecast of slow growth during 1991 (see Figure 5.1). At this same time, the 3-month Eurodollar rate, the 12-month/Federal Funds rate spread, and the NBER leading indicators index signalled substantially higher growth than was realized. Each of these indicators is currently receiving less than its average weight. Consequently, the time-varying mixing model finds that real M2 has been an unusually useful indicator during the

9. It is useful to remember that the primary components of the NBER leading indicators index are the 6-month Commercial paper spread and the 10-year/1-year spread. So it should not be surprising that the NBER leading indicator index misbehaved during this period when the 3-month Eurodollar rate and the 12-month/Federal Funds rate spreads also misbehaved.

recent recession, despite its generally erratic performance at this horizon versus its relative failure at the twelve month horizon.

By contrast the four-quarter horizon results appear to be a picture of stability. Real M2 and the 12-month/Federal Funds rate spread receive the largest unconditional weights, 41% and 37% respectively. The Federal Funds rate and the 10-year/Federal Funds rate spread receive considerably less (around 10% each). The graphs of the time-varying weights indicate that, at this horizon, real M2 and the 12-month/Federal Funds rate spread have been reasonably reliable indicators, always staying near their unconditional weight. On the other hand, the 10-year/Federal Funds spread has been extremely unreliable, going to zero or negative in 1987-88 and during the recent recession.

The contrast between the dominance of the NBER leading indicator index at the six-month forecast horizon versus its lack of independent information at the twelve-month horizon demonstrates strongly the need for a different set of indicators for each forecast horizon. The usefulness of the 12-month/Federal Funds rate spread and real M2 for forecasting real GDP at the twelve-month horizon indicates that a different index would be constructed if this forecast horizon was the relevant objective. A note on standard errors is in order. Examination of Table 5.3 indicates that the standard errors associated with the parameters of these mixing models are fairly large. This is not surprising in light of the high degree of collinearity that would be expected of a set of reasonably successful forecasts. In fact, it is typically the case that only the strongest indicator at a given horizon is statistically significant. All this is saying is that the relative weights among successful indicators is subject to substantial uncertainty and that the marginal information after the first one or two indicators is quickly dropping toward 0. Nevertheless the point estimates and time paths of these relative weights provide a useful bench-mark, even though the precision they are estimated with would not change strongly held prior beliefs.

TABLE 5.1 - KALMAN RESIDUALS FOR SURVIVING INDICATORS

Quarterly (Jul 73 - Dec 91)

Real GDP

Indicator	1 Qtr RMSE	1 Qtr Rank	2 Qtrs RMSE	2 Qtrs Rank	4 Qtrs RMSE	4 Qtrs Rank
EURO3	3.622	4	2.754	3	n.a.	n.a.
FF	n.a.	n.a.	n.a.	n.a.	2.160	2
M2R	3.674	6	2.844	5	2.219	4
CP6TB6	3.656	5	2.760	4	n.a.	n.a.
TB12FF	3.753	7	2.751	2	2.002	1
CM10FF	n.a.	n.a.	n.a.	n.a.	2.161	3
XLI	3.246	1	2.376	1	2.392	5
XRI2	3.427	3	n.a.	n.a.	n.a.	n.a.
LEAD	3.307	2	n.a.	n.a.	n.a.	n.a.
NONE	4.052	8	3.369	6	2.799	6

n.a.: The indicator is not an initial survivor at this forecast horizon.

TABLE 5.2 - MIXED MULTIPERIOD ENCOMPASSING TESTS (Sample Period: Jan 63 - Dec 91)
Probability Value for Null Hypothesis: X is Encompassed by Y

X \ Y	EURO3	FF	M2R	CP6TB6	TB12FF	CM10FF	XLI	XRI2	LEAD	Maximum P Value
GDP: 1 qtr										
EURO3	n.a.	0.100	--	--	--	--	0.107	--	--	0.107
FF	0.958	n.a.	--	--	0.067	--	0.144	--	--	0.958
M2R	--	--	n.a.	--	--	--	0.168	--	0.055	0.168
CP6TB6	--	--	--	n.a.	--	--	0.288	--	--	0.288
TB12FF	0.186	0.193	--	--	n.a.	--	0.453	--	--	0.453
CM10FF	0.168	0.098	--	--	0.260	n.a.	0.809	--	--	0.809
XLI	--	--	--	--	--	--	n.a.	--	--	0.001
XRI2	--	--	--	--	--	--	--	n.a.	--	0.012
LEAD	--	--	--	--	--	--	--	--	n.a.	0.030
GDP: 2 qtrs										
EURO3	n.a.	0.110	--	--	--	--	--	--	--	0.110
FF	0.868	n.a.	--	--	0.161	--	--	--	--	0.868
M2R	--	--	n.a.	--	--	--	0.139	--	--	0.139
CP6TB6	--	--	--	n.a.	--	--	0.304	--	--	0.304
TB12FF	0.064	0.082	--	--	n.a.	--	0.062	--	--	0.082
CM10FF	0.076	--	--	--	0.228	n.a.	0.514	--	--	0.514
XLI	--	--	--	--	--	--	n.a.	--	--	0.000
XRI2	--	--	0.066	--	--	--	0.370	n.a.	--	0.370
LEAD	--	--	0.230	0.088	--	--	0.761	--	n.a.	0.761
GDP: 4 qtrs										
EURO3	n.a.	0.609	--	--	--	--	--	--	--	0.609
FF	--	n.a.	--	--	--	--	--	--	--	0.023
M2R	--	--	n.a.	--	--	--	--	--	--	0.007
CP6TB6	0.270	0.327	0.420	n.a.	0.850	0.779	0.401	--	--	0.850
TB12FF	--	--	--	--	n.a.	--	--	--	--	0.011
CM10FF	--	--	--	--	0.147	n.a.	--	--	--	0.147
XLI	--	--	0.105	--	0.157	0.298	n.a.	--	--	0.298
XRI2	0.791	0.817	0.959	0.364	0.839	0.711	0.939	n.a.	0.690	0.959
LEAD	0.102	0.122	0.960	--	0.240	0.300	0.420	--	n.a.	0.960

NOTE: Values less than or equal to 0.05 are marked with a dash.

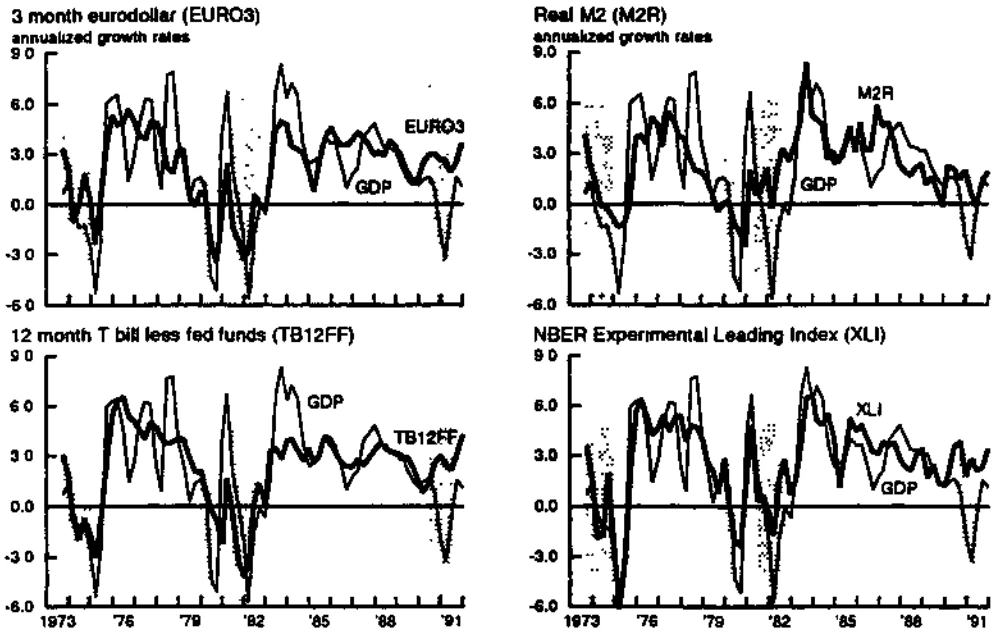
TABLE 5.3 - RELATIVE WEIGHTS IN MIXING REGRESSIONS

	Real GDP		
Indicator	**1 Qtr**	**2 Qtrs**	**4 Qtrs**
EURO3	*	0.093 (0.260)	n.a.
FF	n.a.	n.a.	0.105 (0.209)
M2R	*	0.187 (0.227)	0.414 (0.178)
CP6TB6	*	*	n.a.
TB12FF	*	0.103 (0.238)	0.368 (0.259)
CM10FF	n.a.	n.a.	0.114 (0.212)
XLI	0.533 (0.174)	0.617 (0.197)	*
XRI2	0.214 (0.155)	n.a.	n.a.
LEAD	0.253 (0.206)	n.a.	n.a.

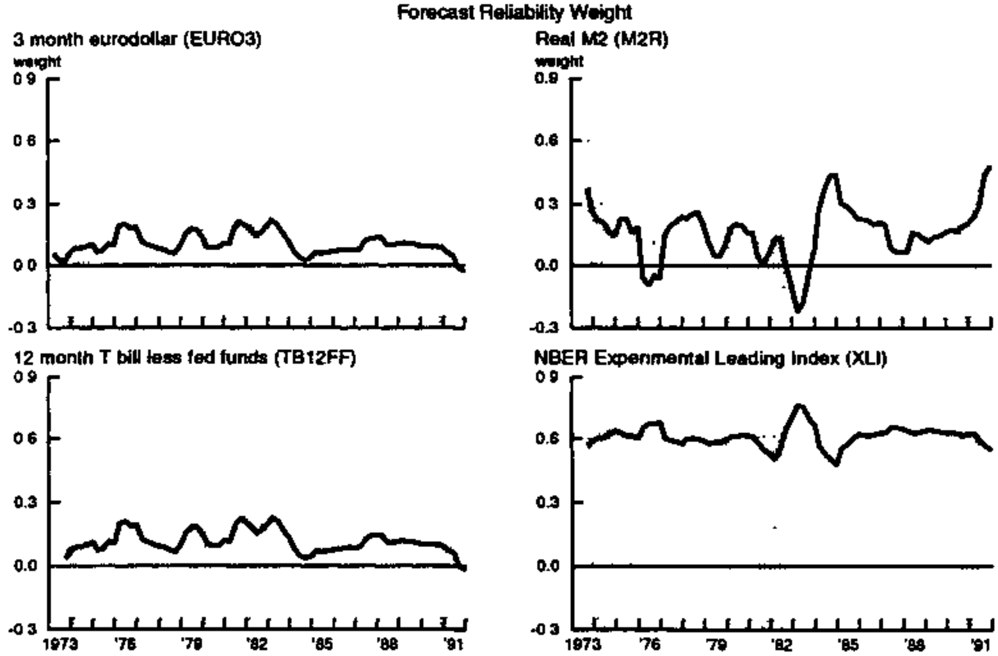
NOTES:
- Numbers in parenthesis are standard errors.
- n.a.: The indicator is not an initial survivor at this forecast horizon.
- (*): The indicator is encompassed by other indicators at this horizon.

5.1. Mixing Results

2 Quarter Ahead Forecast vs. Actual

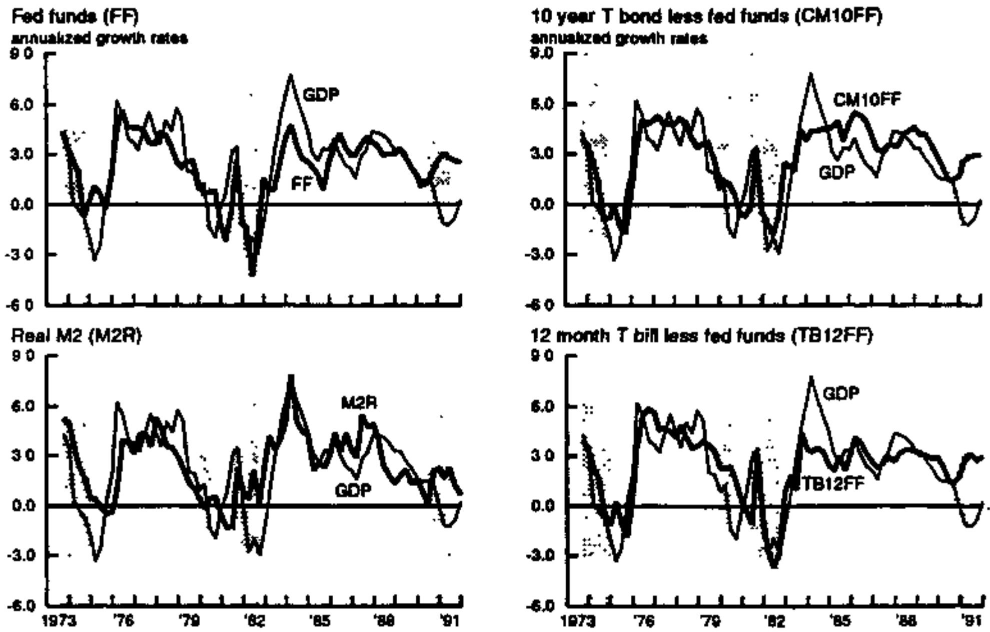


Forecast Reliability Weight

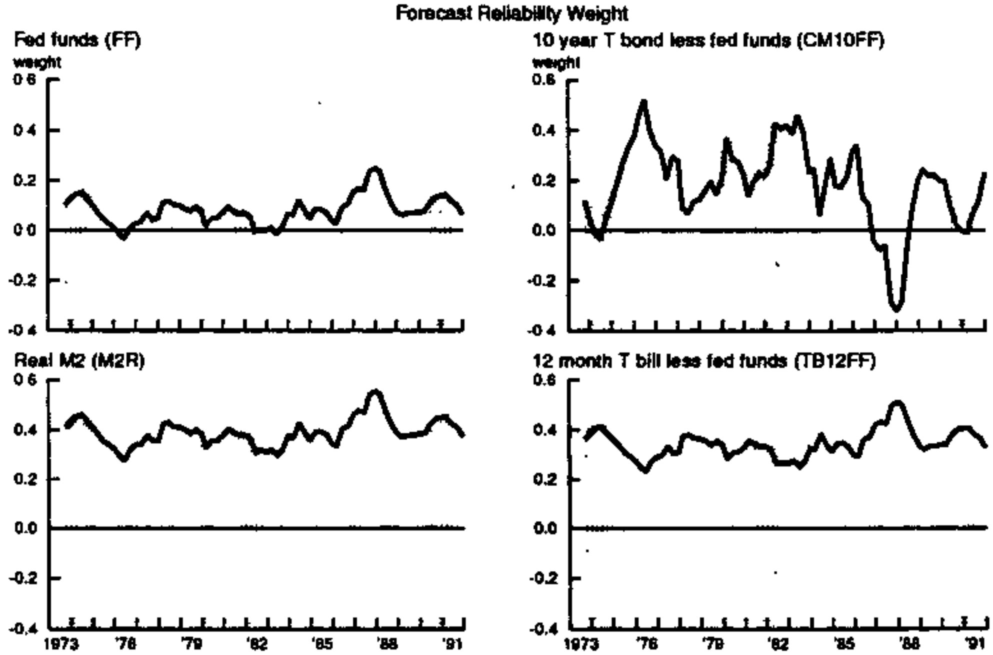


5.2. Mixing Results

4 Quarter Ahead Forecast vs. Actual



Forecast Reliability Weight



CONCLUSION

Four things become clear as the preceding analysis developed. First, the forecast horizon is an essential aspect of choosing and evaluating indicators. Second, substantial information resides in the term and public-private spreads and that both of these seemingly very different types of spreads seem to include significant common as well as distinct information sets. Third, while composite indicators may be extremely useful they are only as good as their design allows. The Stock-Watson NBER leading indicator series does very well at precisely what it was designed for, forecasting economic activity at a six-month horizon. Its usefulness beyond this is far more limited than prior analysis would have suggested. The analysis is also suggestive that the type of general purpose target variable that the old monetary targeting literature sought, probably does not exist at least in terms of real economic activity. Policymakers will continue to need to mix information according to their current focus. Mixing models of the sort used in this paper are meant to be preliminary work in this regard. The early results are intriguing.

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DISCUSSION OF

A POLICYMAKER'S GUIDE TO INDICATORS

OF ECONOMIC ACTIVITY

Richard W. Kopcke[1]

This paper examines various indicators, seeking those that are correlated most highly with the future course of economic activity. First, the indicators are arranged into "natural groups." Second, the paper selects the most promising indicators from each group. Third, the forecasts of the selected indicators are combined to produce mixed forecasts.

The paper includes many, but not all, of the popular indicators. Given that it confines itself to indicators of real economic activity, perhaps the paper should drop nominal M1 and nominal M2 (which apparently perform poorly) from its list to make room for model forecasts, real interest rates, stock prices, consumer confidence, and other indicators mentioned so much in the press.

Although the paper's strategy avoids using explicit economic models, in my opinion, it does not escape the consequences of measurement without theory. On the most elementary level, the paper's horse races should include the forecasts produced by economic models. The mean squared errors of the indicators appears to be high compared to those of the forecasting services surveyed by Stephen McNees. On a deeper level, the paper's strategy seems to require or presume implicit models which remain, undiscussed, behind the findings.

What determines the natural groups of indicators? Interest rates are gathered into one such group, presumably because they are all called interest rates. But they do not seem to be a natural group. The federal funds rate, for example, principally reflects monetary policy. The Baa rate reflects general economic conditions. Perhaps the federal

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funds rate, reserves, etc. constitute a more natural group, while the Baa rate, real M2, etc. constitute another.

Although the battery of tests performed on the indicators in each group are reasonably thorough, they are not entirely convincing without the benefit of the analysis that accompanies models. More importantly, it is not clear how the results of these tests are useful to policymakers.

Historical correlations reflect some mix of fiscal and monetary policies here and abroad as well as some mix of changing aggregate supply and demand. As these mixes vary in the future, these correlations will likely change. Specifically, if the average historical mix should not prevail in this recovery, the indicators may yield poor forecasts of the course of economic activity in the next few years.

Historical correlations between indicators and economic activity may not be a good guide in the future if we know, for example, that: (i) fiscal policy will be unusually restrictive for a recovery in coming years, (ii) the growth rate of the labor force will be less than one-half that prevailing since World War II, (iii) changing demographics will reduce the potential magnitude of a housing boom, (iv) the GDP gap differs from that at the inception of the average recovery, or (v) our economy is now more open to foreign trade than it had been in previous recoveries. Indeed, in the four-quarter forecasts (Chart 5.2, upper graphs), the indicators, too often, are negatively correlated with the course of economic activity during the current business cycle. According to these indicators, the average business cycle is a poor guide to this cycle.

In the 1940s Haavelmo and Duesenberry explained that the correlations among state variables (which include both indicators and economic activity) could not be interpreted outside a model. Because these correlations are unstable when economic conditions change, the remedy requires the modelling of economic behavior, which entails descriptions of how these correlations are likely to change. Whatever the weakness of these models, however competently they describe the way businesses, consumers, and governments make decisions, these models provide a structure needed for private or public policy analysis. Correlation coefficients are functions of partial correlation coefficients that might be more stable; nonlinearities are allowed. If the Federal Reserve should change its operating procedures (perhaps following some of these indicators), we cannot anticipate how the correlations among the federal funds rate, real M2, and economic activity will change without a model.

To illustrate further the difficulties that interpreting the correlations between indicators and economic activity pose for policymakers, consider the federal funds rate (Chart 5.2, upper leftmost graph). The correlation between the federal funds rate and activity may be relatively low for three reasons: (i) monetary policy has worked well as a shock absorber, offsetting potential disruptions, smoothing the ride; (ii) monetary policy has not reacted to short-run economic conditions; or (iii) monetary policy has been "out of phase" with the business cycle. The correlations of the indicators with activity, by themselves, do not tell us whether operating procedures should change, or how they should change.

Setting aside the problems of structural changes, without a model the correlations among state variables remain dubious guides. The paper's bivariate horse races, for example, do not necessarily select the best indicators. Bivariate correlations do not predict the order in which variables are added to or removed from step-wise regressions, and the results of Granger tests depend on the variables included in the regression. Therefore, an indicator which is deemed the best single candidate in its group may be inferior to another member of its group when more than one indicator (drawing from any group) is to be considered at a time. These problems might diminish if a model were used to form natural groups from the start, but if we ultimately are to consider multivariate forecasts, we ought to begin with multivariate techniques.

In forming multivariate forecasts, the information in each indicator should not be represented simply by its forecast from its bivariate regression with economic activity. These first-stage regressions restrict the information provided by each indicator, so the multivariate regression cannot make full use of the correlations among indicators to describe economic activity. Constraining the weights of the forecasts to be positive or to sum to one in the multivariate regression also prevents the full consideration of all the information in the indicators. No explicit model dictates these restrictions.

Indicators may be valuable to bond traders and others who want instant forecasts, who want inexpensive forecasts, who have little interest in describing the workings of the economy behind the forecasts, or who do not require the most accurate forecast, either because they only need a rough projection or because they make new forecasts very frequently. For the purposes of making policy, however, indicators are not so attractive. Suppose real M2 and the slope of the yield curve foretell unacceptable growth of GDP. What guidance do these indicators give policymakers? Should policy change? If so, how much? How does policy influence M2, the slope of the yield curve, and GDP? I am reminded of the comment that we must control GDP in order to control M2. A dilemma also would confront policymakers when, as is often the case, the indicator that forecasts one horizon best seems too far out of line with the indicator for a slightly shorter horizon. Because the paper concludes that there is no indicator for all seasons, policymakers need a model or metaindicator to interpret the signals.

For want of a model, indicators also seem to be poor guides for policymakers, because they provide no framework for setting either the objectives or the instruments of policy. For example, indicators do not show what paths for GDP are feasible or which paths are consistent with goals for inflation. Indicators, without a model, do not suggest how policymakers should react to economic conditions either to achieve a dynamically stable course for policy or to avoid increasing the volatility of GDP and prices.

In order to integrate consistently forecasts with policy, we build models; yet, indicators retain some allure. Perhaps the interest in indicators remains for one of two reasons. First, although our models are not producing forecasts that are clearly inferior, we may not take proper advantage of these models for analyzing the consequences of policy. Second, the goals of policy may not be specified sufficiently clearly (perhaps for want of agreement) in order to use the models as a guide. In this second case, indicators appear to be useful surrogates; they fail to stir passions while bridging the potentially disparate beliefs of policymakers.

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Discount Window Borrowing and Liquidity

W. J. Coleman, C. Gilles, and P. Labadie[1]

Three features seem central to understanding the relationship between U.S. monetary policy and the comovements of open market operations, monetary aggregates, and interest rates. First, shocks to bank reserves affect interest rates in ways that are not tightly linked to the Fisherian fundamentals (expected inflation, marginal rate of substitution, and marginal productivity of capital). Second, banks often respond to reserve shocks by adjusting their borrowing at the Federal Reserve's discount window. Third, the Federal Reserve often conducts open market operations to smooth interest rates that would otherwise react to private-sector demand shocks. In this paper, we study a stochastic general equilibrium model that incorporates these features in an effort to understand important empirical regularities involving monetary aggregates and interest rates.

The empirical regularities we have in mind are those documented in the vast literature aimed at uncovering a negative correlation between short-term interest rates and exogenous policy shocks to nominal monetary aggregates, a relationship often referred to as the liquidity effect. Cagan (1972) and Cagan and Gandolfi (1969), among many others, have reported finding negative correlations between M1 itself and various short-term interest rates. Subsequent studies have reported similar correlations with innovations in M1 backed out using a Choleski decomposition of the residuals in a vector autoregression (for a variety of orderings). More recently, however, Leeper and Gordon (forthcoming) have made a strong case that these innovations probably do not represent exogenous monetary policy shocks, as the money supply may be endogenously

[1] Board of Governors, Federal Reserve System. We gratefully acknowledge helpful discussions with Jim Clouse and Josh Feinman.

determined in ways that are not captured by any Choleski decomposition. To support their claim, they noted that the statistical properties of these innovations are sensitive to the other endogenous variables included in the VAR. the sample period, and the measure of money selected for analysis. Some researchers, for example Bernanke and Blinder (1990) and Sims (forthcoming), have responded to such criticism by assuming that innovations to interest rates reflect policy shocks, to which the supply of money responds endogenously. For our purpose, however, this strategy does not resolve the central question: if there exists a liquidity effect, then why are these interest rate innovations not robustly negatively correlated with monetary aggregates (an observation also made by Leeper and Gordon)?

Christiano and Eichenbaum (1991) and Strongin (1991) have tried to obtain robust negative correlations by using nonborrowed reserves as the measure of money. This approach contrasts with that of Leeper and Gordon, who experimented with monetary aggregates that are at least as broad as the monetary base. Christiano and Eichenbaum's rationale for using nonborrowed reserves is based on the widely held perception that the Fed controls this aggregate. For this reason they associated policy shocks with innovations to nonborrowed reserves, which they then showed to be negatively correlated with the federal funds rate. In fact, using nonborrowed reserves as the measure of money, they found evidence of a negative correlation regardless of whether money innovations or interest rates innovations were identified as the policy shocks, and they showed that these correlations are remarkably robust to the sample time period. To explain why the innovations to broader monetary aggregates do not exhibit a similar correlation, they noted that these aggregates are largely endogenously determined by the banking system. For example, they argued that total reserves may be inelastic in the short run, and therefore not correlated with interest rates at all. In this example, policy shocks to nonborrowed reserves do not affect total reserves immediately. Strongin refined this argument; he argued that innovations to nonborrowed reserves that are not reflected in shocks to total reserves should be identified as the policy shocks. He asserted, in essence, that shocks to required reserves lead to an adjustment in both nonborrowed and total reserves, whereas open market operations lead to an adjustment in only nonborrowed reserves.

We develop a model that is rich enough to address the empirical issues presented above. To do this, we introduce a banking system, reserve requirements, and a discount window into a model of liquidity based on the works of Grossman and Weiss (1983), Rotemberg (1984), Lucas (1990) and Fuerst (1992). In these models, and here, the term liquidity effect refers not merely to a negative correlation between monetary policy shocks and interest rates but more generally to any non-Fisherian effect on interest rates. Interest rates deviate from their Fisherian fundamentals because of shocks to the demand for bank deposits from businesses to finance new investment projects and perhaps also because of monetary policy shocks. In our model, the interest rate is also the cost (both pecuniary and nonpecuniary) of borrowing reserves from the discount window, so that over time there is a well defined relationship between borrowed reserves and the interest rate. Monetary policy designed to smooth interest rates then leads to rather complicated mutual dependencies among open market operations, both broad and narrow monetary aggregates, and interest rates; in particular, monetary policy can lead to positive correlations between broad monetary aggregates and interest rates in spite of the liquidity effect. When policy shocks are correctly identified, however, the model suggests that broad monetary aggregates are negatively correlated with interest rates, showing evidence of the liquidity effect. Furthermore, the model always generates a negative correlation between nonborrowed reserves and short-term interest rates, regardless of what the policy shocks are and how they are identified. Such a result is due to the way the discount window is operated. In light of this model, one interpretation of Christiano–Eichenbaum and Strongin's results is that they identified the discount window policy. Since this policy implies a negative correlation between nonborrowed reserves and interest rates whether or not the model incorporates a liquidity effect, their results shed little light on the presence of such an effect.

THE MODEL

DESCRIPTION.

To get an overview of the model, consider the following accounting of the assets and liabilities of banks. Their liabilities comprise demand deposits of firms and households as well as savings deposits of households. Their assets are made up of reserves and a portfolio of government securities and loans to firms. Banks are required to hold as reserves a fraction of their demand deposits; to avoid a deficiency, they can borrow reserves at the discount window. Borrowed reserves incur pecuniary and nonpecuniary costs. To start building a model around this balance sheet, think of households as dividing their deposits between demand deposits, which can be used to buy goods, and savings deposits, which cannot. Assume that this division is made before the value of the open market operation is known, resulting in a liquidity effect as described by Lucas (1990) and Fuerst (1992). Also assume, as Fuerst (1992) did, that firms must finance their purchases of investment goods with demand deposits, so that these deposits represent intermediated capital, as in Freeman and Huffman (1991).

To view the model in more detail, consider a representative household that ranks stochastic consumption and leisure streams $\{c_t, \ell_t\}$ according to the utility function

$$E\left[\sum_{t=0}^{\infty}\left(\prod_{i=0}^{t}\beta_i\right)U(c_t,\ell_t)\right],$$

where β_i is the date-i realization of the random discount factor; β_{t+1} is unknown at the beginning of period t but is revealed later during that period. The household begins period t with money balances M_t in an interest-bearing savings account. It immediately transfers amount Z_t to a checking account which bears no interest but can be used during the period to finance consumption c_t; only one transfer during the period is allowed. The household must choose Z_t before it knows the realization of any of the current shocks, or prices for that matter. Its purchases of goods are subject to the finance constraint

$$P_t c_t \leq Z_t.$$

At the end of the period, $M_t - Z_t$ remains in the household's savings account and $Z_t - P_t c_t$ in its checking account.

The household derives income from several sources. It provides labor to the firm, working a fraction of time equal to $1 - \ell_t$ at wage rate W_t; it earns interest at rate r_t^b on the amount $M_t - Z_t$ in its savings account; it collects a transfer X_t from the government; finally, as owner of both the firm and the bank, it collects Π_t^f and Π_t^b, the period's proceeds from the sale of output net of all costs and bank profit respectively. The household receives its income, including income from labor performed during the period, at the beginning of the next period, when it is directly deposited into the savings account. With unspent checking account balances being transferred back into the savings account, the law of motion for M_t is

$$M_{t+1} = Z_t - P_t c_t + (M_t - Z_t)(1 + r_t^b) + W_t(1 - \ell_t) + X_t + \Pi_t^f + \Pi_t^b.$$

The firm, the second agent in the economy, combines capital and labor inputs to produce a homogeneous product sold to buyers of consumption and capital goods. The production function is

$$y_t = F(k_t, n_t, \theta_t),$$

where y_t is the output, k_t and n_t are the inputs of capital and labor, and θ_t is a technological shock. The firm owns the capital stock k_t and hires labor at rate W_t; it makes wage payments at the beginning of the next period using the receipts from the sale of output. The firm must also acquire investment goods i_t; it purchases these goods from other firms in the goods market but cannot use its sales receipts for this purpose. Instead, it finances investment by borrowing B_t from a bank, which charges interest at rate r_t. The bank provides this financing by crediting the amount to the firm's checking account, increasing the balance from its starting level of zero. The firm's finance constraint is

$$B_t \geq P_t i_t.$$

At the end of the period, the firm has spent $P_t i_t$ on investment goods and deposits its current sales receipts, $P_t y_t$, leaving $B_t + P_t(y_t - i_t)$ in its checking account. At the beginning of the next period, the firm repays its bank loan and transfers wages into the worker's savings account. The amount left in the firm's account, Π_t^f, is paid to the firm's owner as dividend:

$$\Pi_t^f = P_t y_t - W_t n_t - P_t i_t - r_t B_t .$$

The stock of capital depreciates at the constant rate δ, so that its law of motion obeys

$$k_{t+1} = (1-\delta)k_t + i_t .$$

The firm makes all its decisions (namely, B_t, i_t, and n_t) with full knowledge of the current shocks and prices.

The bank, the third agent in the economy, starts period t with liabilities equal to M_t (the household's savings account) and holds an equal amount of vault cash as an offsetting asset (we write "vault cash" for definiteness; M_t could also be thought of as an account at the central bank). The household immediately transfers Z_t from its savings to its checking account, without affecting the bank's total liabilities or assets. The bank pays interest r_t^b on $M_t - Z_t$, the amount left in the savings account, but pays no interest on checking deposits. By lending B_t to the firm, an amount that is credited to the firm's checking account, the bank increases both its liabilities and its assets from M_t to $M_t + B_t$. To buy government bonds and to honor checks written to finance purchases of consumption and investment goods, the bank depletes its holding of vault cash, M_t; but it replenishes this cash position by the amount of the checks that firms receive for selling their output, checks that they deposit in their account. The amount of vault cash that the bank holds at the end of the period counts as reserves. Note that for an individual competitive bank, the loan of B_t to a firm drains reserves (when the firm spends the proceeds) just as much as if the bank had spent an equal amount to purchase government securities; therefore, at the same rate of interest, the bank is indifferent between the two types of lending. For the banking system as a whole, however, loans to firms involve no net loss of reserves, but merely a transfer from the borrower's bank to the bank of the producer of investment goods.

Reserves, V_t, pay no interest and are subject to a reserve requirement, a fixed fraction ρ of the amount of checking deposits on the books of the bank at the end of the period:

$$(1) \qquad V_t \geq \rho \times [(Z_t - P_t c_t) + (B_t - P_t i_t + P_t y_t)].$$

If the bank cannot satisfy the reserve requirement with the amount of vault cash it has at the end of the period (after checks have cleared), it can borrow the shortfall from the government at the discount window. Therefore, the following accounting identity must hold

$$(2) \qquad M_t + D_t = q_t G_t + P_t(i_t + c_t - y_t) + V_t,$$

where G_t is the number of one-period pure discount government bonds the bank acquires, at a unit cost of $q_t = 1/(1 + r_t)$, and D_t is the amount it borrows at the discount window. Government bonds, private loans, and discount window borrowing carry the same rate of interest r_t. The bank's objective is to maximize its period profit, which is given by

$$(3) \qquad \Pi_t^b = r_t(B_t + q_t G_t - D_t) - r_t^b(M_t - Z_t).$$

The government, the fourth agent in the economy, sells one-period bonds in the securities market and redeems them at the beginning of the following period, operates the discount window, and makes transfers to the household's bank account. During period t, the government announces the open market operation G_t and the amount of transfers X_t after the household chooses Z_t but before any other decision by any agent has to be made. All money flowing between the government and the private sector, as well as within the banking industry, takes the form of fiat money. The bank starts period t with an amount of fiat money (which it calls vault cash) equal to M_t. Nonborrowed reserves $V_t - D_t$ is the amount left in vault cash after the purchase of government bonds and check clearing but before borrowing at the discount window; in equilibrium, $V_t - D_t = M_t - q_t G_t$ as can be seen from eq. (2).

Let H_t denote the outstanding supply of fiat money at the beginning of period t (M_t is best thought of as the demand for fiat money, so that in equilibrium $H_t = M_t$). The law of motion for H_t, which can also be thought of as the government budget constraint, is as follows:

$$H_{t+1} = H_t + r_t(q_t G_t - D_t) - X_t.$$

Think of government policy as a rule that generates the values of G_t and X_t and that also sets the rate of interest at the discount window. Assume that the government lends reserves at the discount window according to an upward-sloping function $\psi : [0, \infty) \rightarrow [0, \infty)$ that relates the rate of interest it charges to the fraction of total reserves that it lends. Banks cannot lend at the discount window, so that when the equilibrium rate of interest is lower than the minimum rate at which the government is willing to lend, $\psi(0)$, there is no discount window activity:

$$\begin{aligned} r_t &= \psi(D_t/V_t) \qquad \text{whenever } D_t > 0; \\ r_t &\leq \psi(0) \qquad \text{whenever } D_t = 0. \end{aligned}$$

The argument of ψ ought to be the amount *supplied* at the window, which in equilibrium turns out to be equal to D_t, the amount *demanded*. Incorporating this equilibrium relationship directly simplifies the notation, but keep in mind that banks take as given all interest rates, including the rate they face at the discount window (which is equal to the rate on government securities).

When the Federal Reserve lends at the discount window, the borrowing bank pays the discount rate plus a nonpecuniary cost; at the margin, this sum must equal the cost of borrowing from other banks, which is the federal funds rate. The marginal nonpecuniary cost is thus captured by the difference between the federal funds rate and the discount rate, called the *spread*. Historically, the policy of the Federal Reserve seems to have been to supply funds at the discount window at an increasing nonpecuniary cost (spread), which is precisely what the function ψ assumes. This type of discount-window policy has been documented in the empirical literature, and is commonly modeled in the theoretical literature.[2] Chart 1, which graphs the monthly time series for

[2] See for example Polakoff (1960), Goldfeld and Kane (1966), and more recently Goodfriend (1983), Dutkowsky (1984), and Waller (1990). In particular, Fig. 1, p. 346 in Goodfriend depicts an assumed ψ function that is strikingly similar to the function that would best fit the scatter plot of our Chart 2.

the federal funds rate and the nonborrowed reserve ratio (the mirror image of the borrowed reserve ratio), reveals the basis for the findings of the empirical studies. On closer inspection, a picture of the function ψ emerges in a scatter plot of the borrowed reserve ratio against the spread, shown in Chart 2. Since this picture suggests that the Federal Reserve is ready to lend its first dollar at a zero spread, the value of $\psi(0)$ corresponds to the discount rate. With this interpretation of $\psi(0)$, the model simply assumes a constant discount rate.

A word about terminology is in order. V_t is total reserves in the banking system; D_t is borrowed reserves; the difference $V_t - D_t$ is nonborrowed reserves; and required reserves is $\rho \times [Z_t + B_t + P_t(y_t - i_t - c_t)]$. Besides total reserves, it is possible to identify the analogues of several monetary aggregates. M_t (or H_t) corresponds to the monetary base, M0; the analogue of M1 is the sum of all reservable accounts, $Z_t + B_t$; the total libilities of the banking sector at the end of the period, $M_t + B_t$, correspond to M2 (strictly speaking, M1 and M2 both should include $P_t(y_t - c_t - i_t)$ as well, but this is equal to zero in equilibrium); finally, the difference between M2 and M0, which is B_t, is inside money.

It is now useful to summarize the timing of information and decisions. During period t, the realizations of four random variables shock the economy—the technological shock θ_t, the preference shock β_{t+1}, the open market operation G_t, and the government transfer X_t. At the beginning of the period, the household must decide how much to put into its checking account, not knowing the current realization of θ_t, β_{t+1}, G_t, or X_t, and therefore not knowing what interest rates, prices, output, or consumption will be. After it makes this decision, all four shocks are revealed and prices are set. On the basis of these shocks and these prices, the household decides how much to consume and how much to work; the firm decides how much to borrow, how much to invest, and how much labor to hire; and the bank decides how much to lend to the firm and to the government. Then trading takes place and checks clear. The bank monitors its reserve position and borrows at the discount window to cover any reserve deficiency (the bank can be thought of as borrowing at the same time it invests in government bonds or lends to firms, because it has the same information when it engages in any of these activities). At the start of next period, the firm pays its wage bill, repays its bank loan, and pays out its earnings to its shareholder; the government makes transfers to the household's savings account and redeems the bonds that the bank holds; the bank pays interest on its savings account, settles its discount window debt, and pays out its earnings. These activities determine the new initial balance in the household's savings account. Then a new cycle starts.

The activities of the four agents that have been described above must, of course, satisfy the following standard market-clearing conditions.

$$\begin{aligned} y_t &= c_t + i_t && \text{goods market;} \\ n_t &= 1 - \ell_t && \text{labor market;} \\ H_t &= M_t && \text{money market.} \end{aligned}$$

The economy is competitive, and agents have rational expectations. An equilibrium is a set of state-contingent prices and interest rates such that markets clear when all agents solve their optimization problems, treating prices as given. In the next subsection, we are more explicit about what this means.

THE MODEL AS A RECURSIVE SYSTEM

The household solves a dynamic program, which is recursive under standard assumptions about preferences, technology, and the stochastic environment.

ASSUMPTION 1. *The period utility function U is twice continuously differentiable, strictly increasing in both arguments, and strictly concave.*

ASSUMPTION 2. *The production function F has the form $F(k,n,\theta) = \theta f(k,n)$, where f is twice continuously differentiable, strictly increasing in both arguments, concave, and homogeneous of degree one. (Stochastic constant returns to scale.)*

ASSUMPTION 3. *The preference shocks $\{\beta_t\}$ and the technological shocks $\{\theta_t\}$ are generated by independent first-order Markov processes. The support of β_t is contained in $(0,1)$ and that of θ_t is contained in $(0,\infty)$.*

Monetary policy consists of a rule that dictates the value of open market operations, the size of government transfers, and the level of the discount rate;

these instruments are not completely independent of each other. The operation of the discount window is modeled through a fixed function ψ that relates the discount rate to borrowed reserves. Think of the government as announcing this function and keeping it fixed in all periods, leaving the discount rate itself endogenously determined by the demand for borrowed reserves. Given the function ψ, the values of G_t and X_t in period t are implied by the choices of the ratios $g_t = G_t/H_t$ and $\gamma_t = H_{t+1}/H_t$. To induce stationarity and recursivity, choose (g_t, γ_t) as the policy variables and make the following assumption.

ASSUMPTION 4. *The monetary policy shocks $\{g_t, \gamma_t\}$ are generated by a first-order Markov process.*

Starting with the optimization problem faced by the bank simplifies both the notation and the analysis. The bank maximizes its period profit, given in (3), by choosing an optimal portfolio (B_t, G_t, D_t, V_t), subject to the legal reserve constraint (1), and the accounting identity (2). Clearly, optimization requires that $V_t = \rho[Z_t + B_t + P_t(y_t - i_t - c_t)]$ (no excess reserves) if $r_t > 0$. A zero-profit condition, the result of perfect competition and constant returns to scale in the banking industry, implies that $r_t^b = [(M_t + B_t - V_t)/(M_t - Z_t)] \times r_t$; this condition in turn yields $r_t^b = r_t[1 + (1-\rho)(Z_t + B_t)/(M_t - Z_t)]$, which holds whether or not $r_t > 0$. To obtain the last expression, recall the market-clearing condition $y_t = c_t + i_t$.

Since the firm and the bank belong to the household, it is possible to integrate the problems faced by the firm, the bank, and the household. Because money growth induces a trend in nominal variables, stationarity of the equilibrium requires that nominal variables—denoted by uppercase letters—be divided by the supply of fiat money. The new variables are denoted by the corresponding lowercase letters; thus, $m_t = M_t/H_t$, $z_t = Z_t/H_t$, and so forth. Under assumptions 3 and 4, the evolution of the shocks is determined at the beginning of period t by the vector $(\beta_t, \theta_{t-1}, g_{t-1}, \gamma_{t-1})$, which consists of the latest known realizations of the shocks. The state of the economy at that time can then be expressed as $s_t = (\kappa_t, \beta_t, \theta_{t-1}, g_{t-1}, \gamma_{t-1})$, where κ_t is the aggregate per capita stock of capital (as opposed to k_t, which is the individual firm's holding). In equilibrium, of course, individual decisions determine aggregate outcomes, so that $\kappa_t = k_t$. A solution is a set of functions p, w, and r such that $p_t = p(s_t, s_{t+1})$, $w_t = w(s_t, s_{t+1})$, and $r_t = r(s_t, s_{t+1})$ yield the equilibrium values of the normalized price level, the normalized wage rate, and the rate of interest on date t (again, $p_t = P_t/H_t$ and $w_t = W_t/H_t$). Since $q_t = 1/(1 + r_t)$, the equilibrium function r determines a function q satisfying $q_t = q(s_t, s_{t+1})$.

Given such pricing functions, let $J(m, k, s)$ denote the value of the optimal discounted stream of utility for a household starting a given period with money balances m, while the firm owns capital stock k and the economy is in state $s = (\kappa, \beta, \theta, g, \gamma)$. The household first chooses z, which is the transfer from its savings to its checking account. expressed as a fraction of the outstanding supply of fiat money. Then $(\beta', \theta', g', \gamma')$ are revealed (a prime denotes the realization of a variable that was unknown at the beginning of the period), and these shocks determine the current price, wage rate, and rate of interest, as well as the next-period state s'. To determine s', the household must know how the evolution of the aggregate capital stock depends on the state of the economy. In equilibrium, of course, this law of motion follows from the individual optimal decisions. On the basis of an assumed law of motion for κ and of $p(s, s')$, $w(s, s')$, and $r(s, s')$, the household makes its consumption and leisure decisions and the firm makes its labor and investment decisions. What these optimal decisions are can be studied by considering the Bellman equation characterizing J, the value function.

$$J(m, k, s) = \max_{z} E_s \left[\max_{(c,\ell,n,i)} \{U(c, \ell) + \beta J(m', k', s')\} \right]$$

subject to

$$\begin{aligned} (4) \qquad z &\geq pc\,; \\ \pi^f &= p\theta' f(k, n) - (1 + r)pi - wn\,; \\ k' &= (1 - \delta)k + i\,; \\ m' &= \frac{w(1 - \ell) + (m - z)(1 + r^b) + x' + \pi^f + (z - pc)}{\gamma'}\,; \end{aligned}$$

the last constraint on the problem is the law of motion for κ. Here p, w, and r are short for $p(s,s')$, $w(s,s')$, and $r(s,s')$, and E_s is the expectation conditional on s. Using the results of the bank's optimization problem, the market-clearing condition $\theta' f(k,n) = c + i$, and the firm's optimization condition $b = pi$, we have $r \geq 0$, $v \geq \rho(z+b)$, and $v = \rho(z+b)$ if $r > 0$.

OPTIMIZATION AND EQUILIBRIUM CONDITIONS.

The Bellman equation for J includes two maximization operators; the first refers to the choice of z, which is conditional only on s, and the second refers to the choice of (c,ℓ,n,i) which is conditional on both s and s'. Corresponding to the latter choice, we have the following four first-order conditions:

$$(c) \qquad \frac{U_1(c,\ell)}{p(s,s')} = \lambda + \beta \frac{J_1(m',k',s')}{\gamma'};$$

$$(\ell) \qquad \frac{U_2(c,\ell)}{w(s,s')} = \beta \frac{J_1(m',k',s')}{\gamma'};$$

$$(n) \qquad w(s,s') = p(s,s')\theta' f_2(k,n);$$

$$(i) \qquad J_2(m',k',s') = p(s,s')[1 + r(s,s')] \frac{J_1(m',k',s')}{\gamma'};$$

where λ is the Kuhn-Tucker multiplier associated with the finance constraint (4), so that $\lambda(z - pc) = 0$. Indexes to the functions U and J denote partial derivatives; therefore, U_1, for example, is the partial derivative of U with respect to its first argument, consumption.

The first-order condition associated with the choice of z is

$$(z) \qquad E_s\left[\frac{U_1(c,\ell)}{p(s,s')}\right] = E_s\left[\beta[1 + r^b(s,s')] \frac{J_1(m',k',s')}{\gamma'}\right].$$

To solve the dynamic programming problem, we need the following envelope conditions, which give the marginal values of money and capital:

$$(m) \qquad J_1(m,k,s) = E_s\left[\frac{U_1(c,\ell)}{p(s,s')}\right];$$

$$(k) \qquad J_2(m,k,s) = E_s\Big[\Big(U_1(c,\ell) - p\lambda\Big)\Big(\theta' f_1(k,n) + (1+r)(1-\delta)\Big)\Big];$$

where p is short for $p(s,s')$, and similarly for w and r.

Finally, an equilibrium in this economy is a set of functions $w(s,s')$, $p(s,s')$, and $r(s,s')$ [or equivalently $q(s,s')$] and a law of motion for the aggregate capital stock κ such that the associated solution of the dynamic programming problem—that is, values for (z,λ,c,l,n,i,v,d) that solve the first-order and envelope conditions—satisfies the following equilibrium conditions:

$$\begin{aligned}
c+i &= \theta' f(k,n)\,;\\
1-\ell &= n\,;\\
qg' + v - d &= m\,;\\
m &= 1\,;\\
k' &= \kappa'\,;\\
r^b &= \left[1+(1-\rho)\frac{z+pi}{m-z}\right]\times r\,;\\
d\times r &= d\times \psi(d/v)\,.
\end{aligned}$$

The last equation states that, when the monetary authorities lend at the discount window ($d>0$), they do so in accordance with their supply behavior, so that $r=\psi(d/v)$. In the third equilibrium condition, $qg'+v-d=m$, v is equal to $\rho(z+pi)$ unless $r=0$, in which case v can exceed required reserves.

Solving the Model

Consider initially a slightly simplified version of the model in which labor is inelastically supplied ($\ell = 0$) and money supply is constant ($\gamma = 1$). To solve this simplified model, first reduce the system of equations that determines the equilibrium to only three equations in the three unknown functions c, z, and (a transformation of) J_1.

To simplify the notation, define $\xi(\beta,s') = \beta J_1(1,\kappa',s')$.[3] Then the first-order condition (c) becomes

$$U_1(c) = (\lambda+\xi)\,p.$$

[3] Recall that κ is one of the arguments of s, so that the function ξ is well defined.

Here and below ξ stands for $\xi(\beta, s')$; accordingly ξ' below stands for $\xi(\beta', s'')$. Using this equation and the constraint $z \geq pc$, which holds with equality whenever $\lambda > 0$, isolate p as

$$p = \min\left\{\frac{z}{c}, \frac{U_1(c)}{\xi}\right\}. \tag{5}$$

Substitute this equation in $\xi = \beta E_{s'}\left[U_1(c')/p'\right]$, which follows from the definition of ξ and the envelope condition (m), to obtain

$$\xi = \beta E_{s'}\left[\max\left\{\frac{c'U_1(c')}{z'}, \xi'\right\}\right]; \tag{6}$$

this equation is the first of the set of three to be solved (ξ now replaces J_1). The second equation follows from substituting the expression (5) for p into the first-order condition (z), obtaining

$$E_s\left[\max\left\{\frac{cU_1(c)}{z}, \xi\right\}\right] = E_s[(1 + r^b)\xi]. \tag{7}$$

The last equation in the system follows from the first-order equation (i) and the envelope condition (k):

$$\begin{aligned}&\min\left\{\frac{z\xi}{c}, U_1(c)\right\}\\ &= \beta q E_{s'}\left[\min\left\{\frac{z'\xi'}{c'}, U_1(c')\right\}(\theta'' f_1(k') + (1 + r')(1 - \delta))\right].\end{aligned} \tag{8}$$

To write (6) – (8) solely in terms of c, z, and ξ, express r and r^b in terms of these functions as follows:

$$r = \psi(d/v);$$

and

$$r^b = \left[1 + (1 - \rho)\frac{z + b}{1 - z}\right] r; \tag{9}$$

where

$$d = qg' + v - 1\,;$$
$$v = \rho(z + b);$$
$$b = \min\left\{\frac{zi}{c}, \frac{iU_1(c)}{\xi}\right\};$$

and finally,

$$i = \theta' f(k) - c\,.$$

These equations hold provided $d > 0$ and $r > 0$; if $d = 0$, then $r \le \psi(0)$, while if $r = 0$, then $v \ge \rho(z + b)$. Rather than solving this model explicitly, which can be done numerically using the methodology presented by Coleman (1992), we devise an example which admits a closed-form solution. This example highlights all the features of the model that are useful in interpreting the empirical regularities mentioned earlier.

AN EXAMPLE

To develop an intuitive understanding of the model, it is instructive to consider a parametrization that allows a closed-form solution. Suppose that (a) utility is logarithmic; (b) production satisfies $f(k) = k^\alpha$, for $0 < \alpha < 1$; (c) capital depreciates completely over each period; and (d) the technological shocks θ, the policy shocks g, and the preference shocks β are all iid (although not necessarily independent of each other). Now, conjecture that no excess cash is ever held in the goods market and that z is constant at $\bar{z}$. Under these circumstances, $b = \bar{z}i/c$, $i = k'$, and equations (6)–(8) simplify to

$$\xi = \frac{\beta'}{\bar{z}},$$

$$1 = E_s\left[\beta(1 + r^b)\right], \tag{10}$$

$$\frac{1}{c} = \beta' q E_{s'}\left[\frac{\theta'' \alpha (k')^{\alpha - 1}}{c'}\right], \tag{11}$$

where the interest rate r satisfies

$$r = \psi\left(\frac{qg' + \rho(1 + k'/c)\bar{z} - 1}{\rho(1 + k'/c)\bar{z}}\right), \tag{12}$$

and r^b is given by (9). Further conjecture that the consumption function can be written as

$$c = \frac{1}{1 + h(\beta' q)} \theta' k^{\alpha},$$

for some function h. Note that because $k'/c = h(\beta' q)$, the function h can be thought of as the investment to consumption ratio. Since h depends only on $\beta' q$ and since $q = 1/(1+r)$, (12) determines r as a function of $\bar{z}$, β', and g'. Write this function, which implies that r and q are iid and independent of s, as $r = R(\bar{z}, \beta', g')$ and correspondingly $q = Q(\bar{z}, \beta', g')$; now substitute these equations into (9), and the resulting equation into (10), to obtain

$$1 = E_s \left[\beta' \left(1 + \left(1 - \frac{(1-\rho)[1 + h(Q(\bar{z}, \beta', g'))]\bar{z}}{1 - \bar{z}} \right) R(\bar{z}, \beta', g') \right) \right].$$

This equation has the important implication that z does not depend on s, because s enters only through the conditional expectation, and β' and g' are iid. This observation verifies the conjecture $z(s) = \bar{z}$. To find h, substitute the conjecture about the consumption function into (11) and simplify to obtain

$$h(\beta' q) = \alpha \beta' q (1 + E_{s'}[h(\beta'' q')]).$$

Using the fact that β' and q are iid (because $q = Q(\bar{z}, \beta', g')$, and (β, g) is iid), this equation implies

$$h(\beta' q) = \frac{\alpha \beta' q}{1 - E[\alpha \beta' q]},$$

where $E[\,.\,]$ is the unconditional expectation, taken over the constant distribution of (β', q). It is then straightforward to verify that the finance constraint in the goods market is always binding; therefore, all the initial conjectures were correct.

This example leads to a sharp characterization of the response of monetary aggregates and the interest rate to supply and demand shocks. Using the equilibrium value of $k'/c = h$, rewrite (12) as

$$(13) \qquad \frac{1}{q} = 1 + \psi \left(1 - \frac{(1 - qg')(1 - E[\alpha \beta' q])}{\rho \bar{z}(1 + \alpha \beta' q - E[\alpha \beta' q])} \right).$$

Consider first the effect of technological shocks, θ'. Such shocks do not affect r, as (13) makes clear, and thus they do not affect any of the monetary aggregates. They have real effects, of course, since they affect output, consumption, and investment. But they fail to move nominal interest rates (although real rates certainly do) because the demand for consumption and investment goods shift proportionately. This feature is due to the choice of utility and production functions, and is not a general feature of the model. It indicates, however, that in the general case productivity shocks can affect interest rates and monetary aggregates in either direction. Before turning to the effect of other shocks, it is helpful to list the relevant equations. The first is (13), which determines the correlation between each shock and the nominal rate of interest. The others are:

$$\text{total reserves:} \quad v = \rho\bar{z}[1 + h(\beta' q)]; \tag{14}$$

$$\text{nonborrowed reserves:} \quad v - d = 1 - qg'; \tag{15}$$

$$\text{borrowed reserves:} \quad d = v \times \psi^{-1}(r); \tag{16}$$

$$\text{M1:} \quad \bar{z} + b = \bar{z}[1 + h(\beta' q)]; \tag{17}$$

$$\text{M2:} \quad 1 + b = 1 + \bar{z}h(\beta' q). \tag{18}$$

To isolate the effect of policy shocks, assume first that there are no other shocks (a similar procedure will uncover the effect of preference shocks). Note that the left side of (13) is decreasing in q, while the right side is increasing both in q and in g' (recall that ψ is increasing); therefore g' and q vary inversely. For the same reason, but considering the right side as a function of q and qg', q and qg' vary inversely also. Hence, g', r, and qg' all move in the same direction. In view of (15), then, policy shocks induce a negative correlation between the nominal rate of interest r and nonborrowed reserves $v - d$. They also induce a negative correlation between r and v, total reserves, as (14) reveals since h increases in q. The correlation between r and v can be entirely attributed to the variance of inside money, $\bar{z}h(\beta' q)$; this variance also induces a negative correlation between r and the broader monetary aggregates M1 and M2, as shown by (17) and (18). From (16), it is clear that the ratio of borrowed to total reserves is positively correlated with the interest rate, a relation which has nothing to do with the source of the shock but is due exclusively to the form of ψ, that is, to the operation of the discount window. If total reserves did not respond to the policy shock (an assumption which is sometimes made in empirical work), the form of ψ alone would induce a positive correlation between the interest rate and borrowed reserves.

Suppose now that shocks to β are the only shocks in the system. The left side of (13) is decreasing in q, while the right side is increasing in q and decreasing in $\beta' q$; therefore, q and $\beta' q$ (and therefore q and β' also) move in opposite directions, while β' and $\beta' q$ move in the same direction. Equations (14)–(18) then show that preference shocks induce a positive correlation between the interest rate and any of the reserve or monetary aggregates (total, nonborrowed, and borrowed reserves; inside money, M1, and M2).

It is now possible to use the example to study more complicated policies. Suppose that in response to positive preference shocks that would otherwise increase interest rates, the government chooses its open market operation to keep the rate constant, which corresponds to a small realization of g' (in this case, β and g are still iid, but not independent of each other). With the interest rate constant, β' high and g' low, all the reserve and monetary aggregates are high (but the borrowed reserve ratio is constant). If the policy response only partially offsets the preference shock, all reserve and monetary aggregates may still rise, while the rate of interest rises also. In that case, despite the presence of a liquidity effect in the model, open market operations could be seen as "inducing" a positive correlation between interest rates and various monetary aggregates (and nonborrowed reserves as well).

Conclusion: Interpreting the Empirical Literature

As mentioned in the introduction, the empirical literature directed to measuring the effect of monetary policy shocks on interest rates is replete with seemingly conflicting results. The model provides a framework for thinking about these results and for interpreting the literature; the example brings out the important features of the model. First, the model highlights the role of inside money creation as an avenue for total reserves to respond to open market operations. In this sense, the model fails to support Strongin's identifying restrictions that total reserves do not respond to open market operations within a month or a quarter. Second, the model suggests that the operation of the discount window, summarized by a fixed and positively sloped supply function, can alone generate a negative correlation between nonborrowed reserves and the federal funds rate. Such a correlation has been documented by Christiano and Eichenbaum (1991). While they identified policy shocks as innovations to nonborrowed reserves, the model suggests an alternative explanation that has nothing to do with policy shocks. Third, although the model is designed to have a liquidity effect, a policy of interest-rate smoothing hinders efforts to detect its presence. This could explain the difficulties econometricians have had in measuring this effect. To identify policy shocks, it is not sufficient to identify a variable (such as nonborrowed reserves) that is under the control of the Fed, since the Fed may use its instrument to achieve particular objectives. In this sense, the model points to the familiar need, and provides a framework for, identifying demand and supply shocks to estimate a liquidity effect.

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Chart 1. Federal Funds Rate and Nonborrowed Reserves Ratio
Monthly, January 1961 - July 1992

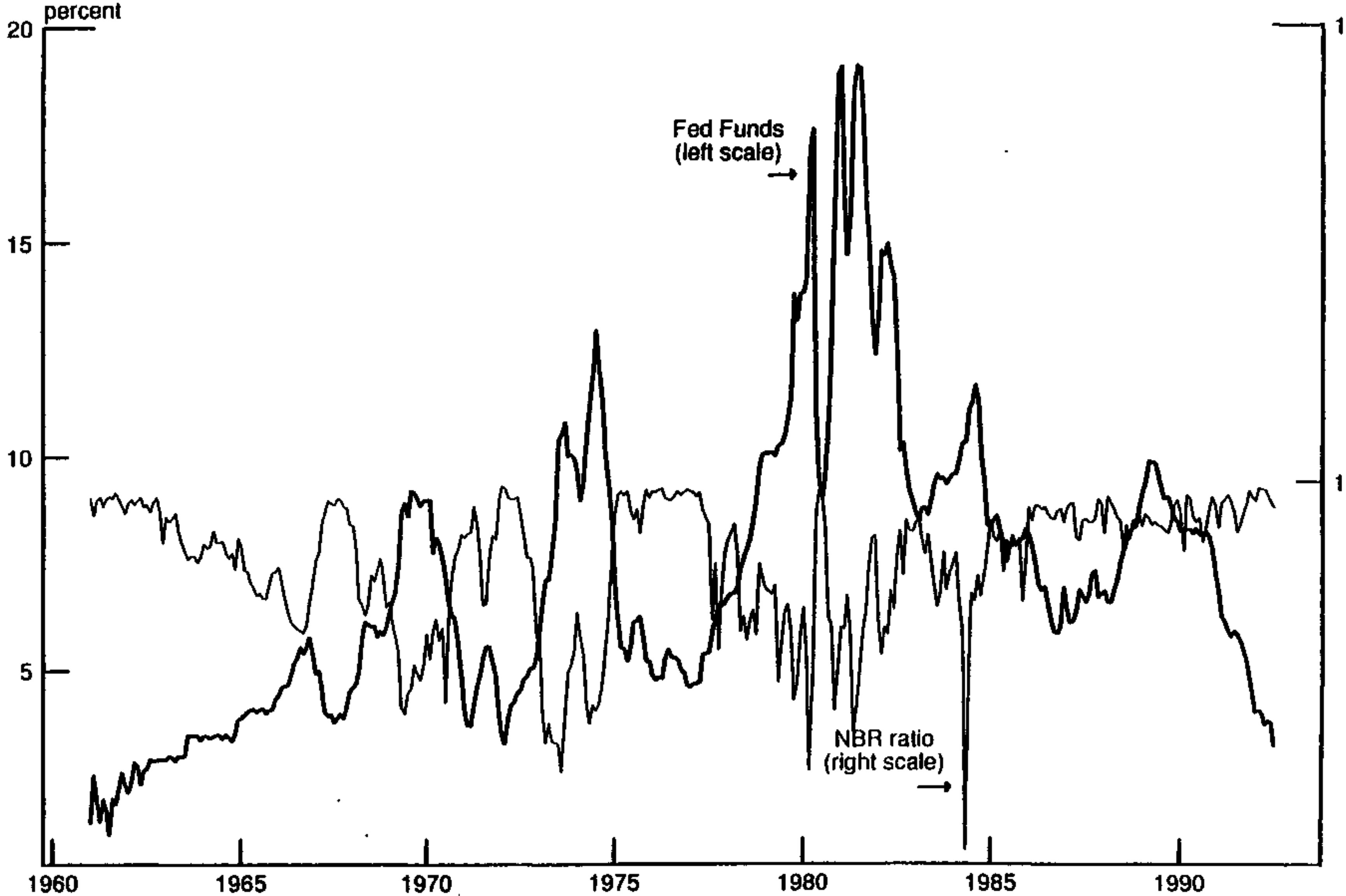
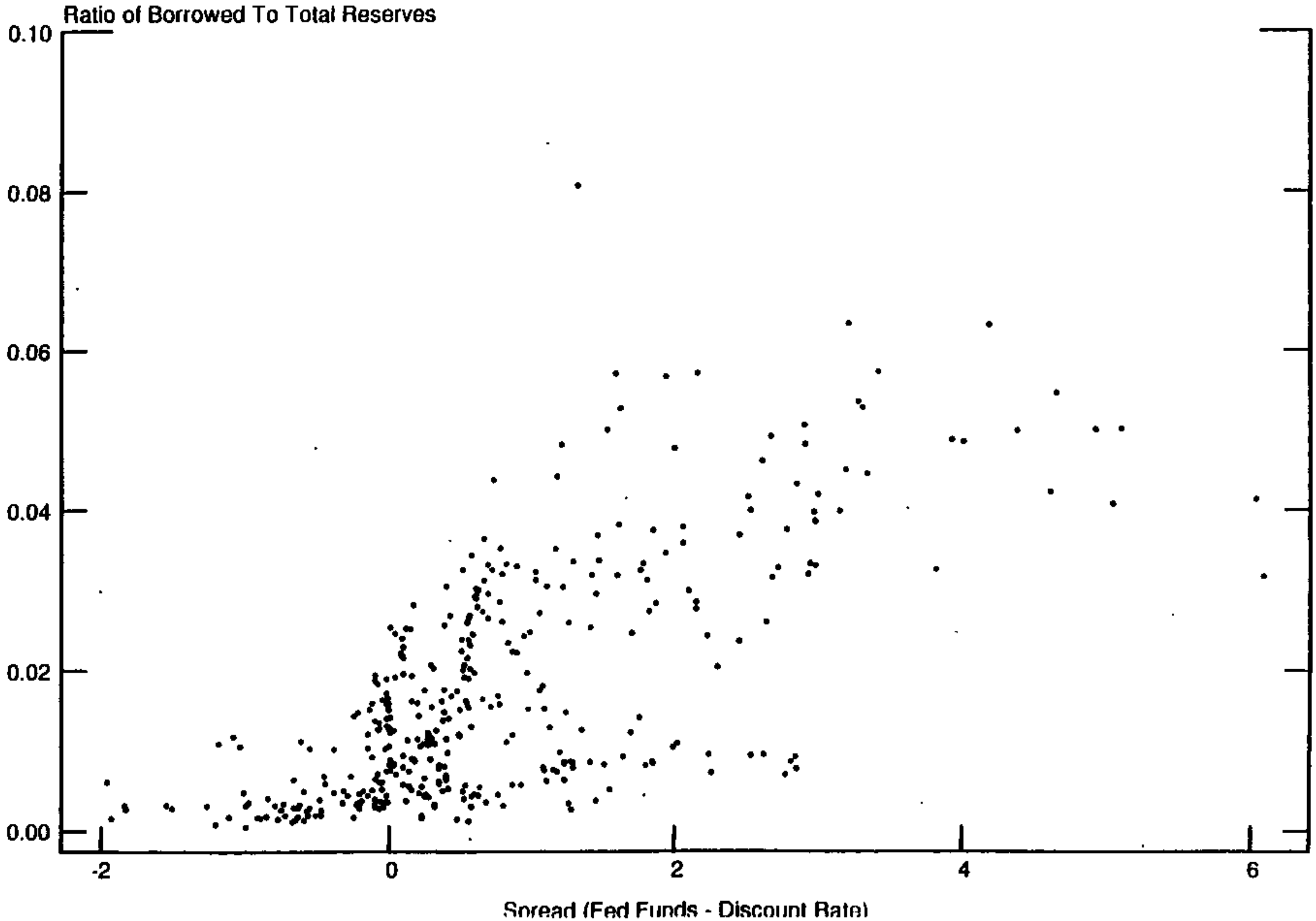


Chart 2. The Psi Function; 1961(1)-1992(7).



Comments on "Discount Window Borrowing and Liquidity"
by Coleman, Gilles, and Labadie
Michael Dotsey

I have been asked to discuss "Discount Window Borrowing and Liquidity" which I view as very interesting but preliminary work toward examining "liquidity effects" in a framework that incorporates a fairly (primitive) reserves market. I use the term primitive with regard to the reserves market since no interesting dynamic behavior is present in this market. Viewing work on BR^d, especially that of Goodfriend (1983) this is a shortcoming that I hope will be addressed by later generations of the model. The paper, however, is very rigorous and state of the art on other dimensions and the authors deserve a lot of credit for moving the liquidity effects literature in this direction.

The empirical motivation for the paper can be traced to work by Christiano and Eichenbaum (1992) and especially to that of Strongin (1991). Strongin's work is fairly persuasive and indicates that in order for any model to replicate data on liquidity type effects reserve market behavior is likely to be a crucial ingredient. This is because the liquidity effect only shows up in NBR's or to be more accurate, in the part of NBR that represents independent monetary policy. This paper's novel inclusion of reserve market behavior represents a commendable extension of this basic line of research.[1]

In reading this paper, I found that it raised at least as many questions as it answered. Much of my confusion is not the

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1. One thing I would like to see done in these estimations is removing settlement day data. This data could potentially contaminate the results. Suppose for instance the Fed misforecasts float or treasury balances believing there will be more of these funds available than are actually there. NBR will be low on the settlement day and the funds rate will be high, perhaps by a substantial amount. Two such occurrences in a month (at least 25% probability) could make monthly average NBR a little low and monthly average r_F a little high. While I doubt this is the reason for Strongin's results it would be nice to purge the data of what is merely an interbank friction.

result nor the fault of this paper in particular, but rather comes from a lack of understanding and perhaps misgivings of this literature in general. In my comments I will discuss some of these misgivings and, hopefully, my comments will lead to some discussion from the rest of the audience.

The paper extends a branch of research that is attempting to understand the effect of monetary policy on interest rates and real activity. In particular these papers' search for a mechanism that will explain (1) how contractionary monetary policy raises short-term interest rates and (2) how it causes declines in economic activity. This literature received its impetus from Lucas's (1990) influential paper. A common feature of most of this literature involves cash-in-advance constraints that constrain the amount of money available for use in a loan or securities market, however, no two papers seem to use the same exact specification.

Lucas's original setup and CGL (1991) envision bond traders as only having limited funds and, therefore, open market operations affect the price of bonds and thus interest rates. The appeal of Lucas's setup is that it eliminates the differential wealth effect of open market operations that were present in earlier literature (eg Grossman and Weiss and Rotemberg). Fuerst (1991) extends Lucas's setup to a production economy that places a CIA constraint on both investment and labor expenditures. Unlike households' portfolio decisions, production decisions are made after the stochastic state of the economy is known. Since individuals must choose the portion of their portfolio to lend to firms via intermediaries prior to observing the monetary transfer or the market clearing interest rate, the monetary transfer can affect the tightness or looseness of the loan market. Hence liquidity effects that have real consequences result from monetary policy. Christiano (1991) subjects the Fuerst model and an alternative version of that model in which investment decisions are also made prior to the realization of shocks to a statistical comparison with a RBC model that contains a standard CIA constraint. For reasonable parameter specifications the Fuerst model can not produce a liquidity effect that dominates anticipated inflation effects on the nominal interest rate while the sluggish capital model can produce a dominant liquidity effect. Both these models produce too much variability in consumption and the counterfactual result that consumption and prices move in opposite directions. They also produce very low interest elasticities of money demand and monetary policy has very little effect on variations in output. Furthermore, anticipated inflation has much too large an effect on labor, consumption, and output. To remedy this last result, Christiano and Eichenbaun (1992) relax the CIA constraint on investment. They also split the period into two parts allowing firms to adjust their hiring decision after observing open market operations while initial hiring and investment decisions are made prior to observing open market operations. They do this with the hope of magnifying the response of employment and output to liquidity effects. In CGL's current paper firms face a CIA constraint on investment but can pay workers out of end of period revenues. Also, monetary transfers are made directly to consumers after their portfolio decision has been made. Thus these transfers do not affect the funds available in the credit market and, therefore, do not give rise to a "liquidity effect." Because there is a CIA constraint on capital, monetary policy can have inflation tax effects as well. As their work progresses separating liquidity effects from inflation tax effects will be important.

Not all of these scenarios can be correct. Why are CIA constraints placed where they are? These assumptions of infinite transactions costs are not innocuous. They are the driving force in these models. It seems that rather than trying to incorporate a realistic financial structure into a dynamic macro model and then testing the model, investigators are trying to find a mathematical structure that produces the correlations they desire. Apart from Christiano (1991) very little effort is made to see if these models are an improvement on basic RBC models or even if they produce counterfactural predictions along other dimensions. Since other classes of models can produce negative correlations between NBR and the funds rate, examining how CIA models fit the data along other dimensions will be important if the CIA approach is to gain widespread acceptance.

For example a model like that in Goodfriend's (1987) paper can potentially produce correlations of the type this literature is seeking. In that model, which has no rigidities, purposeful behavior by the Fed can set up negative correlations between the funds rate and NBR. If the Fed wishes to reduce inflation, it can do so by reducing the future money supply and in particular future NBR. Due to anticipated inflation effects, the nominal interest rate would fall increasing the demand for money and total reserves. If the Fed wishes to reduce price level surprises it can supply the necessary NBR to prevent price level movements. Thus this policy sets up the requisite negative correlation. If that was all that was going on one would expect this negative correlation to carry over to broader aggregates. However, M2-M1 components of M2 which involve a large savings motive should be positively correlated with the real rate of interest and movements in BR, which are highly variable and positively correlated with the funds rate, could cause TR to be positively correlated on net as well.

Alternatively say the Fed is following an exogenous upward movement in the real rate of interest in an attempt to target inflation. If the own rate on money balances is sticky then money (M1) and hence total reserves will decline along their demand curve. (Also, M2 could be rising with the real rates.) This would set up a negative relationship between NBR and the funds rate. As r_m adjusted, total reserve demand would increase as would NBR as the Fed defended the new higher funds rate. If the Fed did not react instantaneously or vigorously enough to the increased reserve demand the funds rate could rise further and then fall as nonborrowed reserves were pumped into the system reinforcing the initial negative correlation. Also, sticky price models may be able to generate some of the correlations displayed in the data as well.

Also, the question of what constitutes a period is somewhat fuzzy in this literature. Is it a day or perhaps a week? Most people make some form of cash management decision weekly and I can not think of any time where a shortage of cash has affected my real consumption for more than a day or two. Perhaps I'm taking the CIA constraint too literally, but if the period is rather short, as I believe it is, then the propagation mechanisms needed to match the data would seem incredible by RBC model standards.

I have strayed a little far afield so let me return to this paper more specifically. My primary confusion is linking the author's major contribution which shows how different measures of money can have different correlations with interest rates with the motivation for their paper which appears to be the results found in Strongin. In this paper money

(1) $$M_{t+1} = M_t + r_t(G_t - D_t) + x_t.$$

The x_t portion of measured money provides no liquidity effects. The G_t portion, that is open market operations has the standard liquidity effects since it influences the portion of firm borrowing that must be financed by discount window loans. The equilibrium condition that is being used is

(2) $$NBR_t = V_t - D_t = M_t - G_t$$

where $V_t = \phi(M_t+B_t)$. An increase in G_t (an open market sale) requires more discount window borrowing and an increase in interest rates since $r = \psi(D/TR)$ is increasing. Using M_{t+1} can contaminate regression results since it rises by $r_t(G_t-D_t)$, which will in general be positive in this model and no liquidity effect will be present. Furthermore, growth in money via transfers will further bias econometric results.

For econometric purposes I see no useful way of isolating any aggregate to uncover liquidity effects. X_t type disturbances, in reality, involve transfers from the Treasury. These involve a reduction in Treasury accounts at the Fed and an increase in NBR. What the model here indicates is that one wants to examine only changes in reserves that involve changes in the public's asset positions and that exclude any interest or lump sum payments.

While these decompositional problems are important for this model and may in fact be important more generally, they seem to have little to do with Strongin's empirical strategy nor do they affect interpretations in other models. Strongin tries to separate "pure" supply movements in NBR from those engendered by policy responses to changes in TR. Whether his identification procedure is a good one or not could be debated, but he is not concerned with measurement or decompositional problems in various reserve measures.

The decompositional problem arises in CGL because of their modeling of x_t as having no liquidity effects. In Fuerst or Christiano and Eichenbaun, there is only x_t and it enters the model in a way that produces liquidity effects. That is NBR supply disturbances that are not responses to TR shocks produce liquidity effects. It seems that Strongin's methodology is more closely aligned with these models.

Whether decompositional problems are important or not, I don't know. They arise in this model by a specification that at this point seems somewhat arbitrary. It is no more arbitrary than any other specification in the literature, but that does not make it convincing. I believe the author's need to make a convincing argument as to why some forms of money creation are more likely to involve liquidity effects than others if their message is to carry weight. After all, in this model one could easily reverse the roles of X_t and G_t or make them complimentary.

The discussion on page 11 regarding the estimation of ψ is also a little confusing. With

$$n = 1 - \frac{d}{v} = \frac{M-G}{V} \tag{3}$$

they claim that ψ can be estimated no matter what the shock. But is that relevant? We would like to know how ψ is influenced contingent on different shocks. Here a positive V shock induced by a shift in the demand for loans causes ψ to rise and n to fall, while a decline in NBR due to an open market sale (G up) also causes n to fall and ψ to rise. It is only the latter effect that one has in mind when discussing liquidity effects, so perhaps the ratio is not the correct variable to focus on. Rather, in this model it should be the relationship between the level of NBR and the funds rate. Also in estimating ψ, one would expect shifts in the function over time since administration of the discount window has changed over time. For example, I believe window administration was more lax when the Fed faced a membership problem.

I would also downplay somewhat figure one. The interest rate of consequence is the spread between the funds rate and the discount rate. When one looks at this graph the correlations seem at least as pronounced. But has anything but a borrowed reserve demand function been uncovered?

Finally, the discussion concerning adjustably pegging the interest rate based solely on technological disturbances raises questions concerning the nominal determinacy of the model (see McCallum (1981, 1986)).

Overall, I thought this paper was interesting and represents a nice attempt to start thinking about how behavior in the market for reserves influences the correlations we observe between various monetary measures and the funds rate. Given my qualms concerning this methodology's ability to explain anything at business cycle frequencies, I would suggest directing the model in an alternative direction. Perhaps this framework could be used to help explain short-term term structure movements in interest rates and examine the so-called "ozone hole." This line of inquiry would be interesting since it could integrate reserve market behavior and a tight specification of policy in a fully developed general equilibrium model.

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Credit Conditions and External Finance:
Interpreting the Behavior of Financial Flows and Interest Rate Spreads

Kenneth N. Kuttner[1]

A flurry of recent macroeconomic research has drawn attention to the relationship between monetary policy, credit conditions, and the markets for short-term debt. Two recent papers have focused on firms' substitution between bank and non-bank external finance in particular, proposing macroeconomic indicators based on financial market activity. Kashyap, Stein, and Wilcox (1992) employ quantity data directly, arguing that the share of bank loans out of firms' total short-term finance is an informative index of Federal Reserve policy and loan availability more generally. In a complementary line of research, Friedman and Kuttner (1992) identify monetary policy and bank lending as potential sources of fluctuations in the spread between yields on commercial paper and Treasury bills. While both papers have demonstrated solid empirical links between these financial indicators and real economic activity, neither has rigorously assessed the extent to which fluctuations in these indicators actually represent exogenous changes in credit conditions, rather than endogenous responses to changing economic conditions. This paper's goal is to provide such an assessment.

The paper begins with a sketch of the mechanism through which credit conditions affect firms' short-term financing, drawing a distinction between the effects of the Federal Reserve's open market operations and other factors influencing banks' willingness to lend. The second section summarizes the reduced-form relationships between real output, the interest rate, and three alternative indices

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1. Senior Economist, Federal Reserve Bank of Chicago. I am grateful to Benjamin Friedman and David Wilcox for their comments and suggestions.

of credit conditions: the composition of external finance, the spread between the loan rate and the commercial paper rate, and the analogous spread between commercial paper and Treasury bills.

The third section turns to a closer examination of the impact of monetary policy and loan availability on bank and non-bank finance using structural VAR techniques. Identifying monetary policy with innovations to non-borrowed reserves and controlling for firms' financing requirements, the first of the three models estimates the dynamic effects of monetary and lending shocks on the composition of external finance, the interest rate, and real output. The second structural VAR system assesses the effects of reserves and lending shocks on the paper–bill spread. The third model identifies lending shocks with innovations in the loan–paper spread. Estimates of these models confirm that all three variables respond appropriately to reserves shocks. In addition, lending shocks, whether identified through financial flows or via fluctuations in the loan spread, induce a substitution between bank and non-bank finance.

Less clear is the extent to which any of these measures exclusively reflects the effects of changing loan availability. The fact that positive lending shocks are associated with *increases* in the interest rate and the paper–bill spread suggests that changes in the composition of external finance have more to do with firms' financing requirements than with exogenous changes in banks' willingness to lend. Another slightly puzzling observation is that the largest source of changes to the composition of external finance seems to be wholly unrelated to both reserves and bank lending. Together, these two results suggest that while credit conditions are one important determinant of firms' choice of financing, short-term debt flows may be informative for reasons other than those involving the substitution between bank/non-bank substitution. Although its implications for real activity are rather weak, the loan spread appears to be a plausible alternative measure of credit conditions.

A model of financial flows and interest rate spreads

How do the markets for short-term bank and non-bank finance respond to monetary impulses? And how do non-monetary shocks affect these markets? And how might one construct an index of the availability of intermediated funds?

As a first step towards answering these questions, this section analyzes a simple model of the markets for commercial paper, bank loans, and Treasury bills in the style of Brainard (1964) or Bosworth and Duesenberry (1973). While not as detailed as either of those models, it is adapted to highlight firms' tradeoff between bank and non-bank finance. It also draws an important distinction between purely monetary influences acting through open market operations, and credit conditions defined more broadly, which may include other factors affecting banks' willingness to lend.

One of the model's more obvious properties is that an injection of reserves causes the interest rate to fall — the familiar "liquidity effect." Reserves injections also cause the spread between the interest rates on bank lending and commercial paper to fall, and leads to increased reliance on bank finance. Lending shocks, which are assumed to affect only banks' preferences over alternative assets, turn out to have similar effects on the loan–paper spread and the composition of firms' finance. Lending shocks, by contrast, have no effect on the level of interest rates — only the spreads.

The model also identifies two other factors with implications for the money market. First, firms' demand for external finance may induce changes in the relevant interest rate spreads and consequently the composition of finance; controlling for this demand-side influence turns out to be a major challenge to the construction of an empirical measure of credit availability. Similarly, the stock of outstanding Treasury bills may have tangible effects on the spreads and the composition of finance.

The three players in the money market are households, banks, and firms, who participate in the markets for reserves, commercial paper, Treasury bills, and loans. Specifically, households' portfolios include demand deposits (DD), commercial paper (P), and Treasury bills (B) according to

$$DD^d = \phi(r_P)\,W,\ \ \phi' < 0 \qquad \text{Deposit demand}$$

$$P^d = f(r_P, r_B)\,W,\ \ \frac{\partial f}{\partial r_P} > 0 \text{ and } \frac{\partial f}{\partial r_B} < 0 \qquad \text{Paper demand}$$

$$B^d_{hh} = (1 - \phi - f(r_P, r_B))\,W, \qquad \text{Bill demand}$$

where W is the sum of deposits, paper, and bills held by households. Households' demand for non-interest-bearing bank deposits is a decreasing function of the prevailing paper rate, r_P. A key assumption is that households view commercial paper and Treasury bills as imperfect substitutes, so that changes in their relative supplies affect their respective yields.[2] Households require a higher paper rate (or a lower bill rate) to hold a larger share of their portfolio as commercial paper.

Demand deposits are banks' sole liability. Their assets are divided among Treasury bills, loans (L), and deposits at the Federal Reserve (R) according to:

$$R^d = \rho(r_P)DD, \ \rho' < 0 \qquad \text{Reserve demand}$$

$$L^d = g(r_L, r_P, \lambda)DD, \ \frac{\partial g}{\partial r_L} > 0 \text{ and } \frac{\partial g}{\partial r_P} < 0 \qquad \text{Loan demand}$$

$$B_b^d = (1 - \rho(r_P) - g(r_L, r_P, \lambda))DD. \qquad \text{Bill demand}$$

Banks' demand for non-interest-bearing reserves falls with the prevailing paper rate, while loan demand is increasing in the loan rate and decreasing in the paper rate.[3] The stock of reserves is set at R^s by the Federal Reserve; discount window borrowing is ignored.

Banks' demand for loans is also allowed to depend on the variable λ, representing any other factors affecting banks' willingness to lend. These "lending" shocks lead banks to shift the composition of their portfolios between bills and loans; negative shifts in λ may be interpreted as "credit crunch" episodes. These may occur in reaction to a perceived deterioration in borrowers' creditworthiness, or to more stringent capital requirements as suggested by Bernanke and Lown (1991). They may also be the result of the "moral suasion" instrument of monetary policy; Owens and Schreft (1992) identify a number of episodes in which banks contracted their lending in response to Federal Reserve pressure. Whatever the source, the key feature of these "lending" shocks is that they need not be accompanied by overt monetary policy in the form of open market operations.[4]

2. Friedman and Kuttner (1992) discuss some possible reasons for this imperfect substitutability. Lawler (1978) also finds evidence for imperfect substitutability at seasonal frequencies.

3. Note that throughout the paper, assets are "demanded" while liabilities are "supplied." Hence, banks "demand" loans and bills, while firms "supply" loans and paper.

4. This point is stressed by Friedman (1991).

Finally, firms choose between bank lending and paper issuance as sources of short-term finance according to

$$L^s = h(r_L, r_P)F, \frac{\partial h}{\partial r_L} < 0 \text{ and } \frac{\partial h}{\partial r_P} > 0 \qquad \text{Loan supply}$$

$$P^s = (1 - h(r_L, r_P))F. \qquad \text{Paper supply}$$

For simplicity, the amount to be financed, F, is assumed to be exogenous with respect to the various interest rates. Because firms view loans and paper as imperfect substitutes, they will finance some portion of F through bank lending even though r_L generally exceeds r_P; as discussed by Kashyap, Stein and Wilcox (hereafter KSW), this presumably reflects some intangible benefit accruing to the firm from maintaining a relationship with a bank. Firms' share of bank finance (the KSW "mix") responds predictably to the loan and paper rates: an increase in the loan rate (or a decrease in the paper rate), leads firms to substitute away from bank finance towards non-bank external finance.[5]

In equilibrium, the demand for the four assets equals their supply,

$$\rho(r_P)\phi(r_P)W = R^s$$

$$g(r_L, r_P, \lambda)\phi W - h(r_L, r_P)F = 0$$

$$f(r_P, r_B)W - (1 - h(r_L, r_P))F = 0$$

$$(1 - g(r_L, r_P, \lambda))\phi W + (1 - f(r_P, r_B) - \phi)W = B^s,$$

determining yields and quantities as functions of the exogenous R^s, λ, F, and B^s. Walras' law allows the bill market equation to be dropped. Further simplification is possible by assuming the asset demand and supply functions to be homogeneous of degree zero with respect to the assets'

5. This model embodies the assumption that bank and commercial paper finance are viable alternatives for an economically relevant group of firms. However, there is increasing evidence that this set of firms is rather small, and that much of the observed variation in the aggregate composition of finance is due to the relative availability of finance to small and large firms; see Gertler and Gilchrist (1992) and Oliner and Rudebusch (1992).

yields, so that (for example) $g(r_L + c, r_P + c, \lambda) = g(r_L, r_P, \lambda)$ for any constant c. In this case, the f, g and h functions can be specified in terms of interest rate spreads, and the system reduces to:

$$\begin{aligned} \rho(r_P)\phi(r_P)W &= R^s \\ g(z_{LP}, \lambda)\phi(r_P)W - h(z_{LP})F &= 0 \\ f(z_{PB})W - (1 - h(z_{LP}))F &= 0 \end{aligned} \tag{1}$$

where z_{LP} and z_{PB} denote the loan–paper and paper–bill spreads.

Analyzing the comparative statics of (1) is simplified by its (somewhat artificial) recursive structure. The interest rate level is entirely determined by supply and demand in the market for reserves; the fall in reserves resulting from a contractionary open market operation requires a higher rate to equilibrate the reserves market, as illustrated in Figure 1.[6] This higher interest rate leads in turn to a shrinkage of demand deposits and the banking system as a whole. Banks respond by raising the loan–paper spread, prompting some of its borrowers to switch to alternative forms of finance — short-term paper in this model. The increased supply of paper (relative to bills) leads to a widening spread between the paper and bill rates.

The effects of an adverse lending shock resemble those of a reserves contraction in that both produce a rising loan spread and a substitution towards non-bank finance. Although both shocks produce similar effects on banks' portfolios, they differ in one important respect: reserves shocks affect the level of the short-term interest rate, while lending shocks leave the paper rate unchanged. A fall in λ leads banks to shift the *composition* of their portfolios away from loans and into Treasury bills, leaving their reserve demand and the paper rate (and consequently deposits and the banking system's size) unchanged. Banks increase their spreads relative to the paper rate in order to reduce their stock of loans. As before, firms' increased reliance on commercial paper drives up the paper–bill spread.

6. Total wealth is held constant in an open market operation, as the withdrawal of reserves is offset by a sale of Treasury securities.

The observation that both reserves and lending shocks may contribute to real economic fluctuations is one explanation of the widespread interest in constructing a broader measure of credit conditions than reserves or the interest rate in isolation, which reflect largely those shocks originating from the reserves market. The attractive feature of the credit conditions indicators discussed here is their ability to detect the effects of changes in loan availability and reserves fluctuations: in this model, the "mix," the loan-paper spread, and the paper-bill all reflect the impact of both types of shocks. In fact, in the absence of any other shocks, all three of these measures should respond to monetary and credit factors in qualitatively similar ways.

One problem common to all three of these measures (and the interest rate itself) is their susceptibility to contamination from changes in firms' overall demand for financing, which may alter yield spreads and the composition of external finance for reasons having nothing to do with to exogenous changes in credit conditions.[7] This can be illustrated by examining the comparative statics of (1) in response to an increase in F, the dollar amount of funds firms wish to raise from the short-term credit markets. A greater demand for loanable funds unambiguously increases the prevailing interest rate, r_P. Its effects on the loan–paper spread (and therefore the composition of external finance) is ambiguous, as it depends on firms' share of bank finance (h) relative to households' wealth fraction in bank deposits (ϕ), and the share of banks' portfolios held as loans (g). When $h(z_{LP}) > \phi(r_P)g$ (as is presumably the case), increases in F cause loan demand growth in excess of deposit growth, driving up the relative cost of bank finance and the share of paper in firms' external finance.[8] The same inequality is also relevant for the paper–bill spread; a second sufficient condition for a rising spread is that $(1 - h(z_{LP})) > f(z_{PB})$, so that the increasing paper demand would require households to hold a larger *share* of paper in their portfolios.

7. Under most of the Federal Reserves' post-Accord operating procedures, non-borrowed reserves may also be contaminated in this way; see Strongin (1991).

8. A special feature of the KSW model is that changing financing requirements affect loans and paper proportionally, leaving the "mix" unchanged.

One additional complication for interpreting the paper–bill spread as a measure of credit conditions is that it may be affected by changes in the outstanding stock of Treasury bills. In addition, the wealth effects associated with changes in the volume of Treasury finance may alter the level of interest rates and loan spread, and consequently the composition of external finance.[9] In this model, an increase in the supply of bills reduces the paper–bill spread, as investors require higher returns to entice them to hold the additional stock of bills. This increase in banks' demand for loans leads to a fall in the loan rate relative to the paper rate, and increased reliance on bank finance.

To summarize, the model's main implications are:

- Both reserves and lending shocks alter the relative price of bank and non-bank finance, inducing a substitution between alternative forms of external finance.
- By affecting the supply of commercial paper, this substitution also affects the relative yields on Treasury bills and commercial paper.
- Changes in reserves affect the level of interest rates, while lending shocks leave the level unchanged.
- Firms' overall financing requirements may affect interest rate spreads and their composition of short-term finance.

The goal of the paper's subsequent empirical work is to explore these implications. Specifically, it attempts to identify lending shocks through their impact on the composition of external finance and interest rate spreads, while controlling for reserves and the overall demand for loanable funds.

Short-term credit markets and real economic activity

One desirable feature of any index of credit conditions is a systematic link between it and subsequent fluctuations in real economic activity.[10] The results below summarize the predictive properties of the KSW "mix," the prime–paper spread, and the paper–bill spread. The results show that the "mix"

9. Of course, this assumes that households view government bonds as net wealth; see Barro (1974).

10. Economists and market observers have long recognized the cyclical properties of commercial paper, bank lending, and their relative yields; see, for example, Foulke (1931), Selden (1963), and Stigum (1990).

and the paper–bill spread are good predictors of future changes in real GDP (although this alone does not justify their interpretation as measures of credit availability).

"Causality" tests

Table 1 examines the incremental information content of the three measures for future changes in real GDP in the presence of traditional measures of monetary policy: non-borrowed reserves and the commercial paper rate. Regressions 1–3 are four-variate reduced-form equations of the form

$$\Delta x_t = \mu_0 + \mu_1 t + \sum_{i=1}^{4} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{4} \beta_i \Delta \ln(R)_{t-i} + \sum_{i=1}^{4} \gamma_i \Delta r_{P,t-i} + \sum_{i=1}^{4} \delta_i \Delta q_{t-i} + \varepsilon_t$$

where x is the logarithm of real GDP, R is non-borrowed reserves adjusted for extended credit and deflated by the GDP deflator, r_P is the commercial paper rate, and q denotes, in turn, the "mix", the loan–paper spread, and the paper–bill spread. As in KSW, the "mix" is computed as the observed ratio of bank lending to the sum of lending to commercial paper, or $L/(L+P)$.[11] The results use the six-month commercial paper and Treasury bill yields, and the prime rate (from the Federal Reserve H.15 release) is used as the lending rate.

The table reports F-tests for the exclusion of the four δ_i terms for the entire 1960:2–1991:4 sample, as well as two shorter samples. One truncated sample begins in 70:3, when Regulation Q was eliminated for most large CDs.[12] Another begins in 1975:1. Although this date is somewhat arbitrary, it corresponds roughly to the beginning of a rapid expansion of the commercial paper market, during which it became a more popular vehicle for non-financial firms' short-term finance.[13]

11. The augmented Dickey-Fuller t_t statistic (computed with eight lags) for the stationarity of the "mix" is –4.10, rejecting the null hypothesis of nonstationarity at the 1% level. Consequently, it is included here in levels along with a linear trend term.

12. Regulation Q interest rate ceilings on 30–89 day CDs in denominations of $100,000 were eliminated on June 24, 1970. Ceilings on CDs with maturities in excess of 90 days remained in place until March 16, 1973.

The 1975–91 sample also excludes the Penn Central and Franklin National disruptions of 1970 and 1974, and covers the period in which ratings were assigned to commercial paper issues.[14]

The results of the first regression corroborate the strong link between the "mix" and real output found by KSW, supporting their finding that the composition of finance has significant predictive power for future real economic activity, even in the presence of reserves and interest rates. The poor performance of the loan–paper spread in the second regression (again in the presence of reserves and the commercial paper rate) is consistent with the notion that banks' lending rates are relatively uninformative.[15] The third regression demonstrates the incremental information content of the paper–bill spread — at least in the earlier samples.

Impulse responses

While the *F*-statistics for "causality" give some indication of the strength of the predictive power of these financial indicators, they give no indication of the size or direction of their impact. The impulse response functions plotted in Figure 2 provide a richer description of the effects of innovations to the financial indicators. Each of the three rows of graphs is from the VAR corresponding to regressions 1–3 in Table 1. In each case, the system has been orthogonalized (according to the triangular Cholesky decomposition) with the credit conditions index in last place. Three responses are plotted for each regression: the financial indicator's effects on output and the interest rate, and the effect of reserves innovations on the financial indicator. The dotted lines depict the approximate 95% confidence bounds.

Panels (a) and (b) from the first specification show that "mix" innovations indeed act like reasonable measures of credit conditions; reserves injections increase the share of bank loans, and

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13. At the end of 1974, non-financial commercial paper accounted for only 13.5 billion dollars. By 1982, this figure had grown 325.2 per cent to 57.4 billion. See Hurley (1977, 1982), and Stigum (1990).

14. Moody's and Standard and Poor's began rating commercial paper in 1974.

15. Similar results are obtained with the average of large banks' lending rates obtained from the Federal Reserve Survey of Terms of Bank Lending reported in release E.2.

output rises in response to positive "mix" shocks, which might be interpreted as the pure lending component of credit conditions. The panel (c) plot, however, is something of a puzzle. It shows that "mix" innovations are associated with a *rising* commercial paper rate — not what one would expect from an increased willingness to lend on the part of banks, and inconsistent with the implications of the model presented earlier.[16] However, this pattern *is* consistent with banks passively supplying more loans in response to rising demand for credit.

The second row of plots confirm the generally weak relationship between the prime–paper spread and real output. One interesting feature of the loan spread is that it initially *rises* in response to a reserves innovation — clearly inconsistent with the loosening of credit conditions implied by the reserves injection. The loan spread ultimately falls, however, suggesting that this response is due to a certain sluggishness in the way banks adjust their lending rates.

The impulse response functions from the paper–bill spread regression are all consistent with what one would expect from an indicator of credit conditions: positive shocks to the spread generate declining real output, while reserves injections reduce the spread. Furthermore, unlike the "mix", innovations in the spread itself have essentially no impact on the level of interest rates.

Comparing the "mix" and the paper–bill spread

Because regressions 1–3 included each of the credit conditions measures in isolation, the results raise an important question: to what extent are the three indicators measuring the same phenomenon? An obvious way to address this question is to include more than one indicator in the same regression to see if the presence of one vitiates the predictive power of the other.

The results from two additional regressions (numbered 4 and 5) are reported in Table 1. The results from specification 4, which includes both the "mix" and the loan spread, are not surprising given the weak performance of the loan spread in isolation — the F-statistics for the "mix" remain virtually unchanged. Somewhat more surprising are the results from specification 5, in which both the "mix" and the paper–bill spread appear. Here, the relationship between the two variables and real

16. The "mix" terms are significant in the interest rate equation at the 10% level.

output is uniformly *stronger* (judged by the F-statistics) than when they are included individually. Clearly, one (or both) of the indicators is doing something other than simply summarizing the state of credit market conditions.

The roles of commercial paper and bank loans

The model sketched earlier suggests that flows of commercial paper and bank lending are informative to the extent that they reflect the substitution between the two forms of finance in response to a monetary or a lending shock. KSW exploit this insight by looking at the ratio of bank loans to the sum of loans and paper; shocks that affect both forms of debt proportionally are presumed to stem from sources other than loan availability. A useful check on this specification is to verify that paper and lending flows enter an unrestricted regression in such a way that the "mix" is the variable that matters.

This is easily accomplished by differentiating the "mix" (designated $\hat{h}$) with respect to time,

$$\frac{d\hat{h}}{dt} = \frac{P}{(L+P)^2} \times \dot{L} - \frac{L}{(L+P)^2} \times \dot{P}$$
$$= \hat{h}(1-\hat{h})\dot{L}/L - \hat{h}(1-\hat{h})\dot{P}/P,$$

decomposing its movements into distinct lending and paper contributions. In discrete time, the analogous decomposition,

$$\Delta\hat{h}_t = \hat{h}_{t-1}(1-\hat{h}_{t-1})\Delta L_t/L_{t-1} - \hat{h}_{t-1}(1-\hat{h}_{t-1})\Delta P_t/P_{t-1} \equiv \Delta\hat{h}_L - \Delta\hat{h}_P$$

expresses $\Delta\hat{h}$ as a weighted sum of commercial paper and bank loan growth rates, denoted $\Delta\hat{h}_L$ and $\Delta\hat{h}_P$. If $\Delta\hat{h}$ were in fact the appropriate measure of the impact of credit conditions on the real economy, the two components would enter real output regressions with equal and opposite signs; the regression itself would "choose" the KSW specification.

Table 2 displays the results of this experiment. Panel (a) reports the outcome of a regression of first-differenced log real GDP on four lags of output, $\Delta\hat{h}_L$ and $\Delta\hat{h}_P$ over the 1960:2–91:4 sample. Judged by the F-statistics, the commercial paper terms are much more informative than the lending terms; $\Delta\hat{h}_P$ is significant at the 0.01 level, while the $\Delta\hat{h}_L$ terms are not significant at even the 0.10 level.[17] The sum of the estimated coefficients on lending is negative, but statistically insignificant.

The regression in panel (b) refines the test by specifying the regression in terms of $\Delta\hat{h}$ and $\Delta\hat{h}_P$ — simply a transformation of the regression in panel (a). Excluding the four lags of $\Delta\hat{h}_P$ is equivalent to restricting the coefficients on $\Delta\hat{h}_L$ and $\Delta\hat{h}_P$ to have equal and opposite signs. Here, the $\Delta\hat{h}$ terms are statistically insignificant, while the $\Delta\hat{h}_P$ terms are significant at the 0.05 level. Moreover, the negative estimated sum of the "mix" coefficients is inconsistent with the substitution hypothesis, although this sum is again statistically insignificant.

To guard against the possibility that the results in the first two panels are an artifact of the differenced specification, panel (c) reports the results of a regression that includes a linear trend and $\hat{h}$ in levels. While not $\Delta\hat{h}_P$ terms are not as strong in the levels specification, the coefficients on the $\hat{h}$ terms remain statistically insignificant.

These experiments show that the "mix" owes its predictive power in large part to something other than the substitution between bank and paper finance. In unrestricted equations, $\hat{h}$ terms are generally insignificant, while the hypothesis that commercial paper in isolation does not matter for predicting real output *can* be rejected. This observation suggests a closer examination of lending and commercial paper flows individually, and their relation to monetary policy and credit conditions.

A structural approach to identifying lending shocks

The atheoretical results in the preceding section provided some evidence in favor of interpreting the financing "mix" and the paper–bill spread as measures of credit conditions, although innovations in the composition of finance were, contrary to the simple model, are associated with a rising interest rate. One reason for this pattern may be the result of inadequately controlling for the overall demand for short-term finance. As demonstrated earlier, an increase in the amount to be financed need not raise bank and non-bank finance proportionally. In this case, if increases in firms' demand for funds

17. This is consistent with the results of King (1986).

are accommodated primarily through bank lending, the "mix" may rise for reasons unrelated to credit conditions.

Figure 3 plots the financing gap (defined as the difference between firms' capital expenditures less inventory IVA and after-tax internal funds) along with commercial paper and bank loan flows, demonstrating the close relationship between the financing gap and the volume of bank lending (although commercial paper appears to have become more sensitive to the financing gap in the later part of the sample). To control for credit demand, the results in this section include the financing gap as an additional determinant of firms' debt issuance.

A more interesting alternative hypothesis is that is that the substitution mechanism inadequately explains the joint behavior of commercial paper and bank lending, and that factors other than monetary policy are what drive the observed fluctuations in the composition of short-term external finance. The apparent asymmetry between the effects of loan and paper flows uncovered in Table 2 provides some circumstantial evidence for this view.

The results presented in this section attempt to address these issues by separately analyzing flows of lending and commercial paper in a structural VAR setting that controls for the overall demand for loanable funds. Moving to a more structural approach also addresses the possibility that the interest rate's odd response to "mix" shocks is as an artifact of the artificial triangular structure of the Cholesky decomposition employed earlier. The first model focuses on the response of lending and paper flows to reserves fluctuations, and examines the properties of the innovations identified as lending shocks. The second describes the response of the paper–bill spread to the financial flows generated by reserves and lending shocks. The third uses fluctuations in the loan–paper spread as an alternative means of identifying lending shocks.

A review of structural VARs

Beginning with an unrestricted k-variate dynamic simultaneous equation system,

$$y_t = \sum_{i=0}^{\tau} B_i y_{t-i} + Av_t,$$

the standard VAR achieves identification by restricting the contemporaneous relationships between the elements of y, i.e., by setting $B_0 = 0$ and $A = I$, while placing no restrictions on the covariance matrix of v, *i.e.*, $E(vv') = \Omega$. The structural VAR introduced by Blanchard and Watson (1986) and Bernanke (1986) achieves identification by allowing some nonzero elements in the B_0 matrix, while restricting the covariance matrix of v, the structural disturbances, to be diagonal. Off-diagonal elements in A can be introduced to allow distinct elements of y to depend on common structural shocks. Thus, structural VARs differ from traditional structural models by replacing the assumption of an exogenous instrument set with the assumption of orthogonal structural shocks. At the same time, the dynamics of the system are left unrestricted, as in the conventional VAR.

Another interpretation of the structural VAR is as a decomposition of the covariance matrix of VAR residuals. If the structural disturbances are uncorrelated with one another, *i.e.*, $E(vv') = D$, Ω, the covariance matrix of the VAR errors becomes a nonlinear function of the structural parameters:

$$\begin{aligned}\Omega &= E(B_0^{-1}Av_tv_t'A'B_0^{-1}) \\ &= B_0^{-1}ADA'B_0^{-1}.\end{aligned}$$

If the system is just-identified, the above equality is exact; $B_0^{-1}AD^{1/2}$ is a matrix square root of Ω, and $A^{-1}B_0$ diagonalizes Ω.[18]

Reserves, lending, and short-term debt flows

The first model is a just-identified six-variable system involving financing gap (F), bank lending, non-financial commercial paper (P) the commercial paper rate (r_P), real GDP (x), and non-borrowed reserves adjusted for extended credit (R). The interest rate is differenced, while reserves and GDP enter as log differences. The lending and paper data are again taken from the Flow of Funds accounts for the non-farm, non-financial corporate and noncorporate sectors. With F, P and L expressed

18. With a total of $2k^2$ elements in A and B_0 and only $k(k+1)/2$ unique elements in Ω, it is clear that the structural parameters are not identified without additional restrictions on A and B_0. The Cholesky decomposition, which is equivalent to setting $B_0 = I$ and making A lower triangular, is but one possibility. In overidentified systems, the problem becomes one of choosing the structural parameters in B_0 and A to generate the best fit between the fitted and the observed covariance matrices.

as shares of the total dollar volume of outstanding paper and loans, changes in the "mix" can be constructed as the weighted average of the two flows:

$$\Delta \hat{h} = (1-\hat{h})\frac{\Delta L}{L+P} + \hat{h}\frac{\Delta P}{L+P}.$$

The substance of the model is contained in the six equations describing the contemporaneous relationships between the variables,

$$R = b_{1,6}x + v_1 \qquad \text{Reserves (2}a\text{)}$$

$$F = b_{2,1}R + b_{2,6}x + v_2 \qquad \text{Financing gap (2}b\text{)}$$

$$r_P = b_{3,1}R + b_{3,2}F + v_3 \qquad \text{Interest rate (2}c\text{)}$$

$$L = b_{4,1}R + b_{4,2}F + b_{4,3}r_P + v_4 \qquad \text{Lending (2}d\text{)}$$

$$P = b_{5,1}R + b_{5,2}F + b_{5,3}r_P + a_{5,4}v_4 + v_5 \qquad \text{Paper (2}e\text{)}$$

$$x = b_{6,3}r_P + b_{6,4}L + b_{6,5}P + v_6 \qquad \text{Output (2}f\text{).}$$

No restrictions are placed on the dynamics of the system; consequently, terms dated $t-1$ and before are omitted, but implicit.

Equation 2a allows the Federal Reserve to vary reserves contemporaneously with real GDP in a primitive feedback relationship. The financing gap (equation 2b) also depends on the level of real economic activity. Consistent with the model presented earlier, the commercial paper rate in 2c is a function of reserves and the financing gap.

The model's key equations are 2d and 2e, describing the behavior of bank lending and commercial paper flows as a function of the financing gap, reserves, and the interest rate. The coefficients on F measure the proportion of the current financing gap satisfied financed through loans and paper. The two equations' coefficients on R determine the immediate response, ceteris paribus, of the two forms of short-term finance to changes the banking system's reserve position. The v_4 term in the lending equation represents lending shocks that are orthogonal to reserve and financing gap innovations, which would include factors such as credit crunches. For this interpretation of v_4 to be legitimate, one of two conditions has to hold: either the observed financing gap must appropriately control for firms' demand for funds, or the amount of funds banks have available is fixed in the current quarter.

The v_4 innovation also appears in the commercial paper equation with the coefficient a_{54}, allowing commercial paper to respond directly to lending shocks. This parameter determines the extent to which lending shocks are "recycled" into the commercial paper market within the current quarter. The v_5 term in the commercial paper equation accounts for shocks to paper issuance uncorrelated with the other structural disturbances. The final equation for real GDP is a reduced-form equation describing the economy's response to the reserves and credit shocks in the preceding equations.

The parameter estimates in Table 3 summarize the model's contemporaneous behavior, while the impulse responses functions plotted in Figure 4 describe its dynamics of the system whose orthogonalization is implicit in equations 2a–2f. Like the earlier reduced-form regressions, these results provide some evidence to support the use of lending flows as an indicator of credit conditions, while confirming the doubts raised in the atheoretical VARs. First, The negative estimate of the coefficient on R in the lending equation (2d) contradicts the hypothesis that the primary effect of monetary policy is a substitution between bank and non-bank finance; the contemporaneous response of an injection of non-borrowed reserves, ceteris paribus, is a *fall* in bank lending.

However, because of the contemporaneous relationship from reserves to the financing gap and short-term finance via the interest rate and output, the coefficients on R in equations 2d and 2e do not by themselves determine the overall response of the "mix" to a reserves shock. The actual responses can be read from the impulse response function, plotted in the top panel of Figure 4.[19] This shows that the net effect of a reserves injection is initially rather small, with the loan share gradually rising after two to three quarters.

19. The sample average values of h are used to compute the approximate response of the "mix" from the impulse response functions of the underlying variables.

Figure 4 also shows that lending shocks seem to have a considerably larger impact on the composition of external finance than reserves for the first four quarters. Lending shocks' effect is strengthened somewhat by the statistically significant negative estimate of a_{54}, which is consistent with roughly 10% of the lending shock being "recycled" into the paper market in the current quarter. The coefficients on F in the paper and lending equations show that neither responds immediately to fluctuations in the financing gap.

A strong liquidity effect is associated with injections of non-borrowed reserves; the paper rate falls contemporaneously (the negative coefficient on R in equation 2c) and over a longer horizon (the center panel of Figure 4). These results also confirm the curious positive relation between the "mix" and the level of interest rates highlighted earlier in the paper. The center panel shows that positive lending innovations imply a *rising* interest rate, contradicting the theoretical model's implications for the effects of lending shocks.

Both monetary and lending shocks are important sources of output fluctuations. Increased bank lending is contemporaneously associated with more rapid real GDP growth in the short run, as shown by both the positive (but not quite significant) coefficient on L and the impulse response function.

What about shocks to commercial paper, v_5? The top panel of Figure 4 shows that these shocks — which are, by construction, orthogonal to the system's other structural disturbances — have the largest and most persistent impact on the composition of external finance. Interestingly, the center panel shows that these innovations have essentially no implications for the interest rate, although they do seem to have a small, negative impact on real output.

Financial flows and interest-rate spreads

Recent papers by Bernanke (1990) and Friedman and Kuttner (1992) suggest that the substitution between bank and non-bank debt is an important source of fluctuations in the paper–bill spread. As discussed earlier, monetary contractions reduce lending by shrinking the stock of deposits, leading firms to raise the loan rate relative to the paper rate, discouraging intermediated borrowing. Similarly, adverse lending shocks cause banks to shift from loans to Treasury bills. As firms turn to the paper market to satisfy their financing needs, the paper supply rises and bill supply to households falls, raising the paper–bill spread. If this is the way in which credit conditions affect the spread, one would expect to find the mechanism operating through the volume of outstanding non-financial commercial paper.

The second structural VAR is designed to detect the operation of this mechanism. It augments the first model (equations 2a–2f) with the addition of a seventh equation for the paper–bill spread,

$$x = b_{6,3}r_P + b_{6,4}L + b_{6,5}P + b_{6,7}(r_P - r_B) + v_6 \qquad \text{Output (3}f\text{)}$$

$$r_P - r_B = b_{7,1}R + b_{7,2}F + b_{7,3}r_P + b_{7,4}L + b_{7,5}P + v_7, \quad \text{Paper–Bill spread (3g)}$$

and also includes the spread in the output equation. The remaining five equations are identical to those in the earlier model (2a–e).

The parameter estimates reported in Table 4 provide weak evidence for bank/non-bank substitution as a source of paper-bill spread. The positive and marginally significant on the paper term shows that flows of non-financial paper do exert an influence on the spread.[20] However, the very large, significant coefficient on reserves shows indicates that a great deal of the impact of monetary policy is transmitted to the spread via other routes.

The impulse responses in the top panel of Figure 5 confirm the spread's strong reaction to non-borrowed reserves innovations. Positive shocks to the financing gap also drive up the spread, as predicted, while paper shocks have little or no impact. Lending shocks again pose a problem, however. If the lending innovations identified by the VAR correspond to changes in the availability of loans, the model suggests that positive shocks should be associated with a *falling* paper–bill spread. The opposite is true: lending shocks imply a *rising* spread. Again, this pattern is consistent

20. By contrast, the results in Table 10 of Friedman and Kuttner (1992) using the *total* volume of commercial paper outstanding are consistent with a stronger link between paper issuance and the spread.

with bank lending responding passively to changes in the demand for funds inadequately captured by the financing gap.

The bottom panel of Figure 5 suggests something other than bank/non-bank substitution is driving the paper–bill spread. Despite the inclusion of a variety of financial variables purporting to capture the impact of monetary policy on credit markets, the graph shows that the spread continues have strong implications for future output — comparable in magnitude to those of non-borrowed reserves. Even accounting for reserves, lending, and paper shocks, orthogonal spread innovations still result in falling real economic activity.

Identifying lending shocks with loan spread innovations

In light of the conclusion that lending flows (and the "mix") may in part represent endogenous response to firms' financing demands, the third structural VAR uses an alternative assumption to identify lending shocks, attributing (orthogonalized) innovations in the loan-paper spread to changes in banks' willingness to lend. In the context of the simple model presented earlier, the loan spread should embody exactly the same information as the "mix." In practice, as KSW note, the loan rate is likely to be a poor measure of the true cost of bank finance, an observation that motivates their use of the quantity variables. Indeed, the sluggish response of the loan rate to changes in the paper rate corroborates this view. The weak response of output to the loan–paper spread makes this approach seem even less promising.

With these reservations in mind, the first structural VAR can be adapted to incorporate the loan-paper spread. An equation for the loan spread is added to the system, and lending and paper flows are allowed to depend on this spread, as well as on reserves and the financing gap. The covariation between the flows that is a function of credit conditions is a result of their common dependence on the loan spread. This identification scheme will work if the financing gap is an imperfect proxy for the overall demand for funds so long as banks passively accommodate firms' funding requirements within the quarter at the going spread (that is, if their demand for loans is elastic).

The modified system is:

$$R = b_{1,6}x + v_1 \qquad \text{Reserves}^{\cdot}(4a)$$

$$F = b_{2,1}R + b_{2,6}x + v_2 \qquad \text{Financing gap } (4b)$$

$$r_P = b_{3,1}R + b_{3,2}F + v_3 \qquad \text{Interest rate } (4c)$$

$$r_L - r_P = b_{4,1}R + b_{4,2}F + b_{4,3}r_P \qquad \text{Loan spread } (4d)$$

$$L = b_{5,1}R + b_{5,2}F + b_{5,3}r_P + b_{5,4}(r_L - r_P) + v_5 \qquad \text{Lending } (4e)$$

$$P = b_{6,1}R + b_{6,2}F + b_{6,3}r_P + b_{6,4}(r_L - r_P) + a_{6,5}v_5 + v_6 \qquad \text{Paper } (4f)$$

$$x = b_{7,3}r_P + b_{7,4}(r_L - r_P) + b_{7,5}L + b_{7,6}P + v_7 \qquad \text{Output } (4g).$$

Under the assumptions outlined above, the innovations to the loan spread equation are now associated with changes in credit conditions, while the v_5 lending innovations represent shocks to firms' loan supply (that is, their demand for funds).

The parameter estimates in Table 5 accord surprisingly well with the implications of the model. Although its sluggish response makes the loan spread is subject to large, transitory effects from the paper rate and reserves, the negative estimated $b_{5,4}$ and the positive $b_{6,4}$ show that loan and paper volume respond as they should to the spread. Furthermore, reserves have no discernible independent impact on financial flows. A rising loan spread is contractionary, although again, the effect is statistically weak.

The corresponding impulse response functions appear in Figure 6. The top panel again illustrates the consequences of sluggish loan rate adjustment, with reserves injections causing the loan spread to rise sharply in the current quarter. Over time, reserves innovations produce a falling spread. The center panel shows the familiar liquidity effect, and the positive impact of lending innovations on the commercial paper rate. In this model, however, with innovations to loan volume interpreted as shocks to firms' funding requirements, the result is perfectly natural. By contrast, innovations in the loan spread have quite mild effects on the paper rate.

Conclusions

This paper has examined the relationship between monetary policy, loan availability, and alternative indicators of credit market activity. One of is main findings is that the substitution between bank and non-bank finance is indeed an identifiable effect of monetary policy as measured by innovations to non-borrowed reserves. This substitution is, however, not the only factor affecting financial flows. One of the major contributors to the aggregate composition of firms' short-term obligations is flows of commercial paper unrelated to lending shocks.

Furthermore, the portion of bank lending not attributable to monetary policy is associated with increases in the commercial paper rate and the paper–bill spread, suggesting that the behavior of the KSW "mix" is in part due to changes in firms' demand for loanable funds. Despite its apparent slow adjustment to changes in market interest rates, the loan–paper spread is a plausible alternative indicator of credit conditions.

The paper–bill spread responds appropriately to monetary shocks, rising in response to a reserves contraction. However, the strength of its response cannot entirely be accounted for by flows of non-financial paper, suggesting that its informativeness as a predictor of real economic activity may be due to other sources, such as changes in banks' issuance of negotiable CDs. This is consistent with the observation that non-financial commercial paper comprises a tiny share of the relevant market — only 25% of total commercial paper, and less than 9% of the sum of paper, CDs and Treasury bills.[21] Understanding how Federal Reserve policy and credit conditions affect the paper–bill spread will require expanding the model to take into account the behavior of other relevant assets, such as CDs and financial paper.

21. These figures are for 1991:4. The share of non-financial commercial paper is even smaller earlier in the sample.

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1. *F*-Statistics for Alternative Measures of Credit Conditions in Quarterly Real Output Equations

Specification	60:2–91:4	70:3–91:4	75:1–91:4
(1) "Mix" alone	3.36**	2.09*	2.86**
(2) Loan spread alone	0.11	0.30	0.46
(3) Paper–bill spread alone	3.81***	2.71**	1.81
(4) "Mix" + loan spread			
"mix" terms	3.37**	1.81	3.07**
loan spread terms	0.23	0.14	0.79
(5) "Mix" + paper–bill spread			
"mix" terms	4.17***	2.46	4.39***
paper-bill spread terms	4.62***	3.07**	3.30**

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Notes: The regressions are based on quarterly data for the sample indicated.
In addition to the variables indicated, each regression includes four lags of real GDP growth, real non-borrowed reserves growth, the differenced commercial paper rate, plus constant and trend terms.

2. Decomposing Changes in the Composition of External Finance

(a) Regression with separate commercial paper and bank lending terms

	Exclusion F-stat (p-value)	Sum of coefficients (p-value)
Commercial paper ($\Delta\hat{h}_P$)	4.00	-0.51
	(0.005)	(0.04)
Bank lending ($\Delta\hat{h}_L$)	1.39	-0.90
	(0.24)	(0.22)

(b) Regression with the differenced "mix" and commercial paper

	Exclusion F-stat (p-value)	Sum of coefficients (p-value)
"Mix" ($\Delta\hat{h}$)	1.45	-0.91
	(0.22)	(0.23)
Commercial paper ($\Delta\hat{h}_P$)	2.64	-1.38
	(0.04)	(0.04)

(c) Regression with the "mix" in levels, commercial paper, and linear trend

	Exclusion F-stat (p-value)	Sum of coefficients (p-value)
"Mix" ($\hat{h}$)	1.48	0.11
	(0.21)	(0.16)
Commercial paper ($\Delta\hat{h}_P$)	2.27	-1.77
	(0.07)	(0.01)

Notes: The regressions are based on quarterly data for 1960:2 through 1991:4. The specifications include four lags of each included variable and a constant term.

3. Structural VAR Estimates, Credit Conditions Identified via Lending Flows (equations 2a–2f)

2a.	$R = -0.625\ x + v_1$				
	(1.94)				
2b.	$F = 0.159\ r +$	$1.974\ x + v_2$			
	(1.05)	(4.11)			
2c.	$r_p = -0.208\ R +$	$0.037\ F + v_3$			
	(6.96)	(2.10)			
2d.	$L = -0.396\ R -$	$0.022\ F +$	$2.125\ r_p + v_4$		
	(1.51)	(0.16)	(3.23)		
2e.	$P = 0.135\ R +$	$0.027\ F +$	$0.444\ r_p -$	$0.094\ v_4 + v_5$	
	(1.29)	(0.51)	(1.68)	(2.71)	
2f.	$x = -0.023\ r +$	$0.019\ L +$	$0.004\ P + v_6$		
	(0.23)	(1.50)	(0.14)		

Notes: Estimates are based on quarterly data for 1960:2 through 1991:4. Regressions include three lags of each variable, constant and trend terms. Numbers in parentheses are t-statistics.

4. Structural VAR Estimates of the Effects of Lending Shocks on the Paper–Bill Spread (equations 3a–3g)

3a. $$R = \underset{(1.51)}{-0.558}\; x + v_1$$

3b. $$F = \underset{(0.33)}{0.048}\; r + \underset{(3.70)}{1.882}\; x + v_2$$

3c. $$r_P = \underset{(7.63)}{-0.216}\; R + \underset{(1.57)}{0.027}\; F + v_3$$

3d. $$L = \underset{(1.18)}{-0.306}\; R - \underset{(0.17)}{0.022}\; F + \underset{(3.05)}{2.051}\; r_P + v_4$$

3e. $$P = \underset{(1.05)}{0.110}\; R + \underset{(0.71)}{0.038}\; F + \underset{(1.73)}{0.470}\; r_P - \underset{(2.61)}{0.091}\; v_4 + v_5$$

3f. $$x = \underset{(1.20)}{0.123}\; r + \underset{(1.35)}{0.016}\; L + \underset{(0.76)}{0.023}\; P - \underset{(3.20)}{0.897}\; (r_P - r_B) + v_6$$

3g. $$r_P - r_B = \underset{(1.40)}{0.016}\; R + \underset{(6.20)}{0.181}\; r + \underset{(0.07)}{0.000}\; F + \underset{(0.46)}{0.002}\; L + \underset{(1.71)}{0.016}\; P + v_7$$

Notes: Estimates are based on quarterly data for 1960:2 through 1991:4. Regressions include three lags of each variable, constant and trend terms. Numbers in parentheses are t-statistics.

5. Structural VAR Estimates, Credit Conditions Identified via the Loan Spread (equations 4a–2g)

4a. $$R = \underset{(0.85)}{-0.347}\, x + v_1$$

4b. $$F = \underset{(0.89)}{0.122}\, r + \underset{(4.46)}{2.132}\, x + v_2$$

4c. $$r_P = \underset{(8.10)}{-0.202}\, R + \underset{(0.96)}{0.016}\, F + v_3$$

4d. $$r_L - r_P = \underset{(4.99)}{0.070}\, R + \underset{(1.77)}{0.014}\, F - \underset{(6.56)}{0.261}\, r_P + v_4$$

4e. $$L = \underset{(0.14)}{-0.039}\, R + \underset{(0.15)}{0.021}\, F + \underset{(0.96)}{0.783}\, r_P - \underset{(2.99)}{4.727}\, (r_L - r_P) + v_5$$

4f. $$P = \underset{(0.27)}{0.030}\, R + \underset{(0.06)}{0.003}\, F + \underset{(2.18)}{0.722}\, r_P + \underset{(1.83)}{1.176}\, (r_L - r_P) - \underset{(2.42)}{0.085}\, v_5 + v_6$$

4g. $$x = \underset{(0.39)}{-0.047}\, r - \underset{(1.54)}{0.362}\, (r_L - r_P) + \underset{(1.28)}{0.016}\, L + \underset{(0.46)}{0.015}\, P + v_7$$

Notes: Estimates are based on quarterly data for 1960:2 through 1991:4.
Regressions include three lags of each variable, constant and trend terms.
Numbers in parentheses are t-statistics.

Figure 1

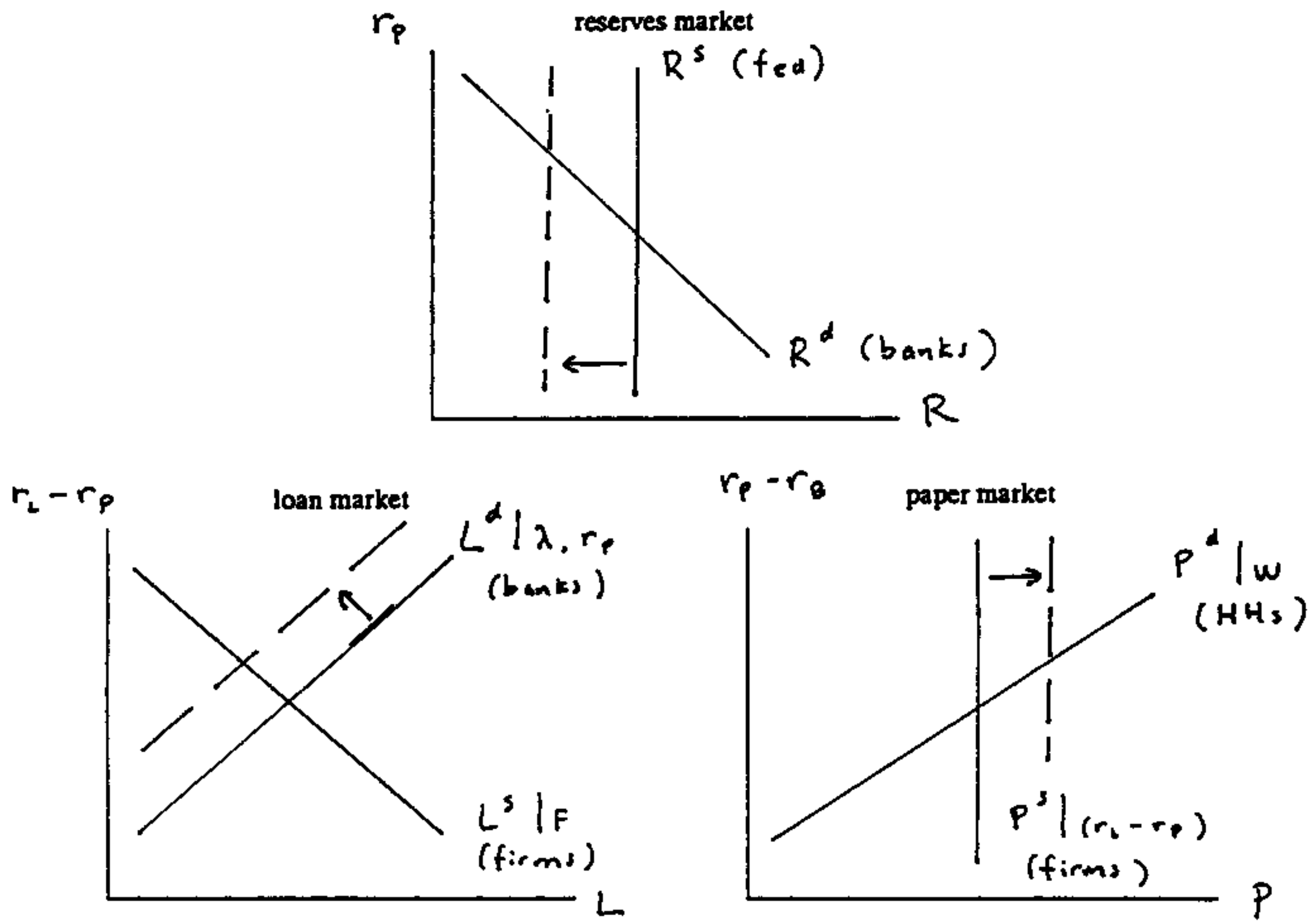


Figure 2

Impulse Response Functions of Credit Conditions Indicators

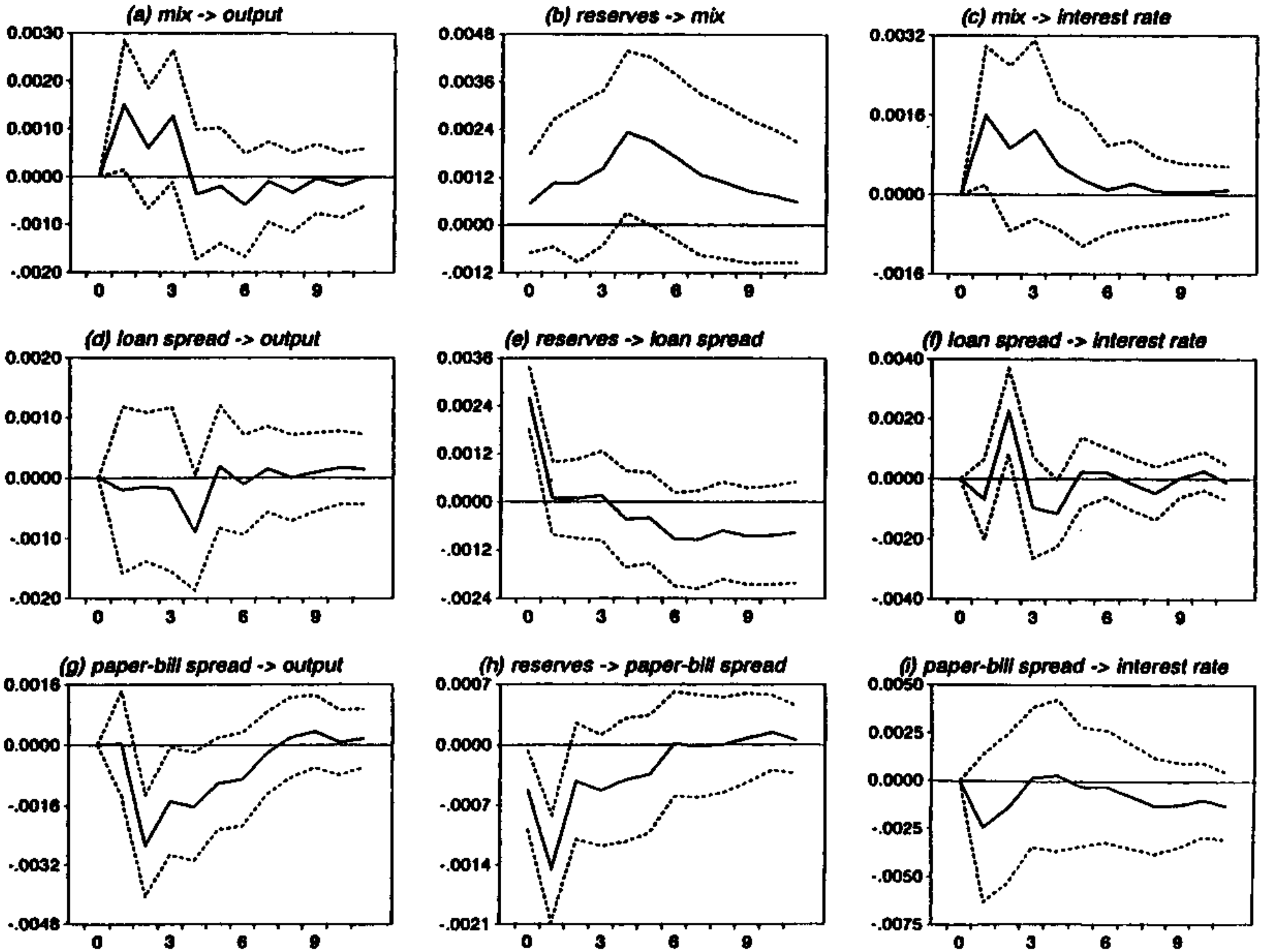


Figure 3: Financing Gap and Financial Flows

bank lending and paper issuance, four-quarter moving average

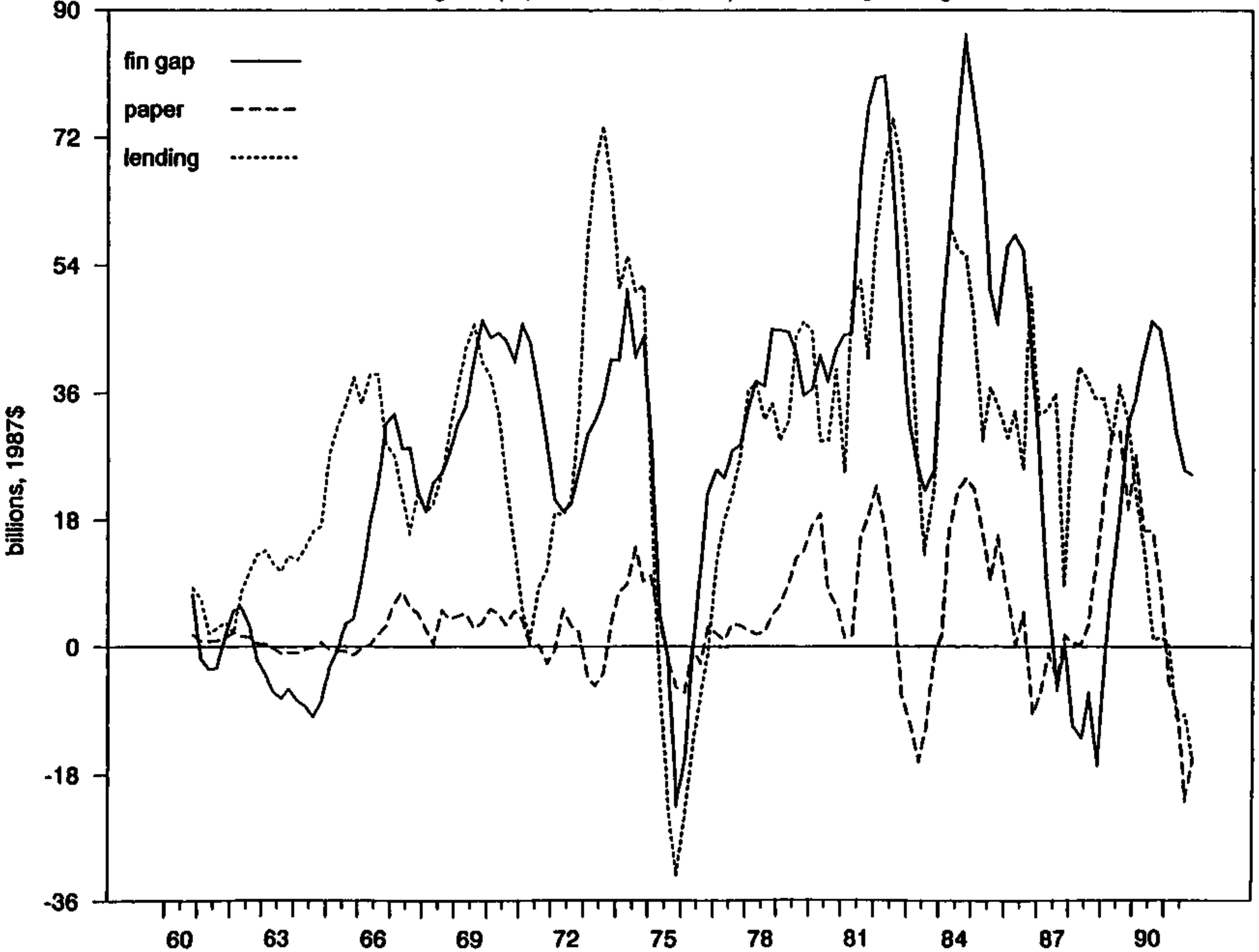


Figure 4: credit conditions = lending shocks

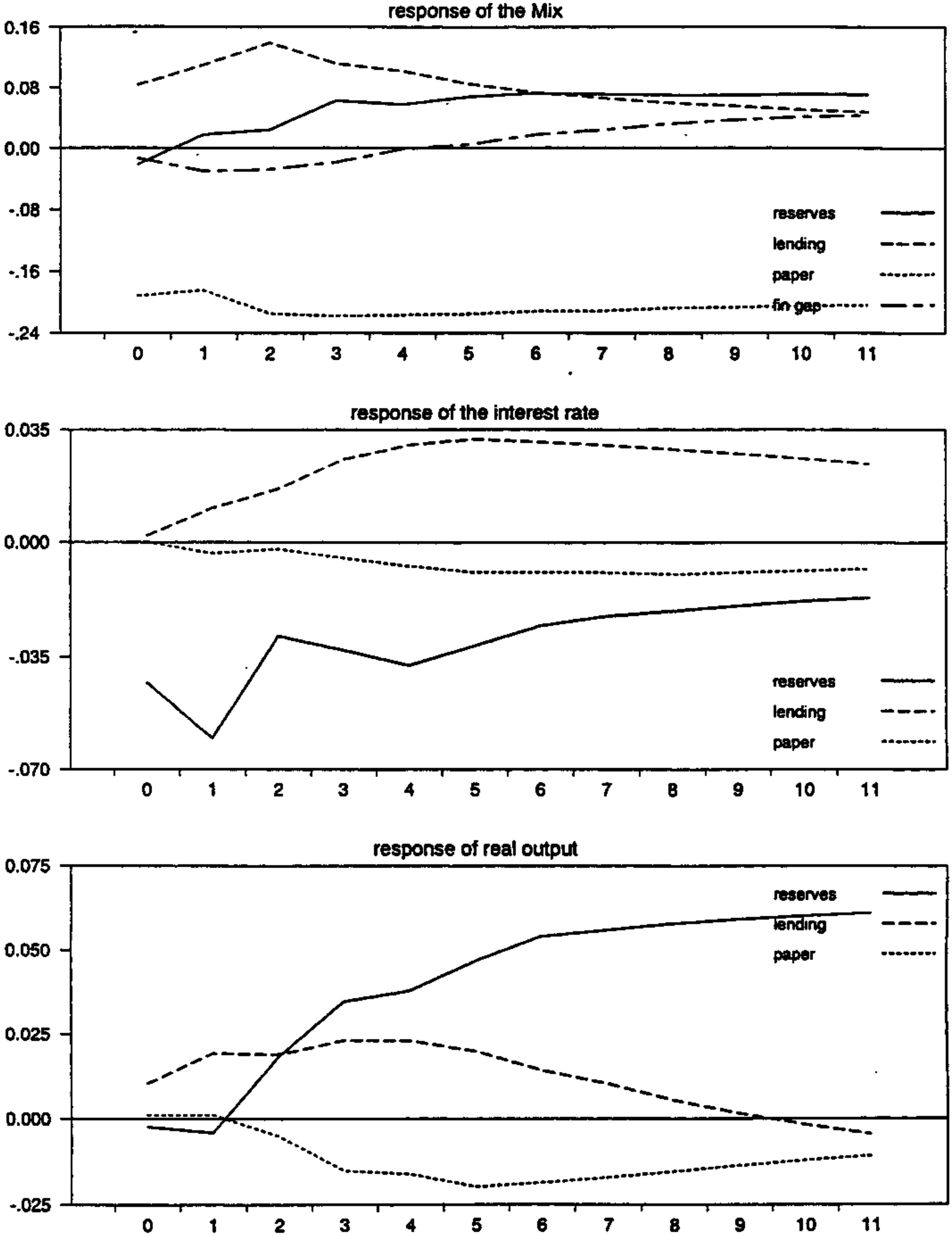
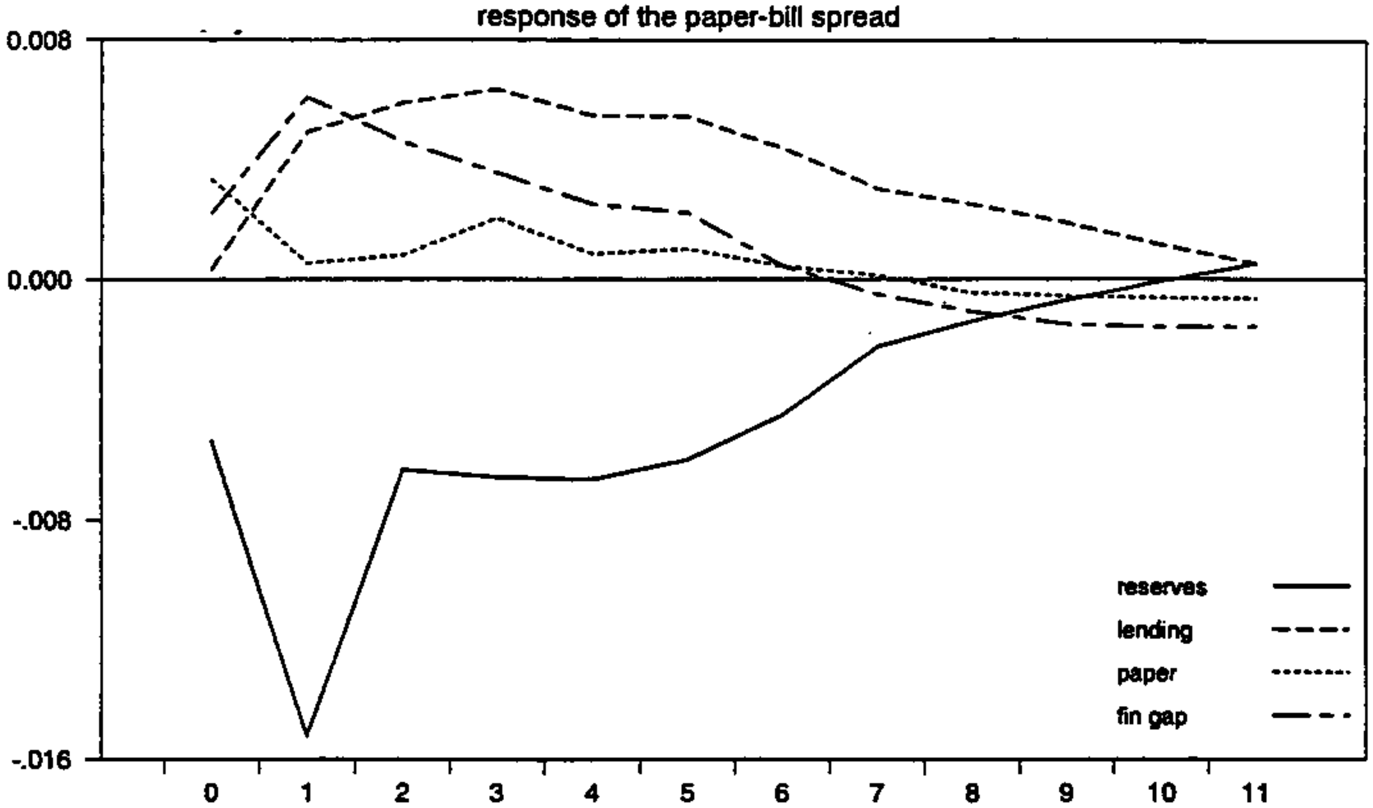


Figure 5: credit conditions = lending shocks



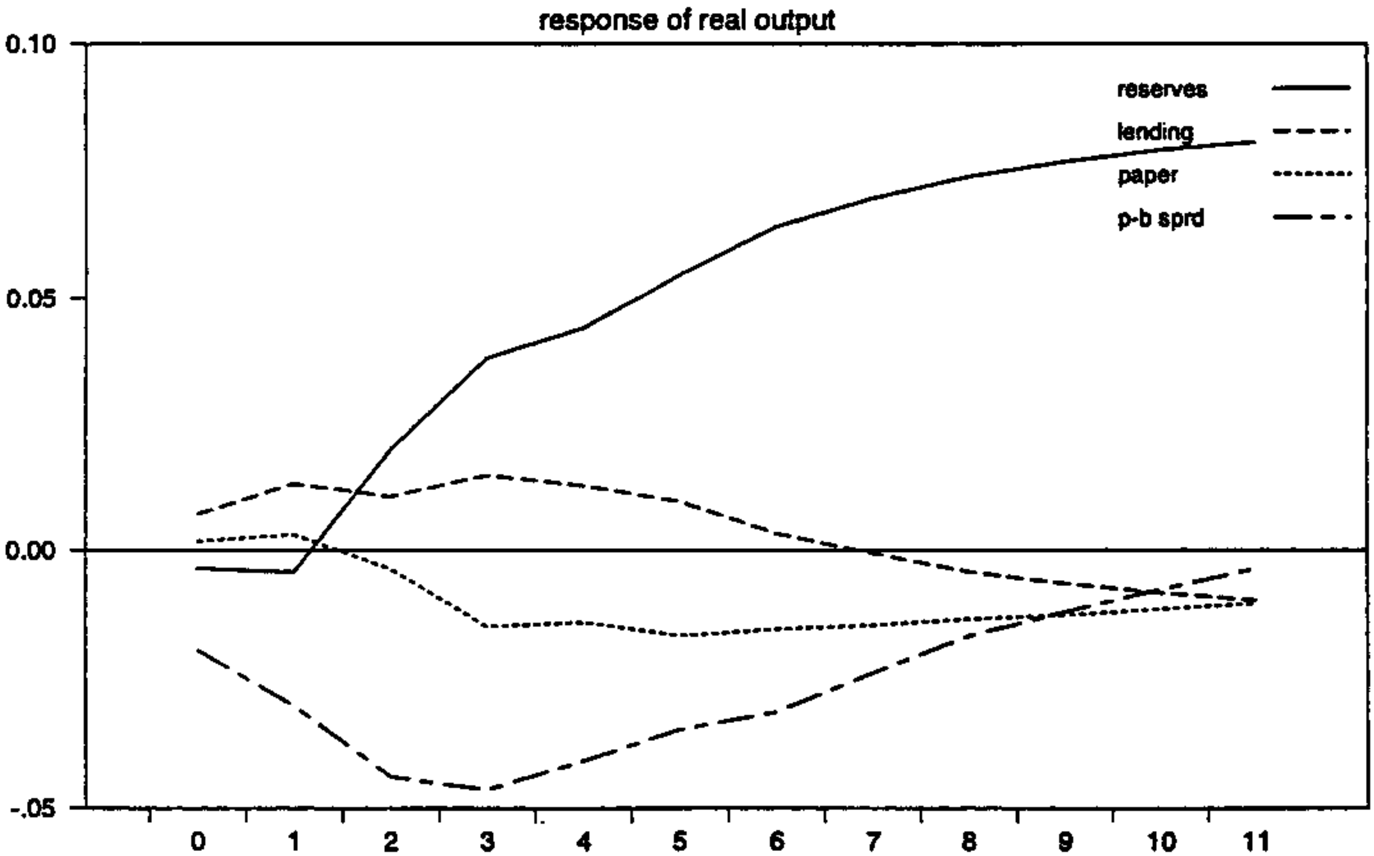
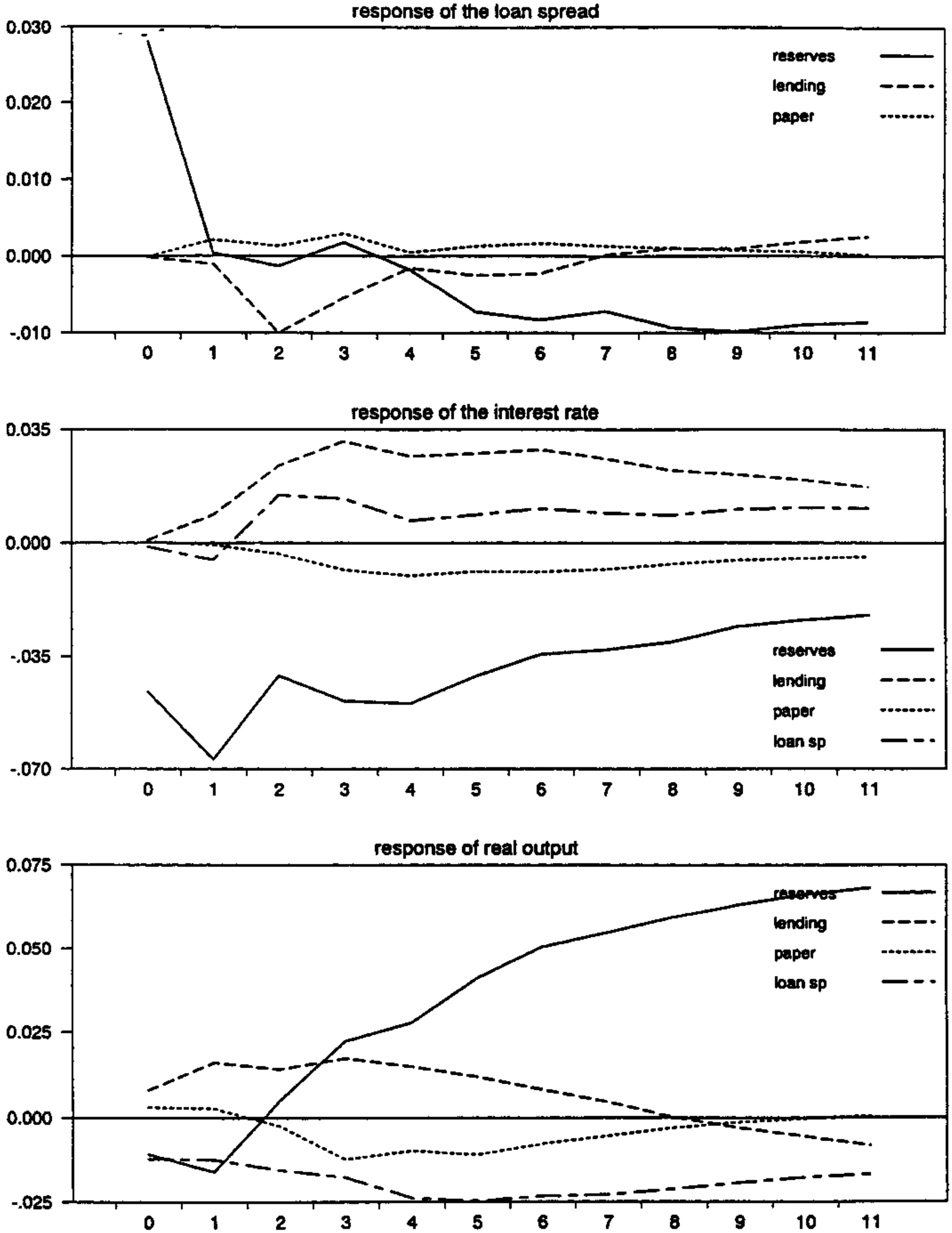


Figure 6: credit conditions = loan spread shocks



COMMENTS ON

CREDIT CONDITIONS AND EXTERNAL FINANCE:

INTERPRETING THE BEHAVIOR OF FINANCIAL FLOWS AND INTEREST RATE SPREADS

David Wilcox[1]

Two opposing views have animated much recent research on the transmission channels of monetary policy. One view (stated in its extreme form) is that the impulses of monetary policy are transmitted to the real economy exclusively via the market for reserves. By manipulating the quantity of available reserves, the Federal Reserve is able to change the relative supply of money and bonds. Given this change in relative supply, the interest rate must change in order to clear the markets for money and bonds. In turn, the change in the interest rate alters the user cost of capital, and so influences the investment decisions of businesses and the spending decisions of households.

An essential assumption implicit in this so-called "money" view of the transmission mechanism is that bank loans, market-intermediated privately-issued debt such as commercial paper and corporate bonds, and privately-held government debt can be treated as perfect substitutes. Indeed, this assumption is embedded in the conventional IS-LM model, where the aggregate non-money financial asset is simply labelled "bonds" for convenience. According to the money view, the reduction in bank loans that accompanies a reduction in reserves is of no particular significance in itself because firms can satisfy any unmet demand for external finance by issuing market-intermediated debt which is indistinguishable from bank debt. For this reason, the money view often is summarized by the proposition that bank loans are not "special."

The opposing view of the transmission mechanism assigns a central role to bank loans. According to this view, bank loans, market-intermediated privately-issued debt, and government debt are *not* perfect substitutes. The reduction in the volume of bank loans that accompanies a move toward a more restrictive monetary policy is

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contractionary in itself, even controlling for any associated change in interest rates. In effect, bank loans behave as if they were a factor of production. A reduction in their availability increases their relative price (the spread between the loan rate and the open-market rate increases). In response, firms seek cheaper alternatives for their external finance. However, given the imperfect substitutability of other forms of debt for bank loans, the reduction in loan availability implies a contraction in real activity.

The important distinction between the money view and the loans view is that the latter implies that the impulses of monetary policy are transmitted not only through the overall level of interest rates, but also through the relative prices and relative quantities of bank loans and other forms of external finance. If the loans view is right, fluctuations in the quantities and prices of bank loans, commercial paper, other private debt, and government debt will be worth keeping track of separately because they will be informative for either the current or future state of the economy, or both. Moreover, the loans view suggests, as Kuttner (this volume) and Friedman (1991) emphasize, that there is no reason for being uniquely interested in changes in the stance of monetary policy; other factors (including but not restricted to the stringency of regulatory oversight) will also be worthy of study to the extent that they bear on loan availability.

THE IDENTIFICATION PROBLEM

One approach to investigating the empirical significance of the loans channel has been to regress some measure of real activity (such as industrial production or GNP) on current and lagged measures of bank loans. A positive correlation between bank loans and real activity has sometimes been interpreted as contradicting the money view and supporting the existence of a separate loans channel. The flaw in this argument is not hard to spot: A positive correlation between bank loans and real activity could simply reflect an endogenous *response* of the demand for bank loans to changes in real activity rather than an exogenous *cause* of changes in real activity. Even a finding of a positive correlation between bank loans and *subsequent* changes in activity (as opposed to contemporaneous ones) would not be convincing evidence of a separate loans channel; such a phenomenon could reflect, for example, a need to secure financing some months or even quarters before the bulk of the associated activity is to take place.

An important challange taken up in the more recent literature has been to solve this identification problem in a convincing manner.[2]

SUMMARY OF KUTTNER'S PAPER

Ken Kuttner's paper makes two important contributions to the literature on the monetary policy transmission mechanism: one theoretical, the other empirical.

On the theoretical front, he presents a very nice compact model of the flow of funds in a simple economy. He distinguishes five financial instruments in his model (in contrast to the usual two): deposits ("money"), bank loans, commercial paper, reserves, and government debt.[3] He posits the existence of a representive firm, a representative bank, and a representative household, and endows each of them with standard portfolio behavior (households' demand for money is declining in the opportunity cost of holding money, and so forth). Then he derives the implications of changes in the stance of monetary policy, changes in banks' willingness to lend, and changes in firms' demand for external finance for three quantities: the mix of external finance, the spread between the loan rate and the commercial paper rate, and the spread between the paper rate and the Treasury bill rate.

The beauty of Kuttner's model is that it delivers sensible results very directly. For example, a reduction in banks' willingness to lend causes the loan-paper spread to rise.[4] In response, firms

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2. The approach proposed in Kashyap, Stein, and Wilcox (1992) is to focus on changes in the *composition* of external finance rather than fluctuations in any one component alone. Intuitively, one would not expect changes in the volume of bank loans relative to the volume of other debt to be informative for current or future changes in real activity if bank debt is a perfect substitute for non-bank debt.

3. Implicitly, other corporate liabilities such as medium- and long-term bonds are treated as perfect substitutes for commercial paper.

4. Kuttner interprets "negative shifts in λ as 'credit crunch' episodes." He notes, however, that a negative shift in λ could reflect a "perceived deterioration in borrowers' creditworthiness." In my opinion, it would be more useful to reserve the term "credit

(Footnote continues on next page)

shift the mix of external finance away from bank loans and toward market-mediated debt. The increased issuance of commercial paper drives up the spread between commercial paper rates and bill rates.[5] With respect to these three key variables, the effects of a reduction in banks' willingness to lend are identical to the effects of a move by the Federal Reserve toward a more restictive monetary policy, suggesting that any one of the three might be useful as an index of loan availability.[6]

In fact, it turns out that these three variables also respond in qualitatively the same manner to the other two exogenous factors in Kuttner's model (monetary policy and the demand for external finance). That is, no matter what the conceptual experiment being run in Kuttner's model, the loan-paper spread will always move in the same direction as the paper-bill spread, and the two spreads will always move in the opposite direction of the mix.

In light of these predictions from his theoretical model, Kuttner's finding that the loan-paper spread significantly underperforms the mix and the paper-bill spread as indicators for future real GNP is interesting and a bit puzzling. Kashyap, Stein,

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(Footnote continued from previous page)
crunch" for periods in which some potential borrowers are turned away even though, *with identical characteristics in every respect (including "credit worthiness")*, they would have been granted credit in "normal" times.

5. In Kuttner's model, the commercial paper rate is taken as the benchmark rate over which the Federal Reserve has direct control in the reserves market. As a result, a reduction in banks' willingness to lend has no effect on the *level* of the commercial paper rate. As was noted in the text, however, it does increase the loans-paper spread. As a result, the volume of commercial paper outstanding rises and the paper-bill spread increases. Given the fixity of the paper rate in the face of this experiment, it must be that the bill rate has declined. If the bill rate (rather than the paper rate) were assumed to clear the market for reserves, all the essential results still would hold (the mix would shift away from loans, the loans-paper spread and the paper-bills spread both would rise), but the bill rate would be fixed and the paper rate would rise.

6. Kuttner notes that the effects of a shift in monetary policy are not identical in every respect to the effects of a shift in banks' willingness to lend: The former affects the level of the interest rate in the market for reserves, whereas the latter does not.

and Wilcox (1992) argued that the mix might be preferable to the loan-paper spread as an indicator of loan availability (because the stated loan rate would not adequately reflect changes in non-price terms of loan contracts such as collateral requirements), but then proceeded to find in their sample that the predictive power of the two variables was roughly comparable. It would be worth attempting to reconcile Kuttner's results with those of KSW, and (assuming Kuttner's results hold up) attempting to verify the KSW hypothesis about why the loan-paper spread might be an inferior performer.

On the empirical side, Kuttner's paper introduces a new approach to solving the identification problem. He posits several simple "structual vector autoregression" models of the markets for reserves, bank loans, and commercial paper. Kuttner is bold enough to supply sufficient prior restrictions on the specification of the various equations, and finds that, for the most part the estimates that follow are well in line with the predictions that were outlined in his theoretical section. The major exception--and one that deserves further investigation--is that increases in banks' willingness to lend (counterintuitively) appear to cause *increases* in interest rates.

AN ASYMMETRIC-INFORMATION-BASED ACCOUNT OF SUBSTITUTION BETWEEN LOANS AND PAPER

In line with most of its recent predecessors, Kuttner's paper adopts an aggregate perspective: The model is inhabited by representative banks, households, and non-bank firms, and the empirical work is conducted using aggregate data. As in the earlier papers, this perspective--through no fault of the author--sets up certain tensions of both an expositional sort and a substantive sort. On the expositional side, the most natural way to tell the story of the loans channel involves an appeal to heterogeneity among firms: Some are capable of issuing commercial paper while others are not. Obviously, a story such as this is difficult to link up directly to a model with a single representative non-bank firm. On the substantive side, the representative-agent approach to modelling the problem fuels the intuition that some firms should be observed to be on the margin between bank loans and commercial paper. The purpose of the rest of these comments is to sketch verbally a model that allows for heterogeneity among firms, and then to point out two important implications of such an approach.

The loans view is predicated on the assertion that non-bank debt is not perfectly substitutable for bank debt. That imperfect substitutability can be motivated as reflecting market imperfections that arise when borrowers have more information about their economic prospects than do prospective lenders. Banks specialize in "information-intensive" lending--that is, in lending to customers (such as small businesses) for whom the asymmetric-information problem is more acute, and hence more difficult for arms-length capital markets to solve.

A contractionary shift in the stance of monetary policy will cause banks to reduce the size of their loan portfolios.[7] Banks will tend to cut off their most risky customers and continue to service their most creditworthy ones. Firms that are denied credit by banks may be unable to borrow from any other lender. Certainly, they will not be able to issue debt in arms-length capital markets; nor will they be able to attract financing from other non-bank sources simply by announcing their willingness to pay a higher rate of interest on the debt, because potential lenders will recognize that only the riskiest firms would be willing to offer a higher rate of return. In the end, these firms are likely to be particularly vulnerable to the monetary contraction.

After a monetary contraction, a larger fraction of total external finance will be provided via arms-length capital markets and a smaller fraction through bank loans. This change in composition may reflect either (or both) of two factors: First, it may reflect increased issuance of trade credit by large, financially secure firms to their smaller, less creditworthy suppliers. An increase in commercial paper borrowing would be used, in effect, to finance the rise in trade credit. Large firms may be willing to act, in effect, as financial intermediaries because they will have accumulated substantial inside information about the financial stability of their suppliers in the course of having interacted with them before the

7. A lower level of reserves will only support a lower level of deposits. The lower level of deposits (which comprise banks' liabilities) implies that assets will have to decline as well. Given that banks view loans and securities as imperfect substitutes, some of that decline in assets will be absorbed in loans.

credit crunch. Alternatively, the increase in the share of commercial paper in total external finance may reflect that large firms tend to expand when their smaller rivals are weakened by financial stringency; the large firms take the opportunity to seize some portion of the product market, financing the larger scale of their operations with the increase in commercial paper issuance.

These two mechanisms show that bank loans and commercial paper can be substitutes at the aggregate level even though not so for any individual firm. Failure to observe firms operating on the margin between bank loans and other market-mediated debt does not constitute evidence against the heterogeneous-firms version of the loans channel.

IMPLICATIONS OF THE ASYMMETRIC-INFORMATION-BASED APPROACH

The informal discussion in the previous section points to two important implications for future research. First, the very motivation of banks specializing in information-intensive lending suggests that further progress probably would flow from the analysis of models that allow for heterogeneous non-bank firms. In particular, it seems likely that most such models will imply that, when the Federal Reserve adopts a more restrictive monetary policy, banks will shrink their loan portfolios by refusing credit to their riskiest (least financially stable) customers. Commercial paper issuance will rise because firms already issuing paper will issue more--either to finance their own expanded operations, or to finance the passthrough of trade credit to their suppliers.[8] By contrast, a representative-firm model suggests that all firms should be on the margin between bank debt and commercial paper, and that when the Federal Reserve tightens we should observe a rebalancing of liabilities taking place at the individual firm level. The implausibility of this account is obvious, given that fewer than 1300 firms in the United States have commercial paper programs rated by Moody's.

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8. Firms that are growing in size will, at some point, find it possible to issue commercial paper for the first time. If the profitability of commercial paper issuance is an inverse function of bank-loan availability, establishment of commercial paper programs will tend to be bunched into periods immediately following tightenings of monetary policy. Historically, of course, the commercial paper market was not always as well-developed as it is now; as the market deepened and became more efficient, even firms that had been large and creditworthy for a long time established new programs.

The second implication of the disaggregated approach is that future empirical work should focus on micro-level datasets. Such investigations will be essential for: (1) establishing the identity of bank customers who are denied credit in the wake of a tightening by the Federal Reserve; and (2) establishing the source of the accompanying increase in commercial paper issuance.

Discount Window Borrowing and Liquidity

W. J. Coleman, C. Gilles, and P. Labadie[1]

Three features seem central to understanding the relationship between U.S. monetary policy and the comovements of open market operations, monetary aggregates, and interest rates. First, shocks to bank reserves affect interest rates in ways that are not tightly linked to the Fisherian fundamentals (expected inflation, marginal rate of substitution, and marginal productivity of capital). Second, banks often respond to reserve shocks by adjusting their borrowing at the Federal Reserve's discount window. Third, the Federal Reserve often conducts open market operations to smooth interest rates that would otherwise react to private-sector demand shocks. In this paper, we study a stochastic general equilibrium model that incorporates these features in an effort to understand important empirical regularities involving monetary aggregates and interest rates.

The empirical regularities we have in mind are those documented in the vast literature aimed at uncovering a negative correlation between short-term interest rates and exogenous policy shocks to nominal monetary aggregates, a relationship often referred to as the liquidity effect. Cagan (1972) and Cagan and Gandolfi (1969), among many others, have reported finding negative correlations between M1 itself and various short-term interest rates. Subsequent studies have reported similar correlations with innovations in M1 backed out using a Choleski decomposition of the residuals in a vector autoregression (for a variety of orderings). More recently, however, Leeper and Gordon (forthcoming) have made a strong case that these innovations probably do not represent exogenous monetary policy shocks, as the money supply may be endogenously

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[1] Board of Governors, Federal Reserve System. We gratefully acknowledge helpful discussions with Jim Clouse and Josh Feinman.

determined in ways that are not captured by any Choleski decomposition. To support their claim, they noted that the statistical properties of these innovations are sensitive to the other endogenous variables included in the VAR. the sample period, and the measure of money selected for analysis. Some researchers, for example Bernanke and Blinder (1990) and Sims (forthcoming), have responded to such criticism by assuming that innovations to interest rates reflect policy shocks, to which the supply of money responds endogenously. For our purpose, however, this strategy does not resolve the central question: if there exists a liquidity effect, then why are these interest rate innovations not robustly negatively correlated with monetary aggregates (an observation also made by Leeper and Gordon)?

Christiano and Eichenbaum (1991) and Strongin (1991) have tried to obtain robust negative correlations by using nonborrowed reserves as the measure of money. This approach contrasts with that of Leeper and Gordon, who experimented with monetary aggregates that are at least as broad as the monetary base. Christiano and Eichenbaum's rationale for using nonborrowed reserves is based on the widely held perception that the Fed controls this aggregate. For this reason they associated policy shocks with innovations to nonborrowed reserves, which they then showed to be negatively correlated with the federal funds rate. In fact, using nonborrowed reserves as the measure of money, they found evidence of a negative correlation regardless of whether money innovations or interest rates innovations were identified as the policy shocks, and they showed that these correlations are remarkably robust to the sample time period. To explain why the innovations to broader monetary aggregates do not exhibit a similar correlation, they noted that these aggregates are largely endogenously determined by the banking system. For example, they argued that total reserves may be inelastic in the short run, and therefore not correlated with interest rates at all. In this example, policy shocks to nonborrowed reserves do not affect total reserves immediately. Strongin refined this argument; he argued that innovations to nonborrowed reserves that are not reflected in shocks to total reserves should be identified as the policy shocks. He asserted, in essence, that shocks to required reserves lead to an adjustment in both nonborrowed and total reserves, whereas open market operations lead to an adjustment in only nonborrowed reserves.

We develop a model that is rich enough to address the empirical issues presented above. To do this, we introduce a banking system, reserve requirements, and a discount window into a model of liquidity based on the works of Grossman and Weiss (1983), Rotemberg (1984), Lucas (1990) and Fuerst (1992). In these models, and here, the term liquidity effect refers not merely to a negative correlation between monetary policy shocks and interest rates but more generally to any non-Fisherian effect on interest rates. Interest rates deviate from their Fisherian fundamentals because of shocks to the demand for bank deposits from businesses to finance new investment projects and perhaps also because of monetary policy shocks. In our model, the interest rate is also the cost (both pecuniary and nonpecuniary) of borrowing reserves from the discount window, so that over time there is a well defined relationship between borrowed reserves and the interest rate. Monetary policy designed to smooth interest rates then leads to rather complicated mutual dependencies among open market operations, both broad and narrow monetary aggregates, and interest rates; in particular, monetary policy can lead to positive correlations between broad monetary aggregates and interest rates in spite of the liquidity effect. When policy shocks are correctly identified, however, the model suggests that broad monetary aggregates are negatively correlated with interest rates, showing evidence of the liquidity effect. Furthermore, the model always generates a negative correlation between nonborrowed reserves and short-term interest rates, regardless of what the policy shocks are and how they are identified. Such a result is due to the way the discount window is operated. In light of this model, one interpretation of Christiano–Eichenbaum and Strongin's results is that they identified the discount window policy. Since this policy implies a negative correlation between nonborrowed reserves and interest rates whether or not the model incorporates a liquidity effect, their results shed little light on the presence of such an effect.

THE MODEL

DESCRIPTION.

To get an overview of the model, consider the following accounting of the assets and liabilities of banks. Their liabilities comprise demand deposits of firms and households as well as savings deposits of households. Their assets are made up of reserves and a portfolio of government securities and loans to firms. Banks are required to hold as reserves a fraction of their demand deposits; to avoid a deficiency, they can borrow reserves at the discount window. Borrowed reserves incur pecuniary and nonpecuniary costs. To start building a model around this balance sheet, think of households as dividing their deposits between demand deposits, which can be used to buy goods, and savings deposits, which cannot. Assume that this division is made before the value of the open market operation is known, resulting in a liquidity effect as described by Lucas (1990) and Fuerst (1992). Also assume, as Fuerst (1992) did, that firms must finance their purchases of investment goods with demand deposits, so that these deposits represent intermediated capital, as in Freeman and Huffman (1991).

To view the model in more detail, consider a representative household that ranks stochastic consumption and leisure streams $\{c_t, \ell_t\}$ according to the utility function

$$E\left[\sum_{t=0}^{\infty}\left(\prod_{i=0}^{t}\beta_i\right)U(c_t,\ell_t)\right],$$

where β_i is the date-i realization of the random discount factor; β_{t+1} is unknown at the beginning of period t but is revealed later during that period. The household begins period t with money balances M_t in an interest-bearing savings account. It immediately transfers amount Z_t to a checking account which bears no interest but can be used during the period to finance consumption c_t; only one transfer during the period is allowed. The household must choose Z_t before it knows the realization of any of the current shocks, or prices for that matter. Its purchases of goods are subject to the finance constraint

$$P_t c_t \leq Z_t.$$

At the end of the period, $M_t - Z_t$ remains in the household's savings account and $Z_t - P_t c_t$ in its checking account.

The household derives income from several sources. It provides labor to the firm, working a fraction of time equal to $1 - \ell_t$ at wage rate W_t; it earns interest at rate r_t^b on the amount $M_t - Z_t$ in its savings account; it collects a transfer X_t from the government; finally, as owner of both the firm and the bank, it collects Π_t^f and Π_t^b, the period's proceeds from the sale of output net of all costs and bank profit respectively. The household receives its income, including income from labor performed during the period, at the beginning of the next period, when it is directly deposited into the savings account. With unspent checking account balances being transferred back into the savings account, the law of motion for M_t is

$$M_{t+1} = Z_t - P_t c_t + (M_t - Z_t)(1 + r_t^b) + W_t(1 - \ell_t) + X_t + \Pi_t^f + \Pi_t^b.$$

The firm, the second agent in the economy, combines capital and labor inputs to produce a homogeneous product sold to buyers of consumption and capital goods. The production function is

$$y_t = F(k_t, n_t, \theta_t),$$

where y_t is the output, k_t and n_t are the inputs of capital and labor, and θ_t is a technological shock. The firm owns the capital stock k_t and hires labor at rate W_t; it makes wage payments at the beginning of the next period using the receipts from the sale of output. The firm must also acquire investment goods i_t; it purchases these goods from other firms in the goods market but cannot use its sales receipts for this purpose. Instead, it finances investment by borrowing B_t from a bank, which charges interest at rate r_t. The bank provides this financing by crediting the amount to the firm's checking account, increasing the balance from its starting level of zero. The firm's finance constraint is

$$B_t \geq P_t i_t.$$

At the end of the period, the firm has spent $P_t i_t$ on investment goods and deposits its current sales receipts, $P_t y_t$, leaving $B_t + P_t(y_t - i_t)$ in its checking account. At the beginning of the next period, the firm repays its bank loan and transfers wages into the worker's savings account. The amount left in the firm's account, Π_t^f, is paid to the firm's owner as dividend:

$$\Pi_t^f = P_t y_t - W_t n_t - P_t i_t - r_t B_t \,.$$

The stock of capital depreciates at the constant rate δ, so that its law of motion obeys

$$k_{t+1} = (1-\delta)k_t + i_t \,.$$

The firm makes all its decisions (namely, B_t, i_t, and n_t) with full knowledge of the current shocks and prices.

The bank, the third agent in the economy, starts period t with liabilities equal to M_t (the household's savings account) and holds an equal amount of vault cash as an offsetting asset (we write "vault cash" for definiteness; M_t could also be thought of as an account at the central bank). The household immediately transfers Z_t from its savings to its checking account, without affecting the bank's total liabilities or assets. The bank pays interest r_t^b on $M_t - Z_t$, the amount left in the savings account, but pays no interest on checking deposits. By lending B_t to the firm, an amount that is credited to the firm's checking account, the bank increases both its liabilities and its assets from M_t to $M_t + B_t$. To buy government bonds and to honor checks written to finance purchases of consumption and investment goods, the bank depletes its holding of vault cash, M_t; but it replenishes this cash position by the amount of the checks that firms receive for selling their output, checks that they deposit in their account. The amount of vault cash that the bank holds at the end of the period counts as reserves. Note that for an individual competitive bank, the loan of B_t to a firm drains reserves (when the firm spends the proceeds) just as much as if the bank had spent an equal amount to purchase government securities; therefore, at the same rate of interest, the bank is indifferent between the two types of lending. For the banking system as a whole, however, loans to firms involve no net loss of reserves, but merely a transfer from the borrower's bank to the bank of the producer of investment goods.

Reserves, V_t, pay no interest and are subject to a reserve requirement, a fixed fraction ρ of the amount of checking deposits on the books of the bank at the end of the period:

$$V_t \geq \rho \times [(Z_t - P_t c_t) + (B_t - P_t i_t + P_t y_t)]. \tag{1}$$

If the bank cannot satisfy the reserve requirement with the amount of vault cash it has at the end of the period (after checks have cleared), it can borrow the shortfall from the government at the discount window. Therefore, the following accounting identity must hold

$$M_t + D_t = q_t G_t + P_t(i_t + c_t - y_t) + V_t, \tag{2}$$

where G_t is the number of one-period pure discount government bonds the bank acquires, at a unit cost of $q_t = 1/(1+r_t)$, and D_t is the amount it borrows at the discount window. Government bonds, private loans, and discount window borrowing carry the same rate of interest r_t. The bank's objective is to maximize its period profit, which is given by

$$\Pi_t^b = r_t(B_t + q_t G_t - D_t) - r_t^b(M_t - Z_t). \tag{3}$$

The government, the fourth agent in the economy, sells one-period bonds in the securities market and redeems them at the beginning of the following period, operates the discount window, and makes transfers to the household's bank account. During period t, the government announces the open market operation G_t and the amount of transfers X_t after the household chooses Z_t but before any other decision by any agent has to be made. All money flowing between the government and the private sector, as well as within the banking industry, takes the form of fiat money. The bank starts period t with an amount of fiat money (which it calls vault cash) equal to M_t. Nonborrowed reserves $V_t - D_t$ is the amount left in vault cash after the purchase of government bonds and check clearing but before borrowing at the discount window; in equilibrium, $V_t - D_t = M_t - q_t G_t$ as can be seen from eq. (2).

Let H_t denote the outstanding supply of fiat money at the beginning of period t (M_t is best thought of as the demand for fiat money, so that in equilibrium $H_t = M_t$). The law of motion for H_t, which can also be thought of as the government budget constraint, is as follows:

$$H_{t+1} = H_t + r_t(q_t G_t - D_t) - X_t.$$

Think of government policy as a rule that generates the values of G_t and X_t and that also sets the rate of interest at the discount window. Assume that the government lends reserves at the discount window according to an upward-sloping function $\psi : [0, \infty) \to [0, \infty)$ that relates the rate of interest it charges to the fraction of total reserves that it lends. Banks cannot lend at the discount window, so that when the equilibrium rate of interest is lower than the minimum rate at which the government is willing to lend, $\psi(0)$, there is no discount window activity:

$$r_t = \psi(D_t/V_t) \qquad \text{whenever } D_t > 0;$$
$$r_t \leq \psi(0) \qquad \text{whenever } D_t = 0.$$

The argument of ψ ought to be the amount *supplied* at the window, which in equilibrium turns out to be equal to D_t, the amount *demanded*. Incorporating this equilibrium relationship directly simplifies the notation, but keep in mind that banks take as given all interest rates, including the rate they face at the discount window (which is equal to the rate on government securities).

When the Federal Reserve lends at the discount window, the borrowing bank pays the discount rate plus a nonpecuniary cost; at the margin, this sum must equal the cost of borrowing from other banks, which is the federal funds rate. The marginal nonpecuniary cost is thus captured by the difference between the federal funds rate and the discount rate, called the *spread*. Historically, the policy of the Federal Reserve seems to have been to supply funds at the discount window at an increasing nonpecuniary cost (spread), which is precisely what the function ψ assumes. This type of discount-window policy has been documented in the empirical literature, and is commonly modeled in the theoretical literature.[2] Chart 1, which graphs the monthly time series for

[2] See for example Polakoff (1960), Goldfeld and Kane (1966), and more recently Goodfriend (1983), Dutkowsky (1984), and Waller (1990). In particular, Fig. 1, p. 346 in Goodfriend depicts an assumed ψ function that is strikingly similar to the function that would best fit the scatter plot of our Chart 2.

the federal funds rate and the nonborrowed reserve ratio (the mirror image of the borrowed reserve ratio), reveals the basis for the findings of the empirical studies. On closer inspection, a picture of the function ψ emerges in a scatter plot of the borrowed reserve ratio against the spread, shown in Chart 2. Since this picture suggests that the Federal Reserve is ready to lend its first dollar at a zero spread, the value of $\psi(0)$ corresponds to the discount rate. With this interpretation of $\psi(0)$, the model simply assumes a constant discount rate.

A word about terminology is in order. V_t is total reserves in the banking system; D_t is borrowed reserves; the difference $V_t - D_t$ is nonborrowed reserves; and required reserves is $\rho \times [Z_t + B_t + P_t(y_t - i_t - c_t)]$. Besides total reserves, it is possible to identify the analogues of several monetary aggregates. M_t (or H_t) corresponds to the monetary base, M0; the analogue of M1 is the sum of all reservable accounts, $Z_t + B_t$; the total libilities of the banking sector at the end of the period, $M_t + B_t$, correspond to M2 (strictly speaking, M1 and M2 both should include $P_t(y_t - c_t - i_t)$ as well, but this is equal to zero in equilibrium); finally, the difference between M2 and M0, which is B_t, is inside money.

It is now useful to summarize the timing of information and decisions. During period t, the realizations of four random variables shock the economy—the technological shock θ_t, the preference shock β_{t+1}, the open market operation G_t, and the government transfer X_t. At the beginning of the period, the household must decide how much to put into its checking account, not knowing the current realization of θ_t, β_{t+1}, G_t, or X_t, and therefore not knowing what interest rates, prices, output, or consumption will be. After it makes this decision, all four shocks are revealed and prices are set. On the basis of these shocks and these prices, the household decides how much to consume and how much to work; the firm decides how much to borrow, how much to invest, and how much labor to hire; and the bank decides how much to lend to the firm and to the government. Then trading takes place and checks clear. The bank monitors its reserve position and borrows at the discount window to cover any reserve deficiency (the bank can be thought of as borrowing at the same time it invests in government bonds or lends to firms, because it has the same information when it engages in any of these activities). At the start of next period, the firm pays its wage bill, repays its bank loan, and pays out its earnings to its shareholder; the government makes transfers to the household's savings account and redeems the bonds that the bank holds; the bank pays interest on its savings account, settles its discount window debt, and pays out its earnings. These activities determine the new initial balance in the household's savings account. Then a new cycle starts.

The activities of the four agents that have been described above must, of course, satisfy the following standard market-clearing conditions.

$$
\begin{aligned}
y_t &= c_t + i_t && \text{goods market;} \\
n_t &= 1 - \ell_t && \text{labor market;} \\
H_t &= M_t && \text{money market.}
\end{aligned}
$$

The economy is competitive, and agents have rational expectations. An equilibrium is a set of state-contingent prices and interest rates such that markets clear when all agents solve their optimization problems, treating prices as given. In the next subsection, we are more explicit about what this means.

THE MODEL AS A RECURSIVE SYSTEM

The household solves a dynamic program, which is recursive under standard assumptions about preferences, technology, and the stochastic environment.

ASSUMPTION 1. *The period utility function U is twice continuously differentiable, strictly increasing in both arguments, and strictly concave.*

ASSUMPTION 2. *The production function F has the form $F(k, n, \theta) = \theta f(k, n)$, where f is twice continuously differentiable, strictly increasing in both arguments, concave, and homogeneous of degree one. (Stochastic constant returns to scale.)*

ASSUMPTION 3. *The preference shocks $\{\beta_t\}$ and the technological shocks $\{\theta_t\}$ are generated by independent first-order Markov processes. The support of β_t is contained in $(0, 1)$ and that of θ_t is contained in $(0, \infty)$.*

Monetary policy consists of a rule that dictates the value of open market operations, the size of government transfers, and the level of the discount rate;

these instruments are not completely independent of each other. The operation of the discount window is modeled through a fixed function ψ that relates the discount rate to borrowed reserves. Think of the government as announcing this function and keeping it fixed in all periods, leaving the discount rate itself endogenously determined by the demand for borrowed reserves. Given the function ψ, the values of G_t and X_t in period t are implied by the choices of the ratios $g_t = G_t/H_t$ and $\gamma_t = H_{t+1}/H_t$. To induce stationarity and recursivity, choose (g_t, γ_t) as the policy variables and make the following assumption.

ASSUMPTION 4. *The monetary policy shocks $\{g_t, \gamma_t\}$ are generated by a first-order Markov process.*

Starting with the optimization problem faced by the bank simplifies both the notation and the analysis. The bank maximizes its period profit, given in (3), by choosing an optimal portfolio (B_t, G_t, D_t, V_t), subject to the legal reserve constraint (1), and the accounting identity (2). Clearly, optimization requires that $V_t = \rho[Z_t + B_t + P_t(y_t - i_t - c_t)]$ (no excess reserves) if $r_t > 0$. A zero-profit condition, the result of perfect competition and constant returns to scale in the banking industry, implies that $r_t^b = [(M_t + B_t - V_t)/(M_t - Z_t)] \times r_t$; this condition in turn yields $r_t^b = r_t[1 + (1-\rho)(Z_t + B_t)/(M_t - Z_t)]$, which holds whether or not $r_t > 0$. To obtain the last expression, recall the market-clearing condition $y_t = c_t + i_t$.

Since the firm and the bank belong to the household, it is possible to integrate the problems faced by the firm, the bank, and the household. Because money growth induces a trend in nominal variables, stationarity of the equilibrium requires that nominal variables—denoted by uppercase letters—be divided by the supply of fiat money. The new variables are denoted by the corresponding lowercase letters; thus, $m_t = M_t/H_t$, $z_t = Z_t/H_t$, and so forth. Under assumptions 3 and 4, the evolution of the shocks is determined at the beginning of period t by the vector $(\beta_t, \theta_{t-1}, g_{t-1}, \gamma_{t-1})$, which consists of the latest known realizations of the shocks. The state of the economy at that time can then be expressed as $s_t = (\kappa_t, \beta_t, \theta_{t-1}, g_{t-1}, \gamma_{t-1})$, where κ_t is the aggregate per capita stock of capital (as opposed to k_t, which is the individual firm's holding). In equilibrium, of course, individual decisions determine aggregate outcomes, so that $\kappa_t = k_t$. A solution is a set of functions p, w, and r such that $p_t = p(s_t, s_{t+1})$, $w_t = w(s_t, s_{t+1})$, and $r_t = r(s_t, s_{t+1})$ yield the equilibrium values of the normalized price level, the normalized wage rate, and the rate of interest on date t (again, $p_t = P_t/H_t$ and $w_t = W_t/H_t$). Since $q_t = 1/(1 + r_t)$, the equilibrium function r determines a function q satisfying $q_t = q(s_t, s_{t+1})$.

Given such pricing functions, let $J(m, k, s)$ denote the value of the optimal discounted stream of utility for a household starting a given period with money balances m, while the firm owns capital stock k and the economy is in state $s = (\kappa, \beta, \theta, g, \gamma)$. The household first chooses z, which is the transfer from its savings to its checking account, expressed as a fraction of the outstanding supply of fiat money. Then $(\beta', \theta', g', \gamma')$ are revealed (a prime denotes the realization of a variable that was unknown at the beginning of the period), and these shocks determine the current price, wage rate, and rate of interest, as well as the next-period state s'. To determine s', the household must know how the evolution of the aggregate capital stock depends on the state of the economy. In equilibrium, of course, this law of motion follows from the individual optimal decisions. On the basis of an assumed law of motion for κ and of $p(s, s')$, $w(s, s')$, and $r(s, s')$, the household makes its consumption and leisure decisions and the firm makes its labor and investment decisions. What these optimal decisions are can be studied by considering the Bellman equation characterizing J, the value function.

$$J(m, k, s) = \max_{z} E_s \left[\max_{(c,\ell,n,i)} \{U(c, \ell) + \beta J(m', k', s')\} \right]$$

subject to

$$\begin{aligned}
(4) \qquad z &\geq pc\,; \\
\pi^f &= p\theta' f(k, n) - (1 + r)pi - wn\,; \\
k' &= (1 - \delta)k + i\,; \\
m' &= \frac{w(1 - \ell) + (m - z)(1 + r^b) + x' + \pi^f + (z - pc)}{\gamma'}\,;
\end{aligned}$$

the last constraint on the problem is the law of motion for κ. Here p, w, and r are short for $p(s,s')$, $w(s,s')$, and $r(s,s')$, and E_s is the expectation conditional on s. Using the results of the bank's optimization problem, the market-clearing condition $\theta' f(k,n) = c + i$, and the firm's optimization condition $b = pi$, we have $r \geq 0$, $v \geq \rho(z+b)$, and $v = \rho(z+b)$ if $r > 0$.

OPTIMIZATION AND EQUILIBRIUM CONDITIONS.

The Bellman equation for J includes two maximization operators; the first refers to the choice of z, which is conditional only on s, and the second refers to the choice of (c,ℓ,n,i) which is conditional on both s and s'. Corresponding to the latter choice, we have the following four first-order conditions:

$$(c) \qquad \frac{U_1(c,\ell)}{p(s,s')} = \lambda + \beta\frac{J_1(m',k',s')}{\gamma'};$$

$$(\ell) \qquad \frac{U_2(c,\ell)}{w(s,s')} = \beta\frac{J_1(m',k',s')}{\gamma'};$$

$$(n) \qquad w(s,s') = p(s,s')\theta' f_2(k,n);$$

$$(i) \qquad J_2(m',k',s') = p(s,s')[1+r(s,s')]\frac{J_1(m',k',s')}{\gamma'};$$

where λ is the Kuhn-Tucker multiplier associated with the finance constraint (4), so that $\lambda(z - pc) = 0$. Indexes to the functions U and J denote partial derivatives; therefore, U_1, for example, is the partial derivative of U with respect to its first argument, consumption.

The first-order condition associated with the choice of z is

$$(z) \qquad E_s\left[\frac{U_1(c,\ell)}{p(s,s')}\right] = E_s\left[\beta[1+r^b(s,s')]\frac{J_1(m',k',s')}{\gamma'}\right].$$

To solve the dynamic programming problem, we need the following envelope conditions, which give the marginal values of money and capital:

$$(m) \qquad J_1(m,k,s) = E_s\left[\frac{U_1(c,\ell)}{p(s,s')}\right];$$

$$(k) \qquad J_2(m,k,s) = E_s\Big[\Big(U_1(c,\ell) - p\lambda\Big)\Big(\theta' f_1(k,n) + (1+r)(1-\delta)\Big)\Big];$$

where p is short for $p(s,s')$, and similarly for w and r.

Finally, an equilibrium in this economy is a set of functions $w(s, s')$, $p(s, s')$, and $r(s, s')$ [or equivalently $q(s, s')$] and a law of motion for the aggregate capital stock κ such that the associated solution of the dynamic programming problem—that is, values for $(z, \lambda, c, l, n, i, v, d)$ that solve the first-order and envelope conditions—satisfies the following equilibrium conditions:

$$
\begin{aligned}
c + i &= \theta' f(k, n); \\
1 - \ell &= n; \\
qg' + v - d &= m; \\
m &= 1; \\
k' &= \kappa'; \\
r^b &= \left[1 + (1-\rho)\frac{z + pi}{m - z}\right] \times r; \\
d \times r &= d \times \psi(d/v).
\end{aligned}
$$

The last equation states that, when the monetary authorities lend at the discount window ($d > 0$), they do so in accordance with their supply behavior, so that $r = \psi(d/v)$. In the third equilibrium condition, $qg' + v - d = m$, v is equal to $\rho(z + pi)$ unless $r = 0$, in which case v can exceed required reserves.

Solving the Model

Consider initially a slightly simplified version of the model in which labor is inelastically supplied ($\ell = 0$) and money supply is constant ($\gamma = 1$). To solve this simplified model, first reduce the system of equations that determines the equilibrium to only three equations in the three unknown functions c, z, and (a transformation of) J_1.

To simplify the notation, define $\xi(\beta, s') = \beta J_1(1, \kappa', s')$.[3] Then the first-order condition (c) becomes

$$U_1(c) = (\lambda + \xi)p.$$

[3] Recall that κ is one of the arguments of s, so that the function ξ is well defined.

Here and below ξ stands for $\xi(\beta, s')$; accordingly ξ' below stands for $\xi(\beta', s'')$. Using this equation and the constraint $z \geq pc$, which holds with equality whenever $\lambda > 0$, isolate p as

$$(5) \qquad p = \min\left\{\frac{z}{c}, \frac{U_1(c)}{\xi}\right\}.$$

Substitute this equation in $\xi = \beta E_{s'}[U_1(c')/p']$, which follows from the definition of ξ and the envelope condition (m), to obtain

$$(6) \qquad \xi = \beta E_{s'}\left[\max\left\{\frac{c'U_1(c')}{z'}, \xi'\right\}\right];$$

this equation is the first of the set of three to be solved (ξ now replaces J_1). The second equation follows from substituting the expression (5) for p into the first-order condition (z), obtaining

$$(7) \qquad E_s\left[\max\left\{\frac{cU_1(c)}{z}, \xi\right\}\right] = E_s[(1 + r^b)\xi].$$

The last equation in the system follows from the first-order equation (i) and the envelope condition (k):

$$\begin{aligned} &\min\left\{\frac{z\xi}{c}, U_1(c)\right\} \\ (8) \qquad &= \beta q E_{s'}\left[\min\left\{\frac{z'\xi'}{c'}, U_1(c')\right\}(\theta'' f_1(k') + (1 + r')(1 - \delta))\right]. \end{aligned}$$

To write (6) – (8) solely in terms of c, z, and ξ, express r and r^b in terms of these functions as follows:

$$r = \psi(d/v);$$

and

$$(9) \qquad r^b = \left[1 + (1 - \rho)\frac{z + b}{1 - z}\right] r;$$

where

$$d = qg' + v - 1\,;$$
$$v = \rho(z + b);$$
$$b = \min\left\{\frac{zi}{c}, \frac{iU_1(c)}{\xi}\right\};$$

and finally,

$$i = \theta' f(k) - c\,.$$

These equations hold provided $d > 0$ and $r > 0$; if $d = 0$, then $r \leq \psi(0)$, while if $r = 0$, then $v \geq \rho(z + b)$. Rather than solving this model explicitly, which can be done numerically using the methodology presented by Coleman (1992), we devise an example which admits a closed-form solution. This example highlights all the features of the model that are useful in interpreting the empirical regularities mentioned earlier.

An Example

To develop an intuitive understanding of the model, it is instructive to consider a parametrization that allows a closed-form solution. Suppose that (a) utility is logarithmic; (b) production satisfies $f(k) = k^\alpha$, for $0 < \alpha < 1$; (c) capital depreciates completely over each period; and (d) the technological shocks θ, the policy shocks g, and the preference shocks β are all iid (although not necessarily independent of each other). Now, conjecture that no excess cash is ever held in the goods market and that z is constant at $\bar{z}$. Under these circumstances, $b = \bar{z}i/c$, $i = k'$, and equations (6)–(8) simplify to

$$\xi = \frac{\beta'}{\bar{z}},$$

$$1 = E_s\left[\beta(1 + r^b)\right], \tag{10}$$

$$\frac{1}{c} = \beta' q E_{s'}\left[\frac{\theta'' \alpha (k')^{\alpha-1}}{c'}\right], \tag{11}$$

where the interest rate r satisfies

$$r = \psi\left(\frac{qg' + \rho(1 + k'/c)\bar{z} - 1}{\rho(1 + k'/c)\bar{z}}\right), \tag{12}$$

and r^b is given by (9). Further conjecture that the consumption function can be written as

$$c = \frac{1}{1 + h(\beta' q)} \theta' k^\alpha,$$

for some function h. Note that because $k'/c = h(\beta' q)$, the function h can be thought of as the investment to consumption ratio. Since h depends only on $\beta' q$ and since $q = 1/(1+r)$, (12) determines r as a function of $\bar{z}$, β', and g'. Write this function, which implies that r and q are iid and independent of s, as $r = R(\bar{z}, \beta', g')$ and correspondingly $q = Q(\bar{z}, \beta', g')$; now substitute these equations into (9), and the resulting equation into (10), to obtain

$$1 = E_s \left[\beta' \left(1 + \left(1 - \frac{(1-\rho)[1 + h(Q(\bar{z}, \beta', g'))]\bar{z}}{1 - \bar{z}} \right) R(\bar{z}, \beta', g') \right) \right].$$

This equation has the important implication that z does not depend on s, because s enters only through the conditional expectation, and β' and g' are iid. This observation verifies the conjecture $z(s) = \bar{z}$. To find h, substitute the conjecture about the consumption function into (11) and simplify to obtain

$$h(\beta' q) = \alpha \beta' q (1 + E_{s'}[h(\beta'' q')]).$$

Using the fact that β' and q are iid (because $q = Q(\bar{z}, \beta', g')$, and (β, g) is iid), this equation implies

$$h(\beta' q) = \frac{\alpha \beta' q}{1 - E[\alpha \beta' q]},$$

where $E[\,.\,]$ is the unconditional expectation, taken over the constant distribution of (β', q). It is then straightforward to verify that the finance constraint in the goods market is always binding; therefore, all the initial conjectures were correct.

This example leads to a sharp characterization of the response of monetary aggregates and the interest rate to supply and demand shocks. Using the equilibrium value of $k'/c = h$, rewrite (12) as

$$(13) \qquad \frac{1}{q} = 1 + \psi \left(1 - \frac{(1 - qg')(1 - E[\alpha \beta' q])}{\rho \bar{z}(1 + \alpha \beta' q - E[\alpha \beta' q])} \right).$$

Consider first the effect of technological shocks, θ'. Such shocks do not affect r, as (13) makes clear, and thus they do not affect any of the monetary aggregates. They have real effects, of course, since they affect output, consumption, and investment. But they fail to move nominal interest rates (although real rates certainly do) because the demand for consumption and investment goods shift proportionately. This feature is due to the choice of utility and production functions, and is not a general feature of the model. It indicates, however, that in the general case productivity shocks can affect interest rates and monetary aggregates in either direction. Before turning to the effect of other shocks, it is helpful to list the relevant equations. The first is (13), which determines the correlation between each shock and the nominal rate of interest. The others are:

$$\text{total reserves:} \quad v = \rho\bar{z}[1 + h(\beta' q)]; \tag{14}$$

$$\text{nonborrowed reserves:} \quad v - d = 1 - qg'; \tag{15}$$

$$\text{borrowed reserves:} \quad d = v \times \psi^{-1}(r); \tag{16}$$

$$\text{M1:} \quad \bar{z} + b = \bar{z}[1 + h(\beta' q)]; \tag{17}$$

$$\text{M2:} \quad 1 + b = 1 + \bar{z}h(\beta' q). \tag{18}$$

To isolate the effect of policy shocks, assume first that there are no other shocks (a similar procedure will uncover the effect of preference shocks). Note that the left side of (13) is decreasing in q, while the right side is increasing both in q and in g' (recall that ψ is increasing); therefore g' and q vary inversely. For the same reason, but considering the right side as a function of q and qg', q and qg' vary inversely also. Hence, g', r, and qg' all move in the same direction. In view of (15), then, policy shocks induce a negative correlation between the nominal rate of interest r and nonborrowed reserves $v - d$. They also induce a negative correlation between r and v, total reserves, as (14) reveals since h increases in q. The correlation between r and v can be entirely attributed to the variance of inside money, $\bar{z}h(\beta' q)$; this variance also induces a negative correlation between r and the broader monetary aggregates M1 and M2, as shown by (17) and (18). From (16), it is clear that the ratio of borrowed to total reserves is positively correlated with the interest rate, a relation which has nothing to do with the source of the shock but is due exclusively to the form of ψ, that is, to the operation of the discount window. If total reserves did not respond to the policy shock (an assumption which is sometimes made in empirical work), the form of ψ alone would induce a positive correlation between the interest rate and borrowed reserves.

Suppose now that shocks to β are the only shocks in the system. The left side of (13) is decreasing in q, while the right side is increasing in q and decreasing in $\beta' q$; therefore, q and $\beta' q$ (and therefore q and β' also) move in opposite directions, while β' and $\beta' q$ move in the same direction. Equations (14)–(18) then show that preference shocks induce a positive correlation between the interest rate and any of the reserve or monetary aggregates (total, nonborrowed, and borrowed reserves; inside money, M1, and M2).

It is now possible to use the example to study more complicated policies. Suppose that in response to positive preference shocks that would otherwise increase interest rates, the government chooses its open market operation to keep the rate constant, which corresponds to a small realization of g' (in this case, β and g are still iid, but not independent of each other). With the interest rate constant, β' high and g' low, all the reserve and monetary aggregates are high (but the borrowed reserve ratio is constant). If the policy response only partially offsets the preference shock, all reserve and monetary aggregates may still rise, while the rate of interest rises also. In that case, despite the presence of a liquidity effect in the model, open market operations could be seen as "inducing" a positive correlation between interest rates and various monetary aggregates (and nonborrowed reserves as well).

Conclusion: Interpreting the Empirical Literature

As mentioned in the introduction, the empirical literature directed to measuring the effect of monetary policy shocks on interest rates is replete with seemingly conflicting results. The model provides a framework for thinking about these results and for interpreting the literature; the example brings out the important features of the model. First, the model highlights the role of inside money creation as an avenue for total reserves to respond to open market operations. In this sense, the model fails to support Strongin's identifying restrictions that total reserves do not respond to open market operations within a month or a quarter. Second, the model suggests that the operation of the discount window, summarized by a fixed and positively sloped supply function, can alone generate a negative correlation between nonborrowed reserves and the federal funds rate. Such a correlation has been documented by Christiano and Eichenbaum (1991). While they identified policy shocks as innovations to nonborrowed reserves, the model suggests an alternative explanation that has nothing to do with policy shocks. Third, although the model is designed to have a liquidity effect, a policy of interest-rate smoothing hinders efforts to detect its presence. This could explain the difficulties econometricians have had in measuring this effect. To identify policy shocks, it is not sufficient to identify a variable (such as nonborrowed reserves) that is under the control of the Fed, since the Fed may use its instrument to achieve particular objectives. In this sense, the model points to the familiar need, and provides a framework for, identifying demand and supply shocks to estimate a liquidity effect.

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Chart 1. Federal Funds Rate and Nonborrowed Reserves Ratio
Monthly, January 1961 - July 1992

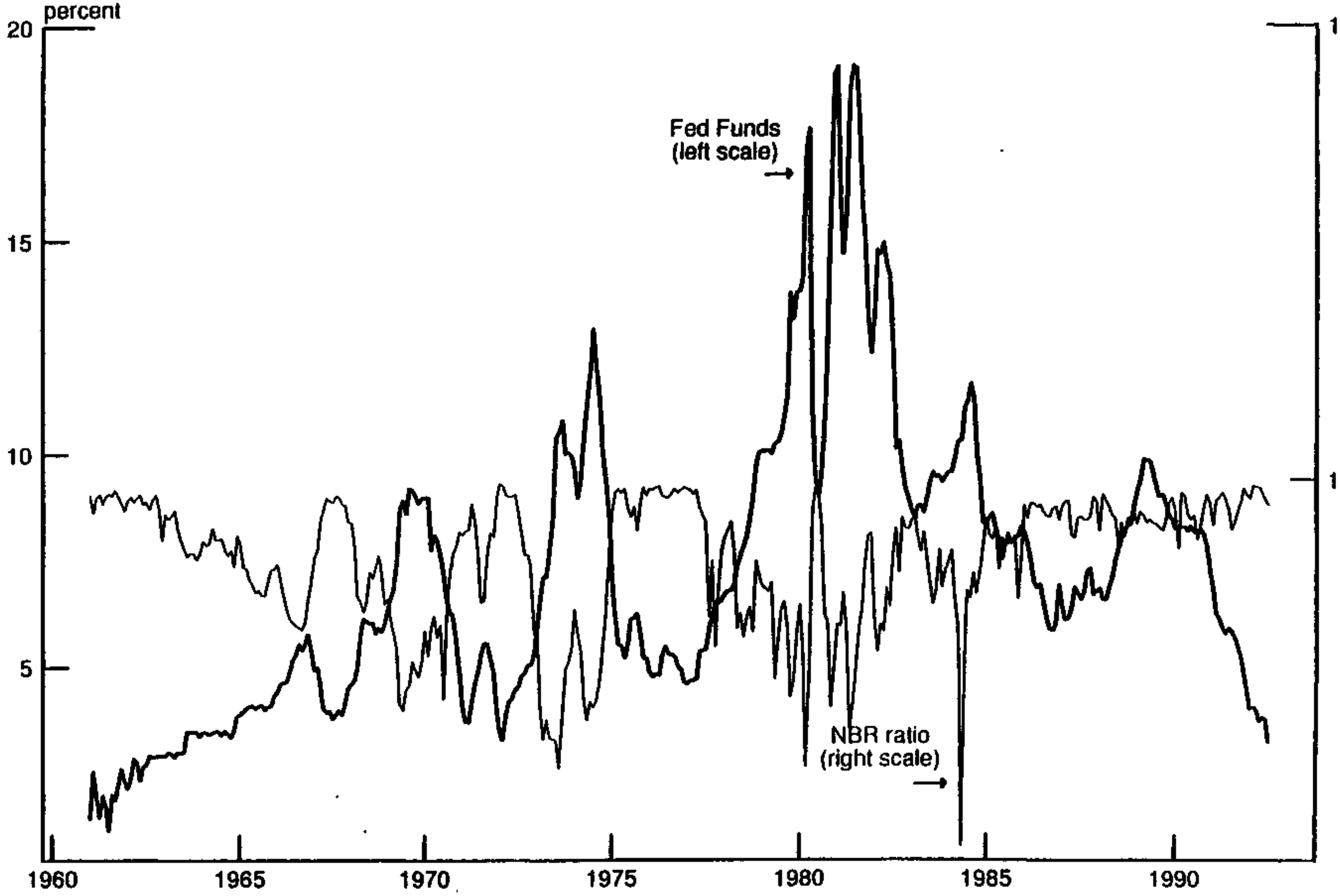
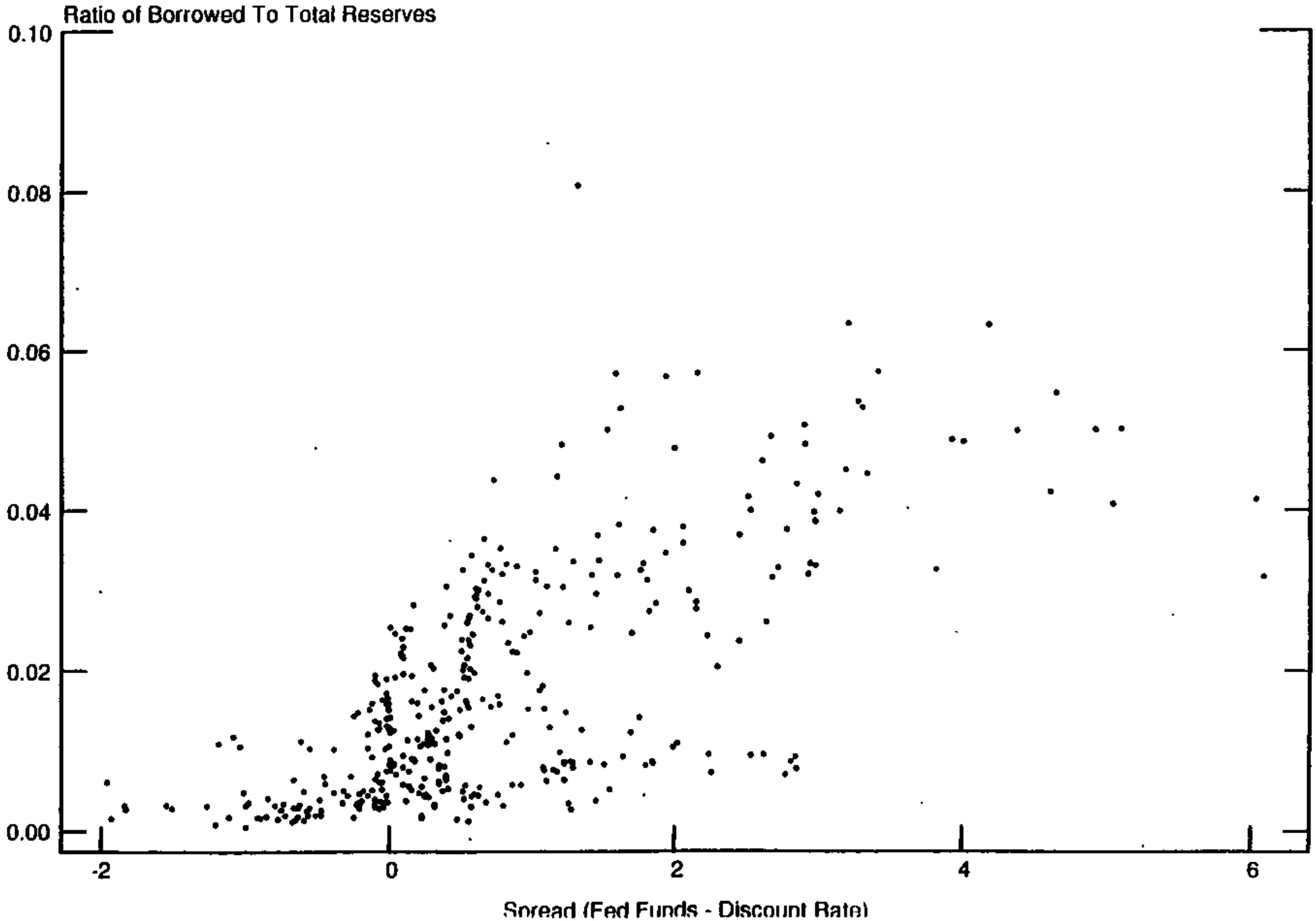


Chart 2. The Psi Function; 1961(1)-1992(7).



Comments on "Discount Window Borrowing and Liquidity"

by Coleman, Gilles, and Labadie

Michael Dotsey

I have been asked to discuss "Discount Window Borrowing and Liquidity" which I view as very interesting but preliminary work toward examining "liquidity effects" in a framework that incorporates a fairly (primitive) reserves market. I use the term primitive with regard to the reserves market since no interesting dynamic behavior is present in this market. Viewing work on BR^d, especially that of Goodfriend (1983) this is a shortcoming that I hope will be addressed by later generations of the model. The paper, however, is very rigorous and state of the art on other dimensions and the authors deserve a lot of credit for moving the liquidity effects literature in this direction.

The empirical motivation for the paper can be traced to work by Christiano and Eichenbaum (1992) and especially to that of Strongin (1991). Strongin's work is fairly persuasive and indicates that in order for any model to replicate data on liquidity type effects reserve market behavior is likely to be a crucial ingredient. This is because the liquidity effect only shows up in NBR's or to be more accurate, in the part of NBR that represents independent monetary policy. This paper's novel inclusion of reserve market behavior represents a commendable extension of this basic line of research.[1]

In reading this paper, I found that it raised at least as many questions as it answered. Much of my confusion is not the

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1. One thing I would like to see done in these estimations is removing settlement day data. This data could potentially contaminate the results. Suppose for instance the Fed misforecasts float or treasury balances believing there will be more of these funds available than are actually there. NBR will be low on the settlement day and the funds rate will be high, perhaps by a substantial amount. Two such occurrences in a month (at least 25% probability) could make monthly average NBR a little low and monthly average r_F a little high. While I doubt this is the reason for Strongin's results it would be nice to purge the data of what is merely an interbank friction.

result nor the fault of this paper in particular, but rather comes from a lack of understanding and perhaps misgivings of this literature in general. In my comments I will discuss some of these misgivings and, hopefully, my comments will lead to some discussion from the rest of the audience.

The paper extends a branch of research that is attempting to understand the effect of monetary policy on interest rates and real activity. In particular these papers' search for a mechanism that will explain (1) how contractionary monetary policy raises short-term interest rates and (2) how it causes declines in economic activity. This literature received its impetus from Lucas's (1990) influential paper. A common feature of most of this literature involves cash-in-advance constraints that constrain the amount of money available for use in a loan or securities market, however, no two papers seem to use the same exact specification.

Lucas's original setup and CGL (1991) envision bond traders as only having limited funds and, therefore, open market operations affect the price of bonds and thus interest rates. The appeal of Lucas's setup is that it eliminates the differential wealth effect of open market operations that were present in earlier literature (eg Grossman and Weiss and Rotemberg). Fuerst (1991) extends Lucas's setup to a production economy that places a CIA constraint on both investment and labor expenditures. Unlike households' portfolio decisions, production decisions are made after the stochastic state of the economy is known. Since individuals must choose the portion of their portfolio to lend to firms via intermediaries prior to observing the monetary transfer or the market clearing interest rate, the monetary transfer can affect the tightness or looseness of the loan market. Hence liquidity effects that have real consequences result from monetary policy. Christiano (1991) subjects the Fuerst model and an alternative version of that model in which investment decisions are also made prior to the realization of shocks to a statistical comparison with a RBC model that contains a standard CIA constraint. For reasonable parameter specifications the Fuerst model can not produce a liquidity effect that dominates anticipated inflation effects on the nominal interest rate while the sluggish capital model can produce a dominant liquidity effect. Both these models produce too much variability in consumption and the counterfactual result that consumption and prices move in opposite directions. They also produce very low interest elasticities of money demand and monetary policy has very little effect on variations in output. Furthermore, anticipated inflation has much too large an effect on labor, consumption, and output. To remedy this last result, Christiano and Eichenbaun (1992) relax the CIA constraint on investment. They also split the period into two parts allowing firms to adjust their hiring decision after observing open market operations while initial hiring and investment decisions are made prior to observing open market operations. They do this with the hope of magnifying the response of employment and output to liquidity effects. In CGL's current paper firms face a CIA constraint on investment but can pay workers out of end of period revenues. Also, monetary transfers are made directly to consumers after their portfolio decision has been made. Thus these transfers do not affect the funds available in the credit market and, therefore, do not give rise to a "liquidity effect." Because there is a CIA constraint on capital, monetary policy can have inflation tax effects as well. As their work progresses separating liquidity effects from inflation tax effects will be important.

Not all of these scenarios can be correct. Why are CIA constraints placed where they are? These assumptions of infinite transactions costs are not innocuous. They are the driving force in these models. It seems that rather than trying to incorporate a realistic financial structure into a dynamic macro model and then testing the model, investigators are trying to find a mathematical structure that produces the correlations they desire. Apart from Christiano (1991) very little effort is made to see if these models are an improvement on basic RBC models or even if they produce counterfactural predictions along other dimensions. Since other classes of models can produce negative correlations between NBR and the funds rate, examining how CIA models fit the data along other dimensions will be important if the CIA approach is to gain widespread acceptance.

For example a model like that in Goodfriend's (1987) paper can potentially produce correlations of the type this literature is seeking. In that model, which has no rigidities, purposeful behavior by the Fed can set up negative correlations between the funds rate and NBR. If the Fed wishes to reduce inflation, it can do so by reducing the future money supply and in particular future NBR. Due to anticipated inflation effects, the nominal interest rate would fall increasing the demand for money and total reserves. If the Fed wishes to reduce price level surprises it can supply the necessary NBR to prevent price level movements. Thus this policy sets up the requisite negative correlation. If that was all that was going on one would expect this negative correlation to carry over to broader aggregates. However, M2-M1 components of M2 which involve a large savings motive should be positively correlated with the real rate of interest and movements in BR, which are highly variable and positively correlated with the funds rate, could cause TR to be positively correlated on net as well.

Alternatively say the Fed is following an exogenous upward movement in the real rate of interest in an attempt to target inflation. If the own rate on money balances is sticky then money (M1) and hence total reserves will decline along their demand curve. (Also, M2 could be rising with the real rates.) This would set up a negative relationship between NBR and the funds rate. As r_m adjusted, total reserve demand would increase as would NBR as the Fed defended the new higher funds rate. If the Fed did not react instantaneously or vigorously enough to the increased reserve demand the funds rate could rise further and then fall as nonborrowed reserves were pumped into the system reinforcing the initial negative correlation. Also, sticky price models may be able to generate some of the correlations displayed in the data as well.

Also, the question of what constitutes a period is somewhat fuzzy in this literature. Is it a day or perhaps a week? Most people make some form of cash management decision weekly and I can not think of any time where a shortage of cash has affected my real consumption for more than a day or two. Perhaps I'm taking the CIA constraint too literally, but if the period is rather short, as I believe it is, then the propagation mechanisms needed to match the data would seem incredible by RBC model standards.

I have strayed a little far afield so let me return to this paper more specifically. My primary confusion is linking the author's major contribution which shows how different measures of money can have different correlations with interest rates with the motivation for their paper which appears to be the results found in Strongin. In this paper money

(1) $$M_{t+1} = M_t + r_t(G_t - D_t) + x_t.$$

The x_t portion of measured money provides no liquidity effects. The G_t portion, that is open market operations has the standard liquidity effects since it influences the portion of firm borrowing that must be financed by discount window loans. The equilibrium condition that is being used is

(2) $$NBR_t = V_t - D_t = M_t - G_t$$

where $V_t = \phi(M_t + B_t)$. An increase in G_t (an open market sale) requires more discount window borrowing and an increase in interest rates since $r = \psi(D/TR)$ is increasing. Using M_{t+1} can contaminate regression results since it rises by $r_t(G_t-D_t)$, which will in general be positive in this model and no liquidity effect will be present. Furthermore, growth in money via transfers will further bias econometric results.

For econometric purposes I see no useful way of isolating any aggregate to uncover liquidity effects. X_t type disturbances, in reality, involve transfers from the Treasury. These involve a reduction in Treasury accounts at the Fed and an increase in NBR. What the model here indicates is that one wants to examine only changes in reserves that involve changes in the public's asset positions and that exclude any interest or lump sum payments.

While these decompositional problems are important for this model and may in fact be important more generally, they seem to have little to do with Strongin's empirical strategy nor do they affect interpretations in other models. Strongin tries to separate "pure" supply movements in NBR from those engendered by policy responses to changes in TR. Whether his identification procedure is a good one or not could be debated, but he is not concerned with measurement or decompositional problems in various reserve measures.

The decompositional problem arises in CGL because of their modeling of x_t as having no liquidity effects. In Fuerst or Christiano and Eichenbaun, there is only x_t and it enters the model in a way that produces liquidity effects. That is NBR supply disturbances that are not responses to TR shocks produce liquidity effects. It seems that Strongin's methodology is more closely aligned with these models.

Whether decompositional problems are important or not, I don't know. They arise in this model by a specification that at this point seems somewhat arbitrary. It is no more arbitrary than any other specification in the literature, but that does not make it convincing. I believe the author's need to make a convincing argument as to why some forms of money creation are more likely to involve liquidity effects than others if their message is to carry weight. After all, in this model one could easily reverse the roles of X_t and G_t or make them complimentary.

The discussion on page 11 regarding the estimation of ψ is also a little confusing. With

$$n = 1 - \frac{d}{v} = \frac{M-G}{V} \tag{3}$$

they claim that ψ can be estimated no matter what the shock. But is that relevant? We would like to know how ψ is influenced contingent on different shocks. Here a positive V shock induced by a shift in the demand for loans causes ψ to rise and n to fall, while a decline in NBR due to an open market sale (G up) also causes n to fall and ψ to rise. It is only the latter effect that one has in mind when discussing liquidity effects, so perhaps the ratio is not the correct variable to focus on. Rather, in this model it should be the relationship between the level of NBR and the funds rate. Also in estimating ψ, one would expect shifts in the function over time since administration of the discount window has changed over time. For example, I believe window administration was more lax when the Fed faced a membership problem.

I would also downplay somewhat figure one. The interest rate of consequence is the spread between the funds rate and the discount rate. When one looks at this graph the correlations seem at least as pronounced. But has anything but a borrowed reserve demand function been uncovered?

Finally, the discussion concerning adjustably pegging the interest rate based solely on technological disturbances raises questions concerning the nominal determinacy of the model (see McCallum (1981, 1986)).

Overall, I thought this paper was interesting and represents a nice attempt to start thinking about how behavior in the market for reserves influences the correlations we observe between various monetary measures and the funds rate. Given my qualms concerning this methodology's ability to explain anything at business cycle frequencies, I would suggest directing the model in an alternative direction. Perhaps this framework could be used to help explain short-term term structure movements in interest rates and examine the so-called "ozone hole." This line of inquiry would be interesting since it could integrate reserve market behavior and a tight specification of policy in a fully developed general equilibrium model.

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Credit Conditions and External Finance:

Interpreting the Behavior of Financial Flows and Interest Rate Spreads

Kenneth N. Kuttner[1]

A flurry of recent macroeconomic research has drawn attention to the relationship between monetary policy, credit conditions, and the markets for short-term debt. Two recent papers have focused on firms' substitution between bank and non-bank external finance in particular, proposing macroeconomic indicators based on financial market activity. Kashyap, Stein, and Wilcox (1992) employ quantity data directly, arguing that the share of bank loans out of firms' total short-term finance is an informative index of Federal Reserve policy and loan availability more generally. In a complementary line of research, Friedman and Kuttner (1992) identify monetary policy and bank lending as potential sources of fluctuations in the spread between yields on commercial paper and Treasury bills. While both papers have demonstrated solid empirical links between these financial indicators and real economic activity, neither has rigorously assessed the extent to which fluctuations in these indicators actually represent exogenous changes in credit conditions, rather than endogenous responses to changing economic conditions. This paper's goal is to provide such an assessment.

The paper begins with a sketch of the mechanism through which credit conditions affect firms' short-term financing, drawing a distinction between the effects of the Federal Reserve's open market operations and other factors influencing banks' willingness to lend. The second section summarizes the reduced-form relationships between real output, the interest rate, and three alternative indices

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of credit conditions: the composition of external finance, the spread between the loan rate and the commercial paper rate, and the analogous spread between commercial paper and Treasury bills.

The third section turns to a closer examination of the impact of monetary policy and loan availability on bank and non-bank finance using structural VAR techniques. Identifying monetary policy with innovations to non-borrowed reserves and controlling for firms' financing requirements, the first of the three models estimates the dynamic effects of monetary and lending shocks on the composition of external finance, the interest rate, and real output. The second structural VAR system assesses the effects of reserves and lending shocks on the paper–bill spread. The third model identifies lending shocks with innovations in the loan–paper spread. Estimates of these models confirm that all three variables respond appropriately to reserves shocks. In addition, lending shocks, whether identified through financial flows or via fluctuations in the loan spread, induce a substitution between bank and non-bank finance.

Less clear is the extent to which any of these measures exclusively reflects the effects of changing loan availability. The fact that positive lending shocks are associated with *increases* in the interest rate and the paper–bill spread suggests that changes in the composition of external finance have more to do with firms' financing requirements than with exogenous changes in banks' willingness to lend. Another slightly puzzling observation is that the largest source of changes to the composition of external finance seems to be wholly unrelated to both reserves and bank lending. Together, these two results suggest that while credit conditions are one important determinant of firms' choice of financing, short-term debt flows may be informative for reasons other than those involving the substitution between bank/non-bank substitution. Although its implications for real activity are rather weak, the loan spread appears to be a plausible alternative measure of credit conditions.

A model of financial flows and interest rate spreads

How do the markets for short-term bank and non-bank finance respond to monetary impulses? And how do non-monetary shocks affect these markets? And how might one construct an index of the availability of intermediated funds?

As a first step towards answering these questions, this section analyzes a simple model of the markets for commercial paper, bank loans, and Treasury bills in the style of Brainard (1964) or Bosworth and Duesenberry (1973). While not as detailed as either of those models, it is adapted to highlight firms' tradeoff between bank and non-bank finance. It also draws an important distinction between purely monetary influences acting through open market operations, and credit conditions defined more broadly, which may include other factors affecting banks' willingness to lend.

One of the model's more obvious properties is that an injection of reserves causes the interest rate to fall — the familiar "liquidity effect." Reserves injections also cause the spread between the interest rates on bank lending and commercial paper to fall, and leads to increased reliance on bank finance. Lending shocks, which are assumed to affect only banks' preferences over alternative assets, turn out to have similar effects on the loan–paper spread and the composition of firms' finance. Lending shocks, by contrast, have no effect on the level of interest rates — only the spreads.

The model also identifies two other factors with implications for the money market. First, firms' demand for external finance may induce changes in the relevant interest rate spreads and consequently the composition of finance; controlling for this demand-side influence turns out to be a major challenge to the construction of an empirical measure of credit availability. Similarly, the stock of outstanding Treasury bills may have tangible effects on the spreads and the composition of finance.

The three players in the money market are households, banks, and firms, who participate in the markets for reserves, commercial paper, Treasury bills, and loans. Specifically, households' portfolios include demand deposits (DD), commercial paper (P), and Treasury bills (B) according to

$$DD^d = \phi(r_P)\,W,\ \ \phi' < 0 \qquad \text{Deposit demand}$$

$$P^d = f(r_P, r_B)\,W,\ \ \frac{\partial f}{\partial r_P} > 0 \text{ and } \frac{\partial f}{\partial r_B} < 0 \qquad \text{Paper demand}$$

$$B^d_{hh} = (1 - \phi - f(r_P, r_B))\,W, \qquad \text{Bill demand}$$

where W is the sum of deposits, paper, and bills held by households. Households' demand for non-interest-bearing bank deposits is a decreasing function of the prevailing paper rate, r_P. A key assumption is that households view commercial paper and Treasury bills as imperfect substitutes, so that changes in their relative supplies affect their respective yields.[2] Households require a higher paper rate (or a lower bill rate) to hold a larger share of their portfolio as commercial paper.

Demand deposits are banks' sole liability. Their assets are divided among Treasury bills, loans (L), and deposits at the Federal Reserve (R) according to:

$$R^d = \rho(r_P)DD, \ \ \rho' < 0 \qquad \text{Reserve demand}$$

$$L^d = g(r_L, r_P, \lambda)\,DD, \ \frac{\partial g}{\partial r_L} > 0 \text{ and } \frac{\partial g}{\partial r_P} < 0 \qquad \text{Loan demand}$$

$$B_b^d = (1 - \rho(r_P) - g(r_L, r_P, \lambda))\,DD. \qquad \text{Bill demand}$$

Banks' demand for non-interest-bearing reserves falls with the prevailing paper rate, while loan demand is increasing in the loan rate and decreasing in the paper rate.[3] The stock of reserves is set at R^s by the Federal Reserve; discount window borrowing is ignored.

Banks' demand for loans is also allowed to depend on the variable λ, representing any other factors affecting banks' willingness to lend. These "lending" shocks lead banks to shift the composition of their portfolios between bills and loans; negative shifts in λ may be interpreted as "credit crunch" episodes. These may occur in reaction to a perceived deterioration in borrowers' creditworthiness, or to more stringent capital requirements as suggested by Bernanke and Lown (1991). They may also be the result of the "moral suasion" instrument of monetary policy; Owens and Schreft (1992) identify a number of episodes in which banks contracted their lending in response to Federal Reserve pressure. Whatever the source, the key feature of these "lending" shocks is that they need not be accompanied by overt monetary policy in the form of open market operations.[4]

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2. Friedman and Kuttner (1992) discuss some possible reasons for this imperfect substitutability. Lawler (1978) also finds evidence for imperfect substitutability at seasonal frequencies.

3. Note that throughout the paper, assets are "demanded" while liabilities are "supplied." Hence, banks "demand" loans and bills, while firms "supply" loans and paper.

4. This point is stressed by Friedman (1991).

Finally, firms choose between bank lending and paper issuance as sources of short-term finance according to

$$L^s = h(r_L, r_P)F, \; \frac{\partial h}{\partial r_L} < 0 \text{ and } \frac{\partial h}{\partial r_P} > 0 \qquad \text{Loan supply}$$

$$P^s = (1 - h(r_L, r_P))F. \qquad \text{Paper supply}$$

For simplicity, the amount to be financed, F, is assumed to be exogenous with respect to the various interest rates. Because firms view loans and paper as imperfect substitutes, they will finance some portion of F through bank lending even though r_L generally exceeds r_P; as discussed by Kashyap, Stein and Wilcox (hereafter KSW), this presumably reflects some intangible benefit accruing to the firm from maintaining a relationship with a bank. Firms' share of bank finance (the KSW "mix") responds predictably to the loan and paper rates: an increase in the loan rate (or a decrease in the paper rate), leads firms to substitute away from bank finance towards non-bank external finance.[5]

In equilibrium, the demand for the four assets equals their supply,

$$\rho(r_P)\phi(r_P)W = R^s$$

$$g(r_L, r_P, \lambda)\phi W - h(r_L, r_P)F = 0$$

$$f(r_P, r_B)W - (1 - h(r_L, r_P))F = 0$$

$$(1 - g(r_L, r_P, \lambda))\phi W + (1 - f(r_P, r_B) - \phi)W = B^s,$$

determining yields and quantities as functions of the exogenous R^s, λ, F, and B^s. Walras' law allows the bill market equation to be dropped. Further simplification is possible by assuming the asset demand and supply functions to be homogeneous of degree zero with respect to the assets'

5. This model embodies the assumption that bank and commercial paper finance are viable alternatives for an economically relevant group of firms. However, there is increasing evidence that this set of firms is rather small, and that much of the observed variation in the aggregate composition of finance is due to the relative availability of finance to small and large firms; see Gertler and Gilchrist (1992) and Oliner and Rudebusch (1992).

yields, so that (for example) $g(r_L + c, r_P + c, \lambda) = g(r_L, r_P, \lambda)$ for any constant c. In this case, the f, g and h functions can be specified in terms of interest rate spreads, and the system reduces to:

$$\rho(r_P)\phi(r_P)W = R^s$$
$$g(z_{LP}, \lambda)\phi(r_P)W - h(z_{LP})F = 0 \qquad (1)$$
$$f(z_{PB})W - (1 - h(z_{LP}))F = 0$$

where z_{LP} and z_{PB} denote the loan–paper and paper–bill spreads.

Analyzing the comparative statics of (1) is simplified by its (somewhat artificial) recursive structure. The interest rate level is entirely determined by supply and demand in the market for reserves; the fall in reserves resulting from a contractionary open market operation requires a higher rate to equilibrate the reserves market, as illustrated in Figure 1.[6] This higher interest rate leads in turn to a shrinkage of demand deposits and the banking system as a whole. Banks respond by raising the loan–paper spread, prompting some of its borrowers to switch to alternative forms of finance — short-term paper in this model. The increased supply of paper (relative to bills) leads to a widening spread between the paper and bill rates.

The effects of an adverse lending shock resemble those of a reserves contraction in that both produce a rising loan spread and a substitution towards non-bank finance. Although both shocks produce similar effects on banks' portfolios, they differ in one important respect: reserves shocks affect the level of the short-term interest rate, while lending shocks leave the paper rate unchanged. A fall in λ leads banks to shift the *composition* of their portfolios away from loans and into Treasury bills, leaving their reserve demand and the paper rate (and consequently deposits and the banking system's size) unchanged. Banks increase their spreads relative to the paper rate in order to reduce their stock of loans. As before, firms' increased reliance on commercial paper drives up the paper–bill spread.

6. Total wealth is held constant in an open market operation, as the withdrawal of reserves is offset by a sale of Treasury securities.

The observation that both reserves and lending shocks may contribute to real economic fluctuations is one explanation of the widespread interest in constructing a broader measure of credit conditions than reserves or the interest rate in isolation, which reflect largely those shocks originating from the reserves market. The attractive feature of the credit conditions indicators discussed here is their ability to detect the effects of changes in loan availability and reserves fluctuations: in this model, the "mix," the loan-paper spread, and the paper-bill all reflect the impact of both types of shocks. In fact, in the absence of any other shocks, all three of these measures should respond to monetary and credit factors in qualitatively similar ways.

One problem common to all three of these measures (and the interest rate itself) is their susceptibility to contamination from changes in firms' overall demand for financing, which may alter yield spreads and the composition of external finance for reasons having nothing to do with to exogenous changes in credit conditions.[7] This can be illustrated by examining the comparative statics of (1) in response to an increase in F, the dollar amount of funds firms wish to raise from the short-term credit markets. A greater demand for loanable funds unambiguously increases the prevailing interest rate, r_P. Its effects on the loan–paper spread (and therefore the composition of external finance) is ambiguous, as it depends on firms' share of bank finance (h) relative to households' wealth fraction in bank deposits (ϕ), and the share of banks' portfolios held as loans (g). When $h(z_{LP}) > \phi(r_P)g$ (as is presumably the case), increases in F cause loan demand growth in excess of deposit growth, driving up the relative cost of bank finance and the share of paper in firms' external finance.[8] The same inequality is also relevant for the paper–bill spread; a second sufficient condition for a rising spread is that $(1 - h(z_{LP})) > f(z_{PB})$, so that the increasing paper demand would require households to hold a larger *share* of paper in their portfolios.

7. Under most of the Federal Reserves' post-Accord operating procedures, non-borrowed reserves may also be contaminated in this way; see Strongin (1991).

8. A special feature of the KSW model is that changing financing requirements affect loans and paper proportionally, leaving the "mix" unchanged.

One additional complication for interpreting the paper–bill spread as a measure of credit conditions is that it may be affected by changes in the outstanding stock of Treasury bills. In addition, the wealth effects associated with changes in the volume of Treasury finance may alter the level of interest rates and loan spread, and consequently the composition of external finance.[9] In this model, an increase in the supply of bills reduces the paper–bill spread, as investors require higher returns to entice them to hold the additional stock of bills. This increase in banks' demand for loans leads to a fall in the loan rate relative to the paper rate, and increased reliance on bank finance.

To summarize, the model's main implications are:

- Both reserves and lending shocks alter the relative price of bank and non-bank finance, inducing a substitution between alternative forms of external finance.
- By affecting the supply of commercial paper, this substitution also affects the relative yields on Treasury bills and commercial paper.
- Changes in reserves affect the level of interest rates, while lending shocks leave the level unchanged.
- Firms' overall financing requirements may affect interest rate spreads and their composition of short-term finance.

The goal of the paper's subsequent empirical work is to explore these implications. Specifically, it attempts to identify lending shocks through their impact on the composition of external finance and interest rate spreads, while controlling for reserves and the overall demand for loanable funds.

Short-term credit markets and real economic activity

One desirable feature of any index of credit conditions is a systematic link between it and subsequent fluctuations in real economic activity.[10] The results below summarize the predictive properties of the KSW "mix," the prime–paper spread, and the paper–bill spread. The results show that the "mix"

9. Of course, this assumes that households view government bonds as net wealth; see Barro (1974).

10. Economists and market observers have long recognized the cyclical properties of commercial paper, bank lending, and their relative yields; see, for example, Foulke (1931), Selden (1963), and Stigum (1990).

and the paper–bill spread are good predictors of future changes in real GDP (although this alone does not justify their interpretation as measures of credit availability).

"Causality" tests

Table 1 examines the incremental information content of the three measures for future changes in real GDP in the presence of traditional measures of monetary policy: non-borrowed reserves and the commercial paper rate. Regressions 1–3 are four-variate reduced-form equations of the form

$$\Delta x_t = \mu_0 + \mu_1 t + \sum_{i=1}^{4} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{4} \beta_i \Delta \ln(R)_{t-i} + \sum_{i=1}^{4} \gamma_i \Delta r_{P,t-i} + \sum_{i=1}^{4} \delta_i \Delta q_{t-i} + \varepsilon_t$$

where x is the logarithm of real GDP, R is non-borrowed reserves adjusted for extended credit and deflated by the GDP deflator, r_P is the commercial paper rate, and q denotes, in turn, the "mix", the loan–paper spread, and the paper–bill spread. As in KSW, the "mix" is computed as the observed ratio of bank lending to the sum of lending to commercial paper, or $L/(L+P)$.[11] The results use the six-month commercial paper and Treasury bill yields, and the prime rate (from the Federal Reserve H.15 release) is used as the lending rate.

The table reports F-tests for the exclusion of the four δ_i terms for the entire 1960:2–1991:4 sample, as well as two shorter samples. One truncated sample begins in 70:3, when Regulation Q was eliminated for most large CDs.[12] Another begins in 1975:1. Although this date is somewhat arbitrary, it corresponds roughly to the beginning of a rapid expansion of the commercial paper market, during which it became a more popular vehicle for non-financial firms' short-term finance.[13]

11. The augmented Dickey-Fuller t_t statistic (computed with eight lags) for the stationarity of the "mix" is –4.10, rejecting the null hypothesis of nonstationarity at the 1% level. Consequently, it is included here in levels along with a linear trend term.

12. Regulation Q interest rate ceilings on 30–89 day CDs in denominations of $100,000 were eliminated on June 24, 1970. Ceilings on CDs with maturities in excess of 90 days remained in place until March 16, 1973.

The 1975–91 sample also excludes the Penn Central and Franklin National disruptions of 1970 and 1974, and covers the period in which ratings were assigned to commercial paper issues.[14]

The results of the first regression corroborate the strong link between the "mix" and real output found by KSW, supporting their finding that the composition of finance has significant predictive power for future real economic activity, even in the presence of reserves and interest rates. The poor performance of the loan–paper spread in the second regression (again in the presence of reserves and the commercial paper rate) is consistent with the notion that banks' lending rates are relatively uninformative.[15] The third regression demonstrates the incremental information content of the paper–bill spread — at least in the earlier samples.

Impulse responses

While the *F*-statistics for "causality" give some indication of the strength of the predictive power of these financial indicators, they give no indication of the size or direction of their impact. The impulse response functions plotted in Figure 2 provide a richer description of the effects of innovations to the financial indicators. Each of the three rows of graphs is from the VAR corresponding to regressions 1–3 in Table 1. In each case, the system has been orthogonalized (according to the triangular Cholesky decomposition) with the credit conditions index in last place. Three responses are plotted for each regression: the financial indicator's effects on output and the interest rate, and the effect of reserves innovations on the financial indicator. The dotted lines depict the approximate 95% confidence bounds.

Panels (a) and (b) from the first specification show that "mix" innovations indeed act like reasonable measures of credit conditions; reserves injections increase the share of bank loans, and

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13. At the end of 1974, non-financial commercial paper accounted for only 13.5 billion dollars. By 1982, this figure had grown 325.2 per cent to 57.4 billion. See Hurley (1977, 1982), and Stigum (1990).

14. Moody's and Standard and Poor's began rating commercial paper in 1974.

15. Similar results are obtained with the average of large banks' lending rates obtained from the Federal Reserve Survey of Terms of Bank Lending reported in release E.2.

output rises in response to positive "mix" shocks, which might be interpreted as the pure lending component of credit conditions. The panel (c) plot, however, is something of a puzzle. It shows that "mix" innovations are associated with a *rising* commercial paper rate — not what one would expect from an increased willingness to lend on the part of banks, and inconsistent with the implications of the model presented earlier.[16] However, this pattern *is* consistent with banks passively supplying more loans in response to rising demand for credit.

The second row of plots confirm the generally weak relationship between the prime–paper spread and real output. One interesting feature of the loan spread is that it initially *rises* in response to a reserves innovation — clearly inconsistent with the loosening of credit conditions implied by the reserves injection. The loan spread ultimately falls, however, suggesting that this response is due to a certain sluggishness in the way banks adjust their lending rates.

The impulse response functions from the paper–bill spread regression are all consistent with what one would expect from an indicator of credit conditions: positive shocks to the spread generate declining real output, while reserves injections reduce the spread. Furthermore, unlike the "mix", innovations in the spread itself have essentially no impact on the level of interest rates.

Comparing the "mix" and the paper–bill spread

Because regressions 1–3 included each of the credit conditions measures in isolation, the results raise an important question: to what extent are the three indicators measuring the same phenomenon? An obvious way to address this question is to include more than one indicator in the same regression to see if the presence of one vitiates the predictive power of the other.

The results from two additional regressions (numbered 4 and 5) are reported in Table 1. The results from specification 4, which includes both the "mix" and the loan spread, are not surprising given the weak performance of the loan spread in isolation — the F-statistics for the "mix" remain virtually unchanged. Somewhat more surprising are the results from specification 5, in which both the "mix" and the paper–bill spread appear. Here, the relationship between the two variables and real

16. The "mix" terms are significant in the interest rate equation at the 10% level.

output is uniformly *stronger* (judged by the F-statistics) than when they are included individually. Clearly, one (or both) of the indicators is doing something other than simply summarizing the state of credit market conditions.

The roles of commercial paper and bank loans

The model sketched earlier suggests that flows of commercial paper and bank lending are informative to the extent that they reflect the substitution between the two forms of finance in response to a monetary or a lending shock. KSW exploit this insight by looking at the ratio of bank loans to the sum of loans and paper; shocks that affect both forms of debt proportionally are presumed to stem from sources other than loan availability. A useful check on this specification is to verify that paper and lending flows enter an unrestricted regression in such a way that the "mix" is the variable that matters.

This is easily accomplished by differentiating the "mix" (designated $\hat{h}$) with respect to time,

$$\begin{aligned}\frac{d\hat{h}}{dt} &= \frac{P}{(L+P)^2}\times \dot{L} - \frac{L}{(L+P)^2}\times \dot{P}\\ &= \hat{h}(1-\hat{h})\dot{L}/L - \hat{h}(1-\hat{h})\dot{P}/P,\end{aligned}$$

decomposing its movements into distinct lending and paper contributions. In discrete time, the analogous decomposition,

$$\Delta\hat{h}_t = \hat{h}_{t-1}(1-\hat{h}_{t-1})\Delta L_t/L_{t-1} - \hat{h}_{t-1}(1-\hat{h}_{t-1})\Delta P_t/P_{t-1} \equiv \Delta\hat{h}_L - \Delta\hat{h}_P$$

expresses $\Delta\hat{h}$ as a weighted sum of commercial paper and bank loan growth rates, denoted $\Delta\hat{h}_L$ and $\Delta\hat{h}_P$. If $\Delta\hat{h}$ were in fact the appropriate measure of the impact of credit conditions on the real economy, the two components would enter real output regressions with equal and opposite signs; the regression itself would "choose" the KSW specification.

Table 2 displays the results of this experiment. Panel (a) reports the outcome of a regression of first-differenced log real GDP on four lags of output, $\Delta\hat{h}_L$ and $\Delta\hat{h}_P$ over the 1960:2–91:4 sample. Judged by the F-statistics, the commercial paper terms are much more informative than the lending terms; $\Delta\hat{h}_P$ is significant at the 0.01 level, while the $\Delta\hat{h}_L$ terms are not significant at even the 0.10 level.[17] The sum of the estimated coefficients on lending is negative, but statistically insignificant.

The regression in panel (b) refines the test by specifying the regression in terms of $\Delta\hat{h}$ and $\Delta\hat{h}_P$ — simply a transformation of the regression in panel (a). Excluding the four lags of $\Delta\hat{h}_P$ is equivalent to restricting the coefficients on $\Delta\hat{h}_L$ and $\Delta\hat{h}_P$ to have equal and opposite signs. Here, the $\Delta\hat{h}$ terms are statistically insignificant, while the $\Delta\hat{h}_P$ terms are significant at the 0.05 level. Moreover, the negative estimated sum of the "mix" coefficients is inconsistent with the substitution hypothesis, although this sum is again statistically insignificant.

To guard against the possibility that the results in the first two panels are an artifact of the differenced specification, panel (c) reports the results of a regression that includes a linear trend and $\hat{h}$ in levels. While not $\Delta\hat{h}_P$ terms are not as strong in the levels specification, the coefficients on the $\hat{h}$ terms remain statistically insignificant.

These experiments show that the "mix" owes its predictive power in large part to something other than the substitution between bank and paper finance. In unrestricted equations, $\hat{h}$ terms are generally insignificant, while the hypothesis that commercial paper in isolation does not matter for predicting real output *can* be rejected. This observation suggests a closer examination of lending and commercial paper flows individually, and their relation to monetary policy and credit conditions.

A structural approach to identifying lending shocks

The atheoretical results in the preceding section provided some evidence in favor of interpreting the financing "mix" and the paper–bill spread as measures of credit conditions, although innovations in the composition of finance were, contrary to the simple model, are associated with a rising interest rate. One reason for this pattern may be the result of inadequately controlling for the overall demand for short-term finance. As demonstrated earlier, an increase in the amount to be financed need not raise bank and non-bank finance proportionally. In this case, if increases in firms' demand for funds

17. This is consistent with the results of King (1986).

are accommodated primarily through bank lending, the "mix" may rise for reasons unrelated to credit conditions.

Figure 3 plots the financing gap (defined as the difference between firms' capital expenditures less inventory IVA and after-tax internal funds) along with commercial paper and bank loan flows, demonstrating the close relationship between the financing gap and the volume of bank lending (although commercial paper appears to have become more sensitive to the financing gap in the later part of the sample). To control for credit demand, the results in this section include the financing gap as an additional determinant of firms' debt issuance.

A more interesting alternative hypothesis is that is that the substitution mechanism inadequately explains the joint behavior of commercial paper and bank lending, and that factors other than monetary policy are what drive the observed fluctuations in the composition of short-term external finance. The apparent asymmetry between the effects of loan and paper flows uncovered in Table 2 provides some circumstantial evidence for this view.

The results presented in this section attempt to address these issues by separately analyzing flows of lending and commercial paper in a structural VAR setting that controls for the overall demand for loanable funds. Moving to a more structural approach also addresses the possibility that the interest rate's odd response to "mix" shocks is as an artifact of the artificial triangular structure of the Cholesky decomposition employed earlier. The first model focuses on the response of lending and paper flows to reserves fluctuations, and examines the properties of the innovations identified as lending shocks. The second describes the response of the paper–bill spread to the financial flows generated by reserves and lending shocks. The third uses fluctuations in the loan–paper spread as an alternative means of identifying lending shocks.

A review of structural VARs

Beginning with an unrestricted k-variate dynamic simultaneous equation system,

$$y_t = \sum_{i=0}^{\tau} B_i y_{t-i} + Av_t,$$

the standard VAR achieves identification by restricting the contemporaneous relationships between the elements of y, i.e., by setting $B_0 = 0$ and $A = I$, while placing no restrictions on the covariance matrix of v, *i.e.*, $E(vv') = \Omega$. The structural VAR introduced by Blanchard and Watson (1986) and Bernanke (1986) achieves identification by allowing some nonzero elements in the B_0 matrix, while restricting the covariance matrix of v, the structural disturbances, to be diagonal. Off-diagonal elements in A can be introduced to allow distinct elements of y to depend on common structural shocks. Thus, structural VARs differ from traditional structural models by replacing the assumption of an exogenous instrument set with the assumption of orthogonal structural shocks. At the same time, the dynamics of the system are left unrestricted, as in the conventional VAR.

Another interpretation of the structural VAR is as a decomposition of the covariance matrix of VAR residuals. If the structural disturbances are uncorrelated with one another, *i.e.*, $E(vv') = D$, Ω, the covariance matrix of the VAR errors becomes a nonlinear function of the structural parameters:

$$\begin{aligned}\Omega &= E(B_0^{-1}Av_tv_t'A'B_0^{-1}) \\ &= B_0^{-1}ADA'B_0^{-1}.\end{aligned}$$

If the system is just-identified, the above equality is exact; $B_0^{-1}AD^{1/2}$ is a matrix square root of Ω, and $A^{-1}B_0$ diagonalizes Ω.[18]

Reserves, lending, and short-term debt flows

The first model is a just-identified six-variable system involving financing gap (F), bank lending, non-financial commercial paper (P) the commercial paper rate (r_P), real GDP (x), and non-borrowed reserves adjusted for extended credit (R). The interest rate is differenced, while reserves and GDP enter as log differences. The lending and paper data are again taken from the Flow of Funds accounts for the non-farm, non-financial corporate and noncorporate sectors. With F, P and L expressed

18. With a total of $2k^2$ elements in A and B_0 and only $k(k+1)/2$ unique elements in Ω, it is clear that the structural parameters are not identified without additional restrictions on A and B_0. The Cholesky decomposition, which is equivalent to setting $B_0 = I$ and making A lower triangular, is but one possibility. In overidentified systems, the problem becomes one of choosing the structural parameters in B_0 and A to generate the best fit between the fitted and the observed covariance matrices.

as shares of the total dollar volume of outstanding paper and loans, changes in the "mix" can be constructed as the weighted average of the two flows:

$$\Delta \hat{h} = (1-\hat{h})\frac{\Delta L}{L+P} + \hat{h}\frac{\Delta P}{L+P}.$$

The substance of the model is contained in the six equations describing the contemporaneous relationships between the variables,

$$R = b_{1,6}x + v_1 \qquad \text{Reserves (2}a\text{)}$$

$$F = b_{2,1}R + b_{2,6}x + v_2 \qquad \text{Financing gap (2}b\text{)}$$

$$r_P = b_{3,1}R + b_{3,2}F + v_3 \qquad \text{Interest rate (2}c\text{)}$$

$$L = b_{4,1}R + b_{4,2}F + b_{4,3}r_P + v_4 \qquad \text{Lending (2}d\text{)}$$

$$P = b_{5,1}R + b_{5,2}F + b_{5,3}r_P + a_{5,4}v_4 + v_5 \qquad \text{Paper (2}e\text{)}$$

$$x = b_{6,3}r_P + b_{6,4}L + b_{6,5}P + v_6 \qquad \text{Output (2}f\text{).}$$

No restrictions are placed on the dynamics of the system; consequently, terms dated $t-1$ and before are omitted, but implicit.

Equation 2a allows the Federal Reserve to vary reserves contemporaneously with real GDP in a primitive feedback relationship. The financing gap (equation 2b) also depends on the level of real economic activity. Consistent with the model presented earlier, the commercial paper rate in 2c is a function of reserves and the financing gap.

The model's key equations are 2d and 2e, describing the behavior of bank lending and commercial paper flows as a function of the financing gap, reserves, and the interest rate. The coefficients on F measure the proportion of the current financing gap satisfied financed through loans and paper. The two equations' coefficients on R determine the immediate response, ceteris paribus, of the two forms of short-term finance to changes the banking system's reserve position. The v_4 term in the lending equation represents lending shocks that are orthogonal to reserve and financing gap innovations, which would include factors such as credit crunches. For this interpretation of v_4 to be legitimate, one of two conditions has to hold: either the observed financing gap must appropriately control for firms' demand for funds, or the amount of funds banks have available is fixed in the current quarter.

The v_4 innovation also appears in the commercial paper equation with the coefficient a_{54}, allowing commercial paper to respond directly to lending shocks. This parameter determines the extent to which lending shocks are "recycled" into the commercial paper market within the current quarter. The v_5 term in the commercial paper equation accounts for shocks to paper issuance uncorrelated with the other structural disturbances. The final equation for real GDP is a reduced-form equation describing the economy's response to the reserves and credit shocks in the preceding equations.

The parameter estimates in Table 3 summarize the model's contemporaneous behavior, while the impulse responses functions plotted in Figure 4 describe its dynamics of the system whose orthogonalization is implicit in equations 2a–2f. Like the earlier reduced-form regressions, these results provide some evidence to support the use of lending flows as an indicator of credit conditions, while confirming the doubts raised in the atheoretical VARs. First, The negative estimate of the coefficient on R in the lending equation (2d) contradicts the hypothesis that the primary effect of monetary policy is a substitution between bank and non-bank finance; the contemporaneous response of an injection of non-borrowed reserves, ceteris paribus, is a *fall* in bank lending.

However, because of the contemporaneous relationship from reserves to the financing gap and short-term finance via the interest rate and output, the coefficients on R in equations 2d and 2e do not by themselves determine the overall response of the "mix" to a reserves shock. The actual responses can be read from the impulse response function, plotted in the top panel of Figure 4.[19] This shows that the net effect of a reserves injection is initially rather small, with the loan share gradually rising after two to three quarters.

19. The sample average values of $\bar{h}$ are used to compute the approximate response of the "mix" from the impulse response functions of the underlying variables.

Figure 4 also shows that lending shocks seem to have a considerably larger impact on the composition of external finance than reserves for the first four quarters. Lending shocks' effect is strengthened somewhat by the statistically significant negative estimate of a_{54}, which is consistent with roughly 10% of the lending shock being "recycled" into the paper market in the current quarter. The coefficients on F in the paper and lending equations show that neither responds immediately to fluctuations in the financing gap.

A strong liquidity effect is associated with injections of non-borrowed reserves; the paper rate falls contemporaneously (the negative coefficient on R in equation 2c) and over a longer horizon (the center panel of Figure 4). These results also confirm the curious positive relation between the "mix" and the level of interest rates highlighted earlier in the paper. The center panel shows that positive lending innovations imply a *rising* interest rate, contradicting the theoretical model's implications for the effects of lending shocks.

Both monetary and lending shocks are important sources of output fluctuations. Increased bank lending is contemporaneously associated with more rapid real GDP growth in the short run, as shown by both the positive (but not quite significant) coefficient on L and the impulse response function.

What about shocks to commercial paper, v_5? The top panel of Figure 4 shows that these shocks — which are, by construction, orthogonal to the system's other structural disturbances — have the largest and most persistent impact on the composition of external finance. Interestingly, the center panel shows that these innovations have essentially no implications for the interest rate, although they do seem to have a small, negative impact on real output.

Financial flows and interest-rate spreads

Recent papers by Bernanke (1990) and Friedman and Kuttner (1992) suggest that the substitution between bank and non-bank debt is an important source of fluctuations in the paper–bill spread. As discussed earlier, monetary contractions reduce lending by shrinking the stock of deposits, leading firms to raise the loan rate relative to the paper rate, discouraging intermediated borrowing. Similarly, adverse lending shocks cause banks to shift from loans to Treasury bills. As firms turn to the paper market to satisfy their financing needs, the paper supply rises and bill supply to households falls, raising the paper–bill spread. If this is the way in which credit conditions affect the spread, one would expect to find the mechanism operating through the volume of outstanding non-financial commercial paper.

The second structural VAR is designed to detect the operation of this mechanism. It augments the first model (equations 2a–2f) with the addition of a seventh equation for the paper–bill spread,

$$x = b_{6,3}r_P + b_{6,4}L + b_{6,5}P + b_{6,7}(r_P - r_B) + v_6 \qquad \text{Output (3}f\text{)}$$

$$r_P - r_B = b_{7,1}R + b_{7,2}F + b_{7,3}r_P + b_{7,4}L + b_{7,5}P + v_7, \qquad \text{Paper–Bill spread (3g)}$$

and also includes the spread in the output equation. The remaining five equations are identical to those in the earlier model (2a–e).

The parameter estimates reported in Table 4 provide weak evidence for bank/non-bank substitution as a source of paper-bill spread. The positive and marginally significant on the paper term shows that flows of non-financial paper do exert an influence on the spread.[20] However, the very large, significant coefficient on reserves shows indicates that a great deal of the impact of monetary policy is transmitted to the spread via other routes.

The impulse responses in the top panel of Figure 5 confirm the spread's strong reaction to non-borrowed reserves innovations. Positive shocks to the financing gap also drive up the spread, as predicted, while paper shocks have little or no impact. Lending shocks again pose a problem, however. If the lending innovations identified by the VAR correspond to changes in the availability of loans, the model suggests that positive shocks should be associated with a *falling* paper–bill spread. The opposite is true: lending shocks imply a *rising* spread. Again, this pattern is consistent

20. By contrast, the results in Table 10 of Friedman and Kuttner (1992) using the *total* volume of commercial paper outstanding are consistent with a stronger link between paper issuance and the spread.

with bank lending responding passively to changes in the demand for funds inadequately captured by the financing gap.

The bottom panel of Figure 5 suggests something other than bank/non-bank substitution is driving the paper–bill spread. Despite the inclusion of a variety of financial variables purporting to capture the impact of monetary policy on credit markets, the graph shows that the spread continues have strong implications for future output — comparable in magnitude to those of non-borrowed reserves. Even accounting for reserves, lending, and paper shocks, orthogonal spread innovations still result in falling real economic activity.

Identifying lending shocks with loan spread innovations

In light of the conclusion that lending flows (and the "mix") may in part represent endogenous response to firms' financing demands, the third structural VAR uses an alternative assumption to identify lending shocks, attributing (orthogonalized) innovations in the loan-paper spread to changes in banks' willingness to lend. In the context of the simple model presented earlier, the loan spread should embody exactly the same information as the "mix." In practice, as KSW note, the loan rate is likely to be a poor measure of the true cost of bank finance, an observation that motivates their use of the quantity variables. Indeed, the sluggish response of the loan rate to changes in the paper rate corroborates this view. The weak response of output to the loan–paper spread makes this approach seem even less promising.

With these reservations in mind, the first structural VAR can be adapted to incorporate the loan-paper spread. An equation for the loan spread is added to the system, and lending and paper flows are allowed to depend on this spread, as well as on reserves and the financing gap. The covariation between the flows that is a function of credit conditions is a result of their common dependence on the loan spread. This identification scheme will work if the financing gap is an imperfect proxy for the overall demand for funds so long as banks passively accommodate firms' funding requirements within the quarter at the going spread (that is, if their demand for loans is elastic).

The modified system is:

$$R = b_{1,6}x + v_1 \qquad \text{Reserves}^{*}(4a)$$

$$F = b_{2,1}R + b_{2,6}x + v_2 \qquad \text{Financing gap } (4b)$$

$$r_P = b_{3,1}R + b_{3,2}F + v_3 \qquad \text{Interest rate } (4c)$$

$$r_L - r_P = b_{4,1}R + b_{4,2}F + b_{4,3}r_P \qquad \text{Loan spread } (4d)$$

$$L = b_{5,1}R + b_{5,2}F + b_{5,3}r_P + b_{5,4}(r_L - r_P) + v_5 \qquad \text{Lending } (4e)$$

$$P = b_{6,1}R + b_{6,2}F + b_{6,3}r_P + b_{6,4}(r_L - r_P) + a_{6,5}v_5 + v_6 \qquad \text{Paper } (4f)$$

$$x = b_{7,3}r_P + b_{7,4}(r_L - r_P) + b_{7,5}L + b_{7,6}P + v_7 \qquad \text{Output } (4g).$$

Under the assumptions outlined above, the innovations to the loan spread equation are now associated with changes in credit conditions, while the v_5 lending innovations represent shocks to firms' loan supply (that is, their demand for funds).

The parameter estimates in Table 5 accord surprisingly well with the implications of the model. Although its sluggish response makes the loan spread is subject to large, transitory effects from the paper rate and reserves, the negative estimated $b_{5,4}$ and the positive $b_{6,4}$ show that loan and paper volume respond as they should to the spread. Furthermore, reserves have no discernible independent impact on financial flows. A rising loan spread is contractionary, although again, the effect is statistically weak.

The corresponding impulse response functions appear in Figure 6. The top panel again illustrates the consequences of sluggish loan rate adjustment, with reserves injections causing the loan spread to rise sharply in the current quarter. Over time, reserves innovations produce a falling spread. The center panel shows the familiar liquidity effect, and the positive impact of lending innovations on the commercial paper rate. In this model, however, with innovations to loan volume interpreted as shocks to firms' funding requirements, the result is perfectly natural. By contrast, innovations in the loan spread have quite mild effects on the paper rate.

Conclusions

This paper has examined the relationship between monetary policy, loan availability, and alternative indicators of credit market activity. One of is main findings is that the substitution between bank and non-bank finance is indeed an identifiable effect of monetary policy as measured by innovations to non-borrowed reserves. This substitution is, however, not the only factor affecting financial flows. One of the major contributors to the aggregate composition of firms' short-term obligations is flows of commercial paper unrelated to lending shocks.

Furthermore, the portion of bank lending not attributable to monetary policy is associated with increases in the commercial paper rate and the paper–bill spread, suggesting that the behavior of the KSW "mix" is in part due to changes in firms' demand for loanable funds. Despite its apparent slow adjustment to changes in market interest rates, the loan–paper spread is a plausible alternative indicator of credit conditions.

The paper–bill spread responds appropriately to monetary shocks, rising in response to a reserves contraction. However, the strength of its response cannot entirely be accounted for by flows of non-financial paper, suggesting that its informativeness as a predictor of real economic activity may be due to other sources, such as changes in banks' issuance of negotiable CDs. This is consistent with the observation that non-financial commercial paper comprises a tiny share of the relevant market — only 25% of total commercial paper, and less than 9% of the sum of paper, CDs and Treasury bills.[21] Understanding how Federal Reserve policy and credit conditions affect the paper–bill spread will require expanding the model to take into account the behavior of other relevant assets, such as CDs and financial paper.

21. These figures are for 1991:4. The share of non-financial commercial paper is even smaller earlier in the sample.

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1. *F*-Statistics for Alternative Measures of Credit Conditions in Quarterly Real Output Equations

Specification	60:2–91:4	70:3–91:4	75:1–91:4
(1) "Mix" alone	3.36**	2.09*	2.86**
(2) Loan spread alone	0.11	0.30	0.46
(3) Paper–bill spread alone	3.81***	2.71**	1.81
(4) "Mix" + loan spread			
"mix" terms	3.37**	1.81	3.07**
loan spread terms	0.23	0.14	0.79
(5) "Mix" + paper–bill spread			
"mix" terms	4.17***	2.46	4.39***
paper-bill spread terms	4.62***	3.07**	3.30**

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Notes: The regressions are based on quarterly data for the sample indicated.
In addition to the variables indicated, each regression includes four lags of real GDP growth, real non-borrowed reserves growth, the differenced commercial paper rate, plus constant and trend terms.

2. Decomposing Changes in the Composition of External Finance

(a) Regression with separate commercial paper and bank lending terms

	Exclusion F-stat (p-value)	Sum of coefficients (p-value)
Commercial paper ($\Delta\hat{h}_P$)	4.00 (0.005)	-0.51 (0.04)
Bank lending ($\Delta\hat{h}_L$)	1.39 (0.24)	-0.90 (0.22)

(b) Regression with the differenced "mix" and commercial paper

	Exclusion F-stat (p-value)	Sum of coefficients (p-value)
"Mix" ($\Delta\hat{h}$)	1.45 (0.22)	-0.91 (0.23)
Commercial paper ($\Delta\hat{h}_P$)	2.64 (0.04)	-1.38 (0.04)

(c) Regression with the "mix" in levels, commercial paper, and linear trend

	Exclusion F-stat (p-value)	Sum of coefficients (p-value)
"Mix" ($\hat{h}$)	1.48 (0.21)	0.11 (0.16)
Commercial paper ($\Delta\hat{h}_P$)	2.27 (0.07)	-1.77 (0.01)

Notes: The regressions are based on quarterly data for 1960:2 through 1991:4.
The specifications include four lags of each included variable and a constant term.

3. Structural VAR Estimates, Credit Conditions Identified via Lending Flows (equations 2a–2f)

2a.	$R = -0.625\ x + v_1$ $\quad\ \ (1.94)$
2b.	$F = 0.159\ r + 1.974\ x + v_2$ $\quad\ \ (1.05)\quad (4.11)$
2c.	$r_P = -0.208\ R + 0.037\ F + v_3$ $\quad\ \ (6.96)\quad (2.10)$
2d.	$L = -0.396\ R - 0.022\ F + 2.125\ r_P + v_4$ $\quad\ \ (1.51)\quad (0.16)\quad (3.23)$
2e.	$P = 0.135\ R + 0.027\ F + 0.444\ r_P - 0.094\ v_4 + v_5$ $\quad\ \ (1.29)\quad (0.51)\quad (1.68)\quad (2.71)$
2f.	$x = -0.023\ r + 0.019\ L + 0.004\ P + v_6$ $\quad\ \ (0.23)\quad (1.50)\quad (0.14)$

Notes: Estimates are based on quarterly data for 1960:2 through 1991:4. Regressions include three lags of each variable, constant and trend terms. Numbers in parentheses are *t*-statistics.

4. Structural VAR Estimates of the Effects of Lending Shocks on the Paper–Bill Spread (equations 3a–3g)

3a.	$R =$	$-0.558\ x + v_1$					
		(1.51)					
3b.	$F =$	$0.048\ r +$	$1.882\ x + v_2$				
		(0.33)	(3.70)				
3c.	$r_P =$	$-0.216\ R +$	$0.027\ F + v_3$				
		(7.63)	(1.57)				
3d.	$L =$	$-0.306\ R -$	$0.022\ F +$	$2.051\ r_P + v_4$			
		(1.18)	(0.17)	(3.05)			
3e.	$P =$	$0.110\ R +$	$0.038\ F +$	$0.470\ r_P -$	$0.091\ v_4 +$		v_5
		(1.05)	(0.71)	(1.73)	(2.61)		
3f.	$x =$	$0.123\ r +$	$0.016\ L +$	$0.023\ P -$	$0.897\ (r_P - r_B) + v_6$		
		(1.20)	(1.35)	(0.76)	(3.20)		
3g.	$r_P - r_B =$	$0.016\ R +$	$0.181\ r +$	$0.000\ F +$	$0.002\ L +$		$0.016\ P + v_7$
		(1.40)	(6.20)	(0.07)	(0.46)		(1.71)

Notes: Estimates are based on quarterly data for 1960:2 through 1991:4. Regressions include three lags of each variable, constant and trend terms. Numbers in parentheses are t-statistics.

5. Structural VAR Estimates, Credit Conditions Identified via the Loan Spread (equations 4a–2g)

4a. $$R = \underset{(0.85)}{-0.347}\, x + v_1$$

4b. $$F = \underset{(0.89)}{0.122}\, r + \underset{(4.46)}{2.132}\, x + v_2$$

4c. $$r_P = \underset{(8.10)}{-0.202}\, R + \underset{(0.96)}{0.016}\, F + v_3$$

4d. $$r_L - r_P = \underset{(4.99)}{0.070}\, R + \underset{(1.77)}{0.014}\, F - \underset{(6.56)}{0.261}\, r_P + v_4$$

4e. $$L = \underset{(0.14)}{-0.039}\, R + \underset{(0.15)}{0.021}\, F + \underset{(0.96)}{0.783}\, r_P - \underset{(2.99)}{4.727}\, (r_L - r_P) + v_5$$

4f. $$P = \underset{(0.27)}{0.030}\, R + \underset{(0.06)}{0.003}\, F + \underset{(2.18)}{0.722}\, r_P + \underset{(1.83)}{1.176}\, (r_L - r_P) - \underset{(2.42)}{0.085}\, v_5 + v_6$$

4g. $$x = \underset{(0.39)}{-0.047}\, r - \underset{(1.54)}{0.362}\, (r_L - r_P) + \underset{(1.28)}{0.016}\, L + \underset{(0.46)}{0.015}\, P + v_7$$

Notes: Estimates are based on quarterly data for 1960:2 through 1991:4.
Regressions include three lags of each variable, constant and trend terms.
Numbers in parentheses are t-statistics.

Figure 1

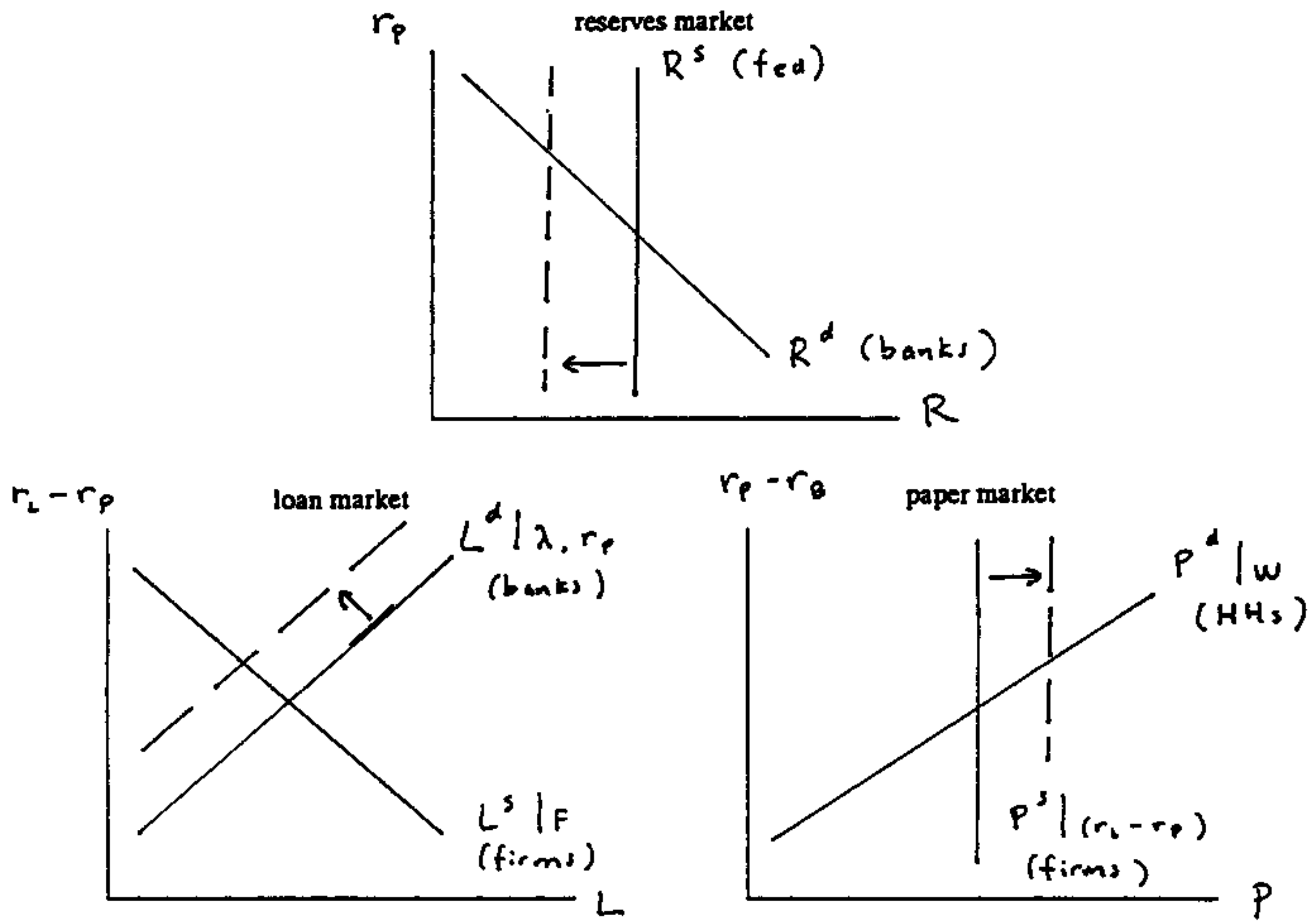

r_p
reserves market
R^s (fed)
R^d (banks)
R
$r_L - r_p$
loan market
$L^d | \lambda, r_p$
(banks)
$L^s | F$
(firms)
L
$r_p - r_B$
paper market
$P^d | W$
(HHs)
$P^s | (r_L - r_p)$
(firms)
P

Figure 2

Impulse Response Functions of Credit Conditions Indicators

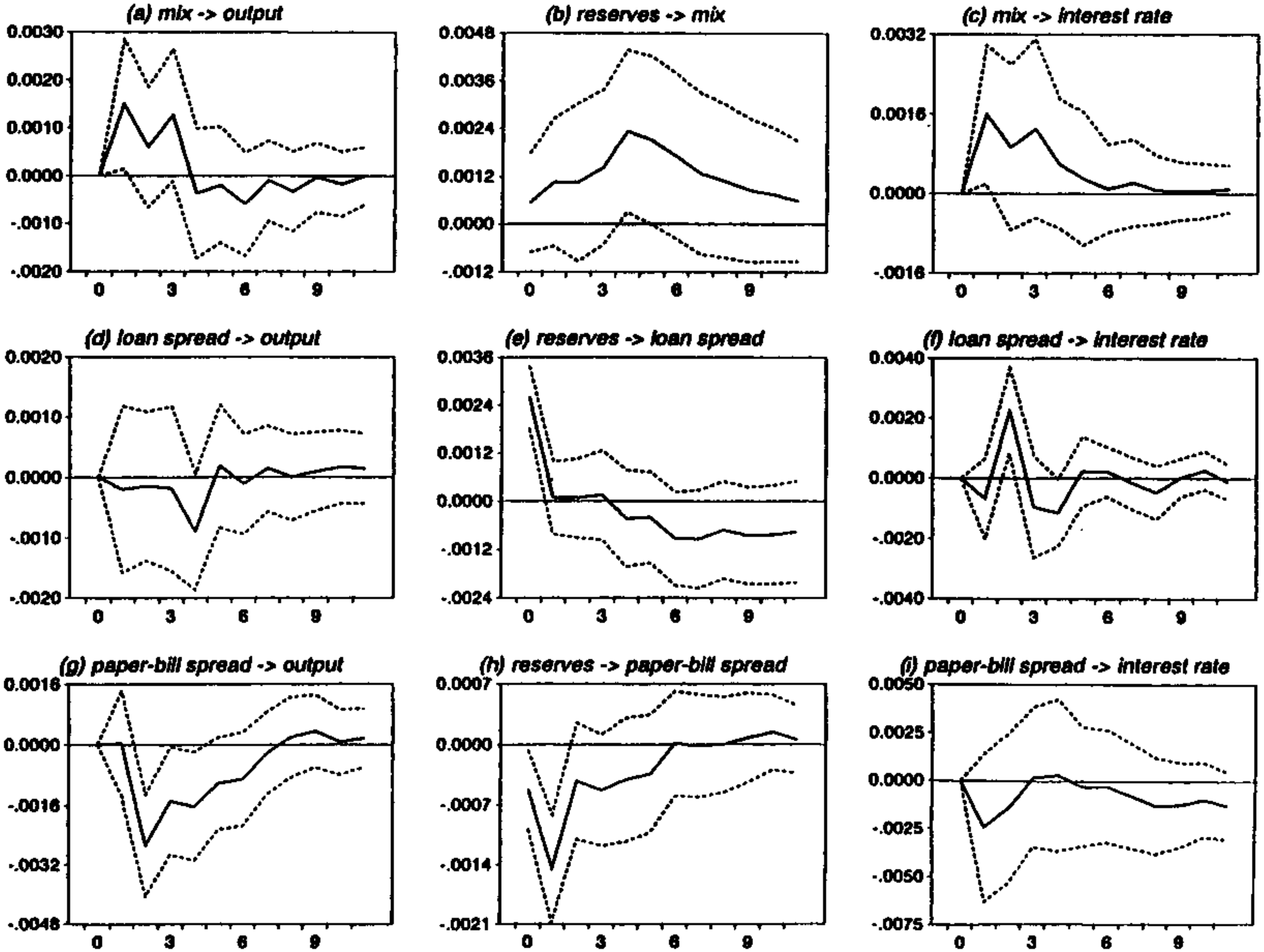


Figure 3: Financing Gap and Financial Flows

bank lending and paper issuance, four-quarter moving average

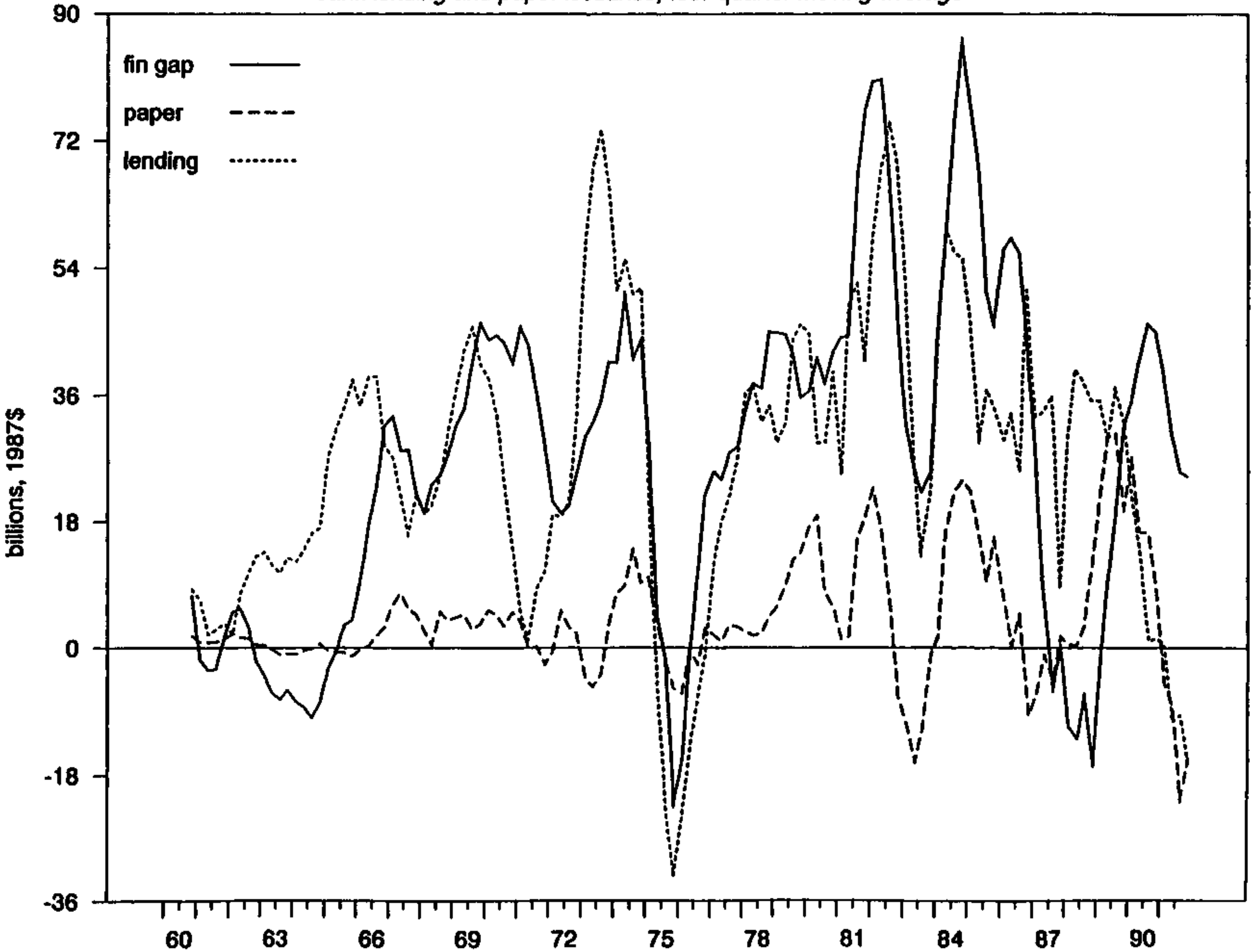


Figure 4: credit conditions = lending shocks

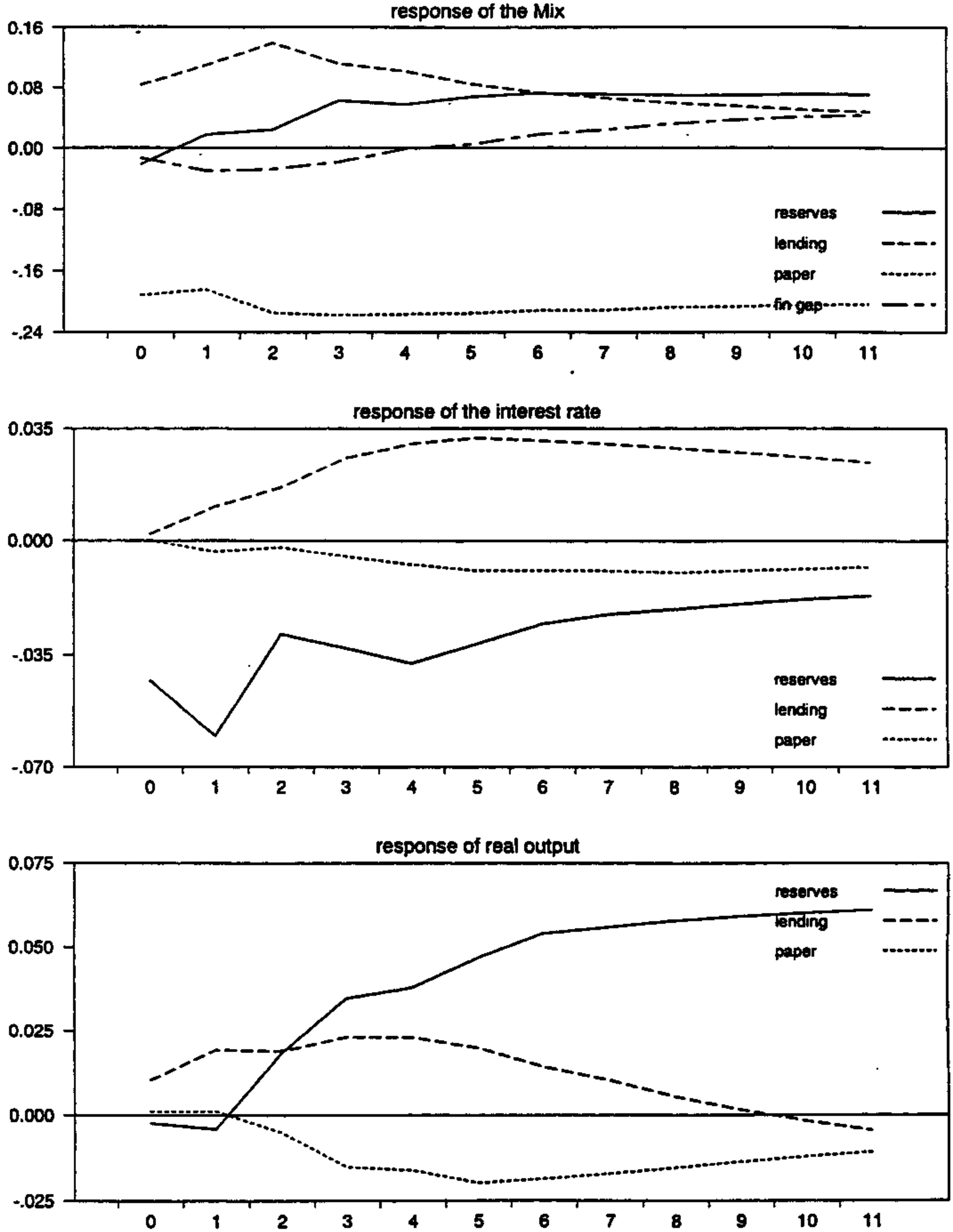
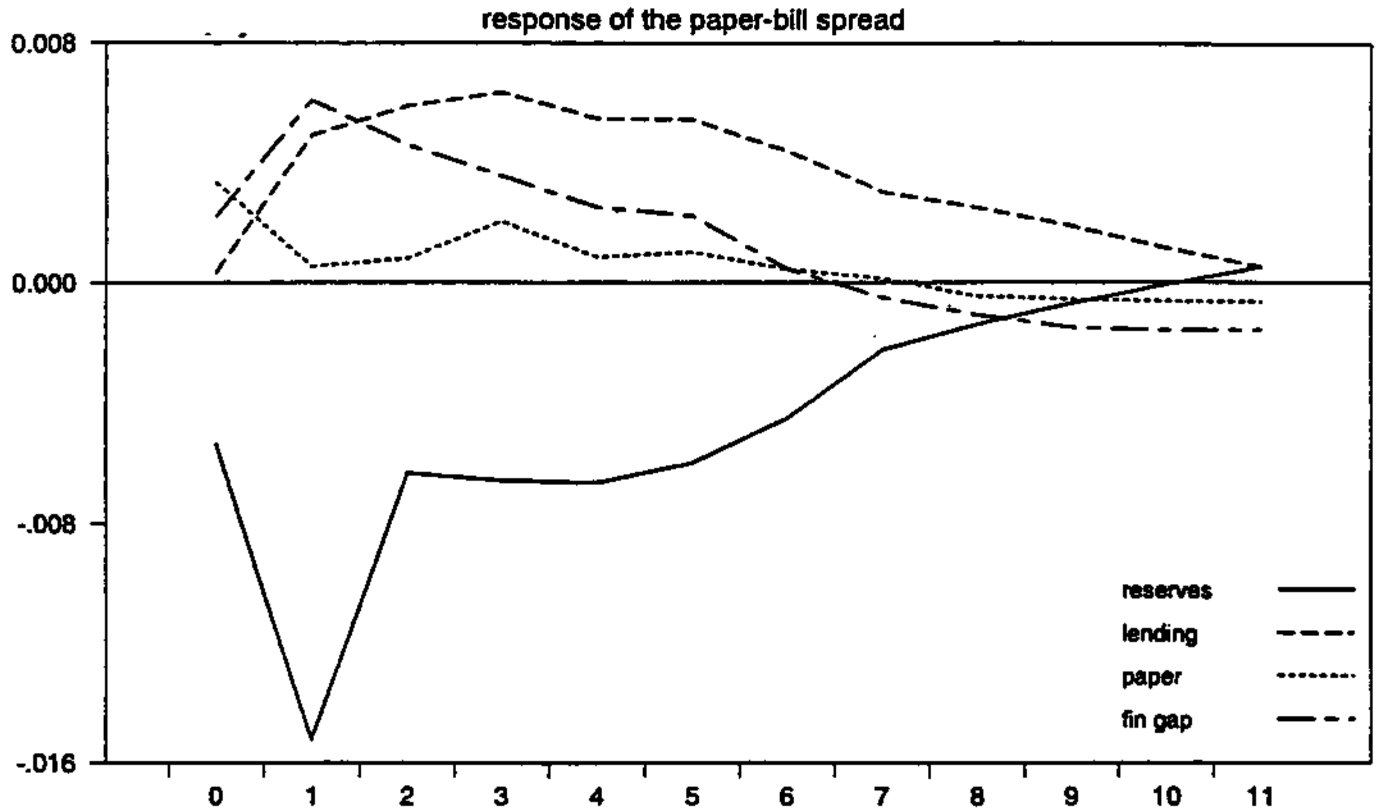


Figure 5: credit conditions = lending shocks



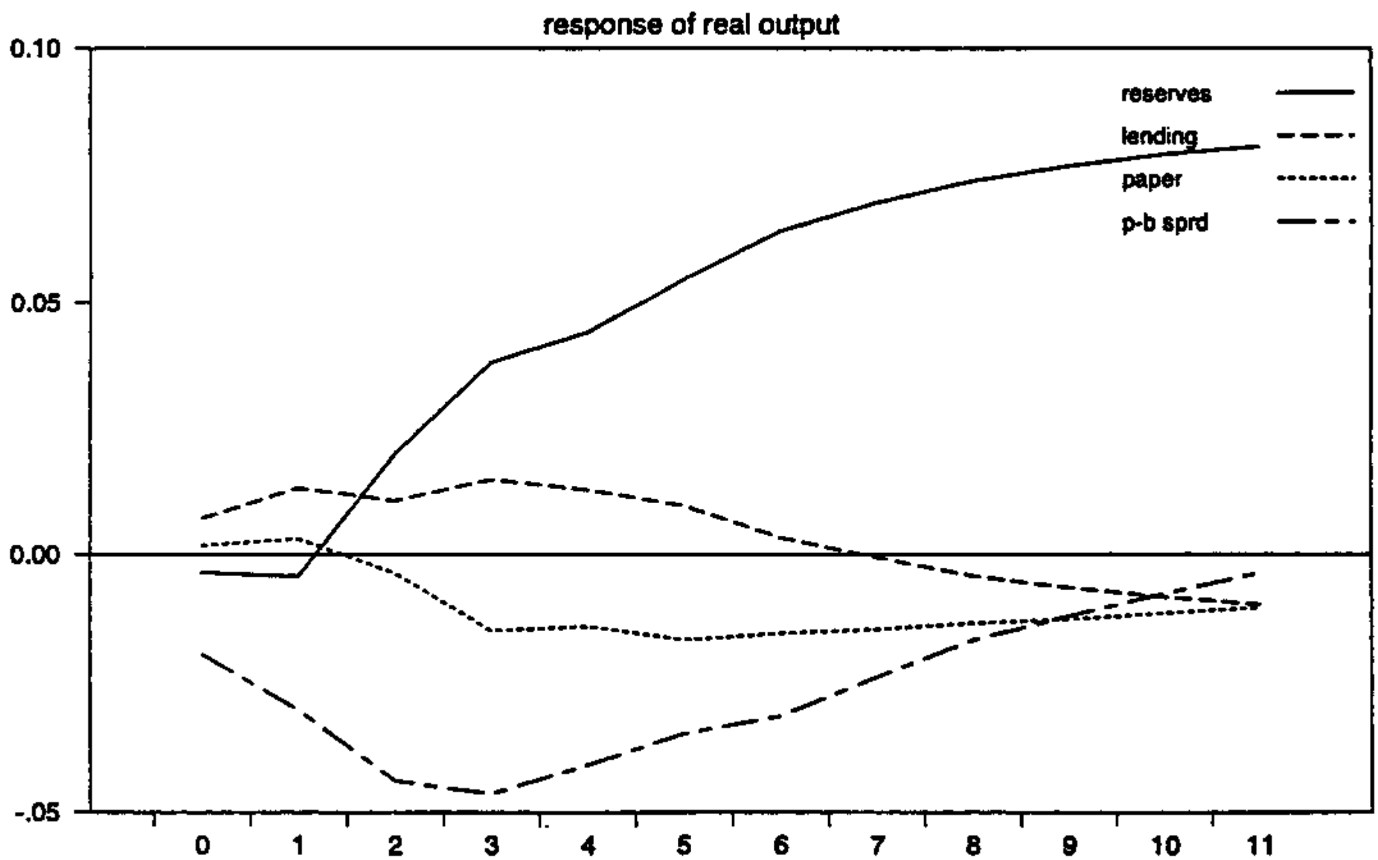
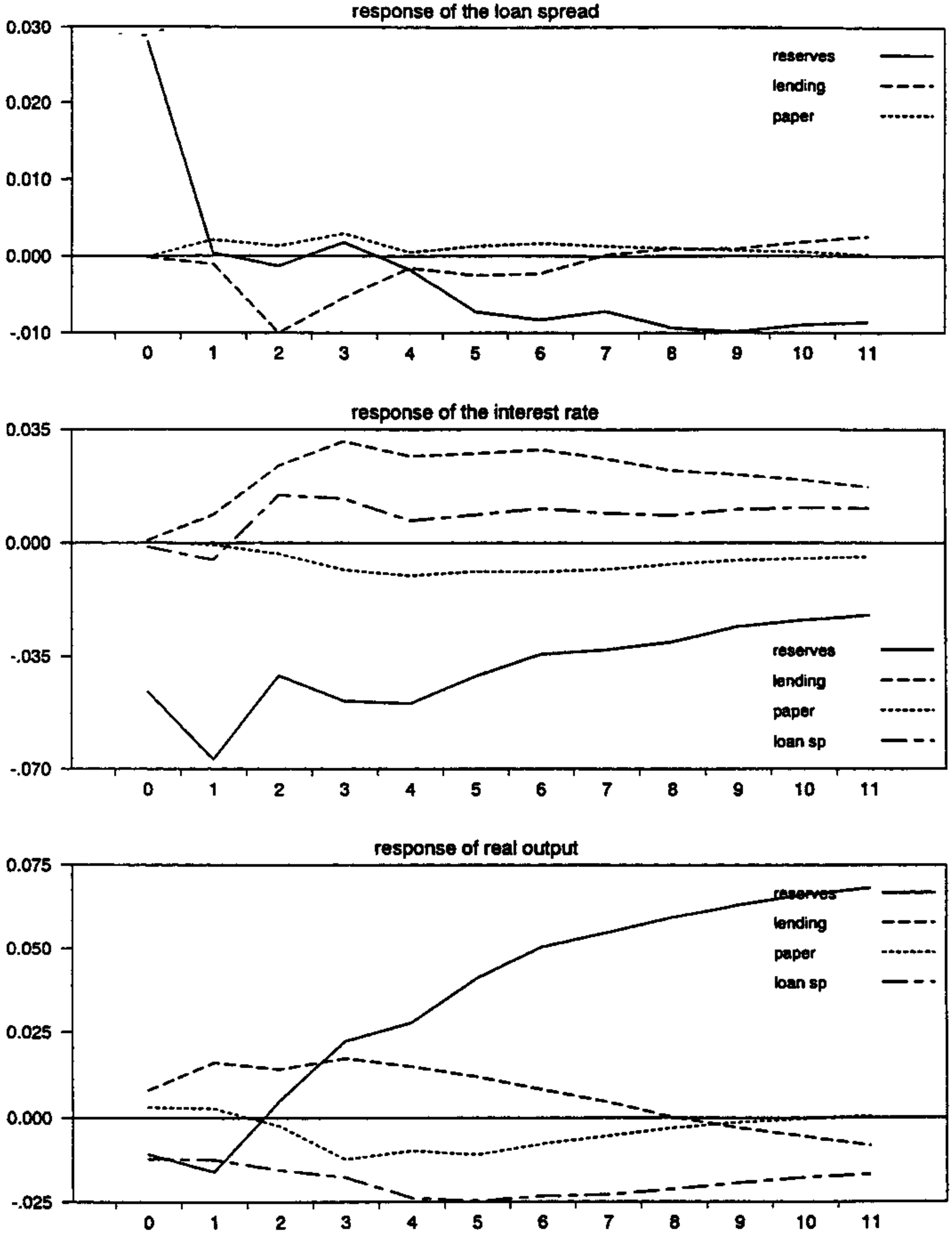


Figure 6: credit conditions = loan spread shocks



COMMENTS ON
CREDIT CONDITIONS AND EXTERNAL FINANCE:
INTERPRETING THE BEHAVIOR OF FINANCIAL FLOWS AND INTEREST RATE SPREADS

David Wilcox[1]

Two opposing views have animated much recent research on the transmission channels of monetary policy. One view (stated in its extreme form) is that the impulses of monetary policy are transmitted to the real economy exclusively via the market for reserves. By manipulating the quantity of available reserves, the Federal Reserve is able to change the relative supply of money and bonds. Given this change in relative supply, the interest rate must change in order to clear the markets for money and bonds. In turn, the change in the interest rate alters the user cost of capital, and so influences the investment decisions of businesses and the spending decisions of households.

An essential assumption implicit in this so-called "money" view of the transmission mechanism is that bank loans, market-intermediated privately-issued debt such as commercial paper and corporate bonds, and privately-held government debt can be treated as perfect substitutes. Indeed, this assumption is embedded in the conventional IS-LM model, where the aggregate non-money financial asset is simply labelled "bonds" for convenience. According to the money view, the reduction in bank loans that accompanies a reduction in reserves is of no particular significance in itself because firms can satisfy any unmet demand for external finance by issuing market-intermediated debt which is indistinguishable from bank debt. For this reason, the money view often is summarized by the proposition that bank loans are not "special."

The opposing view of the transmission mechanism assigns a central role to bank loans. According to this view, bank loans, market-intermediated privately-issued debt, and government debt are *not* perfect substitutes. The reduction in the volume of bank loans that accompanies a move toward a more restrictive monetary policy is

1. David Wilcox is on the staff of the Board of Governors of the Federal Reserve System.

contractionary in itself, even controlling for any associated change in interest rates. In effect, bank loans behave as if they were a factor of production. A reduction in their availability increases their relative price (the spread between the loan rate and the open-market rate increases). In response, firms seek cheaper alternatives for their external finance. However, given the imperfect substitutability of other forms of debt for bank loans, the reduction in loan availability implies a contraction in real activity.

The important distinction between the money view and the loans view is that the latter implies that the impulses of monetary policy are transmitted not only through the overall level of interest rates, but also through the relative prices and relative quantities of bank loans and other forms of external finance. If the loans view is right, fluctuations in the quantities and prices of bank loans, commercial paper, other private debt, and government debt will be worth keeping track of separately because they will be informative for either the current or future state of the economy, or both. Moreover, the loans view suggests, as Kuttner (this volume) and Friedman (1991) emphasize, that there is no reason for being uniquely interested in changes in the stance of monetary policy; other factors (including but not restricted to the stringency of regulatory oversight) will also be worthy of study to the extent that they bear on loan availability.

THE IDENTIFICATION PROBLEM

One approach to investigating the empirical significance of the loans channel has been to regress some measure of real activity (such as industrial production or GNP) on current and lagged measures of bank loans. A positive correlation between bank loans and real activity has sometimes been interpreted as contradicting the money view and supporting the existence of a separate loans channel. The flaw in this argument is not hard to spot: A positive correlation between bank loans and real activity could simply reflect an endogenous *response* of the demand for bank loans to changes in real activity rather than an exogenous *cause* of changes in real activity. Even a finding of a positive correlation between bank loans and *subsequent* changes in activity (as opposed to contemporaneous ones) would not be convincing evidence of a separate loans channel; such a phenomenon could reflect, for example, a need to secure financing some months or even quarters before the bulk of the associated activity is to take place.

An important challange taken up in the more recent literature has been to solve this identification problem in a convincing manner.[2]

SUMMARY OF KUTTNER'S PAPER

Ken Kuttner's paper makes two important contributions to the literature on the monetary policy transmission mechanism: one theoretical, the other empirical.

On the theoretical front, he presents a very nice compact model of the flow of funds in a simple economy. He distinguishes five financial instruments in his model (in contrast to the usual two): deposits ("money"), bank loans, commercial paper, reserves, and government debt.[3] He posits the existence of a representive firm, a representative bank, and a representative household, and endows each of them with standard portfolio behavior (households' demand for money is declining in the opportunity cost of holding money, and so forth). Then he derives the implications of changes in the stance of monetary policy, changes in banks' willingness to lend, and changes in firms' demand for external finance for three quantities: the mix of external finance, the spread between the loan rate and the commercial paper rate, and the spread between the paper rate and the Treasury bill rate.

The beauty of Kuttner's model is that it delivers sensible results very directly. For example, a reduction in banks' willingness to lend causes the loan-paper spread to rise.[4] In response, firms

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2. The approach proposed in Kashyap, Stein, and Wilcox (1992) is to focus on changes in the *composition* of external finance rather than fluctuations in any one component alone. Intuitively, one would not expect changes in the volume of bank loans relative to the volume of other debt to be informative for current or future changes in real activity if bank debt is a perfect substitute for non-bank debt.

3. Implicitly, other corporate liabilities such as medium- and long-term bonds are treated as perfect substitutes for commercial paper.

4. Kuttner interprets "negative shifts in λ as 'credit crunch' episodes." He notes, however, that a negative shift in λ could reflect a "perceived deterioration in borrowers' creditworthiness." In my opinion, it would be more useful to reserve the term "credit

(Footnote continues on next page)

shift the mix of external finance away from bank loans and toward market-mediated debt. The increased issuance of commercial paper drives up the spread between commercial paper rates and bill rates.[5] With respect to these three key variables, the effects of a reduction in banks' willingness to lend are identical to the effects of a move by the Federal Reserve toward a more restictive monetary policy, suggesting that any one of the three might be useful as an index of loan availability.[6]

In fact, it turns out that these three variables also respond in qualitatively the same manner to the other two exogenous factors in Kuttner's model (monetary policy and the demand for external finance). That is, no matter what the conceptual experiment being run in Kuttner's model, the loan-paper spread will always move in the same direction as the paper-bill spread, and the two spreads will always move in the opposite direction of the mix.

In light of these predictions from his theoretical model, Kuttner's finding that the loan-paper spread significantly underperforms the mix and the paper-bill spread as indicators for future real GNP is interesting and a bit puzzling. Kashyap, Stein,

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(Footnote continued from previous page)
crunch" for periods in which some potential borrowers are turned away even though, *with identical characteristics in every respect (including "credit worthiness")*, they would have been granted credit in "normal" times.

5. In Kuttner's model, the commercial paper rate is taken as the benchmark rate over which the Federal Reserve has direct control in the reserves market. As a result, a reduction in banks' willingness to lend has no effect on the *level* of the commercial paper rate. As was noted in the text, however, it does increase the loans-paper spread. As a result, the volume of commercial paper outstanding rises and the paper-bill spread increases. Given the fixity of the paper rate in the face of this experiment, it must be that the bill rate has declined. If the bill rate (rather than the paper rate) were assumed to clear the market for reserves, all the essential results still would hold (the mix would shift away from loans, the loans-paper spread and the paper-bills spread both would rise), but the bill rate would be fixed and the paper rate would rise.

6. Kuttner notes that the effects of a shift in monetary policy are not identical in every respect to the effects of a shift in banks' willingness to lend: The former affects the level of the interest rate in the market for reserves, whereas the latter does not.

and Wilcox (1992) argued that the mix might be preferable to the loan-paper spread as an indicator of loan availability (because the stated loan rate would not adequately reflect changes in non-price terms of loan contracts such as collateral requirements), but then proceeded to find in their sample that the predictive power of the two variables was roughly comparable. It would be worth attempting to reconcile Kuttner's results with those of KSW, and (assuming Kuttner's results hold up) attempting to verify the KSW hypothesis about why the loan-paper spread might be an inferior performer.

On the empirical side, Kuttner's paper introduces a new approach to solving the identification problem. He posits several simple "structual vector autoregression" models of the markets for reserves, bank loans, and commercial paper. Kuttner is bold enough to supply sufficient prior restrictions on the specification of the various equations, and finds that, for the most part the estimates that follow are well in line with the predictions that were outlined in his theoretical section. The major exception--and one that deserves further investigation--is that increases in banks' willingness to lend (counterintuitively) appear to cause *increases* in interest rates.

AN ASYMMETRIC-INFORMATION-BASED ACCOUNT OF SUBSTITUTION BETWEEN LOANS AND PAPER

In line with most of its recent predecessors, Kuttner's paper adopts an aggregate perspective: The model is inhabited by representative banks, households, and non-bank firms, and the empirical work is conducted using aggregate data. As in the earlier papers, this perspective--through no fault of the author--sets up certain tensions of both an expositional sort and a substantive sort. On the expositional side, the most natural way to tell the story of the loans channel involves an appeal to heterogeneity among firms: Some are capable of issuing commercial paper while others are not. Obviously, a story such as this is difficult to link up directly to a model with a single representative non-bank firm. On the substantive side, the representative-agent approach to modelling the problem fuels the intuition that some firms should be observed to be on the margin between bank loans and commercial paper. The purpose of the rest of these comments is to sketch verbally a model that allows for heterogeneity among firms, and then to point out two important implications of such an approach.

The loans view is predicated on the assertion that non-bank debt is not perfectly substitutable for bank debt. That imperfect substitutability can be motivated as reflecting market imperfections that arise when borrowers have more information about their economic prospects than do prospective lenders. Banks specialize in "information-intensive" lending--that is, in lending to customers (such as small businesses) for whom the asymmetric-information problem is more acute, and hence more difficult for arms-length capital markets to solve.

A contractionary shift in the stance of monetary policy will cause banks to reduce the size of their loan portfolios.[7] Banks will tend to cut off their most risky customers and continue to service their most creditworthy ones. Firms that are denied credit by banks may be unable to borrow from any other lender. Certainly, they will not be able to issue debt in arms-length capital markets; nor will they be able to attract financing from other non-bank sources simply by announcing their willingness to pay a higher rate of interest on the debt, because potential lenders will recognize that only the riskiest firms would be willing to offer a higher rate of return. In the end, these firms are likely to be particularly vulnerable to the monetary contraction.

After a monetary contraction, a larger fraction of total external finance will be provided via arms-length capital markets and a smaller fraction through bank loans. This change in composition may reflect either (or both) of two factors: First, it may reflect increased issuance of trade credit by large, financially secure firms to their smaller, less creditworthy suppliers. An increase in commercial paper borrowing would be used, in effect, to finance the rise in trade credit. Large firms may be willing to act, in effect, as financial intermediaries because they will have accumulated substantial inside information about the financial stability of their suppliers in the course of having interacted with them before the

7. A lower level of reserves will only support a lower level of deposits. The lower level of deposits (which comprise banks' liabilities) implies that assets will have to decline as well. Given that banks view loans and securities as imperfect substitutes, some of that decline in assets will be absorbed in loans.

credit crunch. Alternatively, the increase in the share of commercial paper in total external finance may reflect that large firms tend to expand when their smaller rivals are weakened by financial stringency; the large firms take the opportunity to seize some portion of the product market, financing the larger scale of their operations with the increase in commercial paper issuance.

These two mechanisms show that bank loans and commercial paper can be substitutes at the aggregate level even though not so for any individual firm. Failure to observe firms operating on the margin between bank loans and other market-mediated debt does not constitute evidence against the heterogeneous-firms version of the loans channel.

IMPLICATIONS OF THE ASYMMETRIC-INFORMATION-BASED APPROACH

The informal discussion in the previous section points to two important implications for future research. First, the very motivation of banks specializing in information-intensive lending suggests that further progress probably would flow from the analysis of models that allow for heterogeneous non-bank firms. In particular, it seems likely that most such models will imply that, when the Federal Reserve adopts a more restrictive monetary policy, banks will shrink their loan portfolios by refusing credit to their riskiest (least financially stable) customers. Commercial paper issuance will rise because firms already issuing paper will issue more--either to finance their own expanded operations, or to finance the passthrough of trade credit to their suppliers.[8] By contrast, a representative-firm model suggests that all firms should be on the margin between bank debt and commercial paper, and that when the Federal Reserve tightens we should observe a rebalancing of liabilities taking place at the individual firm level. The implausibility of this account is obvious, given that fewer than 1300 firms in the United States have commercial paper programs rated by Moody's.

8. Firms that are growing in size will, at some point, find it possible to issue commercial paper for the first time. If the profitability of commercial paper issuance is an inverse function of bank-loan availability, establishment of commercial paper programs will tend to be bunched into periods immediately following tightenings of monetary policy. Historically, of course, the commercial paper market was not always as well-developed as it is now; as the market deepened and became more efficient, even firms that had been large and creditworthy for a long time established new programs.

The second implication of the disaggregated approach is that future empirical work should focus on micro-level datasets. Such investigations will be essential for: (1) establishing the identity of bank customers who are denied credit in the wake of a tightening by the Federal Reserve; and (2) establishing the source of the accompanying increase in commercial paper issuance.

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PRICE AND OUTPUT STABILITY UNDER ALTERNATIVE MONETARY POLICY RULES

Joseph E. Gagnon and Ralph W. Tryon[1]

This paper is an empirical study of alternative monetary policy regimes in the United States using stochastic simulation of the MX3 multicountry rational-expectations macro model developed by the staff of the Board of Governors. We focus on the implications of interest rate smoothing and incomplete information for the stability of prices, output, and long-term interest rates when the monetary authority targets nominal income. We also conduct a limited number of simulations with a modified version of our model that incorporates staggered real price contracts in the manner of Fuhrer and Moore (1992). The paper builds on the methods and results of an earlier paper (Gagnon and Tryon (1992)) that examined monetary policy rules using stochastic simulations of the MX3 model.

There are several findings. First, we confirm our earlier result that the variabilities of prices and output are roughly equal whether the monetary authority targets the monetary base or nominal income, and we obtain confidence intervals for this result. Second, we find that interest rate smoothing provides a significant reduction in interest rate variability with almost no increase in the variability of price and output. Third, it appears that random errors in the observation of the target variable may not significantly increase the variability of price and output. Fourth, while staggered real price contracts tend to increase the size and persistence of price and output deviations, they do not lead to different conclusions about the relative effects of nominal income targetting with and without interest rate smoothing. Finally, we find that the variability of the long-term interest rate is much lower than that of the short-term interest rate in all the monetary regimes studied.

1. Division of International Finance, Board of Governors of the Federal Reserve System. We are grateful to Mark Unferth for very capable assistance in running the simulations and preparing the tables.

STOCHASTIC SIMULATION FRAMEWORK

The paper uses stochastic simulations of the MX3 multicountry model to evaluate different monetary policy rules. MX3 is a medium-sized rational-expectations model of the United States, Japan, Germany, and the rest of the world.[2] We analyze the effectiveness of different monetary policy rules in stabilizing the economy. The policy rules are simple feedback relations between the short-term interest rate and deviations of the target variable from its target value. The target value in each case is the baseline path for the target variable; the baseline path is the deterministic solution for the model. The functional form and the parameters of the policy rules are chosen arbitrarily at plausible values, rather than as the solution to an optimization problem.

We simulate the MX3 model for multiple replications of each rule, using random shocks drawn from a joint normal distribution using the estimated covariance matrix of the model residuals for the period 1976-88.[3] The simulation range for each replication is over 20 quarters, from 1989 through 1993. The baseline path is the simulation over the same period without any stochastic shocks, converging toward a steady state. For each replication, we calculate the deviation of each variable of interest, including the (log) levels and growth rates of income, prices, and interest rates, from the baseline values. The root-mean-squared deviation (RMSD) across replications is calculated for each rule; this measure of variability is compared across rules.

Comparison of rules

Using the RMSD to compare different rules implies that the monetary authority's objective is stated in terms of the second moments, rather than the first moments, of the data. The choice of this objective reflects our conviction that the average levels of real economic variables are invariant to any well-specified monetary policy rule in the long run.

2. For a description of the theory and estimation of the model, see Gagnon (1991). We do not believe that any of our results are strongly dependent on the use of a multicountry model rather than a purely domestic model. Nonetheless, it is a property of the model that foreign responses to U.S. shocks can have feedback effects on the United States through the exchange rate and the trade balance.

3. For a description of the historical residuals and their calculation, see Gagnon and Tryon (1992).

Although nominal variables do depend on monetary policy, this study ignores the factors involved in choosing a long-run inflation rate and focuses solely on deviations from the long-run rate.

The use of second moments as measures of economic performance may be rationalized on two grounds. First, fluctuations of variables around their expected values give rise to adjustment costs as agents adapt their behavior to the new conditions. Second, agents may be risk averse, so that their utility is increased when monetary policy succeeds in reducing the variance of an important variable. Of course it is possible that, by reducing the variance of one variable, policy may increase the variance of some other variable. In conducting the analysis it is necessary to consider all of the most important variables. Implicitly or explicitly, policymakers may have to weigh stabilization of one variable against the destabilization of another.

The transition from one policy regime to another is likely to involve significant costs as agents learn gradually about the new regime. It would be of interest to consider the problem of making such a regime shift less costly, but we do not pursue that topic here. The assumption behind all the stochastic simulations in this paper is that the regime shift is understood perfectly by the private sector and is fully credible. Thus, comparisons of economic performance across policy regimes reflect differences in the long-run stochastic behavior of the economy and not the short-run transition costs.

Number of replications

To begin a stochastic simulation, residuals are drawn for one period from a normal distribution with mean zero and the estimated historical variance-covariance matrix. The model is solved in 1989Q1 by using these residuals and the fixed lags and exogenous variables. The future expectations are computed by the Fair-Taylor algorithm. Future residuals are assumed to be zero. The stochastic solution for 1989Q1 is then used for the necessary lags in solving 1989Q2. In solving 1989Q2, a new draw of residuals is taken from their estimated distribution, but future residuals are again assumed to be zero. This process is repeated for twenty quarters, thus completing one stochastic replication over the baseline period. Twenty stochastic replications are conducted for each policy rule, for a total of 400 draws of the residuals.[4]

In order to make more accurate comparisons across policy rules, we repeated the same sequence of stochastic shocks for each rule. Somewhat to our surprise we found that differences in the computed RMSDs across replications for the same rule were two orders of magnitude greater than differences in the RMSDs across policy rules for the same replication. To test whether the RMSD under one rule differed significantly from the RMSD under another rule, we computed the difference between the two RMSDs for each replication. Assuming that these differences are normally distributed, we were able to test the null hypothesis that their mean value is zero, i.e. that there is no difference in the stability of the given variable under either policy rule.

Because of the adjustment lags present in many equations in MX3, the random shocks tend to have persistent effects. Within a given replication, as shocks are drawn in successive periods their effects are combined with the gradually declining effects of earlier shocks. Since each replication begins without the effects of any lagged shocks, the RMSD of most variables increases over the first few years of a replication. In order to focus on the long-run stability of the variables, we computed RMSDs for only the last two years (eight quarters) of each five-year replication.[5]

There were four replications for which we were unable to obtain a solution in at least one period for at least one policy rule. In order to obtain 20 complete replications with identical shocks under all rules, we simulated the model for a total of 24 sets of stochastic shocks. Difficulty in solving the model for a particular set of shocks is clearly not independent of the nature of those shocks. Unusually large shocks are more likely to lead to solution problems. Thus, our results may be biased by the exclusion of those replications that could not be solved under all policy rules.

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4. These replications were conducted with TROLL 13.1 software using the stochastic simulator package. Each replication requires about 40 minutes of processing (CPU) time on an Amdahl 5850.

5. The RMSDs of a few variables continued to increase mildly over the fourth year of the replications, but we did not believe that the increase was strong enough to warrant discarding an additional year of data.

The number of replications run for each rule was determined primarily by limits on available computer time. In order to gauge the significance of our results, we report confidence intervals and t-tests calculated on the assumption that the MX3 model is approximately log-normal. This assumption was tested using 100 replications of a single period stochastic disturbance; the deviations from baseline for all variables of interest were checked for normality using the Jarque-Bera test statistic. We were unable to reject the null hypothesis of normality at the 95% confidence level for all variables except consumption and the real exchange rate.

To economize on computation time, the Fair-Taylor algorithm was allowed only one type-III iteration over a forecast horizon of twenty quarters. The type-II convergence criterion used was 0.02 percent. In most cases type-II convergence was achieved, but sometimes the solution stops at the iteration limit of 100. A series of test solutions indicated that these restrictions allow reasonably accurate results.

MONETARY BASE AND NOMINAL INCOME TARGETTING

We begin with two simple alternatives, monetary base and nominal income targetting:

$$(1) \quad RS_t - RS_t^* = 1.5 \left[\log(MB_t) - \log(MB_t^*)\right]$$

$$(2) \quad RS_t - RS_t^* = 1.5 \left[\log(GDPV_t) - \log(GDPV_t^*)\right]$$

where RS is the short-term interest rate in decimal form at an annual rate; MB is the monetary base; and $GDPV$ is nominal GDP. Asterisks denote target values. In rule (1) the monetary authorities target the monetary base; in rule (2) the monetary authorities target nominal GDP. Unlike in our previous work, in this paper we implement the monetary policy reaction functions only for the United States: in the other regions monetary policy is assumed to hold the monetary base fixed (on its baseline path).

Columns 1 and 2 of Table 1 summarize the results of the stochastic simulations for these rules. The table shows the root-mean-square deviation (RMSD) of each variable from its baseline path over the period 1992:1-1993:4 averaged over the 20 replications. Below each RMSD is a 90 percent confidence interval for the true RMSD based on a sample of 20 independent observations.[6] *PGDP* is the GDP deflator; *CAB* is the current account balance divided by nominal GDP; *RERW* is a weighted real exchange rate; *RL* is the long-term interest rate; *C* is real private consumption; and *MBR* is the monetary base deflated by the consumption deflator.[7] The variables are measured in logarithms, except for the interest rates and the ratio of the current account balance to nominal GDP, which are decimal fractions. We also report statistics for the first differences (quarterly growth rates) of some of these variables. Column 1 of Table 2 shows the mean values of the differences in RMSDs for these two policy rules. An asterisk denotes that the difference is significantly different from zero at the 10 percent level; two asterisks denote significance at the 5 percent level.

The most striking aspect of these results is that the monetary base and nominal income rules are very similar. As expected, the RMSD of nominal GDP is lower with nominal income targetting (by 0.9 percentage points), and the RMSD of the monetary base is lower when it is targetted (by 0.4 percentage points). (The monetary base rule does not require that the money base target be met exactly, so there is partial accomodation of money demand shocks in this case.) In each case the RMSD of real GDP from baseline is about 6 percentage points, while the RMSD in the growth rate of real GDP is around 2 percentage points. The variability of the growth rate is significantly lower for the nominal income rule, but the magnitude of the difference is slight (0.2 percentage points). The variability of the price level and inflation is essentially the same under both regimes. Thus, the reduction in variability of nominal income is not passed through

6. The confidence intervals are computed under the assumption that the deviations of each variable from baseline are normally distributed. For normal deviations the sample variance follows a chi-square distribution. Although the sample contains 160 observations, we allowed for only 20 degrees of freedom in computing our confidence intervals because the deviations within each of the 20 replications were highly autocorrelated. Our intervals are therefore larger than true 90 percent confidence intervals.

7. The discussion of our results focuses on the RMSDs for output, prices, and interest rates. The real exchange rate and the current account balance are presented as macro variables of general interest. Consumption and real money balances are included because they represent an alternative pair of variables that the monetary authority might wish to stabilize. Generally speaking, consumption variability is highly correlated with output variability. The variability of the real monetary base is less easy to characterize.

to its components (real output and prices); instead, this regime effectively exploits offsetting variations in the components to meet the target for nominal income.

There is a significant difference in the variability of the interest rate: under nominal income targetting the RMSD of the short-term interest rate is higher by 117 basis points and the variability of its first difference is 175 basis points higher. This increased variability is passed through to the long-term interest rate and the real exchange rate.

These results are consistent with our earlier findings.[8] A priori, one might expect nominal income targetting to stabilize prices and output better than monetary base targetting, because (log) nominal income is simply an equal-weighted average of the price level and output in logarithms. The similarity of nominal income and monetary base targetting implies that money demand shocks in MX3 are not too large relative to other disturbances. Since money demand in MX3 is roughly proportional to nominal income, and the adjustment lag is relatively short, it is perhaps not surprising that these two rules have similar effects on prices and output.

INTEREST RATE SMOOTHING

An important feature of feedback rules of the form used in (1) and (2) is that they can lead to "instrument instability," i.e., substantial variation in short-term interest rates from one period to the next. This is not necessarily a theoretical problem, since the interest rate need not enter directly into private agents' utility or the monetary authority's objective function. However, excessive interest rate (or exchange rate) volatility is sometimes viewed as undesirable in and of itself. To address this question, we consider a variation of the nominal income rule

8. These results are also robust to changes in the feedback coefficient by a factor of two or three. Gagnon and Tryon (1992) show that increasing the feedback coefficient reduces the RMSD of the target variable and increases the RMSD of the short-term interest rate. A higher feedback coefficient on nominal income does not reduce the RMSD of the price level or output separately.

that smooths fluctuations in the short-term interest rate.[9] The rule is calibrated so that a persistent deviation in nominal GDP will provide the same interest rate response as rule (2) in the long run, but not in the short run:

$$(3) \qquad RS_t - RS_t^* = 0.8 \left[RS_{t-1} - RS_{t-1}^*\right] + (1-0.8)\,1.5 \left[\log(GDPV_t) - \log(GDPV_t^*)\right]$$

The results are shown in column 3 of Table 1 and columns 2 and 3 of Table 2. The addition of interest rate smoothing to the nominal income rule reduces the RMSD of the change in the short-term interest rate by 200 basis points. This reduction is not at the expense of any important increase in volatility in the targets; the RMSD of nominal income rises by only 0.2 percentage points; the changes in the variability of real output and prices are of the same order of magnitude. Nominal income targetting combined with interest rate smoothing produces almost exactly the same results as the monetary base rule, as shown in column 2 of Table 2.

The ability of interest rate smoothing to dampen fluctuations in interest rates without substantial increases in the RMSDs of other variables is noteworthy.[10] We believe that this result is due to two basic properties of the MX3 model. First, adjustment lags are quite large throughout the model, implying that the short-run response of the model to monetary policy is much less than the long-run response. Second, the behavioral equations are forward-looking, so that future monetary policy has a strong impact on current behavior. If the interest smoothing rule is credible, agents believe that a sustained upward shock to nominal income will cause the monetary authority to initiate a series of increases in the short-term interest rate. These expected future increases in the interest

9. Alternatively, this rule could be motivated by a desire to include lagged information in the target. In a model with adjustment lags it is optimal in principle to react to both current and lagged shocks. However, it is infeasible to compute the optimal response pattern to lagged information in a model of this size.

10. This result appears to be robust with respect to the parameters of the smoothing rule. We performed a limited number of trials with different feedback coefficients on the lagged interest rate and nominal GDP; we found that increasing either coefficient always yielded a smaller RMSD of the associated variable at the expense of the other variable. The RMSDs of real output and prices were unaffected in these trials.

rate will dampen current consumption and investment more than if agents were not forward-looking.

OBSERVATION ERRORS

Rules (4) and (5) incorporate observation error into rules (2) and (3). These rules are motivated by the fact that the monetary authority cannot accurately observe current nominal GDP. Many components of nominal GDP are observable contemporaneously, but many others are measured only with a lag. We postulate that the monetary authority uses the contemporaneously available indicators of nominal GDP to make an unbiased estimate of current nominal GDP.[11] The contemporaneous indicators may include--but are not limited to--asset prices, commodity prices, interest rate spreads, and in-house surveys of business activity. The error in estimated nominal GDP is captured by ϵ, which is assumed to be normally distributed with zero mean and no autocorrelation.

$$(4) \qquad RS_t - RS_t^* = 1.5 \left[\log(GDPV_t) + \epsilon_t - \log(GDPV_t^*)\right]$$

$$(5) \qquad RS_t - RS_t^* = 0.8 \left[RS_{t-1} - RS_{t-1}^*\right] + (1-0.8)\, 1.5 \left[\log(GDPV_t) + \epsilon_t - \log(GDPV_t^*)\right]$$

To estimate the magnitude of the monetary authority's observation error, we calculated the difference between the consensus forecast for current quarter nominal GDP growth published in *Blue Chip Economic Indicators* and BEA's final estimate of nominal GDP growth.[12] The standard deviation of the error (in logarithms) is 0.0068, or 2/3 of a percent.

The results are shown in the fourth and fifth columns of Tables 1 and 2. The addition of observation error degrades the ability of the authority to control the target variable, and without interest rate smoothing, the RMSD of nominal income increases by 0.4 percentage points.

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11. We believe that the interaction between the private sector and the monetary authority should be modeled symmetrically: if the private sector can respond simultaneously to innovations in the monetary instrument, then the monetary authority should be allowed to react simultaneously to innovations in private variables. We conjecture that dynamic instability of macroeconomic models under some policy rules may be due specifications that do not allow the monetary authority to respond to *any* contemporaneous information.

12. The forecasts were published at the beginning of the third month of the quarter and were based on information collected and analyzed during the second month. The sample period was 1980:1 through 1988:4.

The RMSD of the short-term interest rate rises by about 70 basis points, and the RMSD of the real exchange rate also rises, by about 1.5 percentage points. However, none of these differences is statistically significant.

With interest rate smoothing, there is virtually no difference between the nominal income rules with and without observation error. This is because with smoothing, the authorities do not respond nearly as much to temporary shocks, and the impact of observation errors is correspondingly reduced. The existence of observation error thus strengthens the case for interest rate smoothing. As in the standard signal extraction problem, the monetary authority's optimal response to an innovation in the target variable is reduced by the presence of noise in the observation. Because the effect of an observation error is much less persistent than the effect of a structural disturbance, a partially delayed response of monetary policy helps to filter out the effect of noise on the policy instrument.

REAL PRICE CONTRACTS

In another paper presented at this conference, Fuhrer and Moore argue that U.S. macroeconomic time series are better modeled with staggered price contracts in *real*, as opposed to *nominal*, terms. In particular, Fuhrer and Moore provide evidence that the U.S. inflation rate is much more persistent in the face of shocks than can be explained by staggered nominal price contracts. We wanted to explore the implications of real price contracts in the MX3 model. We were especially interested to see whether our conclusions about nominal income targetting with and without interest rate smoothing are robust to this alternate specification of the model. The real contracting model is described in equations (6)-(8).

$$(6) \qquad \log(PGDP_t) = \alpha_1\log(X_t) + \alpha_2\log(X_{t-1}) + \alpha_3\log(X_{t-2}) + \alpha_4\log(X_{t-3})$$

$$(7) \qquad \log(V_t) = \alpha_1\log(X_t/PGDP_t) + \alpha_2\log(X_{t-1}/PGDP_{t-1}) + \alpha_3\log(X_{t-2}/PGDP_{t-2}) + \alpha_4\log(X_{t-3}/PGDP_{t-3})$$

$$(8) \qquad \log(X_t/PGDP_t) = \alpha_1\log(V_t) + \alpha_2\log(V_{t+1}) + \alpha_3\log(V_{t+2}) + \alpha_4\log(V_{t+3}) + \gamma\left[\alpha_1\log(CU_t) + \alpha_2\log(CU_{t+1}) + \alpha_3\log(CU_{t+2}) + \alpha_4\log(CU_{t+3})\right]$$

The GDP deflator, *PGDP*, is a geometric average of the contract prices, *X*, that are still in effect in the current period. Equation (6) implies that the longest contract price lasts for four quarters. The coefficients α_1 - α_4 sum to unity and equal the proportion of contracts outstanding that were negotiated at times t, t-1, t-2, and t-3, respectively. V is the average real contract price currently in effect. Equation (8) states that the current real contract price depends on the expected future real contract price as well as the expected future level of capacity utilization, *CU*. The parameter γ reflects the sensitivity of the real contract price to excess demand.

We tried to run stochastic simulations of the model using the coefficient values estimated by Fuhrer and Moore, however, we were unable to complete a single replication with those coefficient values. We were able to complete 20 replications using the coefficients in MX3's nominal price contract equations. The problem appears to be associated with the coefficient γ, which is nearly two orders of magnitude larger in MX3 than in Fuhrer and Moore.

The results are displayed in columns 6 and 7 of Tables 1 and 2. The RMSDs of all variables are larger with real price contracts than with nominal price contracts. Although the difference is sometimes quite large, it is never significant. Because of our uncertainty about the appropriate coefficients to use, we choose not to focus on the effect of real price contracts per se. We are interested, however, in the comparison of policy rules with and without interest rate smoothing when contracts are written in real terms. Because inflation is more persistent with real price contracts, we were concerned that interest rate smoothing might prove to be destabilizing under real contracts even though it is not destabilizing under nominal contracts. Column 7 of Table 2 demonstrates that this concern appears unwarranted. Only the nominal monetary base shows any large increase in variability, and that increase is not statistically significant. Moreover, the RMSD of the real monetary base actually declines. The short-term interest rate exhibits a large and significant decrease in variability under interest rate smoothing, just as it did with nominal price contracts.

LONG-TERM INTEREST RATES

It is of some interest to understand the implications of various monetary policy rules for the behavior of long-term interest rates. If long-term interest rates are determined simply by expectations of future short-term interest rates, we should find that long-term rates are less variable than short-term rates. This conclusion follows from that fact that future shocks are expected to equal zero and that the model is expected to gradually return to baseline in the absence of shocks. In order for long-term rates to be more variable than short-term rates, the model would have to allow for permanent shocks to the inflation rate or to the real interest rate. (Alternatively, we could incorporate an ad hoc risk premium in the long-term interest rate.)

The basic MX3 model includes only a one-period interest rate. For this paper, the model was modified to define a long-term interest rate, modeled as an exponentially declining weighted sum of expected future short-term interest rates:

$$(9) \qquad RL_t = (1-\gamma) \sum_{i=0}^{\infty} \gamma^i \, E_t[RS_{t+i}] = (1-\gamma)\, RS_t + \gamma \, E_t[RL_{t+1}]$$

The weights were chosen to approximate a ten-year bond ($\gamma = 0.975$, at a quarterly rate). The long-term interest rate does not enter into any other equation in the model, and there is no stochastic term in this definition.[13]

The results for the long-term interest rate are shown in the last two rows of both tables. As expected from the experimental design, the variability of the long-term rate is in all cases substantially less than the short-term rate.

CONCLUSIONS

This paper contains three main findings. First, in the MX3 model the variabilities of prices and output are roughly equal whether the monetary authority targets the monetary base or nominal income. Second, interest rate smoothing provides a significant reduction in interest rate variability with almost no increase in the variability of prices and output, and this conclusion is not affected by a modification of the model that increases the persistence of the inflation rate. Third, it appears that random errors in the observation of a nominal income target may not significantly increase the variability of prices and output.

13. The consumption and investment equations depend on the long-term interest rate implicitly as a function of expected future short-term rates.

The result that monetary base and nominal income targetting are broadly equivalent is robust within the framework of our model, but may not be entirely conclusive. A priori, there are reasons to prefer nominal income targetting, because nominal income is closer to the ultimate goals of policy than is the money supply. This paper does not resolve the issue of the optimal target variable(s) for monetary policy, nor does it derive optimal coefficients for the rules considered here. Calculation of optimal rules would be prohibitively expensive with our model, and the conclusions would be particularly sensitive to specification and estimation errors in the model.

We believe that our other two findings are robust to the specification of the model and policy rules. The ability of the monetary authority to smooth interest rates to a significant extent without destabilizing other variables depends mainly on the existence of forward-looking agents and adjustment costs in economic activity. The result that observation error does not significantly affect the outcomes under different rules depends on adjustment lags and on the relatively small size of the observation error. Since we were able to measure the observation error directly, we have a high degree of confidence in our finding that it does not destabilize real output and prices significantly.

1. Summary of Stochastic Simulations of Policy Rules

Root-mean-squared deviation from baseline

Variables	Rule 1: *MB*	Rule 2: *GDPV*	Rule 3: *RS & GDPV*	Rule 4: *GDPV & ε*
GDP	0.0730 (0.058-0.098)	0.074 (0.060-0.100)	0.075 (0.060-0.102)	0.069 (0.055-0.094)
Δ*GDP*	0.022 (0.018-0.030)	0.020 (0.016-0.027)	0.022 (0.017-0.029)	0.021 (0.017-0.028)
PGDP	0.087 (0.069-0.117)	0.086 (0.069-0.117)	0.084 (0.067-0.113)	0.087 (0.069-0.117)
Δ*PGDP*	0.014 (0.011-0.020)	0.014 (0.011-0.019)	0.014 (0.011-0.018)	0.014 (0.011-0.019)
GDPV	0.037 (0.030-0.050)	0.027 (0.021-0.036)	0.029 (0.023-0.039)	0.035 (0.028-0.048)
MB	0.020 (0.016-0.030)	0.023 (0.019-0.032)	0.031 (0.025-0.042)	0.030 (0.024-0.041)
CAB	0.004 (0.003-0.005)	0.003 (0.003-0.005)	0.003 (0.003-0.005)	0.004 (0.003-0.005)
RS	0.030 (0.023-0.040)	0.040 (0.032-0.054)	0.026 (0.020-0.035)	0.053 (0.042-0.071)
Δ*RS*	0.010 (0.008-0.013)	0.028 (0.022-0.038)	0.007 (0.006-0.010)	0.034 (0.027-0.046)
RL	0.004 (0.003-0.006)	0.005 (0.004-0.007)	0.004 (0.003-0.006)	0.007 (0.006-0.010)
Δ*RL*	0.002 (0.001-0.002)	0.002 (0.002-0.003)	0.001 (0.001-0.002)	0.003 (0.003-0.005)
RERW	0.130 (0.103-0.175)	0.130 (0.104-0.177)	0.130 (0.104-0.176)	0.157 (0.125-0.213)
Δ*RERW*	0.058 (0.046-0.079)	0.063 (0.050-0.085)	0.060 (0.048-0.082)	0.072 (0.057-0.097)
C	0.061 (0.049-0.083)	0.062 (0.050-0.084)	0.623 (0.050-0.084)	0.067 (0.054-0.091)
Δ*C*	0.016 (0.012-0.021)	0.015 (0.012-0.021)	0.015 (0.012-0.021)	0.016 (0.013-0.022)
MBR	0.077 (0.061-0.104)	0.087 (0.069-0.118)	0.078 (0.062-0.106)	0.090 (0.072-0.122)
Δ*MBR*	0.013 (0.010-0.018)	0.015 (0.012-0.020)	0.013 (0.011-0.018)	0.016 (0.013-0.022)

1. **Summary of Stochastic Simulations of Policy Rules (cont'd)**

Root-mean-squared deviation from baseline

Variables	Rule 5: *GDPV & RS & ε*	Rule 6: *GDPV & FM*	Rule 7: *GDPV & RS & FM*
GDP	0.075 (0.060-0.101)	0.134 (0.107-0.182)	0.139 (0.111-0.188)
Δ*GDP*	0.022 (0.017-0.029)	0.025 (0.020-0.034)	0.028 (0.022-0.037)
PGDP	0.840 (0.067-0.113)	0.161 (0.128-0.218)	0.156 (0.124-0.211)
Δ*PGDP*	0.014 (0.011-0.018)	0.026 (0.021-0.036)	0.027 (0.021-0.036)
GDPV	0.029 (0.023-0.039)	0.047 (0.038-0.064)	0.063 (0.050-0.085)
MB	0.031 (0.024-0.041)	0.035 (0.028-0.048)	0.058 (0.047-0.079)
CAB	0.003 (0.002-0.005)	0.004 (0.003-0.006)	0.004 (0.003-0.005)
RS	0.025 (0.020-0.034)	0.071 (0.056-0.096)	0.056 (0.045-0.076)
Δ*RS*	0.008 (0.006-0.010)	0.031 (0.025-0.042)	0.013 (0.011-0.018)
RL	0.004 (0.003-0.006)	0.010 (0.008-0.013)	0.010 (0.008-0.013)
Δ*RL*	0.001 (0.001-0.002)	0.003 (0.002-0.004)	0.003 (0.002-0.003)
RERW	0.132 (0.110-0.178)	0.153 (0.122-0.207)	0.164 (0.131-0.222)
Δ*RERW*	0.061 (0.048-0.082)	0.064 (0.051-0.087)	0.062 (0.050-0.084)
C	0.062 (0.049-0.083)	0.101 (0.080-0.136)	0.101 (0.081-0.137)
Δ*C*	0.016 (0.012-0.021)	0.020 (0.016-0.027)	0.021 (0.017-0.028)
MBR	0.076 (0.061-0.104)	0.157 (0.125-0.212)	0.141 (0.112-0.191)
Δ*MBR*	0.013 (0.010-0.018)	0.027 (0.021-0.036)	0.024 (0.019-0.033)

2. Differences in RMSDs across Policy Rules

Variables	Rule 1-Rule 2	Rule 1-Rule 3	Rule 2-Rule 3	Rule 2 - Rule 4
GDP	-0.0011	-0.0022	-0.0011	0.0026
ΔGDP	0.0018*	0.0004	-0.0014*	-0.0006
PGDP	0.0009	0.0029	0.0020	-0.0001
ΔPGDP	0.0004	0.0006	0.0002	-0.0001
GDPV	0.0092	0.0074	-0.0018	-0.0039
MB	-0.0036	-0.0106	-0.0070	-0 0042
CAB	0.0001	0.0001	-0.0001	-0.0002
RS	-0.0117	0.0026	0.0143*	-0.0067
ΔRS	-0.0175**	0.0025	0.0200**	-0.0059
RL	-0.0008	-0.0002	0.0006	-0.0009
ΔRL	-0.0007**	-0.0001	0.0006**	-0.0003
RERW	-0.0016	-0.0005	0.0011	-0.0148
ΔRERW	-0.0049*	-0.0024	0.0026	-0.0057
C	-0.0007	-0.0008	-0.0001	-0.0020
ΔC	0.0003	0.0001	-0.0003	-0.0008
MBR	-0.0086	-0.0001	0.0085	-0.0010
ΔMBR	-0.0017	-0.0002	0.0015	-0.0012

* significant at 10 percent level.
** significant at 5 percent level.

2. Differences in RMSDs across Policy Rules (cont'd)

Variables	Rule 3-Rule 5	Rule 2-Rule 6	Rule 6-Rule 7
GDP	0.0003	-0.0497	-0.0044
ΔGDP	0.0001	-0.0047	-0.0021
PGDP	0.0001	-0.0626	0.0031
ΔPGDP	-0.0000	-0.0104	0.0000
GDPV	-0.0000	-0.0172	-0.0089
MB	0.0003	-0.0093	-0.0213
CAB	0.0000	-0.0008	0.0004
RS	0.0002	-0.0259	0.0171*
ΔRS	-0.0004	-0.0028	0.0182**
RL	0.0002	-0.0035	0.0009
ΔRL	0.0002	-0.0006	0.0005
RERW	-0.0011	-0.0169	-0.0045
ΔRERW	-0.0003	-0.0008	0.0020
C	0.0006	-0.0320	0.0000
ΔC	0.0000	-0.0037	-0.0007
MBR	0.0014	-0.0586	0.0148
ΔMBR	0.0001	-0.0099	0.0024

* significant at 10 percent level.
** significant at 5 percent level.

APPENDIX: Some Detailed Results

Tables A1 through A5 present more detail on the results of our stochastic simulations for a small subset of the policy rules. The top panel of Table A1 shows the sample autocorrelations of the deviations of several variables from their baseline values under nominal income targetting (Rule 2). All of the variables have a high degree of autocorrelation in the levels, but none of them have highly autocorrelated growth rates (first differences). This autocorrelation is due to the presence of adjustment lags in most of the model's equations. The autocorrelation is particularly high for the price level, real money balances, and output.

The bottom panel of Table A1 presents statistics relating to the sample distribution of the deviations. These statistics were computed from 100 replications of a one-quarter solution.[14] Of the variables tested, only the weighted real exchange rate and consumption reject our null hypothesis of normality.

Table A2 displays the RMSDs for each quarter, computed across 20 replications. For the levels of the variables, the RMSDs tend to increase over successive quarters. In most cases the RMSD appears to stabilize after 12 quarters, but there is still some slight increase in the RMSDs for real output and the price level after 12 quarters. For the differences of the variables, the RMSDs appear quite stable over time. The average RMSDs differ from those presented in Table 1 because they were computed using observations from all 20 quarters and 20 replications, rather than the last eight quarters of 20 replications. Table A3 contains the RMSDs for each replication, computed across 20 quarters. This table shows how different the results were for each set of stochastic shocks.

Tables A4 and A5 show that the differences in RMSDs across rules are quite small, despite the large differences in RMSDs across quarters and across replications that are documented in Tables A2 and A3.

14. The model was solved for only one quarter because the persistence of deviations in the model implies that the distribution of a variable in a given quarter is dependent on the number of quarters that have been simulated stochastically prior to the given quarter. Hence, if we had included observations from different quarters we would have been sampling from populations with different distributions. As the number of stochastically simulated quarters increases, the distributions of the observed deviations should approach a stationary distribution.

A1. Properties of Simulated Deviations from Baseline
Rule 2: GDPV

First through Fifth Order Autocorrelation[1]

Variables	1	2	3	4	5
GDP	0.976	0.962	0.966	0.963	0.950
Δ*GDP*	-0.161	0.201	0.094	0.023	0.189
PGDP	0.997	0.991	0.983	0.979	0.979
Δ*PGDP*	0.862	0.704	0.640	0.650	0.723
GDPV	0.618	0.265	0.240	0.315	0.396
MB	0.617	0.062	-0.337	-0.274	-0.409
CAB	0.867	0.721	0.605	0.591	0.487
RS	0.618	0.265	0.240	0.315	0.396
Δ*RS*	0.230	-0.247	0.076	0.130	0.077
RL	0.798	0.708	0.722	0.848	0.730
Δ*RL*	-0.108	-0.076	0.215	-0.399	0.116
RERW	0.775	0.506	0.325	0.504	0.595
Δ*RERW*	0.269	-0.042	-0.059	-0.181	-0.186
C	0.964	0.925	0.943	0.943	0.911
Δ*C*	0.015	-0.125	-0.050	-0.322	-0.042
MBR	0.997	0.992	0.989	0.988	0.986
Δ*MBR*	0.592	0.432	0.346	0.478	0.579

Test of Normality[2]

Variables	Jarque-Bera Test Statistic	P-value	Skewness	Excess Kurtosis
GDP	2.64	(.733)	-.396	-.075
PGDP	2.69	(.740)	-.136	-.756
MB	3.23	(.801)	.410	-.320
RS	2.93	(.769)	-.383	-.342
RL	1.70	(.573)	-.027	-.637
CAB	1.51	(.530)	-.229	-.391
RERW	8.16*	(.983)	.697	.120
C	9.39*	(.991)	-.745	.191
MBR	0.28	(.128)	.114	.120

* Reject normality at 5 percent significance level.

[1] Autocorrelations computed from 20 replications of 20 quarters.

[2] Normality tests based on 100 replications of one quarter.

A2. RMSD by Quarter Across 20 Replications
Rule 1: MA

	89 1	89 2	89 3	89 4	90 1	90 2	90 3	90 4
GDP	0.0179	0.0154	0.0234	0.0375	0.0280	0.0359	0.0442	0.0487
ΔGDP	0.0185	0.0185	0.0167	0.0204	0.0207	0.0192	0.0160	0.0254
PGDP	0.0046	0.0105	0.0195	0.0291	0.0384	0.0455	0.0495	0.0531
ΔPGDP	0.0068	0.0068	0.0101	0.0106	0.0104	0.0095	0.0100	0.0119
GDPV	0.0186	0.0121	0.0181	0.0343	0.0289	0.0265	0.0301	0.0286
MB	0.0037	0.0058	0.0085	0.0125	0.0132	0.0150	0.0137	0.0154
CAB	0.0019	0.0019	0.0021	0.0028	0.0020	0.0020	0.0028	0.0032
RS	0.0055	0.0086	0.0127	0.0188	0.0198	0.0225	0.0206	0.0231
ΔRS	0.0086	0.0086	0.0097	0.0107	0.0086	0.0083	0.0085	0.0110
RL	0.0012	0.0013	0.0019	0.0023	0.0019	0.0015	0.0022	0.0029
ΔRL	0.0014	0.0014	0.0015	0.0017	0.0015	0.0014	0.0019	0.0018
RERW	0.0513	0.0552	0.0870	0.1141	0.1102	0.0921	0.1075	0.1085
ΔRERW	0.0552	0.0552	0.0606	0.0590	0.0642	0.0545	0.0565	0.0698
C	0.0134	0.0123	0.0233	0.0356	0.0338	0.0341	0.0423	0.0449
ΔC	0.0134	0.0134	0.0170	0.0179	0.0145	0.0145	0.0150	0.0183
MBR	0.0071	0.0083	0.0149	0.0222	0.0278	0.0326	0.0396	0.0435
ΔMBR	0.0055	0.0055	0.0094	0.0096	0.0105	0.0095	0.0089	0.0095

	91 1	91 2	91 3	91 4	92 1	92 2	92 3	92 4
GDP	0.0443	0.0536	0.0582	0.0606	0.0666	0.0656	0.0687	0.0671
ΔGDP	0.0235	0.0236	0.0244	0.0194	0.0197	0.0233	0.0208	0.0282
PGDP	0.0577	0.0638	0.0690	0.0736	0.0757	0.0773	0.0793	0.0816
ΔPGDP	0.0125	0.0119	0.0109	0.0104	0.0113	0.0131	0.0144	0.0139
GDPV	0.0314	0.0336	0.0338	0.0313	0.0319	0.0310	0.0353	0.0316
MB	0.0157	0.0173	0.0162	0.0157	0.0151	0.0147	0.0165	0.0198
CAB	0.0035	0.0030	0.0030	0.0024	0.0027	0.0029	0.0030	0.0028
RS	0.0235	0.0260	0.0243	0.0236	0.0226	0.0220	0.0247	0.0297
ΔRS	0.0100	0.0096	0.0075	0.0092	0.0090	0.0103	0.0107	0.0090
RL	0.0025	0.0024	0.0028	0.0026	0.0035	0.0037	0.0043	0.0042
ΔRL	0.0013	0.0017	0.0015	0.0016	0.0017	0.0015	0.0012	0.0014
RERW	0.1312	0.1363	0.1342	0.1449	0.1335	0.1438	0.1200	0.1297
ΔRERW	0.0722	0.0562	0.0586	0.0448	0.0486	0.0509	0.0627	0.0508
C	0.0434	0.0491	0.0529	0.0541	0.0596	0.0580	0.0587	0.0589
ΔC	0.0143	0.0183	0.0190	0.0122	0.0154	0.0126	0.0148	0.0153
MBR	0.0479	0.0545	0.0597	0.0643	0.0684	0.0704	0.0731	0.0736
ΔMBR	0.0104	0.0115	0.0119	0.0079	0.0098	0.0113	0.0133	0.0103

A2. RMSD by Quarter Across 20 Replications (cont'd)
Rule 1: MA

	93 1	93 2	93 3	93 4	Avg
GDP	0.0688	0.0714	0.0819	0.0875	0.0561
Δ*GDP*	0.0142	0.0259	0.0222	0.0181	0.0212
PGDP	0.0847	0.0908	0.0963	0.1032	0.0662
Δ*PGDP*	0.0154	0.0160	0.0138	0.0154	0.0120
GDPV	0.0366	0.0391	0.0417	0.0453	0.0319
MB	0.0209	0.0219	0.0222	0.0231	0.0161
CAB	0.0034	0.0044	0.0045	0.0039	0.0030
RS	0.0314	0.0328	0.0333	0.0347	0.0242
Δ*RS*	0.0085	0.0110	0.0085	0.0112	0.0095
RL	0.0045	0.0038	0.0039	0.0043	0.0031
Δ*RL*	0.0014	0.0020	0.0017	0.0014	0.0016
RERW	0.1340	0.1331	0.1280	0.1044	0.1178
Δ*RERW*	0.0542	0.0678	0.0623	0.0637	0.0588
C	0.0570	0.0563	0.0674	0.0707	0.0490
Δ*C*	0.0145	0.0178	0.0175	0.0155	0.0157
MBR	0.0728	0.0762	0.0839	0.0909	0.0574
Δ*MBR*	0.0138	0.0172	0.0151	0.0137	0.0111

A3. RMSD by Replication Across 20 Quarters
Rule 1: MA

	TR 1	TR 2	TR 3	TR 4	TR 5	TR 6	TR 7	TR 8
GDP	0.0436	0.0302	0.0573	0.0291	0.0490	0.0285	0.1074	0.0314
ΔGDP	0.0173	0.0195	0.0221	0.0163	0.0233	0.0167	0.0194	0.0217
PGDP	0.0694	0.0355	0.0545	0.0470	0.0618	0.0381	0.1342	0.0107
ΔPGDP	0.0081	0.0094	0.0098	0.0120	0.0107	0.0121	0.0117	0.0060
GDPV	0.0347	0.0176	0.0235	0.0316	0.0295	0.0212	0.0358	0.0259
MB	0.0205	0.0115	0.0126	0.0136	0.0106	0.0143	0.0188	0.0077
CAB	0.0034	0.0018	0.0024	0.0018	0.0026	0.0032	0.0019	0.0021
RS	0.0307	0.0172	0.0189	0.0204	0.0159	0.0214	0.0282	0.0115
ΔRS	0.0072	0.0084	0.0096	0.0100	0.0079	0.0081	0.0071	0.0062
RL	0.0028	0.0028	0.0033	0.0017	0.0023	0.0030	0.0026	0.0030
ΔRL	0.0017	0.0016	0.0015	0.0014	0.0015	0.0016	0.0013	0.0019
RERW	0.1824	0.0729	0.0575	0.0835	0.0911	0.0814	0.1150	0.1379
ΔRERW	0.0518	0.0432	0.0471	0.0512	0.0571	0.0552	0.0594	0.0485
C	0.0285	0.0271	0.0526	0.0198	0.0569	0.0326	0.0912	0.0304
ΔC	0.0118	0.0139	0.0149	0.0155	0.0178	0.0136	0.0143	0.0118
MBR	0.0465	0.0338	0.0547	0.0298	0.0641	0.0402	0.1144	0.0168
ΔMBR	0.0087	0.0095	0.0112	0.0097	0.0101	0.0110	0.0114	0.0063

	TR 9	TR 10	TR 11	TR 12	TR 13	TR 14	TR 15	TR 16
GDP	0.0239	0.0538	0.0809	0.0447	0.0614	0.0346	0.0195	0.0606
ΔGDP	0.0244	0.0210	0.0183	0.0192	0.0144	0.0332	0.0224	0.0197
PGDP	0.0375	0.0727	0.0780	0.0404	0.0714	0.0309	0.0275	0.0754
ΔPGDP	0.0112	0.0089	0.0110	0.0129	0.0179	0.0064	0.0108	0.0123
GDPV	0.0401	0.0333	0.0254	0.0310	0.0311	0.0374	0.0248	0.0257
MB	0.0135	0.0093	0.0145	0.0134	0.0173	0.0087	0.0127	0.0179
CAB	0.0050	0.0043	0.0020	0.0033	0.0016	0.0032	0.0020	0.0016
RS	0.0202	0.0140	0.0218	0.0201	0.0260	0.0131	0.0191	0.0268
ΔRS	0.0102	0.0107	0.0083	0.0114	0.0117	0.0091	0.0101	0.0090
RL	0.0022	0.0025	0.0036	0.0027	0.0048	0.0022	0.0022	0.0020
ΔRL	0.0014	0.0018	0.0016	0.0015	0.0016	0.0015	0.0015	0.0013
RERW	0.1354	0.1181	0.1447	0.0761	0.0689	0.2531	0.1003	0.0724
ΔRERW	0.0655	0.0732	0.0633	0.0559	0.0473	0.0794	0.0657	0.0571
C	0.0408	0.0713	0.0631	0.0262	0.0415	0.0311	0.0244	0.0523
ΔC	0.0133	0.0186	0.0131	0.0112	0.0161	0.0184	0.0182	0.0145
MBR	0.0373	0.0755	0.0697	0.0331	0.0591	0.0238	0.0230	0.0634
ΔMBR	0.0110	0.0087	0.0099	0.0080	0.0118	0.0097	0.0106	0.0127

A3. RMSD by Replication Across 20 Quarters (cont'd)
Rule 1: MA

	TR 17	TR 18	TR 19	TR 20	Avg
GDP	0.0258	0.0590	0.0665	0.1033	0.0561
ΔGDP	0.0191	0.0236	0.0277	0.0167	0.0212
PGDP	0.0290	0.0833	0.0701	0.1162	0.0662
ΔPGDP	0.0108	0.0201	0.0164	0.0124	0.0120
GDPV	0.0319	0.0537	0.0243	0.0398	0.0319
MB	0.0137	0.0298	0.0227	0.0217	0.0161
CAB	0.0026	0.0031	0.0052	0.0028	0.0030
RS	0.0206	0.0447	0.0341	0.0326	0.0242
ΔRS	0.0114	0.0127	0.0082	0.0093	0.0095
RL	0.0022	0.0045	0.0029	0.0053	0.0031
ΔRL	0.0016	0.0013	0.0016	0.0017	0.0016
RERW	0.0965	0.0832	0.0910	0.1186	0.1178
ΔRERW	0.0585	0.0741	0.0621	0.0433	0.0588
C	0.0303	0.0479	0.0561	0.0774	0.0490
ΔC	0.0157	0.0211	0.0182	0.0174	0.0157
MBR	0.0190	0.0579	0.0576	0.1046	0.0574
ΔMBR	0.0086	0.0182	0.0164	0.0121	0.0111

A4. Difference in RMSD Between Rules 1 and 2 Across Replications

	89 1	89 2	89 3	89 4	90 1	90 2	90 3	90 4
GDP	0.0024	0.0012	0.0020	0.0044	0.0010	0.0004	0.0014	0.0016
ΔGDP	0.0018	0.0018	0.0025	0.0031	0.0019	0.0018	0.0019	0.0032
PGDP	0.0001	0.0003	0.0003	0.0004	0.0004	0.0003	0.0002	0.0002
ΔPGDP	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0002	0.0004
GDPV	0.0027	0.0023	0.0037	0.0063	0.0052	0.0049	0.0053	0.0058
MB	-0.0079	-0.0088	-0.0114	-0.0170	-0.0095	-0.0074	-0.0105	-0.0083
CAB	0.0002	0.0002	0.0003	0.0006	0.0002	-0.0000	0.0002	0.0003
RS	-0.0184	-0.0060	-0.0089	-0.0232	-0.0158	-0.0099	-0.0165	-0.0111
ΔRS	-0.0132	-0.0132	-0.0121	-0.0179	-0.0207	-0.0156	-0.0152	-0.0235
RL	-0.0007	-0.0004	-0.0007	-0.0013	-0.0008	-0.0005	-0.0008	-0.0011
ΔRL	-0.0008	-0.0008	-0.0008	-0.0007	-0.0010	-0.0007	-0.0007	-0.0011
RERW	-0.0065	-0.0030	-0.0051	-0.0098	-0.0045	-0.0018	-0.0041	-0.0053
ΔRERW	-0.0067	-0.0067	-0.0062	-0.0066	-0.0066	-0.0056	-0.0048	-0.0099
C	0.0006	0.0004	0.0009	0.0020	0.0019	0.0014	0.0012	0.0010
ΔC	0.0003	0.0003	0.0007	0.0011	0.0004	0.0004	0.0006	0.0012
MBR	-0.0022	-0.0037	0.0013	0.0020	0.0009	-0.0010	-0.0011	0.0003
ΔMBR	-0.0006	-0.0006	0.0003	-0.0009	-0.0024	-0.0006	-0.0023	-0.0007

	91 1	91 2	91 3	91 4	92 1	92 2	92 3	92 4
GDP	-0.0002	-0.0001	0.0002	-0.0004	0.0002	-0.0007	-0.0008	-0.0017
ΔGDP	0.0021	0.0026	0.0024	0.0014	0.0020	0.0019	0.0018	0.0026
PGDP	0.0003	0.0004	0.0005	0.0004	0.0001	-0.0002	-0.0002	-0.0000
ΔPGDP	0.0004	0.0004	0.0003	0.0001	0.0003	0.0003	0.0005	0.0005
GDPV	0.0058	0.0071	0.0085	0.0086	0.0084	0.0084	0.0082	0.0077
MB	-0.0059	-0.0049	-0.0098	-0.0068	-0.0052	-0.0040	0.0003	-0.0010
CAB	0.0004	0.0003	0.0004	0.0000	0.0002	0.0001	-0.0002	-0.0000
RS	-0.0148	-0.0138	-0.0136	-0.0104	-0.0127	-0.0119	-0.0160	-0.0062
ΔRS	-0.0221	-0.0208	-0.0245	-0.0153	-0.0157	-0.0198	-0.0206	-0.0204
RL	-0.0008	-0.0010	-0.0012	-0.0007	-0.0008	-0.0006	-0.0009	-0.0005
ΔRL	-0.0008	-0.0009	-0.0008	-0.0006	-0.0006	-0.0005	-0.0005	-0.0010
RERW	-0.0056	-0.0038	-0.0050	-0.0001	0.0005	-0.0004	-0.0007	0.0001
ΔRERW	-0.0044	-0.0085	-0.0078	-0.0052	-0.0063	-0.0050	-0.0043	-0.0054
C	0.0005	-0.0001	0.0000	-0.0002	-0.0002	-0.0004	-0.0008	-0.0011
ΔC	0.0005	0.0008	0.0006	0.0004	0.0005	0.0004	0.0001	0.0005
MBR	-0.0029	-0.0036	-0.0046	-0.0054	-0.0052	-0.0072	-0.0093	-0.0111
ΔMBR	-0.0019	-0.0029	-0.0015	-0.0025	-0.0023	-0.0019	-0.0031	0.0012

A4. Difference in RMSD Between Rules 1 and 2 Across Replications (cont'd)

	93 1	93 2	93 3	93 4	Avg
GDP	-0.0017	-0.0024	-0.0015	-0.0018	-0.0003
ΔGDP	0.0011	0.0022	0.0020	0.0009	0.0021
PGDP	0.0002	0.0006	0.0007	0.0008	0.0003
ΔPGDP	0.0005	0.0004	0.0003	0.0003	0.0003
GDPV	0.0094	0.0115	0.0132	0.0137	0.0077
MB	-0.0014	-0.0046	-0.0062	-0.0070	-0.0066
CAB	0.0002	0.0006	0.0003	0.0003	0.0002
RS	-0.0094	-0.0086	-0.0094	-0.0127	-0.0121
ΔRS	-0.0133	-0.0203	-0.0210	-0.0124	-0.0181
RL	-0.0009	-0.0009	-0.0012	-0.0011	-0.0008
ΔRL	-0.0006	-0.0008	-0.0008	-0.0003	-0.0008
RERW	-0.0006	-0.0025	-0.0049	-0.0036	-0.0031
ΔRERW	-0.0029	-0.0078	-0.0046	-0.0036	-0.0059
C	-0.0011	-0.0016	-0.0015	-0.0015	-0.0002
ΔC	0.0003	0.0005	0.0002	-0.0001	0.0005
MBR	-0.0120	-0.0140	-0.0118	-0.0111	-0.0064
ΔMBR	-0.0019	-0.0007	-0.0018	-0.0033	-0.0016

A5. Difference in RMSD Between Rules 1 and 2 Across Quarters

	TR 1	TR 2	TR 3	TR 4	TR 5	TR 6	TR 7	TR 8
GDP	-0.0034	-0.0008	0.0020	-0.0007	-0.0011	-0.0008	-0.0047	0.0062
ΔGDP	0.0017	0.0021	0.0025	0.0015	0.0027	0.0020	0.0017	0.0020
PGDP	0.0036	0.0001	-0.0012	-0.0012	0.0032	0.0018	0.0001	-0.0007
ΔPGDP	0.0004	0.0004	0.0002	0.0002	0.0006	0.0005	0.0001	0.0003
GDPV	0.0086	0.0029	0.0050	0.0053	0.0078	0.0044	0.0072	0.0091
MB	0.0065	-0.0101	-0.0045	-0.0079	-0.0208	-0.0084	-0.0087	-0.0140
CAB	-0.0003	0.0005	0.0001	-0.0001	0.0008	0.0002	0.0004	0.0000
RS	-0.0085	-0.0049	-0.0087	-0.0191	-0.0166	-0.0038	-0.0147	-0.0138
ΔRS	-0.0160	-0.0185	-0.0186	-0.0118	-0.0220	-0.0137	-0.0168	-0.0195
RL	-0.0008	-0.0004	-0.0008	-0.0010	-0.0005	-0.0005	-0.0004	-0.0009
ΔRL	-0.0005	-0.0008	-0.0007	-0.0007	-0.0008	-0.0009	-0.0006	-0.0007
RERW	-0.0044	-0.0026	-0.0045	-0.0080	0.0002	-0.0033	-0.0031	-0.0038
ΔRERW	-0.0044	-0.0053	-0.0053	-0.0047	-0.0079	-0.0055	-0.0038	-0.0034
C	-0.0018	-0.0006	0.0009	0.0004	-0.0012	0.0000	-0.0015	0.0034
ΔC	0.0005	0.0002	0.0006	0.0004	0.0008	0.0003	0.0006	0.0005
MBR	-0.0128	-0.0077	0.0021	-0.0169	0.0019	0.0007	-0.0117	0.0044
ΔMBR	-0.0006	-0.0006	-0.0026	-0.0059	-0.0039	-0.0015	-0.0025	-0.0005

	TR 9	TR 10	TR 11	TR 12	TR 13	TR 14	TR 15	TR 16
GDP	0.0014	-0.0055	0.0027	0.0035	0.0000	0.0033	0.0001	-0.0026
ΔGDP	0.0025	0.0022	0.0010	0.0018	0.0007	0.0040	0.0028	0.0014
PGDP	0.0054	0.0052	-0.0006	0.0001	-0.0052	0.0044	0.0006	0.0002
ΔPGDP	0.0007	0.0005	0.0002	0.0006	0.0005	0.0003	0.0003	0.0002
GDPV	0.0142	0.0115	0.0053	0.0074	0.0053	0.0085	0.0048	0.0044
MB	-0.0047	-0.0199	0.0038	-0.0114	-0.0046	-0.0118	-0.0011	-0.0020
CAB	0.0005	0.0006	-0.0001	0.0005	-0.0004	0.0005	0.0002	0.0002
RS	-0.0186	-0.0187	-0.0085	-0.0152	-0.0128	-0.0303	-0.0109	-0.0052
ΔRS	-0.0221	-0.0176	-0.0146	-0.0184	-0.0115	-0.0360	-0.0215	-0.0152
RL	-0.0014	-0.0002	-0.0007	-0.0010	-0.0010	-0.0014	-0.0009	-0.0007
ΔRL	-0.0008	-0.0007	-0.0004	-0.0009	-0.0004	-0.0014	-0.0010	-0.0006
RERW	0.0045	-0.0007	0.0034	-0.0051	-0.0075	-0.0076	-0.0046	-0.0014
ΔRERW	-0.0062	-0.0052	-0.0040	-0.0067	-0.0052	-0.0116	-0.0087	-0.0019
C	-0.0029	-0.0030	0.0014	0.0015	-0.0001	0.0022	-0.0001	-0.0012
ΔC	0.0006	0.0005	0.0003	0.0001	0.0003	0.0014	0.0006	0.0002
MBR	-0.0081	-0.0088	0.0031	0.0047	-0.0232	-0.0035	-0.0052	-0.0011
ΔMBR	-0.0035	-0.0019	0.0002	-0.0048	-0.0027	-0.0008	-0.0007	-0.0022

A5. Difference in RMSD Between Rules 1 and 2 Across Quarters (cont'd)

	TR 17	TR 18	TR 19	TR 20	Avg
GDP	0.0025	0.0001	0.0027	-0.0014	-0.0003
Δ*GDP*	0.0019	0.0011	0.0027	0.0014	0.0021
PGDP	0.0014	0.0034	-0.0021	-0.0037	0.0003
Δ*PGDP*	0.0001	0.0005	-0.0004	0.0002	0.0003
GDPV	0.0083	0.0176	0.0006	0.0080	0.0077
MB	0.0008	-0.0033	-0.0133	0.0080	-0.0066
CAB	0.0003	0.0002	0.0004	-0.0002	0.0002
RS	-0.0148	-0.0095	-0.0016	-0.0151	-0.0121
Δ*RS*	-0.0144	-0.0131	-0.0242	-0.0089	-0.0181
RL	-0.0010	-0.0014	-0.0003	-0.0012	-0.0008
Δ*RL*	-0.0008	-0.0005	-0.0011	-0.0006	-0.0008
RERW	-0.0051	-0.0075	-0.0025	-0.0029	-0.0031
Δ*RERW*	-0.0061	-0.0071	-0.0083	-0.0048	-0.0059
C	0.0028	0.0001	0.0012	-0.0002	-0.0002
Δ*C*	0.0007	0.0002	0.0008	0.0006	0.0005
MBR	-0.0117	-0.0084	0.0143	-0.0207	-0.0064
Δ*MBR*	0.0003	-0.0003	0.0032	-0.0013	-0.0016

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COMMENTS ON PRICE AND OUTPUT STABILITY UNDER ALTERNATIVE MONETARY POLICY RULES

Satyajit Chatterjee[1]

The goal of this paper is to use a medium sized econometric model of the U.S., West Germany, and Japan, to evaluate the performance of the U.S. economy under alternative monetary policy rules. This model has been developed by the first author and discussed in detail in Gagnon (1991). Two key aspects of the model are that expectation formation is forward looking and approximately rational (in the sense that it approximately corresponds to the predictions of the model) and that the long run properties of the model match those of a standard real neoclassical growth model.

These features make the model attractive for monetary policy analysis. Adherence to rational expectations means that the policy analysis exercise is immune from the Lucas critique. The fact that the long run properties of the model are those of a real neoclassical growth model means that the short run dynamics (for which monetary factors matter) do not extrapolate into bizarre long run behavior. In addition, the behavioral equations of the model, while not grounded in explicit optimization, are carefully motivated. The reader gets a sense of the kind of structure (in terms of preferences, technology and market opportunities) that would generate these decision rules. In what follows I will not comment any further on the structure of the model.

What I will focus on instead are the different monetary policy rules considered in the paper and the manner in which they

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are evaluated. Let me begin with the latter point. The authors "evaluate" policy rules in terms of their effect on output, price and interest rate variability. The presumption is that a rule that generates more variability is inferior to one that generates less. However, a more appealing way to evaluate policy rules is to determine how they affect the variability of utility. From the discussion in Gagnon (1991), it would appear that the authors have in mind a situation where consumption goods and real money balances are the only arguments in people's utility function. Therefore, it is the variability in these quantities that ought to matter. Indeed, since the authors actually estimate the parameters of the utility function they can evaluate the different policy rules directly in terms of expected utility. My sense is that the ranking of rules would be significantly affected by this choice of metric. In particular, rules that smooth interest rates might generate greater variability in real money balances and hence be less desirable.

I turn now to the different policy rules evaluated in the paper. Presumably, the ultimate object of interest here is the character of the optimal monetary policy rule given the structure of the model. However, due to its complexity it is computationally infeasible (but not impossible) to calculate the optimal policy rule for a given criterion function. Instead, the authors provide us with the operating characteristics for a collection of reasonable looking rules. While this is understandable, we are left nevertheless with an uncomfortable imbalance in the paper: while a lot of care has gone into modelling individual decision rules as resembling the result of some sort of optimization exercise, no attempt is made to model the monetary policy rule as resembling the result of some sort of an optimization exercise on part of the monetary authority.

Consequently, I find it difficult to get interested in the operating characteristics of the economy under any of these rules.

What could be done to alleviate this problem? One possibility, which I find personally attractive is to pose the optimal monetary policy question in a model for which it is computationally feasible to obtain an answer. I am thinking about fairly abstract general equilibrium monetary models like the representative agent cash-in-advance models of the type popularized by Lucas (Lucas (1984), Lucas and Stokey (1987)). Recently, researchers (Cooley and Hansen (1989)) have used calibrated versions of this model to obtain answers to question like: what happens to the operating characteristics of the economy if the monetary growth rate is raised from 3% to 6%? It is not too difficult to extend this kind of analysis to compute optimal feedback rules. We would then have a numerical candidate rule which we know to be optimal for a simpler economy. It would then be of interest to see how this rule performs when it is used in an econometric model of the kind that the authors have estimated and which incorporates real world frictions absent from the simpler model.

To summarize, I find the model estimated by the authors to be reasonable and certainly worth taking seriously. My sole concern has to do with the manner in which the model is used. I would liked to have seen different policies ranked according to expected utility (or failing that, at least in terms of variability of consumption and real money balances). I would also liked to have seen some attempt at studying the operating characteristics of an approximately optimal monetary policy rule.

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MONETARY POLICY EXPERIMENTS
IN A STOCHASTIC OVERLAPPING GENERATIONS MODEL
OF THE TERM STRUCTURE

Steven Russell[1]

In recent years economists have begun to experiment with the construction of dynamic, stochastic general equilibrium models designed to confront the data provided by macroeconomic time series -- models that can explain, or help explain, the relationships between and within various series that constitute the "stylized facts" of the business cycle. The exercise of data confrontation seems to take place in two steps. First, an investigator specifies a model, and chooses its parameters in a way that seems empirically plausible. This step is sometimes called "calibration." Next, the model is simulated, and the properties of the artificial time series it generates are compared to those of actual time series data, paying special attention to the particular stylized facts emphasized by the investigator. In practice there is usually some (and often a great deal of) interaction between first and second steps: parameter values are very often chosen with an eye towards producing artificial data with the desired properties.

The model of choice for these sorts of exercises has been the representative agent, infinite-horizon capital accumulation model, augmented by positing stochastic variation in technological productivity. The augmented model has become known as the "real business cycle" (RBC) model. RBC modeling has provided valuable insights into the nature

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and sources of the business cycle, and is clearly a growth industry among macroeconomists.

One common criticism of RBC models is that they emphasize real sources of cyclical variation at the expense of sources that are monetary in nature. Some RBC modelers have attempted to respond to this criticism by introducing money into the model and examining the effects of various assumptions about monetary policy. Unfortunately, the model does not seem well suited to this purpose. Since it is devoid of the sorts of exchange frictions that are necessary to provide a "natural" role for money, money demand must be induced via *ad hoc* devices such as placing real balances in the utility function or imposing cash-in-advance constraints. One characteristic finding is that monetary policy is entirely neutral in the long run, and relatively ineffectual even in the short run. Results of this sort have led critics to allege that RBC practitioners introduce money into their models only in order to demonstrate its unimportance.

One problem with "monetary" RBC models that has attracted a good deal of attention has been their inability to produce liquidity effects -- their inability, that is, to generate nominal interest rates that decline in response to monetary injections. Recently, investigators such as Fuerst (1992) and Christiano and Eichenbaum (1992) have succeeded in constructing RBC models that produce liquidity effects. While this is certainly a very interesting development, a skeptic might view the scope and intricacy of the assumptions these investigators must make in order to achieve such effects as a testament to the limitations of the RBC model as a framework for monetary analysis.

The most popular dynamic general equilibrium alternative to the representative-agent, infinite horizon model is the overlapping generations (OLG) model. The OLG model has been, and for the most part remains, the model of choice for theorists interested in monetary issues. However, OLG modelers have rarely attempted to confront business cycle data in anything like the sense that RBC modelers attempt to do so. The principal reason for this is probably the "time horizon question." RBC models can be calibrated, by appropriate choice of the representative agent's rate of time preference, so that a "period" seems to represent an interval of a quarter or a year, and in particular so that business-cycle-like variation occurs over intervals that are short relative to the decision horizon of the agent. This cannot be done with conventional OLG models, since the agents that populate them live for only two or three periods.

The relative length of agents' decision horizons may not be the only (or best) criterion according to which the empirical plausibility of a model can be evaluated, however. Another criterion is whether the model is flexible enough to capture the features of the economy that most economists consider critical to understanding the phenomena under study. When this criterion is applied, overlapping generations models compare quite favorably to RBC models. The generational heterogeneity of the population of agents creates the potential for an active money market, and active primary and secondary markets for government securities -- active in the sense that the agents in the model actually trade these objects with other agents. In addition, it is relatively easy to introduce the sorts of intragenerational heterogeneity necessary to produce active private credit markets. In OLG models, monetary injections can easily take the form of open market purchases, rather than the "helicopter drops" favored by RBC modelers. Partly as a result, it is relatively easy to use these models to analyze the interaction between fiscal and monetary policy: indeed, realistic descriptions of open market operations virtually require explicit consideration of this interaction.

Perhaps the most important difference between OLG and RBC models is that the former provide a natural role for outside money, as a device to facilitate intergenerational exchange. As a result, in OLG models monetary policy need be neutral in neither the long nor the short run. In particular, it is relatively easy to construct OLG models in which monetary injections (open market purchases, etc.) tend to reduce both real and nominal interest rates, despite their tendency to lead to expectations of future inflation.

This paper attempts to take a small step in the direction of producing "calibrated" overlapping generations models of the role of monetary policy in the business cycle. Although we will not attempt to choose parameter values in the fairly rigorous manner employed in most RBC studies, we will choose them in a way that makes them appear generally plausible, and suggests that more rigorous calibration would be feasible. Similarly, while we will not attempt to duplicate any carefully-specified set of "stylized facts," the experiments we conduct produce levels and degrees of volatility in variables of interest (particularly nominal and real interest rates, and rates of inflation) that lie within ranges we think most readers will regard as reasonable. These results suggest that more rigorous attempts at stylized fact duplication are possible.

This paper has been prepared for the Federal Reserve System Special Meeting on Operating Procedures (June 18-19, 1992), and, in particular, in response to a request for papers examining the impact of different monetary policy rules on the level and volatility of short- and long-term interest rates in a dynamic rational expectations model of the term structure. For this reason, we attempt to identify and report the results of policy experiments that seem consistent with various operating procedures (or perhaps more accurately, targeting procedures) that have frequently been proposed -- experiments that produce reductions in the cyclical variability of nominal interest rates, or real interest rates, or money\credit aggregates (narrow or broad), etc. We also provide a model that is capable of generating and pricing government (and private) bonds with a number of different terms, and that generates considerable cyclical variation in the level and slope of the yield curve. The extent of this variation, it turns out, can be influenced by both monetary and Treasury policy. (Treasury policy, in this model, involves permanent or cyclical changes in the maturity composition of government debt.)

A DETERMINISTIC MODEL

The stochastic model presented in this paper is based on a deterministic model. The latter is a modified version of a model used by Wallace (1984) to study the welfare effects of monetary policy. A description of the underlying deterministic model may help make the presentation of the stochastic model easier to follow.

The deterministic model is peopled by two-period-lived overlapping generations of agents. Each generation consists of two groups of agents, the "savers" and the "borrowers." Every saver is identical to every other saver of his generation, and of all previous and subsequent generations; the same is true of every borrower. The number of members of each group within a generation is equal, and grows at gross rate n from one generation to the next. For simplicity of exposition we will proceed under the assumption that there is a single representative agent belonging to each group. The representative saver is endowed with ω_1 units of the single consumption good during the first period of his life, and has no endowment in the second period. A lump sum tax of τ_1 units of the good is collected from him in his first period. The representative borrower is endowed with ω_2 units of the good in the second period of his life, and nothing in the first. A lump sum tax of τ_2 units of the good is collected from him in his second period. Both the saver and the borrower have preferences representable by the utility function $U(c_1,c_2) = \log(c_1) + \log(c_2)$, where c_1 represents first-period consumption of the good, and c_2 second-period consumption.

Savers may save by lending part of their consumption endowment to the government, or private borrowers, or by purchasing government currency. The gross real interest rate on loans is denoted R. Savers are required to hold reserves of real government currency balances equal, at minimum, to a fraction λ of their real lending. The government issues two types of currency: Treasury currency and Federal Reserve currency. The two varieties of currency are indistinguishable to private agents, and holdings of either type will satisfy the reserve requirements. The gross rate of return on government currency is denoted R_m.

The notion of Treasury currency requires some explanation. One could imagine monetary arrangements under which the Treasury issued currency directly to finance transfer payments, or purchases of goods and services. (This was essentially the situation in the U.S. during the latter part of the nineteenth century.) Currency issues with the former purpose correspond to the monetary injections studied in most monetary RBC models, while issues with the latter purpose correspond to the injections studied in most OLG models. The Federal Reserve System, however, issues currency [base money] in purchase of assets -- in recent times, principally U.S. Treasury securities. Of course, if the Treasury issues these securities with the understanding (explicit or implicit) that the Fed will purchase them and refund the interest, this is no different from direct issuance of currency by the Treasury. If this is not the case, and the Treasury backs obligations purchased by the Fed in the same way that it backs its other obligations, the Fed should be thought of as issuing inside rather than outside money -- that is, as engaging in financial intermediation of a sort that could conceivably be conducted by private financial institutions, were private note issue not prohibited.

In this model it makes a considerable difference whether a Fed open market purchase results in the acquisition of an unbacked Treasury obligation (issuance of "Treasury currency") or of a fully-backed obligation (issuance of "Federal Reserve currency"). To see why, consider the model of Wallace (1984) in which all base money is outside [Treasury] currency, and all Treasury debt is entirely unbacked. Since the real stock of base money is fixed by the reserve requirement, an "open market purchase" (an increase in the ratio of base money to bonds) cannot be achieved by increasing this stock. Instead it is achieved, in equilibrium, by a reduction in the real value of the stock of government debt. The impact of this change in the debt value on the government's budget constraint leads to the changes in real interest rates that open market operations produce in the model.

In this model, by contrast, the real stock of government debt is held fixed, and the bulk of this debt is backed by future taxes. An "open market purchase" (an increase in F, or equivalently β -- see below) increases both the fraction of the government debt that is held by the

Federal Reserve System and, since the total real stock of base money remains fixed, the fraction of this stock that consists of Federal Reserve currency. As a result, some real balances that previously consisted of outside currency, and represented *inter*generational exchanges, now consist of inside currency, and represent *intra*generational (credit) exchanges. This adds to the supply of credit available to private borrowers, and puts downward pressure on the real interest rate, for reasons that are essentially nonbudgetary.

The government in this model borrows by issuing bonds that entitle the purchaser to one unit of the consumption good one period in the future. The real market value of the stock of bonds outstanding at any date t is $B = d\mathcal{B}$, where $\mathcal{B}$ is the real face value of the bonds and d is their unit price, which is equal to R_m/R. The nominal face value of the bonds is the value $\underline{\mathcal{B}}$ solving $\mathcal{B} = p(t)\underline{\mathcal{B}}$, where p(t) is the goods price of a unit of government currency at date t.

If the reserve requirement is binding, the budget constraints of a saver are

$$c_1^s + q^s = \omega_1 - \tau_1, \qquad c_2^s = R_d q^s,$$

where $q^s = m^s + b^s$, with $m^s = \lambda q^s$ and $b^s = (1-\lambda)q^s$, and

$$R_d = (1-\lambda)R + \lambda R_m \ . \tag{1}$$

The variables m^s and b^s denote the saver's holdings of real balances and his real lending, respectively. The solution to his utility maximization problem involves first-period consumption demand of $c_1^{s*} = (\omega_1 - \tau_1)/2$, and first-period savings or asset demand of $S(\tau_1) \equiv (\omega_1-\tau_1)/2$, regardless of the value of R_d.

The budget contraints of a borrower are

$$c_1^b + b^b = \omega_1-\tau_1, \qquad c_2^b = (\omega_2-\tau_2) + Rb^b,$$

where b^b represents his real borrowing, and is presumably negative. (It is assumed, innocuously, that borrowers do not hold government currency.). The solution to this optimization problem involves first-period consumption demand of $c_1^{b*} = (\omega_2-\tau_2)/(2R)$, and first-period loan demand of $D(R,\tau_2) \equiv -(\omega_2-\tau_2)/(2R)$.

The government must finance a per capita (actually, per saver or borrower) real expenditure of g each period. At dates $t\geq2$, the government's budget constraint is

$$(2) \qquad g-\tau_1 = (1-R_m/n)M + (1-R/n)B + (R-R_m)F/n + \tau_2/n ,$$

where M and F represents per capita real balances of Treasury and Federal Reserve currency, respectively, and B represents the per capita real market value of the government's debt.

It is assumed that the government issues real debt at date 1 with a market value exactly equal to its date 1 deficit $g-\tau_1$, and maintains that stock of debt at a constant level thereafter. (The market value of the nominal balances of the initial old is consequently M.) It is also assumed that at dates $t\geq2$ the government earns per capita seigniorage revenues equal to a fraction δ of per capita government expenditures. That is,

$$(3) \qquad \delta g = (1-R_m/n)M + (R-R_m)F/n .$$

In equilibrium we must have $M = m^S - F$ and $B = S + D - M$. The values of τ_1 and F (or equivalently, $\beta \equiv F/\lambda S$) are taken as parameters. This leaves five unknowns R, R_m, R_d, τ_2, and M to be determined from equations (1)-(3) and

$$M + F = \lambda S(\tau_1) \quad , \tag{4}$$

$$(1-\lambda)S(\tau_1) + D(R,\tau_2) = B - F \ . \tag{5}$$

As we noted above, since F represents the fraction of the stock of base money that intermediates government debt, it seems reasonable to think of an increase in F (or β) as an open market purchase. This model can be specified so that such an increase has the effects conventionally attributed to an open market purchase: a decline in the real and nominal interest rates, and an increase in the inflation rate. An example of such a specification is $n = 1.025$; $\omega_1 = 1.534$, $\omega_2 = 1$; $\lambda = 0.1$; $g = \gamma(\omega_1+\omega_2)$, with $\gamma = 0.175$; $\tau_1 = \omega_1 g/(\omega_1+\omega_2)$; $\delta = 0.01$; and $\beta = 0.16$. This specification produces a real interest rate of (approximately) 2.06 percent, a nominal rate of 7.16 percent, and an inflation rate of 4.99 percent. If β is increased to 0.175, the real interest rate drops to 1.87 percent, the nominal rate falls to 7.00 percent, and the inflation rate rises to 5.04 percent.

A serious attempt to calibrate this model would require working with a more general preference/endowment structure, and would greatly increase the computational complexity of the stochastic model presented in the next section. Given the preliminary nature of this investigation, and the author's inexperience in working with computable models, attempting to do this seemed unwise.

The simple structure used here restricts the range of parameter choices which produce solutions that look empirically plausible. The actual choices do not seem too unreasonable, however. The value of population growth rate parameter n was chosen to approximate the trend rate of output growth during the last quarter-century or so. The ratio of ω_1 to ω_2 was chosen to produce a real interest rate of approximately 2 percent, the average ex-post real rate on one-year Treasury bills during the past twenty-five years. The choice of γ is close to the current share of government purchases in GDP, which is about 19 percent.

The choice of λ conforms to the current reserve ratio on transactions deposits, and may seem high given that in this model reserves must be held against liabilities of all types. Currently, reserves account for approximately 25 percent of total base money; in the model, however, all base money takes the form of reserves. In this context the 10 percent reserve ratio can be thought of as a compromise choice, and one that permits reserve requirements to serve as a partial proxy for other sources of money demand that are not explicitly modelled. It produces a reserves\base-to-GDP ratio of approximately 0.025 -- roughly 60 percent higher than the current reserves-to-GDP ratio, and roughly 60 percent lower than the current base-to-GDP ratio.

The choice of λ necessitates a choice for δ (the seigniorage share of government purchases) of 1 percent, in order to produce an inflation rate of approximately 5 percent. Since the base-to-GDP ratio produced by this specification of the model is about 40 percent of the current ratio, it should come as no surprise that this value of the seigniorage share is about 40 percent of the current share. While choosing $\lambda = 0.25$ would permit the model to hit both the current base-to-GDP ratio and the current seigniorage share (given an appropriate adjustment in β), this reserve ratio seems implausibly large. It also produces some significant quantitative (though not qualitative) differences in the properties of the stochastic model presented below.

On balance, it seems likely that choosing assumptions about money demand that are truly empirically plausible will prove to be almost as big a problem in models of this sort as it is in RBC models.

While the results of policy experiments like the one described on the previous page are certainly quite interesting, most economists probably would not regard them as providing reliable guidance concerning the actual effects of changes in monetary policy. Policy changes of the type described in the preceding paragraph above are entirely unanticipated by the agents. Using this model to study the impact of such changes seems inconsistent with the assumption that the agents have perfect foresight. In the "real world" (wherever it may be), moreover, most changes in policy are to at least some extent anticipated. In addition, the changes in policy that can be studied in this model are permanent in nature, while most real-world monetary policy changes seem to be temporary adjustments inspired by the current state of the business cycle.

The following section describes a stochastic generalization of this deterministic model. In the generalized model changes in open market policy will represent the results of draws from a distribution of policy choices that is known to the agents. These policy changes will be explicitly temporary in nature, and will be interpreted as responses to cyclical changes in real variables. The generalized model will also permit the government to issue multiple-period bonds, and to specify the maturity composition of its debt.

A STOCHASTIC MODEL

The principal difference between the model presented in this section and its deterministic predecessor is that in the new model there is stochastic variation in borrowers' endowments. The endowments vary according to a three-state Markov process. The endowment in state i is denoted ω_{2i}, $i = 1,2,3$. It is assumed that $\omega_{21} > \omega_{22} > \omega_{23}$. (State 3 will be thought of as the "recession state.") The probability that next period's state will be j, given that the current state is i, is denoted f_{ji}. For purposes of simplicity it is assumed that $f_{13} = f_{31} = 0$. The matrix of transition probabilities can be used to compute the unconditional probability that state i will arise at an arbitrarily-selected date: this probability is denoted p_i, $i = 1,2,3$. It is assumed that $\sum_{i=1}^{3} p_i \omega_{2i} = \omega_{22}$.

The taxes levied by the government may also vary cyclically. The tax levied on savers during the current period, when the current state is i, is denoted τ_{1i}, $i = 1,2,3$. It is assumed that $\tau_{11} > \tau_{12} > \tau_{13}$, and that $\sum_{i=1}^{3} p_i \tau_{1i} = \tau_{12}$. The tax to be levied on borrowers during the *next* period, given that the *current* state is i, is denoted τ_{2i}, $i = 1,2,3$.

The government borrows by issuing consumption bonds with terms of 1 through K periods. The price of a bond that returns one unit of the consumption good k periods in the future, given that the current state is i, is denoted d_{ki}. (We are looking for equilibria in which the bond price depends on the current date only through the current state.) This could be the price of a newly-issued bond that matures in k periods, or that of a bond issued during a previous period that has k periods left to run. Private agents may borrow or lend by issuing or purchasing similar consumption bonds. (If an agent issues a multiple-term bond during his first period, he must induce another agent to assume his obligation during his second period.) If we let b^s_{ki} denote the quantity of k-period bonds held by the representative saver when the current state is i, and b^b_{ki} the quantity of bonds held by the representative borrower, the quantity issued by the government is $b_{ki} = b^s_{ki}-b^b_{ki}$.

As in the deterministic model, the government imposes a required reserve ratio of λ on private savings. When the reserve requirement is binding, savers' state i real balances of government currency, which is denoted $cash_i$, is given by

$$(6) \qquad cash_i = \lambda(\omega_{1i}-c^s_{1i}-\tau_{1i}) , \quad i = 1,2,3.$$

[Here c^s_{1i} represents the first-period consumption of a saver born in state i -- see below.] The real stock of currency, $cash_i$, consists of Treasury currency, which is denoted m_i, and Federal Reserve currency, which is denoted fed_i. The realized gross rate of return on government currency in state i, given that the previous state was j, is denoted r_{ij}.

Monetary policy consists of the selection by the monetary authority of β_i, the ratio of Federal Reserve currency to total government currency. It will be assumed that $\sum_{i=1}^{3} p_i\beta_i = \beta_2$, so that increases (or decreases) in this ratio during state 3 are matched by decreases (or increases) in state 1.

For purposes of computational tractability, it will be assumed that agents can purchase or issue contingent consumption claims. The price of a claim to a unit of the consumption good should state j arise next period, given that the current state is i, is denoted s_{ji}. The quantity of such claims purchased (or issued) by a saver is denoted

q^s_{ji}, and by a borrower q^b_{ji}. We will look for equilibria in which these claims are not actually traded (in which $q^s_{ji} = q^b_{ji} = 0$ for all i,j).

The budget constraints of savers are

$$(7) \qquad c^s_{1i} + cash_i + \sum_{k=1}^{K} d_{ki} b^s_{ki} + \sum_j s_{ji} q^s_{ji} = \omega_1 - \tau_{1i} ,$$

$$(8) \qquad c^s_{2ji} = r_{ji} cash_i + \sum_{k=1}^{K} d_{(k-1)j} b^s_{ki} + q^s_{ji} ,$$

j = 1,2 if i = 1, j = 1,2,3 if i = 2, j = 2,3 if i = 3.

It is readily seen, by combining the budget constraints, that if savers' holdings of bonds are to be nonzero at all maturities, we must have

$$(9) \qquad d_{1i} = \sum_j s_{ji} , \quad d_{ki} = \sum_j s_{ji} d_{(k-1)i} ,$$

j = 1,2 if i = 1, j = 1,2,3 if i = 2, j = 2,3 if i = 3, k = 2,...,K.

Substituting equations (8) into equation (7), and imposing equations (6) and (9), yields savers' combined budget constraints

$$c^s_{1i} + \sum_j \hat{s}_{ji} c^s_{2ij} = \omega_1 - \tau_{1i} ,$$

$$\text{where} \quad \hat{s}_{ji} = 1 - \lambda [1 - \sum_j r_{ji} s_{ji}],$$

j = 1,2 if i = 1, j = 1,2,3 if i = 2, j = 2,3 if i = 3.

The budget constraints of borrowers are

$$(10) \qquad c^b_{1i} + \sum_{k=1}^{m} d_{ki} b^b_{ki} + \sum_j s_{ji} q^b_{ji} = 0 ,$$

$$(11) \qquad c^b_{2ji} = (\omega_{2i} - \tau_{2i}) + \sum_{k=1}^{m} d_{(k-1)j} b^b_{ki} + q^b_{ji} .$$

$j = 1,2$ and $m = 2$ if $i = 1$, $j = 1,2,3$ and $m = 3$ if $i = 2$,
$j = 2,3$ and $m = 2$ if $i = 3$.

[Note that we are assuming (innocuously) that borrowers in state i do not issue or hold bonds with terms in excess of m, where $m = 2$ if $i = 1$ or 3, and $m = 3$ if $i = 2$.] Performing analogous substitutions and impositions yields borrowers' combined constraints

$$c^b_{1i} + \sum_j s_{ji} c^b_{2ij} = (\omega_{2i} - \tau_{2i}) \sum_j s_{ji} ,$$

$j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$.

Borrowers and savers in state i have preferences representable by the expected utilility function

$$E\{U(c_{1i}, c_{2ji})\} = \log(c_{1i}) + \sum_j f_{ji} \log(c_{2ji}) ,$$

$j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$.

Their consumption demand functions are consequently given by

Savers:

$$(12) \qquad c^s_{1i} = (\omega_1 - \tau_{1i})/2 , \quad i = 1,2,3,$$

(13) $$c^s_{2ji} = f_{ji}c_{1i}/\hat{s}_{ji} ,$$

$j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$.

Borrowers:

(14) $$c^b_{1i} = (\omega_{2i}-\tau_{2i})\sum_j s_{ji}/2 ,$$

(15) $$c_{2ji} = f_{ji}c_{1i}/s_{ji} ,$$

$j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$.

The government's budget constraint in state i, given that the previous state was j, can be written

(16) $$g-\tau_{1i} = (m_i-r_{ij}m_j/n) - fed_j(1/d_{1j}-r_{ij})/n - b_{1j}/n + \sum_{k=1}^{K-1} d_{ki}(b_{ki}-b_{(k+1)j}/n) + d_{Ki}b_{Ki} + \tau_{2j}/n ,$$

$j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$.

[Note that we are assuming that all Federal Reserve currency is backed by holdings of one-period bonds.] Using equations (7)-(8) and (10)-(11) [assuming that the $q_{ij} = 0$] we consequently have

(17) $$g = (\omega_1 + \omega_{2j}/n) + (c^s_{1i} + c^b_{1i}) + (c^s_{2ij} + c^b_{2ij})/n ,$$

$j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$.

It is assumed that the government conducts its fiscal and monetary policy so that if the state of the economy does not change from one period to the next, the share of government expenditures covered by earnings from currency seigniorage is constant. That is,

$$(18) \qquad \delta g = m_i(1-r_{1i}/n) + fed_i(1/d_{1i}-r_{1i})/n, \quad i = 1,2,3.$$

The Treasury dictates the maturity composition of the government debt. In the deterministic model, the total value of the outstanding debt is equal to the government's date 1 deficit. In this model the total value of the state i debt is equal to the value of the government's date 1 deficit in the event that state i appears at date 1. That is,

$$g - \tau_{1i} = \sum_{k=1}^{K} d_{ki}b_{ki}, \quad \text{or equivalently}$$

$$(19) \qquad g + m_i = \omega_1 - c^s_{1i} - c^b_{1i}, \quad i = 1,2,3.$$

The share of the total market value of the government debt in state i assigned to government bonds with remaining terms of k is denoted α_{ki}. That is,

$$(20) \qquad d_{ki}b_{ki} = \alpha_{ki}(g-\tau_{1i}), \quad i = 1,2,3, \; k = 1,\ldots,K.$$

Solution procedure

Taking the three τ_{1i} as parameters, the three reserve requirement equations (6) can be used to obtain numerical values for the three $cash_i$. Given the consumption demand functions (12)-(15), the seven budget constraints (17) and the three constraints (18) can then be used to solve for the three τ_{2i} and the seven s_{ji}. Given the values $cash_i$, the monetary authority's choice of the β_i determines the values of the three m_i and the three fed_i. Equations (18) can then be used to solve for the three r_{ii}. Given the arbitrage conditions (9), all variables of the model other than the various b_{ki} can now be expressed as functions of the four r_{ji}, $i \neq j$.

Nine of the ten state 2 maturity composition conditions (20) [one condition is redundant], combined with the three state 2 borrowers' second-period budget constraints (11) and one of the three state 2 savers' second-period constraints (8), can be used to solve for the three b^b_{k2} and the ten b^s_{k2}. The procedure for states 1 and 3 is similar, except that there are only two b^b_{ki} and two state i borrowers' second-period constraints, and only two savers' second-period constraints (8), one of which must be used. This leaves two of the state 2 savers' constraints, and one each of the state 1 and state 3 savers' constraints, to be used to solve for the four r_{ji}, $i \neq j$. These computations are performed using MAPLE V (Release 1.1), a mathematics package produced by Waterloo Maple Software, Inc.

In practice, the four equations in question are extraordinarily complicated, particularly when K is large. In order to obtain numerical solutions it has proved necessary to leave the state 2 arbitrage conditions unsolved for the d_{k2}, k = 2,...K-1, and to refrain from solving the third state 2 savers budget constraint for b_{K2}. The resulting system of equations is exported to and solved by MATHEMATICA (Version 1.2), a mathematics package produced by Wolfram Research, Inc. When K = 10, the system includes 13 equations, and obtaining a solution takes approximately five minutes on a 386 PC with 4 MB of RAM.

"Calibration"

The entries in the Markov transition matrix are specified as follows: $f_{11}= f_{22}= f_{33}= 1/5$, $f_{21}= f_{23}= 4/5$, and $f_{12}= f_{32}= 2/5$. These values imply that the model economy is in recession (is in state 3) one-fourth of the time, and remains there for an average of about 1 $^1/_3$ periods. If one thinks of a period as a year, as will be done henceforth, the average recession length translates to about 16 months. During the last twenty-five years the U.S. economy has been in an NBER recession about 22 percent of the time, and the average length of a recession has been about 13 $^1/_2$ months. Thus to view the model period as properly calibrated to a year, we would have to define recessions a bit more broadly than the NBER does. [These transition probabilities also produce an average expansion length (number of consecutive periods in state 2 or 3) of about 3 $^7/_8$ periods, which translates to about 46 $^1/_2$ months. The average length of the last four NBER expansions was about 49 $^1/_2$ months.]

The parameter choices from the deterministic model are largely retained in the stochastic model. The value of ω_2 from the deterministic model becomes the value of ω_{22} in the stochastic model. The values of ω_{21} and ω_{23} are set one percent higher and lower than ω_{22}, respectively. This stochastic variation in credit demand is the analogue of the stochastic variation in technology productivity that is posited in RBC models. The degree of variation is chosen so that in what we will the "benchmark case," when monetary policy is neither pro- nor counter-cyclical in a sense to described below, the one-year real interest rate rises about one percent above its average level during the "recession" (state 3), and falls about one percent below this level during the "boom" (state 1). This works out to a standard deviation of 0.7 percent.

It is hard to know how to calibrate this number, and as a result it was chosen mostly for cosmetic purposes. In this model, an agent does not face any uncertainty about the one-year real rate -- it is uniquely determined by the state that appears in his first period. It is possible, however, to calculate an *ex-post* one-year real rate as the difference between the one-year nominal rate and the realized value of the annual inflation rate. In the benchmark case the standard deviation of this *ex-post* real rate is a bit more than one percent. During the last quarter-century, the standard deviation of the observed *ex-post* one-year real rate was far higher -- more than three percent. It seems clear, however, that much of the variation in the inflation rate that underlies this figure was due to variation in monetary policy, and that much of the policy-induced variation was not strictly cyclical in nature, but reflective instead of basic changes in the policy regime.

In the version of the model that is used for conducting the policy experiments, the taxes on savers and borrowers also vary cyclically. In particular, τ_{12} is given the value of τ_1 from the deterministic model, but τ_{11} and τ_{13} are set five percent higher and lower, respectively. This is done partly in an attempt to capture some of the changes in real tax revenues that typically accompany cyclical swings (and are due, presumably, to the combined influence of proportional taxation and cyclical changes in tax rates). It also serves to produce some countercyclical variation in the demand for base money. We originally intended to make these tax changes "Ricardian" in nature -- that is, to impose future tax increases on agents that enjoyed current tax cuts, and vice-versa. This would produce countercyclical variation in the personal savings rate, and would prevent tax changes from redistributing income between savers and borrowers. Unfortunately, computational constraints seemed to make this infeasible. We hope to surmount this problem in future versions of the model.

The values of the parameters δ and λ were taken from the deterministic model. To limit the computational burden, the term of the longest-term bonds (the value of the parameter K) was set equal to ten. The values of the share parameters a_{ki} were accordingly chosen so as to approximate the maturity composition of the portion of the current federal government debt that will mature in ten years or less. (In the benchmark case, these parameters do not vary cyclically.)

POLICY EXPERIMENTS AND THEIR RESULTS

In this section we summarize some the results of the simple monetary experiments we have performed using a version of this model that was parametrized in the manner just described. Most of these experiments involve cyclical variation in β_i, the share of the total currency stock that consists of Federal Reserve currency. For reasons that were described above, we interpret increases and decreases in this parameter as reflecting increases and decreases in the rate at which the Fed conducts open market purchases. We refer to these experiments as "monetary policy experiments."

In each experiment, β_2 is set at 0.16, the value of the nonstochastic parameter β from the deterministic version of model. We then set $\beta_3 = \beta_2 + \Delta$ and $\beta_1 = \beta_2 - \Delta$, for a number of different values of Δ over the range $\Delta = \pm\ 0.035$. We will refer to policies that involve $\Delta > 0$ (and thus $\beta_3 > \beta_2 > \beta_1$) as "countercylical" because they affect real interest rates in a way that acts to partially offset the changes in borrowers' consumption caused by the model's version of the real business cycle -- the exogenous variation in their endowments. We will refer to $\Delta = 0$ (and thus $\beta_1 = \beta_2 = \beta_3$) as the "benchmark case," and identify it as the case in which the Fed adopts an acyclical policy. This identification is not without its arbitrary features, since the policy results in a good deal of variation in nominal interest rates, and in the growth rates of nominal monetary aggregates.

The results of these monetary experiments are summarized in Tables 1A-14A. Each table displays the dependence of the mean, standard deviation, and extreme values of a particular endogenous variable on the choice of the policy variable β_3. The results of procyclical policy choices are displayed on the top half of each table, and those of countercyclical choices on the bottom half. The choices become less procylical (or more countercyclical) as one moves down the table. The results of the benchmark policy choice are displayed, with special emphasis, in the center of each table.

Before commenting on the results further we need to explain the definition and/or construction of certain variables for which statistics are reported. Although both the bonds that agents in the model hold and the interest rates that they care about are real rather than nominal, it is possible to price a hypothetical k-term nominal bond and obtain a k-term nominal interest rate. This is done by using the equilibrium values of the contingent claims prices s_{ij} to price the distribution of future real returns associated with a default-free promise to deliver a dollar of currency in k periods (years). The state i price of a one-year nominal bond is $dnom_{1i} = \sum_j s_{ji} r_{ji}$, and the price of a k-year bond is $dnom_{ki} = \sum_j s_{ji} r_{ji} dnom_{(k-1)i}$, $j = 1,2$ if $i = 1$, $j = 1,2,3$ if $i = 2$, $j = 2,3$ if $i = 3$, and $k = 2,\ldots,K$. The annual yields on these bonds are readily obtained from their prices.

It should be noted that nominal rates on "long-" (greater than one-period-) term securities can be computed in this same fashion in any stochastic OLG model, even if (as is usually the case) no actor in the model either issues or holds such securities. This situation is analogous to that of RBC models, which have sometimes been used to investigate the term structure of interest rates despite being specified in a manner that does not give rise to long-term debt, or indeed to debt of any kind. [See Backus, Gregory and Zin (1989), for example.] What makes this model distinctive is that (1) long-term securities, including both private and government securities, are actually issued and held, (2) the government has the power to determine and manipulate the maturity composition of its debt, and (3) changes in the maturity composition influence the values of both nominal and real variables.

The "broad money\credit" aggregate M_{x_i} will be defined as the sum, in state i, of the nominal stock of base money and the nominal stock of bonds (both government and private) with a remaining term of one year. "Nominal GDP" in state i is defined as the nominal value of the sum of the endowments received by the representative borrower and saver in that state.

Tables 12-14 display some statistics concerning the welfare of representative savers and borrowers born in each of the three states. The first three columns of Tables 12 and 13 report the percentages by which the consumption of borrowers and savers, respectively, would have to be increased in order to leave their conditional expected utility, given the policy choice, unchanged from the benchmark case. The signs are reversed so that a positive value indicates that the agent does better in the relevant state, under the given policy, than he does in the same state under the benchmark policy (and vice-versa). The last column reports the percentage by which the consumption of agents in state i, i = 1,2, *and* 3, would have to be increased to leave their unconditional expected utility, given tne policy choice unchanged from the benchmark state. [Again, the signs are reversed.]

The first three columns of Table 14 display an index of the average welfare of the two agents in state i. The index is constructed by augmenting the consumption of borrowers born in each state, by the same constant of proportionality, until their unconditional expected utility is equal to that of savers. The values of conditional expected utility for state i savers and borrowers are then averaged, unity is added to the average value, and the result is multiplied by ten. This produces a welfare index with values in the vicinity of unity. The fourth column column reports the unconditional expected values of these state i averages.

As was noted earlier, at the this stage of the project there will be no attempt to compare the results of these experiments to any particular set of stylized facts, but simply to make a *prima facie* case for the potential empirical usefulness of this type of model. We consequently confine ourselves to asserting that our experiments produce endogenous random variables whose average levels, and degrees of variability, seem generally plausible. We think that a glance at the statistics presented in the tables will convince most readers that this is indeed the case.

The table below presents historical statistics for what might be regarded as the empirical analogues of several of the variables included in the model. The statistics are simply the means, variances and ranges of annual-average time series for the empirical variables over the quarter-century that began in 1966. These statistics may be compared to the summary statistics on the distibutions of the analogous model variables that are presented in the tables at the end of the paper. It should be stressed that the distributions of the model variables (particularly their variances and ranges) depend critically on the nature of monetary policy. In most cases, the model data match the historical data best if it is assumed that the model's monetary authority adopts a moderately countercyclical policy -- a policy that sets β_3 to 0.175 or 0.18. Consider the case of the one-year nominal interest rate, for example. The historical mean of this series, which is 7.93 percent, is about 80 basis points higher than the mean of the analogous variable in the model. (See Table 1.) The reason for this is that the model was calibrated to an average annual inflation rate of approximately 5 percent, which is about 80 basis points lower than the mean value of the historical inflation rate series. The variance of the historical series is 2.56 percent. This is much larger than the variance of the model's one-year nominal rate series under the benchmark policy, but very close to its variance under the policy $\beta_3 = 0.175$. Similarly, the model is calibrated to come close to the historical mean of the *ex-post* one-year real interest rate series, but the variance of this rate under the benchmark policy is only about a third of the historical value. Under a policy of $\beta_3 = 0.175$, however, the variance of the model's *ex-post* one-year real rate rises to about 80 percent of its historical value (using the GDP deflator as a measure of price level changes); under $\beta_3 = 0.175$, the figure is 95 percent. Similar comments apply to the model's predictions about the inflation rate, the broad money growth rate (compared to the historical series for M2), and the nominal GDP growth rate.

ANNUAL AVERAGES, 1966-1990

Variable*	Mean	σ	Range High	Range Low
Interest rates:				
Nominal (1 year)	7.93	2.56	14.78	4.88
Real (1 year, *ex-post*)				
PGDP deflated	2.21	3.05	8.60	-1.74
CPI deflated	1.99	3.45	9.12	-3.78
Inflation rates:				
GDP deflator	5.71	2.21	9.97	2.73
CPI	5.94	2.99	13.50	1.95
Money growth rates:				
Reserves	5.82	3.37	13.68	-0.71
Monetary base	7.43	1.46	9.73	4.24
M2	8.26	2.84	12.95	3.15
Nominal GDP growth rate:	8.35	2.73	13.10	2.88

*The nominal interest rate series is the annual average of the monthly-average secondary market yields on U.S Treasury securities, reported by the Federal Reserve Board. The inflation rate series are year-to-year percent changes in the annual averages of the implicit GDP price deflator and the all-items CPI for all urban consumers, respectively. The *ex-post* real interest rate series is constructed using the difference between the value of the nominal interest rate series for a given year and the percent change in the relevant price measure from that year to the following year. The (total) reserves, monetary base, and M2 series are year-to-year percent changes in the annual averages of the relevant monthly series. The reserves and base series are adjusted for reserve requirement changes, and reported by the Federal Reserve Bank of St. Louis; the M2 series is reported by the Federal Reserve Board. The nominal GDP series is the year-to-year percent change in the annual averages of the quarterly levels of nominal GDP.

How well does the model do at replicating the behavior of narrow monetary aggregates? Stated differently, how well does what we call a "moderately countercyclical" policy match up with historical Fed policy? Attempts to answer this question are complicated by the fact, which was noted in the second (deterministic model) section, that the monetary variables in the model do not have unambiguous empirical analogues. One obvious matching scheme is to identify total bank reserves in the model ($cash_i$, which is called "base money" in Table 8) with the historical time series for total reserves. As was noted in the second section, using this definition the average level of the reserves/GDP ratio in the model is roughly 60 percent higher than the historical average of this ratio. And since the model abstracts from the gradual decline in the level and coverage of reserve requirements, the mean of the historical reserves growth rate series is almost two percent lower than the mean of the model's total reserves variable. Under the policy $\beta_3 = 0.175$, however, the variance of the model variable (3.91) is not far from that of the historical series (3.37).

Since bank reserves are the only source of currency demand in the model, we might choose, alternatively, to associate the model's reserve series with the historical series for the monetary base. While the mean of the model's reserve growth rate is quite close to the average growth rate of the empirical monetary base series, the average value of the model's reserves/GDP ratio is 60 percent lower than the historical value of the empirical ratio of base money to GDP (again, see the second section). Under the policy $\beta_3 = 0.175$, moreover, the variance of the reserve growth rate in the model is more than twice that of the historical series. The reason for these latter facts is that the empirical base money series is dominated by currency held by the public. This series has been far less volatile, historically, than the empirical reserves series, but has no analogue in the model.

We are also interested in demonstrating that the qualitative results of our experiments may provide some insights into the role of monetary policy in the business cycle. As we suggested earlier, we will emphasize experiments whose results can be interpreted as involving successful attempts to target variables of special interest to the Federal Reserve System. (The word "target" here simply means "minimize the standard deviation of.")

One interesting result is that it is quite feasible in this model for monetary policy to drastically reduce the cyclical variability of nominal interest rates. Inspection of Table 1A reveals that choosing $\beta_3 = 0.145$ can reduce the standard deviation of the one-year nominal rate from its benchmark value of 128 basis points to 11 basis points. Tables 2A and 3A reveal that this policy has similar effects on the variability of longer-term rates. This policy also looks fairly good along other certain other nominal-stabilization dimensions. It succeeds in minimizing the variance of the monetary base among the policies studied, and adds only 0.09 percent to the cyclical variability of the annual inflation rate.

Perhaps not surprisingly, the policy does not perform so well on welfare grounds. Since it tends to smooth variation in real interest rates (reducing the variance of the one-year *ex-ante* real rate from 0.70 to 0.55 percent) it increases the cyclical variablility of borrowers' consumption. [See Table 11, which displays statistics on the real present value of borrowers' contingent consumption bundles.] This produces a distinct reduction in the welfare of state 3 borrowers, and smaller reductions in both the average welfare of borrowers and the average level of welfare across agents of both types.

It should be noted that the welfare effects of active policy, expressed in terms of consumption compensation, are not particularly large in this model. Part of the reason for this is certainly that the very simple assumptions regarding preferences produce agents who are not very risk averse. However, countercyclical policies consistently improve the average welfare of borrowers -- the group directly most strongly affected by real fluctuations -- as well as average welfare across agent types. The marginal improvement in the index of overall welfare tends to decline as the extent of countercyclical intervention is increased, suggesting that there may be an "optimal" counter..yclical policy, according to this welfare criterion. It is clear, however, that such a policy, if it exists, lies well outside the range of policy choices studied here, and would produce very large increases in the cyclical variability of nominal variables. (This might be regarded as a problem with the specification, or alternatively, as an explanation for policymakers' persistent attraction to countercyclical policies.)

Inflation targeting in this model also requires a procyclical choice of β_3 ($\beta_3 = 0.1525$), but the decrease over the benchmark case is only half the size of the decrease needed to target nominal interest rates. The cyclical variability of inflation increases quite sharply as the policy choice moves away from the targeting value (becoming either more procyclical, or countercyclical). Choosing $\beta_3 = 0.18$, for instance -- a countercyclical choice that produces a 17.5 percent reduction in borrowers' consumption variability, relative to the benchmark case -- produces a 275 percent increase in the cyclical variability of inflation.

Tables 7 and 8 report the growth rates of two "monetary aggregates": the nominal quantity of Federal Reserve currency (the real quantity denoted fed_i) and the nominal monetary base (the real quantity is $cash_i$). We think of the former as analogous to a reserve aggregate, partly because it is a relatively small component of the stock of base money (16 percent in the model, compared to a current figure of approximately 25 percent) and partly because it is the object in the model that the Fed manipulates directly in the course of conducting its policy. Not surprisingly, when policy is active (either counter- or procyclical) the cyclical variability of the reserve aggregate is much greater than that that of the monetary base. The countercyclical policy described in the previous paragraph, for instance, increases the cyclical variability of reserves by a factor of more than eight, and produces a range of reserve growth rates from +29 percent (during the transition from state 1 to state 2) to -10 percent (during the transition in the opposite direction). The comparable figures for the monetary base are 2 $^1/_4$, +12 percent, and -3 percent.

The cyclical variability of the growth rate of the "broad money\credit aggregate" M_x is considerably smaller than that of either of the narrow aggregates in the benchmark case, and remains so if policy is countercyclical. If policy is procyclical the broad aggregate tends to be more variable than base money, however. The growth rates of all of the aggregates tend increase and decrease together, and the inflation rate tends to increase and decrease along with them. It is interesting to note, however, that as the policy choice is varied the standard deviation of the inflation rate tends to stay a good deal closer to that of the broad aggregate than to the standard deviations of either of the narrow aggregates. When policy is countercyclical the association between the cyclical variability of the broad aggregate and inflation is particularly close. On the other hand, a policy of inflation targeting requires a 50 percent reduction in the variability of base money growth rate relative to the benchmark case, but a small increase in the variability of the growth rate of the broad aggregate.

Another interesting result is that countercyclical policy tends to produce relatively low inflation and money growth rates during the recession, and (especially) during the period of "recovery" out of the recession. [The minimum inflation, base money, and broad money growth rates almost invariably occur across the transition from state 3 to state 2.] Consider, for example, the quite countercyclical policy choice $\beta_3 = 0.18$, which we have referred to twice previously. Under this policy the "normal" (state 2 to state 2) inflation rate is almost exactly five percent. The rate shoots up to 9.1 percent as the economy slips into the recession (state 2 to state 3), but falls to 1.2 percent during the first year of the recovery (state 3 to state 2). If the recession persists for more than one year, the inflation rate during the recession (state 3 to state 3) is 5.2 percent. As a result, the average *ex-post* inflation rate endured by an agent born during the recession (in state 3) is only 2.0 percent. This compares to 5.2 percent for an agent born during state 2, and 7.98 percent for an agent born during state 3.

Under this policy the normal monetary base and broad aggregate growth rates are identically 7.6 percent. As the economy slips into recession the base money growth rate rises to 13.1 percent, and the broad aggregate growth rate rises to 12.0 percent. During the first year of the recovery, however, these growth rates are 2.6 and 3.5 percent, respectively. The average *ex-post* money growth rates observed by agents born during the recesssion are 3.7 percent for narrow aggregate, and 4.4 percent for the broad one.

At this point we turn to the question of the effect of monetary policy (and, in a moment, Treasury policy) on the relative variability of short- and long-term interest rates, and on the level and slope of the yield curve. Inspection of Tables 1A-3A reveals that in the benchmark case the standard deviation (SD) of the one-year nominal rate is 128 basis points; this is four times the SD of the five-year rate, and eight times the SD of the ten-year rate. Since all three rates tend to vary in the same direction, declining during the recession and rising during the boom, the yield curve is upward-sloping during the recession, and downward-sloping during the boom.

It turns out that countercylical policies tend to increase all three of the aforementioned standard deviations (and procyclical policies, to reduce them) in approximately the same proportion. In the now-familiar case of the countercylical policy $\beta_3 = 0.18$, for example, the SD of the one-year nominal interest rate increases by 142 percent, the SD of the five-year nominal rate by 141 percent, and the SD of the ten-year rate by 145 percent. As a result, countercyclical policy tends to make the recessionary yield curve steeper. In the benchmark case, the recessionary spread between the one- and five-year rates is 132 basis points, and between the one- and ten-year rates 154 basis points. The policy $\beta_3 = 0.18$ increases these spreads to 321 and 375 basis points, respectively.

On balance this model does not seem to give countercyclical monetary policy much power to influence long-term interest rates. Even the most aggressive policy reported ($\beta_3 = 0.195$), which reduces the recessionary one-year nominal rate by almost 430 basis points and drives it down to a level just above 1 percent, succeeds in reducing the five-year rate by only 103 basis points, and the ten-year rate by only 52 basis points. The bulk of these reductions, moreover, reflect the tendency of countercyclical policy to produce low inflation rates during and immediately after the recession. The analogous reductions in the one-, five-, and ten-year *ex-ante* real interest rates (the real rates facing agents) are 51, 14 and 7 basis points, respectively.

For the purposes of this paper, Treasury policy experiments consist of experiments in which the maturity composition of the government debt is changed, either permanently or cyclically. The results of four of these policy experiments -- two of each type -- are reported in Tables 1B-14B. As noted above, in the benchmark case the maturity composition parameters α_{ki} were chosen to approximate the current maturity composition of the portion of the federal government debt that matures in ten years or less. The cyclical experiment whose results are labelled "Long - 10%" takes a real quantity of state 3 debt amounting to ten percent of the total and shifts it from maturities of 1-2 years to maturities of 5-9 years; it does precisely the opposite with real state 3 debt, and leaves real state 2 debt unchanged. The experiment whose results are labelled "Short - 10%" reverses the experiment just described. The permanent experiment whose results are labelled "Long - 10%" shifts the real debt in all three states towards longer terms in precisely the same way that the real state 3 debt was shifted in the cyclical experiment with the same label. Finally, the experiment whose results are labelled "Short - 10%" reverses the experiment just described.

We found the results of these experiments more than a little surprising. A cyclical policy of shortening the maturity structure during the recession and lengthening it during the boom has effects very different from what one might have expected. The policy has virtually no effect on the level of one-year nominal rates during the recession, but tends to increase both five- and ten-year rates by about ten basis points. As a result, the recessionary yield curve becomes slightly steeper at the short end, with the new curve lying above the old one except at the very shortest terms. The same policy increases the one-year nominal rate during the boom by about 25 basis points, and the five- and ten-year rates by about 15 basis points. As a result, the yield curve during the boom becomes slightly also becomes slightly steeper (which is now to say, more *downward*-sloping) at the short end, with the new curve lying above the old one throughout its range. Finally, the policy increases the average levels of the one-, five-, and ten-year rates by a surpisingly uniform figure a bit in excess of ten basis points.

A policy of lengthening the maturity structure during the recession, and shortening it during the boom, has effects that are just the reverse of those of the opposite policy: the nominal interest rates that fell during the boom and recession now rise. Thus this model suggests that if the Treasury desires to adopt a countercyclical debt policy, it should act to lengthen the maturity structure during recessions -- a strategy exactly the reverse of the one that is commonly proposed.

It should be noted that the bulk of the effects of these policy experiments on the yield curve operate throught their impact on rates of inflation, and agents' expectations thereof. Although the effects of these experiments on short- and long-term real (*ex-ante*) interest rates are qualitatively similar to their effects on nominal rates, they are extremely small in magnitude. The one-year real rate, for example, falls by only 1.6 basis points during the recession, and 1.3 points during the boom, in response to a policy that lengthens the maturity structure during the recession (and vice-versa).

Treasury policies that impose permanent shifts on the maturity structure -- that make the same changes in all three states, relative to the benchmark case -- also have effects that seem counterintuitive. Permanent policies, it turns out, influence the cyclicality of nominal interest rates to a much greater extent than cyclical policies. Even more curiously, policies that reduce the cyclical variability of nominal rates when they are undertaken cyclically increase them when they are undertaken permanently, and vice versa. A policy of permanently lengthening the maturity structure, for instance, increases the standard deviation of the one-year nominal rate by a bit more than 13 percent. When the same policy is conducted cyclically, however, it reduces the standard deviation of this rate by a bit less than 8 percent.

A permanent shift that lengthens the maturity structure drives nominal rates up during the boom, and down during the recession, relative to their benchmark levels. The recessionary one-, five-, and ten-year nominal interest rates decline by 28, 7, and 4 basis points, respectively. For the one-year rate these changes are larger than the changes induced by the analogous cyclical shift, while for the five- and ten-year rates they are smaller. This same pattern of rate changes appears during the boom, except that interest rates rise rather than fall. Thus a policy of permanent lengthening shifts the recessionary yield curve downward, and makes it more steeply upward-sloping, while shifting the curve during the boom upward, and making it more steeply downward-sloping. These changes in slope are a good deal more pronounced than the changes produced by cyclical policies. A policy of permanent shortening, by contrast, shifts the yield curves observed during both the recession and the boom closer to the "normal" (state 2) curve: the recessionary yield curve shifts upward, the yield curve during the boom shifts downward, and both curves become flatter.

As was the case with cyclical changes in Treasury policy, the real interest rate effects of permanent policy changes are qualitatively similar to their effects on nominal interest rates, but are quantitatively very small.

EXTENSIONS

The model presented in this paper could be extended in any number of directions in order to make its structure more realistic, or to produce data that come closer to resembling macroeconomic time series data. One obvious extension would be to add to the number of states, either by increasing the dimensionality of the fluctuations in the real forcing variable (in this case, borrowers' endowment) or by adding independent sources of variation in preferences, money demand, etc. Another obvious extension would be to generalize the preferences and endowment patterns of the agents so as to make it possible to adjust both their degree of risk aversion and the sensitivity of their savings and credit demand decisions to variation in interest rates.

A more challenging strategy for extension would be to attempt to add production and investment to the model. This could be done by introducing a capital good, endowing savers with labor (and an initial stock of capital) rather than consumption goods, and endowing borrowers with an intertemporal, decreasing returns technology that uses capital and labor as inputs. The variation in borrowers' endowments could then be replaced with variation in technological productivity, along the lines of RBC models. [A model based on these sorts of endowment and technology assumptions, but without distinct or accumulable capital, appears in Russell (1989).] In this sort of model policy-induced variation in real interest rates would have effects on real output; if workers were given a nontrivial labor-leisure decision, it would also have effects on employment.

Interesting extensions of other sorts would involve investigating the effects of changes in the assumptions about the interaction between fiscal and monetary policy. The role of this interaction in determining the effects of effects of monetary policy experiments has been investigated in related contexts by Sargent and Wallace (1981), Aiyagari and Gertler (1985), and Leeper (1991), among others. The very limited experimentation with alternative specifications that we have been able to conduct to date suggests that the results of policy experiments of the sort studied here are quite sensitive to changes in our assumptions about the level and stability of seigniorage revenue, variation in the real stock of government debt, variation in tax collections, etc.

Pursuing the research strategy of most real business cycle studies would require identifying collections of "monetary stylized facts" to be duplicated. While some of this work has already been done, a good deal more is needed. It will be complicated by the probability that a good deal of the historical variation in the nominal variables that are likely to be of special interest to monetary policy investigators has been strongly influenced by past policy, and by the fact that the nature of this influence is poorly understood.

Finally, the effects of increasing the length of agents' time horizon could be investigated. Recent work by authors such as Kehoe and Levine (1990) and Bullard (1992) suggests that many of the basic results from nonstochastic OLG models in which the agents live for two periods can be extended to cases in which their lives are longer. Whether this is the case in stochastic models, or for results of the type described here, is an open question. An obvious first step would be to attempt to reformulate this model to accommodate agents who live for three or four periods.

It seems likely, of course, that pursuing any of these extensions would result in a considerably more complicated model that would be considerably more difficult to solve. However, since it has proven possible to obtain solutions for the version presented here in a relatively short time, using relatively unsophisticated methods and technology, this may not prove to be a very serious constraint. In addition, it is probably possible to make analytical progress with the model in ways that would reduce its computational complexity.

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1. Nominal Interest Rate - 1 year (percent)

A. Monetary Policy Experiments

β_2	Mean	σ	Range High	Range Low
0.125	7.15	1.93	9.92	4.46
0.130				
0.135				
0.140	7.09	0.56	7.89	6.30
0.145	7.08	0.11	7.23	6.93
0.150	7.08	0.35	7.57	6.58
0.1525	7.07	0.58	7.89	6.75
0.155	7.07	0.81	8.21	5.93
0.1575	7.07	1.04	8.54	5.61
0.160	7.07	1.28	8.87	5.30
0.165	7.07	1.72	9.52	4.66
0.170	7.09	2.18	10.19	4.03
0.175	7.10	2.64	10.87	3.41
0.180	7.12	3.10	11.56	2.80
0.185				
0.190				
0.195	7.20	4.48	13.67	1.01

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
<u>Cyclical</u>				
Short - 10%	7.19	1.35	9.12	5.29
Long - 10%	6.96	1.18	8.62	5.29
<u>Permanent</u>				
Short - 10%	7.08	1.08	8.61	5.55
Long - 10%	7.07	1.45	9.13	5.02

2. Nominal Interest Rate - 5 years (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	7.16	0.48	7.85	6.48
0.130				
0.135				
0.140	7.10	0.14	7.30	6.90
0.145	7.08	0.03	7.12	7.05
0.150	7.07	0.09	7.20	6.95
0.1525	7.07	0.14	7.27	6.87
0.155	7.07	0.20	7.35	6.78
0.1575	7.07	0.26	7.43	6.70
0.160	7.06	0.32	7.51	6.62
0.165	7.07	0.43	7.68	6.46
0.170	7.07	0.54	7.85	6.31
0.175	7.09	0.66	8.02	6.16
0.180	7.10	0.77	8.20	6.01
0.185				
0.190				
0.195	7.16	1.12	8.76	5.59

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	7.18	0.34	7.66	6.71
Long - 10%	6.95	0.29	7.37	6.53
Permanent				
Short - 10%	7.07	0.27	7.45	6.69
Long - 10%	7.06	0.36	7.57	6.55

3. Nominal Interest Rate - 10 years (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	7.16	0.241	7.51	6.82
0.130				
0.135				
0.140	7.10	0.070	7.20	7.00
0.145	7.08	0.013	7.10	7.06
0.150	7.07	0.044	7.13	7.01
0.1525	7.07	0.072	7.17	6.97
0.155	7.07	0.109	7.21	6.92
0.1575	7.07	0.129	7.25	6.88
0.160	7.07	0.158	7.29	6.84
0.165	7.07	0.215	7.37	6.76
0.170	7.07	0.272	7.46	6.69
0.175	7.08	0.330	7.55	6.62
0.180	7.10	0.387	7.65	6.55
0.185				
0.190				
0.195	7.17	0.560	7.96	6.38

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
<u>Cyclical</u>				
Short - 10%	7.18	0.169	7.42	6.94
Long - 10%	6.95	0.147	7.15	6.74
<u>Permanent</u>				
Short - 10%	7.07	0.135	7.26	6.88
Long - 10%	7.06	0.182	7.32	6.80

4. Real Interest Rate - 1 year (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	2.06	0.34	2.55	1.58
0.130				
0.135				
0.140	2.06	0.49	2.76	1.36
0.145	2.06	0.55	2.83	1.29
0.150	2.06	0.60	2.91	1.22
0.1525	2.06	0.62	2.94	1.18
0.155	2.06	0.65	2.98	1.14
0.1575	2.06	0.67	3.01	1.11
0.160	2.06	0.70	3.05	1.07
0.165	2.06	0.75	3.12	1.00
0.170	2.06	0.80	3.19	0.92
0.175	2.06	0.85	3.27	0.85
0.180	2.07	0.91	3.34	0.78
0.185				
0.190				
0.195	2.06	1.06	3.56	0.56

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	2.07	0.70	3.06	1.08
Long - 10%	2.05	0.70	3.04	1.05
Permanent				
Short - 10%	2.06	0.69	3.04	1.08
Long - 10%	2.06	0.71	3.06	1.05

5. Ex-post Real Interest Rate - 1 year (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	2.10	2.76	5.98	-1.93
0.130				
0.135				
0.140	2.13	1.34	3.89	0.28
0.145	2.14	0.93	3.18	1.01
0.150	2.14	0.66	3.14	1.29
0.1525	2.13	0.64	3.11	1.20
0.155	2.13	0.71	3.30	0.87
0.1575	2.13	0.85	3.63	0.54
0.160	2.12	1.04	3.96	0.21
0.165	2.11	1.47	4.63	-0.04
0.170	2.09	1.94	5.31	-1.09
0.175	2.07	2.41	6.00	-1.74
0.180	2.05	2.91	6.69	-2.37
0.185				
0.190				
0.195	1.95	4.40	8.82	-4.49

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	2.13	1.11	4.21	0.21
Long - 10%	2.12	1.00	3.71	0.20
Permanent				
Short - 10%	2.12	0.89	3.71	0.47
Long - 10%	2.12	1.22	4.23	-0.00

6. Inflation Rate (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	5.05	3.53	9.05	1.11
0.130				
0.135				
0.140	4.96	1.62	6.81	3.07
0.145	4.95	0.99	6.08	3.75
0.150	4.94	0.36	5.36	4.43
0.1525	4.94	0.09	5.05	4.78
0.155	4.94	0.29	5.35	4.58
0.1575	4.94	0.60	5.72	4.23
0.160	4.95	0.92	6.09	3.89
0.165	4.97	1.55	6.84	3.20
0.170	4.99	2.18	7.59	2.53
0.175	5.03	2.82	8.36	1.86
0.180	5.07	3.45	9.14	1.20
0.185				
0.190				
0.195	5.25	5.37	11.54	-0.710

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	5.06	0.91	6.12	4.20
Long - 10%	4.84	0.95	6.11	3.57
Permanent				
Short - 10%	4.95	1.20	6.42	3.55
Long - 10%	4.95	1.20	6.42	3.55

7. Fed Currency Growth Rate (percent)

A. Monetary Policy Experiments

β_2	Mean	σ	Range High	Range Low
0.125	10.34	24.42	41.49	-18.15
0.130				
0.135				
0.140	8.33	12.80	23.72	-6.46
0.145	7.95	9.06	18.64	-2.45
0.150	7.69	5.37	13.91	1.83
0.1525	7.62	3.53	11.66	3.66
0.155	7.57	1.70	9.49	5.61
0.1575	7.56	0.15	7.80	7.40
0.160	7.59	1.96	9.89	5.37
0.165	7.72	5.62	14.99	1.45
0.170	8.00	9.30	18.54	-2.47
0.175	8.40	13.01	23.47	-6.34
0.180	8.93	16.77	28.76	-10.16
0.185				
0.190				
0.195	11.41	28.51	47.28	-21.32

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	7.70	1.95	9.87	5.41
Long - 10%	7.47	1.98	9.91	5.04
Permanent				
Short - 10%	7.59	2.25	10.24	5.03
Long - 10%	7.59	1.67	9.56	5.73

8. Base Money Growth Rate (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	7.65	2.60	10.59	4.75
0.130				
0.135				
0.140	7.57	0.65	8.25	6.79
0.145	7.56	0.06	7.65	7.48
0.150	7.56	0.66	8.38	6.79
0.1525	7.57	0.98	8.75	6.43
0.155	7.57	1.31	8.91	6.07
0.1575	7.58	1.63	9.51	5.72
0.160	7.59	1.96	9.89	5.36
0.165	7.61	2.61	10.67	4.67
0.170	7.64	3.26	11.45	3.99
0.175	7.69	3.91	12.25	3.31
0.180	7.74	4.56	13.05	2.64
0.185				
0.190				
0.195	7.93	6.53	15.55	0.704

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
<u>Cyclical</u>				
Short - 10%	7.70	1.95	9.94	5.40
Long - 10%	7.47	1.98	9.92	5.04
<u>Permanent</u>				
Short - 10%	7.59	1.67	9.56	5.70
Long - 10%	7.59	2.25	9.95	5.02

9. Broad Money\Credit Growth Rate (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	8.53	14.06	18.52	-10.20
0.130				
0.135				
0.140	7.59	2.20	10.37	4.86
0.145	7.58	2.00	10.73	4.43
0.150	7.57	1.80	10.23	4.87
0.1525	7.57	1.66	9.79	5.28
0.155	7.57	1.53	9.30	5.75
0.1575	7.58	1.47	9.56	5.67
0.160	7.58	1.47	9.84	5.42
0.165	7.59	1.74	10.38	4.94
0.170	7.61	2.25	10.92	4.49
0.175	7.65	2.88	11.46	4.04
0.180	7.70	3.58	12.02	3.59
0.185				
0.190				
0.195	7.89	5.79	14.94	0.821

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
<u>Cyclical</u>				
Short - 10%	7.72	2.84	11.40	4.23
Long - 10%	7.47	1.86	10.32	4.51
<u>Permanent</u>				
Short - 10%	7.58	1.43	9.72	5.54
Long - 10%	7.57	1.53	9.97	5.29

10. Nominal Output Growth Rate (percent)

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	7.69	4.00	12.22	3.23
0.130				
0.135				
0.140	7.59	2.04	9.91	5.24
0.145	7.57	1.39	9.16	5.92
0.150	7.56	0.75	8.42	6.62
0.1525	7.56	0.42	8.06	6.98
0.155	7.56	0.13	7.69	7.33
0.1575	7.56	0.25	7.94	7.26
0.160	7.57	0.57	8.32	6.90
0.165	7.59	1.21	8.78	6.20
0.170	7.61	1.86	9.85	5.50
0.175	7.64	2.51	10.64	4.82
0.180	7.68	3.16	11.43	4.14
0.185				
0.190				
0.195	7.86	5.13	13.89	2.17

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	7.69	0.56	8.34	6.96
Long - 10%	7.46	0.62	8.34	6.57
Permanent				
Short - 10%	7.57	0.28	7.99	7.23
Long - 10%	7.57	0.86	8.66	6.56

11. Borrowers' Consumption

A. Monetary Policy Experiments

β_3	Mean	σ	Range High	Range Low
0.125	0.809220	0.0134	0.82818	0.790217
0.130				
0.135				
0.140	0.809230	0.0121	0.82630	0.79214
0.145	0.809234	0.0116	0.82567	0.79278
0.150	0.809237	0.0112	0.82505	0.79342
0.1525	0.809239	0.0110	0.82473	0.79374
0.155	0.809240	0.0107	0.82442	0.79405
0.1575	0.809242	0.0105	0.82411	0.79437
0.160	0.80924	0.0103	0.82379	0.79469
0.165	0.809247	0.00984	0.82317	0.79533
0.170	0.809251	0.00939	0.82254	0.79597
0.175	0.809253	0.00895	0.82192	0.79661
0.180	0.809257	0.00850	0.82129	0.79725
0.185				
0.190				
0.195	0.809267	0.00720	0.81941	0.79917

B. Treasury Policy Experiments
(β = 0.16)

	Mean	σ	Range High	Range Low
Cyclical				
Short - 10%	0.809243	0.0103	0.82379	0.79469
Long - 10%	0.809243	0.0103	0.82379	0.79469
Permanent				
Short - 10%	0.809243	0.0103	0.82379	0.79469
Long - 10%	0.809244	0.0103	0.82379	0.79469

12. Borrowers' Welfare

A. Monetary Policy Experiments

β_3	State 1	State 2	State 3	Average
0.125	0.2861	-0.0004	-0.3106	-0.0061
0.130				
0.135				
0.140	0.1638	-0.0002	-0.1772	-0.0034
0.145	0.1229	-0.0002	-0.1328	-0.0025
0.150	0.0820	-0.0001	-0.0885	-0.0017
0.1525	0.0615	-0.0001	-0.0663	-0.0012
0.155	0.0410	-0.0001	-0.0442	-0.0008
0.1575	0.0205	-0.0000	-0.0221	-0.0004
0.160	---	---	---	---
0.165	-0.0411	0.0001	0.0442	0.0008
0.170	-0.0822	0.0002	0.0882	0.0016
0.175	-0.1233	0.0002	0.13229	0.0024
0.180	-0.1645	0.0003	0.17627	0.0032
0.185				
0.190				
0.195	-0.2884	0.0007	0.3079	0.0054

B. Treasury Policy Experiments
(β = 0.16)

	State 1	State 2	State 3	Average
Cyclical				
Short - 10%	0.0064	-0.0004	0.0076	0.0033
Long - 10%	-0.0064	0.0004	-0.0077	-0.0033
Permanent				
Short - 10%	-0.0065	-0.0001	0.0078	0.0003
Long - 10%	0.0067	0.0001	-0.0080	-0.0003

13. Savers' Welfare

A. Monetary Policy Experiments

β_3	State 1	State 2	State 3	Average
0.125	-0.0493	0.0015	0.0015	0.0073
0.130				
0.135				
0.140	-0.0281	0.0009	0.0302	0.0042
0.145	-0.0211	0.0007	0.0227	0.0032
0.150	-0.0141	0.0005	0.0151	0.0021
0.1525	-0.0105	0.0004	0.0113	0.0016
0.155	-0.0070	0.0002	0.0075	0.0011
0.1575	-0.0035	0.0001	0.0038	0.0005
0.160	---	---	---	---
0.165	0.0070	-0.0003	-0.0076	-0.0011
0.170	0.0141	-0.0005	-0.0151	-0.0021
0.175	0.2109	-0.0008	-0.0227	-0.0032
0.180	0.2812	-0.0011	-0.0302	-0.0043
0.185				
0.190				
0.195	0.4919	-0.0020	-0.0529	-0.0076

B. Treasury Policy Experiments
(β = 0.16)

	State 1	State 2	State 3	Average
Cyclical				
Short - 10%	-0.0043	0.0003	-0.0047	-0.0019
Long - 10%	0.0042	-0.0003	0.0048	0.0018
Permanent				
Short - 10%	0.0043	-0.0001	0.0050	0.0006
Long - 10%	-0.0045	-0.0001	0.0050	0.0006

14. Average Welfare

A. Monetary Policy Experiments

β_3	State 1	State 2	State 3	Average
0.125	1.169349	0.985269	0.794169	0.983514
0.130				
0.135				
0.140	1.159199	0.985223	0.805216	0.983715
0.145	1.155810	0.985207	0.808891	0.983779
0.150	1.152417	0.985190	0.812562	0.983840
0.1525	1.150720	0.985182	0.814396	0.983870
0.155	1.149022	0.985173	0.816230	0.983899
0.1575	1.147323	0.985165	0.818062	0.983928
0.160	1.145623	0.985156	0.819893	0.983957
0.165	1.14220	0.985138	0.823554	0.984013
0.170	1.138815	0.985119	0.827211	0.984066
0.175	1.135407	0.985101	0.830864	0.984118
0.180	1.131995	0.985082	0.834514	0.984168
0.185				
0.190				
0.195	1.121740	0.985022	0.845441	0.984306

B. Treasury Policy Experiments
(β = 0.16)

	State 1	State 2	State 3	Average
<u>Cyclical</u>				
Short - 10%	1.145838	0.985140	0.820179	0.984074
Long - 10%	1.145408	0.985172	0.819605	0.983839
<u>Permanent</u>				
Short - 10%	1.145402	0.985153	0.820186	0.983973
Long - 10%	1.145849	0.985159	0.819592	0.983940

Comments on Steve Russell's
MONETARY POLICY EXPERIMENTS IN A STOCHASTIC OVERLAPPING GENERATIONS MODEL OF THE TERM STRUCTURE

Eric M. Leeper*

To decide what we can learn from Steve Russell's paper we need to begin by asking the question: How do we use term structure relationships in policy analysis? We hope to infer from the shape of the term structure what economic agents think will happen in the future to real interest rates and/or inflation. Recent empirical work tells us that long-term rates are good predictors of spot rates a year or more into the future. By imposing some simple Fisher relationship, we then try to figure out whether a positively sloped yield curve portends higher future real spot rates or higher expectations of inflation.[1]

If we decide that expected inflation has risen, we often use this as an argument for tightening monetary policy. If we conclude that the higher rates are real, we resign ourselves to the fact that there's not much monetary policy can do about it (and in the privacy of our own Board rooms we frequently blame irresponsible fiscal behavior).

Embodied in this perspective is the notion that one thing most monetary economists agree about is that monetary policy cannot peg the real interest rate for sustained periods. This view has been held by monetarists for decades and is now held even by economists who take sluggish adjustment of prices as an institutional datum.

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[1]With a more complicated Fisher relation, we can contemplate that there has been an increase in risk, but we usually dismiss this possibility.

There are two necessary features of a model that can yield insights about the term structure: (1) there must be real investment opportunities available so that private agents' decisions can affect the production possibilities frontier, and (2) the government must not have a monopoly in stores of value and means of transferring wealth over time. Steve uses an endowment economy, so there are no interesting real opportunities available to the private sector. He employs an overlapping generations (OLG) model, which is in the class of models in which monetary policy is *presumed* to have a monopoly over ways to move wealth across time. The monopoly status provides the monetary authority with unlimited power to tax the temporal transference of wealth and thus, enables monetary policy to peg short-term and long-term real interest rates.

Steve's framework may be fine for exploring the nominal effects of monetary policy, which do not revolve around having these two modeling requirements met. But it is unlikely that many readers will be convinced that his model will yield useful insights into the effects of monetary policy on the term structure of interest rates.

In general, modelers must present persuasive arguments for using their models to study monetary policy effects. These arguments can take various forms. One example is *a priori* arguments that the model captures essential features of the monetary system that other models fail to capture; for example, what aspects of economic behavior are captured by the model that makes this framework especially well suited to studying monetary policy effects on the term structure? I found Steve's arguments in favor of OLG models to be less than compelling. He sets up a strawman representative agent model with helicopter drops of money and argues that his modeling of open market operations improves upon this representation of monetary policy. But any model that takes monetary *and fiscal policy* seriously will allow the analysis of open market operations, and many examples of such models exist.[2]

Steve's arguments about the role of heterogeneity could be compelling, but after briefly mentioning them in the introduction, he doesn't follow through to talk about how heterogeneity helps interpret or match data. Indeed, he doesn't even emphasize the welfare consequences of monetary policy, and these results are driven by the heterogeneity. Moreover, Steve forces savers to hold money to satisfy a binding reserve requirement, reducing his model to one that imposes a type of cash-in-advance-for-savings constraint. Thus, the usual "tenuousness of monetary equilibria," which many proponents of OLG models put forth as an important feature of the real world that this class of models captures, does not hold in Steve's work.

An alternative argument for proponents of a particular model to make would be that their model is capable of matching certain features of the data, which other models fail to match. In the introduction Steve embeds his work in the real business cycle calibration literature and leads the reader to think that he is going to move boldly in the direction of demonstrating the empirical relevance of OLG models. Steve does contribute to the OLG literature in this regard by parameterizing a stochastic model and simulating it to produce artificial time series. (His work is an empirical advance for OLG models whose only previous claim of empirical relevance was that they produced positive nominal interest rates.)

But his boldness is overly timid: Steve tries too hard to distance himself from the calibration procedure he uses and asserts "a *prima facie* case

[2]Some examples of such models are Aiyagari and Gertler (1985), Leeper (1989,1991), Sims (1991), Novales (1992), and Coleman, Gilles, and Labadie (1992).

for the empirical usefulness of the type of model".[3] In the end, he actually does not advance the case for the empirical usefulness of OLG models as far as Hakkio and Sibert (1990) did in their study of exchange rates. I believe that Steve's timidity stems from giving calibrators of infinitely lived agent models too much credit for having solved difficult questions about how to connect the theory to data: OLG models and infinitely lived agent models have to face exactly the same questions about, for example, what a period is. Choosing the correct value for the discount factor does not suffice to connect a cash-in-advance model to, say, quarterly data; do we really want to impose a technological constraint that says you cannot write checks on your money market mutual fund account to finance transactions over a quarter? Steve interprets a model period as one year. This interpretation is tenuous when the point of the paper is to determine the effects of monetary policies on the prices of multi-period assets. The missing markets produced by the overlapping generations rule out trades that are important for determining these prices, thus the connection of model periods to real time is critical to the results. (Hakkio and Sibert do not solve this problem either, but they acknowledge its existence.[4])

Having said these things, I'll talk briefly about the results. The main result that jumped out at me is that the monetary policy that minimizes the variance of nominal interest rates differs from the policy that minimizes the variance of inflation, which differs from that which minimizes the variance of

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[3]There is plenty of middle ground between Steve's stance and that of many calibrators who essentially assert the empirical relevance of their calibrated models and claim that the models' policy implications should be taken seriously.

[4]Hakkio and Sibert also are clear that their objective is to ask whether certain features that are distinctive about the OLG model will help to account for some of the time series properties of exchange rates.

nominal GNP, which differs from the policy that maximizes the utility of savers, borrowers, or the average of savers and borrowers. These results are recorded in the graphs at the end of the text.

This is an important and I think universal truth about policy, which the heterogeneity of OLG models correctly captures: There is no single "best" monetary policy. Every policy has its winners and losers. I think Steve should push this point harder as a rationale for using the OLG framework, as Wallace (1984) does. Coupling this framework with a more careful analysis of exactly who the winners and losers are may help to explain historical shifts in policies across countries.[5]

I don't think Steve was really trying to mimic the real business cycle calibration exercises. I think he had an analytically intractable model, which he needed to simulate. Why not present the results as outright *examples*, instead of half-heartedly dressing them up as calibration exercises? To this end, Steve could try to connect his hypothetical policies more closely to actual policy experiences and systematically explore the implications of these policies for various nominal variables and the welfare of borrowers and savers. Explorations of these sorts would help alleviate the feeling the reader now gets that the model is being used as a black box (a feeling that is all too common among papers that calibrate models).

I will end by discussing what I consider to be a major source of confusion in the paper: the distinction between "Treasury" and "Federal Reserve" currency. Steve refers to Treasury currency as "outside money" and to Fed currency as "inside money". I think that Steve's distinction between Treasury and Fed currency has nothing to do with inside and outside money as they are traditionally thought of by, for example, Gurley and Shaw (1960).

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[5]Jon Faust (1992) has done something akin to this to rationalize the existence of certain institutional features of the Federal Reserve System.

Traditionally, "outside" money is any liquid liability of the government. It is controlled by the policy authority and, when there are reserve requirements, it is used as a factor of production in the supply of "inside" money. Importantly, "outside" money is *exogenous to the private sector.* "Inside" money is produced within the private equilibrium, usually by the banking system. It is an intermediate good, which is used in the production or allocation of final goods. Thus, the traditional distinction is rooted in the economic environment (i.e., technology, legal system, etc.).

Steve's distinction is based on equilibrium outcomes related to assumptions about monetary and fiscal policy interactions. In Steve's terminology, "outside" money is "Treasury" currency, which results when the Fed purchases an unbacked Treasury security. (He wants us to think of this as helicopter money.) "Inside" money is "Federal Reserve" currency, which is created when the Fed purchases a fully-backed obligation. (He wants us to think of this as an open market purchase.) Not surprisingly, expansions in Treasury currency and Fed currency have very different effects because in one case the government is giving away currency and in the other case the government is getting something in return for the currency increase.

There are three things to keep in mind about Steve's policy experiments: (1) whether you give away currency or give away some other government liability cannot matter (helicopter drops of money and bonds are equivalent); (2) whether you give away currency (helicopter drop) or get something in return (open market operation) matters; (3) whether you give away currency or increase future tax liabilities matters. None of these three facts is related to the notion of "inside" and "outside" money as they are traditionally conceived.

It is disturbing that Steve's notion of "backing" is never defined. I think it involves implicit assumptions about future fiscal behavior. If this is correct, then these implicit assumptions serve to confound monetary effects with fiscal behavior.[6]

Tied in with this notion of "backing" is the assumption that the real stock of government debt is fixed. These two assumptions are critical for determining the consequences of open market operations. An open market purchase increases the fraction of debt held by the Fed and the fraction of real money balances that consists of Fed currency (Steve's "inside" money). Thus, Steve wants us to think of an open market operation as swapping "outside" real balances for "inside" real balances, which increases the supply of credit and lowers real interest rates. This sequence of events builds in the fixity of real debt and the fixity of real balances, which are equilibrium outcomes, and as such should be unrelated to the (more primitive) notions of "inside" and "outside" money. Steve's paper presents the fixed levels of real debt and real balances as if they were technological constraints, rather than implications of assumptions about monetary and fiscal interactions and the reserve requirement. Carefully distinguishing the assumptions about policy behavior from the equilibrium outcomes would help clarify the paper's results.

[6]In this regard Steve is in good company. Every discussion at this conference about price level indeterminacy under an interest rate rule has imposed analogous implicit assumptions about fiscal behavior, and these implicit assumptions drive the indeterminacy result. See Leeper (1991) for a discussion of this issue.

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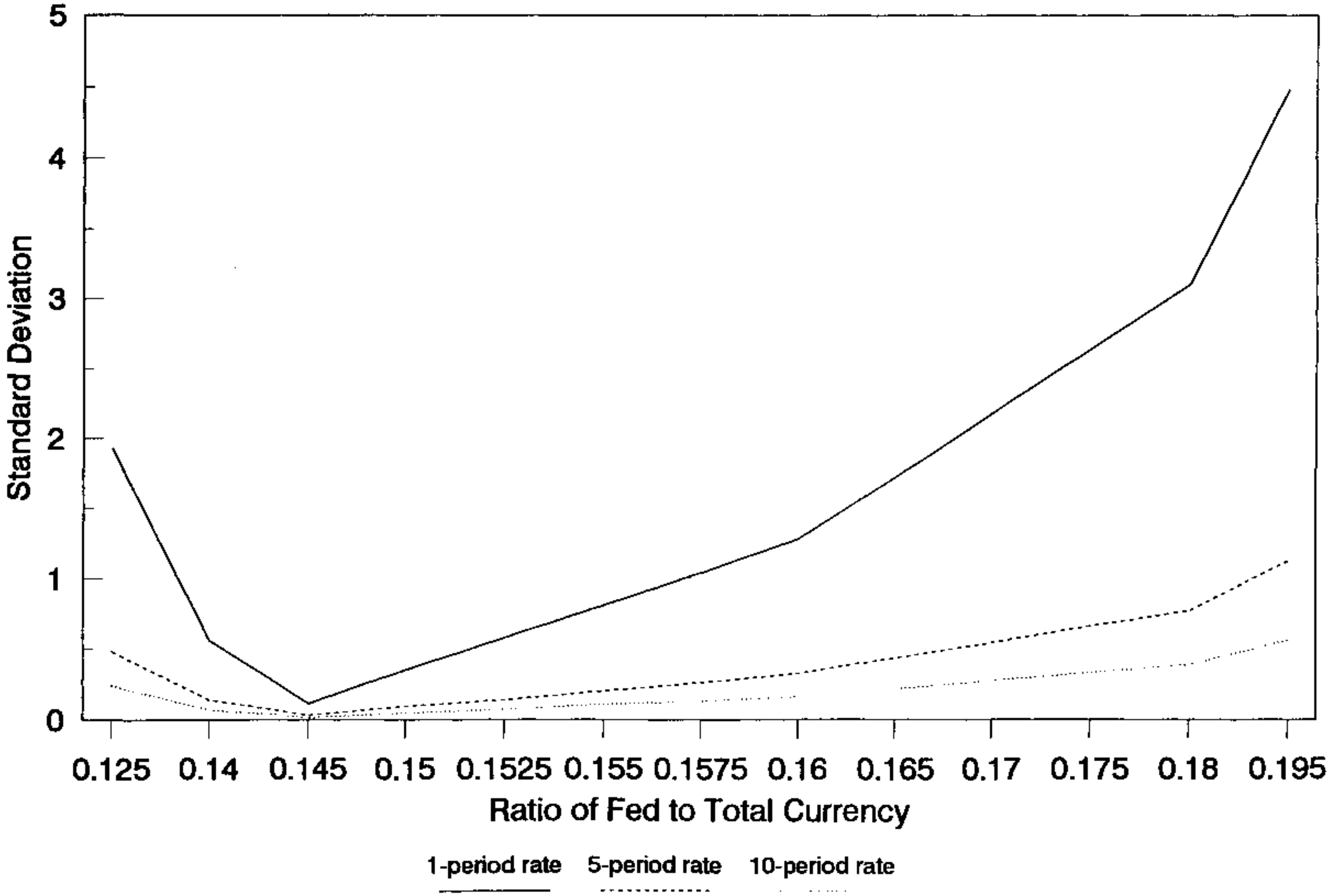
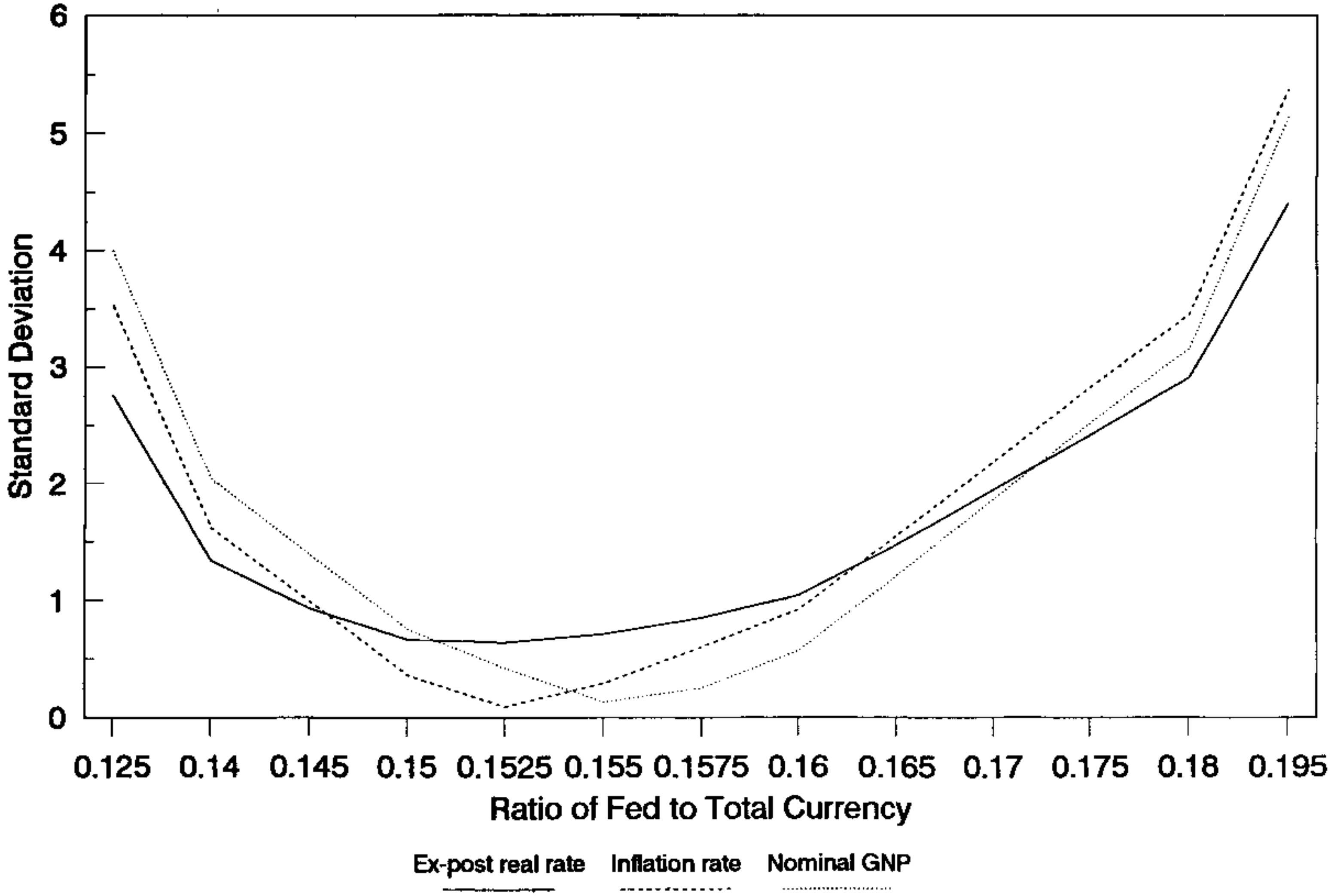
OMO's and Interest Rate Variability



OMO's and Economic Variability



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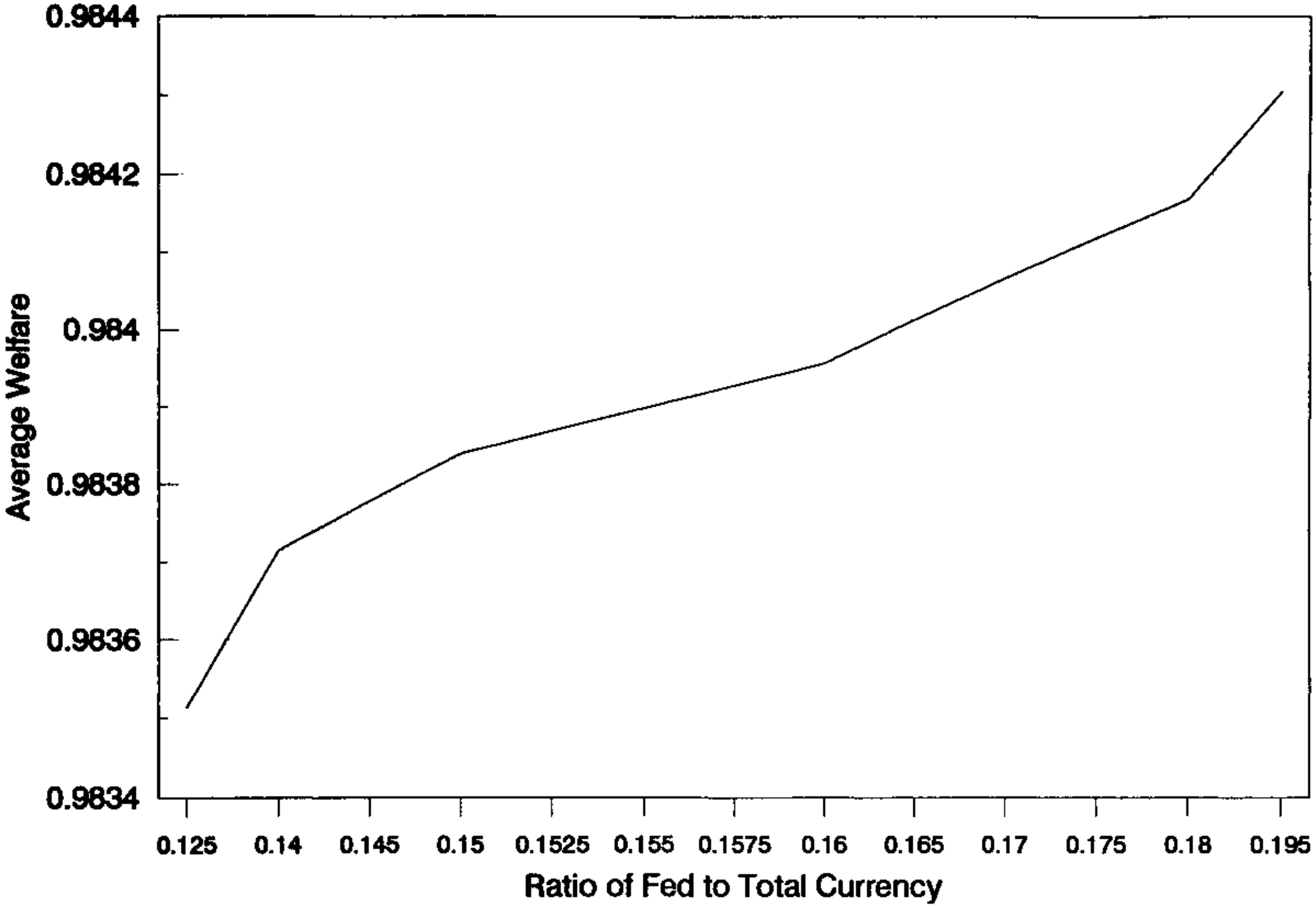

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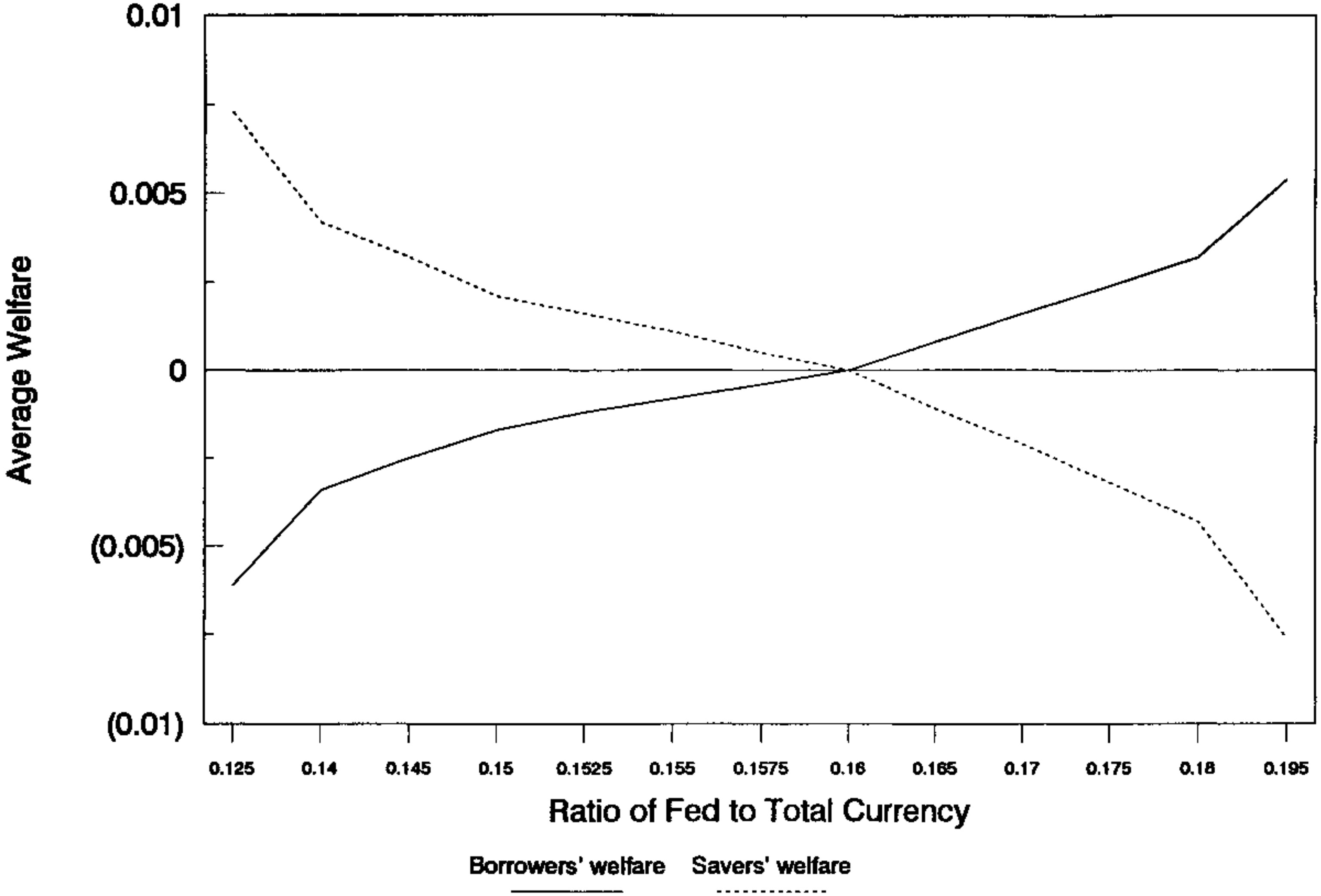

Inflation Persistence

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The most popular model of sticky prices today is the overlapping nominal contract model of Phelps (1978) and Taylor (1980). While that model implies that prices are sticky, it also implies that the inflation rate is so flexible that monetary policy can drive a positive rate of inflation to zero with virtually no loss of output. Phelps recognized this property in his 1978 article "Disinflation without recession," but the nominal contracting model delivers even more optimistic policy prescriptions than he realized. As Ball (1991) has shown, monetary policy can create a disinflationary boom in the Phelps-Taylor specification.

Our purpose is to show that the Phelps-Taylor model is not consistent with the dynamic interaction of inflation, interest rates, and output that we find in the data; to present a new contracting model—specified in real terms rather than nominal terms—that is data-consistent; and to analyze some monetary policy implications of the real contracting model.

Next we present the stylized facts of inflation, interest rates and output that the structural contracting models must explain. Then we estimate and

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†Federal Reserve Board. The opinions we express here are not necessarily shared by the Board of Governors of the Federal Reserve System or its staff. We thank Olivier Blanchard for his comments on an earlier draft.

test the two models of overlapping contracts. After rejecting the nominal contracting model as inconsistent with the data, we perform a battery of policy experiments designed to explore the properties of the real contracting model and to evaluate the effectiveness of monetary policy in recent years. We conclude that policymakers have been been striking a good balance among competing monetary policy objectives.

1 The stylized facts

The key variables in our analysis are quarterly series for the inflation rate, the Treasury bill rate, and the deviation of output from trend; mnemonics and series definitions are listed in Table 1.

Table 1: Quarterly data, 1965Q1–1990Q4

Mnemonic	Definition
y_t	log of per capita nonfarm business output
p_t	log of the implicit deflator for nonfarm business output
r_t	3-month Treasury bill rate
π_t	inflation rate, 4 Δp_t
$\tilde{y}_t$	deviation of y_t from trend, 1959Q1–1990Q4

We characterize the dynamic interaction of inflation, the bill rate, and the output gap with the vector autocorrelation function implied by a stationary vector autoregression for those variables. The autocorrelation function summarizes the stylized facts that we seek to explain with structural models of overlapping contracts.

While we cannot reject the hypotheses that the data contain one or two unit roots, a stationary representation is useful for two reasons. First, the estimated vector autococorrelation function nicely summarizes the conventional wisdom about the behavior of these series in a compact graphical format. Second, we want to show that the orthodox overlapping nominal contracting model cannot capture the persistence that is inherent in the inflation process. By viewing inflation as an I(0) process instead of an I(1) process, we bias downward our estimate of inflation persistence, and we strengthen the argument that the nominal contracting model cannot adequately explain inflation persistence.

Table 2 presents augmented Dickey-Fuller tests for the various series. [1] The initial test regressions are estimated with six lags. Then we reduce the lag lengths until the last lag remains statistically significant and the residuals appear to be uncorrelated. At conventional significance levels, we cannot reject the hypotheses that the inflation rate and the interest rate series are integrated of order one. The log of per capita output, on the other hand, appears to be trend stationary over the sample period.

Table 2: Augmented Dickey-Fuller tests
$\Delta x_t = \beta_0 x_{t-1} + \sum_{i=1}^{n} \beta_i \Delta x_{t-i} + \mu + \gamma t + \epsilon_t$

Series	n	$Q(12)$	β_0	τ_μ	τ_τ
π_t	2	7.2	−.17	−2.23	
r_t	3	19.0	−.09	−2.40	
y_t	3	15.9	−.16		−4.25
$\tilde{y}_t$	3	14.4	−.11	−3.20	

Tables 3 and 4 show test statistics for a Johansen multivariate test regression of a model that includes the inflation rate, the bill rate, and the output gap. [2] The estimation strategy is similar to that used in the Dickey-Fuller test regressions. We begin with a model that includes six lags of each variable. Then we reduce the lag length of each variable until the last lag of

[1] Table 8.5.2 in Fuller (1976) gives critical values for the τ_μ and τ_τ statistics.

[2] Table A.3 in Johansen and Juselius (1990) gives critical values for the maximum eigenvalue and trace statistics.

each variable is jointly significant in all three equations and the residuals are uncorrelated.

Table 3: Johansen test regression
$\Delta x_t = \Pi x_{t-1} + \sum_{i=1}^{n} \Gamma_i \Delta x_{t-i} + \mu + \epsilon_t$

Series	Maximum lag	$Q(12)$
$\Delta\ \pi_t$	3	6.6
$\Delta\ r_t$	2	13.0
$\Delta\ \tilde{y}_t$	3	15.8

The maximum eigenvalue and trace statistics in table 4 are consistent with the univariate Dickey-Fuller tests. We can reject the hypothesis that the vector autoregression contains three unit roots in favor of two unit roots at the one percent significance level. But we can reject two unit roots in favor of one, and one unit root in favor of zero unit roots, only at the twenty percent significance level.

Table 4: Johansen test statistics

Number of unit roots	Maximum eigenvalue	Trace
1	6.64	6.64
2	10.63	17.27
3	46.03	63.30

It is difficult to interpret the model with a single cointegrating vector and two unit roots. Table 5 displays the estimated cointegrating vector, β, and the error-correction coefficients, α, together with their p-values, for the model with two unit roots. The coefficient on the inflation rate is not significantly different from zero, and the deviation of output from trend moves one-for-one with the short-term *nominal* rate. We can easily reject the hypothesis that the short-term *real* rate is driving output in this model. The p-value

Table 5: Cointegrating vector and error-correction coefficients

Variable	β		α	
	Coefficient	p-value	Coefficient	p-value
π_t	9.1	.29	$-.0047$	.014
r_t	-44.3	8.6×10^{-7}	$-.0016$	.064
$\tilde{y}_t$	-46.1	1.1×10^{-8}	.0038	2.3×10^{-5}

of the hypothesis that the coefficients on inflation and the bill rate in the cointegrating vector are equal in magnitude and opposite in sign is 2.2×10^{-4}.

For each variable in the system, table 6 tests the joint hypothesis that the cointegrating-vector coefficient and the error-correction coefficient are both zero. The inflation rate is the variable most weakly coupled with the other two. At any significance level less than five percent, we cannot reject the hypothesis that the inflation rate is completely decoupled from the other two variables in the long-run dynamics of the system.

Table 6: Tests that β_i and α_i are both zero

Variable	p-value
π_t	.050
r_t	1.2×10^{-7}
$\tilde{y}_t$	3.2×10^{-8}

The unconstrained vector autoregression, estimated by ordinary least squares, is actually quite stable. Table 7 displays the non-zero roots of the companion matrix of the stationary vector autoregression. The dominant roots are a complex pair with a modulus of 0.94, well within the unit circle.

We prefer to characterize the operating characteristics of the stationary vector autoregression with its vector autocorrelation function rather than its impulse-response function. Deriving the autocorrelation function requires no

Table 7: Roots of the stationary vector autoregression

Modulus	Period
.94	74.3
.88	17.7
.69	2.8
.64	3.4
.55	4.6
.23	2.0

identifying assumptions, while deriving the impulse-response function does. [3] The autocorrelation function nicely summarizes our intuition about the dynamic interaction of interest rates, inflation, and output.

Figure 1 displays the vector autocorrelation function implied by the stationary vector autoregression. The diagonal elements show the univariate autocorrelation functions of the three variables in the system, and the off-diagonal elements show the lagged cross correlations. Inflation and the bill rate are quite persistent, with positive autocorrelations out to lags of about four years, while the output gap is somewhat less persistent. Much of the conventional wisdom about the dynamic interaction of inflation, interest rates, and output can be found in the off-diagonal elements of the vector autocorrelation function. In the second and third elements of the first row, for example, a high level of the bill rate is followed by a low level of inflation some twelve quarters later, while a high level of output is followed by a high level of inflation about six quarters later. In the second element of the third row, a high level of the bill rate is strongly correlated with a low level of output about six quarters later.

We take the vector autocorrelation function in figure 1, especially its

[3] We do compute the impulse-response functions of the structural models, where we believe that we have made plausible identifying restrictions.

first row and column, to be the stylized facts that the staggered contracting models must explain.

2 Structural models

In order to estimate how much of inflation persistence is inherent in the contracting process itself, we must make some strong identifying assumptions. We estimate and analyze two structural models, each with three stochastic equations, and we investigate how well they can replicate the vector autocorrelation function of the unconstrained vector autoregression. Each structural model contains an I–S curve that relates the output gap to the long-term real interest rate; a monetary policy reaction function that moves the short-term nominal interest rate in response to inflation and the output gap; and a model of overlapping contracts.

2.1 The I–S curve

The real economy is represented in the structural models with a simple I–S curve that relates the output gap to its own lagged values and one lag of the long-term real interest rate, ρ_{t-1}. The long-term real rate is the yield to maturity on a hypothetical long-term real bond. In the initial estimate of the realization of ρ_t, the expected holding-period yield on the long-term real bond is set equal to the expected real return on Treasury bills forecast by the unconstrained vector autoregression for the inflation rate, the bill rate, and output.

The concept of duration, introduced by Macaulay (1938), unifies the representation of holding-period yields on discount bonds and coupon bonds. The duration of a discount bond is simply its maturity. The duration of a coupon bond is a weighted average of the time until the payments on the bond are received; the weighting function is the ratio of the present value of the payment stream to the value of the bond.

Let R_t be the yield to maturity on a coupon bond selling at par, and let M be the maturity of the bond at the end of quarter t. Then the duration of the bond is given by

$$D_t = \frac{1 - e^{-R_t M}}{R_t} \tag{1}$$

and the holding-period yield on the bond from quarter t to quarter $t+1$ is

$$R_t - D_t(R_{t+1} - R_t) \tag{2}$$

For the sake of a convenient linear approximation, we set duration to the constant value of 40 quarters, the average duration of Moody's BAA corporate bond rate over the sample period. [4]

The intertemporal arbitrage condition that equalizes the expected holding-period yields on Treasury bills and long-term bonds is then

$$\rho_t - D[E_t(\rho_{t+1}) - \rho_t] = r_t - E_t(\pi_{t+1}) \tag{3}$$

Solving equation 3 for ρ_t in terms of ρ_{t+1} and $r_t - E_t(\pi_{t+1})$, then recursively substituting the result into itself, the long-term real rate is an exponentially weighted moving average of the forecast path of the real rate of return on Treasury bills.

$$\rho_t = \frac{1}{1+D} \sum_{i=0}^{\infty} \left(\frac{D}{1+D} \right)^i E_t(r_{t+i} - \pi_{t+i+1}) \tag{4}$$

A series that measures the realization of ρ_t is computed by simulating the

[4] A constant duration approximation is conventional in the term structure literature. See Shiller and others (1983) for an example.

vector autoregression, with the vector autoregression residuals exogenous, in conjunction with equation 3. Details of the computation are reported in appendix A. In effect, the calculation uses the vector autoregression to generate an infinite-horizion forecast of the bill rate and the inflation rate at each point in the sample, and then it discounts the implied short-term real rate forecasts according to equation 4.

Preliminary analysis suggests that a single lag of the long-term real rate is sufficient to explain the evolution of output; the coefficient on the contemporaneous value of ρ_t is not significantly different from zero in an instrumental variables estimation of the $\tilde{y}_t$ equation. The I–S curve is estimated by ordinary least squares, and parameter estimates are reported in table 8. [5]

Table 8: I–S curve, dependent variable is $\tilde{y}_t$

Variable	Lag	Coefficient	t-statistic
Constant	—	0.017	4.6
$\tilde{y}$	1	1.254	14.7
	2	−0.415	−5.0
ρ	1	−0.798	−4.8
Residual s.e.	.00903		
$\bar{R}^2$	.920		
$Q(12)$	23.3		

2.2 The reaction function

Monetary policy is represented with a policy reaction function that relates the quarterly change in the bill rate to lagged changes in the bill rate, lagged levels of the inflation rate, and the contemporaneous level of the output gap.

[5] The $Q(12)$ statistic is large because of a residual autocorrelation of −.29 at lag 8.

The beginning of the sample period, 1965, is dictated by our use of the short-term nominal interest rate as the fundamental instrument of monetary policy. The federal funds rate, the overnight rate on interbank loans, was less than the Federal Reserve discount rate prior to the mid-1960s. Since that time, the funds rate has generally traded above the discount rate, and there has been a direct link between Federal Reserve open market transactions and movements in the funds rate.

While the details of reserve accounting and the tactics of monetary policy have changed several times since the mid-1960s, it has always been the case that required reserves have been essentially predetermined over the course of a reserve maintenance period. By draining nonborrowed reserves from the banking system, the Federal Reserve forces banks to borrow at the discount window. When the federal funds rate is trading above the discount rate, the demand for discount window borrowing is negatively related to the spread between the funds rate and the discount rate. As discount window borrowing increases, Federal Reserve District banks apply increasing administrative pressure to the borrowers, and banks in need of reserves are willing to pay an increasing premium in the interbank federal funds market to avoid these "frowns." When the trading desk drains reserves, it forces the funds rate up relative to the discount rate. [6] The 3-month Treasury bill rate proxies for the overnight federal funds rate in our quarterly models.

Because the contemporaneous output gap is significant in the reaction function, the equation is estimated by instrumental variables. The instruments are the same variables that appear in the reduced-form vector autoregression. Four lags of inflation and the output gap and three lags of the bill rate are used as instruments for $\tilde{y}_t$. Table 9 displays the parameter estimates.

[6] See Keir (1981), Goodfriend (1983), Resler and others (1985), and Meulendyke (1989) for more extensive discussions of this mechanism.

Table 9: Reaction function, dependent variable is Δr_t

Variable	Lag	Coefficient	t-statistic
Constant	—	−.00133	−0.7
Δr_t	1	.120	1.3
	2	−.455	−5.1
π_t	1	.056	1.2
	2	.103	2.6
	3	−.126	−2.8
$\tilde{y}_t$	0	.113	3.6
Residual s.e.	.00820		
$\bar{R}^2$	.345		
$Q(12)$	16.0		

The reaction function determines the long-run equilibrium inflation rate in the structural models. Given that the sample mean of the output gap is zero by construction, the estimated mean inflation rate is the constant in the reaction function divided by the sum of the coefficients on lagged inflation. Consistent with the cointegration analysis of the reduced-form vector autoregression in table 5, the equilibrium inflation rate is determined imprecisely. The mean inflation rate is 3.9 percent per year with an asymptotic standard error of 2.7 percent per year.

2.3 Contracting specifications

We analyze two models of staggered contracts. The definition of the aggregate price index in terms of lagged nominal contract prices is common to both specifications, and the models differ in the mechanism that determines the nominal contract price. The first model is essentially that of Taylor (1980); the nominal contract price is negotiated in nominal terms. In the second model, the nominal contract price is negotiated in real terms.

In both specifications, agents negotiate nominal contracts that remain in effect for four quarters. The aggregate log price index in quarter t, p_t, is a weighted average of the log contract prices, x_{t-i}, that were negotiated in the current and the previous three quarters and are still in effect. The weights, f_i, are the proportions of the outstanding contracts that were negotiated in quarters $t-i$,

$$p_t = \sum_{i=0}^{3} f_i x_{t-i} \tag{5}$$

where $f_i \geq 0$ and $\sum f_i = 1$. The sticky price index, p_t, is directly observable, while the flexible contract price, x_t, is not. To recover the realization of the contract price from the realization of the price index, the lag operator $f(L) = f_0 + f_1 L + f_2 L^2 + f_3 L^3$ must be invertible.

The precise shape of the contract distribution is not well-determined by the data. Unconstrained estimation of the contract distribution yields a downward-sloping function with imprecisely estimated weights. Taylor's contract distribution sets all of the f_i to 0.25, but that lag operator is not invertible. We use a downward-sloping linear function of contract length,

$$f_i = .25 + (1.5 - i)\, s, \qquad 0 < s \leq 1/6, \quad i = 0, \ldots, 3 \tag{6}$$

This distribution characterizes the contract distribution with a single slope parameter, s, and it is invertible. When $s = 0$ it is the rectangular distribution of Taylor, and when $s = 1/6$ it is the triangular distribution.

The distribution of contract lengths determines the steady-state real contract price in terms of the steady-state inflation rate, $\bar{\pi}$. With a constant inflation rate, the contract price satisfies $\bar{x}_{t-i} = \bar{x}_t - i\,\bar{\pi}$, and the log of the equilibrium real contract price is the product of the inflation rate and the mean contract length, $\sum i f_i$.

$$\bar{x}_t - \bar{p}_t = \bar{\pi} \sum_{i=1}^{3} i f_i \tag{7}$$

2.3.1 The nominal contracting model

Apart from the downward-sloping distribution of contract lengths, our nominal contracting specification is identical to Taylor's. The current contract price depends upon the price level expected to prevail over the life of the contract, adjusted for excess demand conditions, $\gamma\tilde{y}_t$.

$$x_t = \sum_{i=0}^{3} f_i E_t(p_{t+i} + \gamma\tilde{y}_{t+i}) + \epsilon_t \tag{8}$$

Equivalently, substitute equation 5 into equation 8 to obtain the two-sided representation [7]

$$x_t = \sum_{i=1}^{3} \beta_i x_{t-i} + \sum_{i=1}^{3} \beta_i E_t(x_{t+i}) + \gamma^* \sum_{i=0}^{3} f_i E_t(\tilde{y}_{t+i}) + \epsilon_t \tag{9}$$

where $\beta_i = \sum_j f_j f_{i+j}/(1 - \sum_j f_j^2)$, and $\gamma^* = \gamma/(1 - \sum_j f_j^2)$.

In their contract price decisions, agents compare the current nominal contract price with an average of the nominal contract prices that were negotiated in the recent past and those that are expected to be negotiated in the near future; the weights in the average measure the extent to which the past and future contracts overlap the current one. When output is expected to be high, the current nominal contract price is high relative to the nominal contract prices on overlapping contracts.

The five equations listed in table 10, three stochastic equations and two

[7] When the f_i are constant at 0.25, equation 9 is identical to equation 1 in Taylor (1980).

identities, form the nominal contracting model. The model jointly determines

Table 10: Nominal contracting model

Equation name	Table	Equation	Status
I–S curve	8		Stochastic
Reaction function	9		Stochastic
Long-term real rate		3	Identity
Price index		5	Identity
Contract price		8	Stochastic

the observable price index, bill rate, and output gap. The contract price and the long-term real rate are determined by model identities.

We set the I–S curve and reaction function parameters to their single-equation estimates in tables 8 and 9, and we set the duration parameter, D, in equation 3 to 40 quarters, the mean duration of Moody's BAA corporate bond rate over the sample. Then there are only two undetermined parameters in the nominal contracting model: the slope of the contract distribution, s, and the coefficient of the output gap, γ, in equation 8. Holding the other parameters fixed, we estimate these two parameters by maximum likelihood. [8]

The nominal contracting model cannot determine the slope of the contract distribution with much precision. In the estimate reported here, the slope of the contract distribution is constrained to 0.08, the midpoint of its admissible region (and its estimated value in the real contracting model). As shown in table 11, the maximum likelihood estimate of γ is extremely small, and it is estimated with high precision.

The residuals of the nominal contracting equation are very strongly autocorrelated. The $Q(12)$ statistic is 49.5, and the partial autocorrelation function falls within two standard deviations of zero only after lag 4.

[8] Appendix A outlines the computation of the likelihood function.

Table 11: Nominal contracting estimate

Coefficient	Value	Standard error
γ	1.87×10^{-6}	3.78×10^{-8}
Residual s.e.	.0072	
$Q(12)$	49.5	

The vector autocorrelation function implied by the nominal contracting model for the bill rate, the inflation rate, and output is displayed in figure 2. Comparing the stylized facts in figure 1 with the operating characteristics of the structural model in figure 2 illustrates clearly our basic point: the inflation rate in the nominal contracting model is far too flexible to be consistent with the data. The auto- and cross correlations of the bill rate and output, shown in the bottom-right block of figures 1 and 2, are quite similar. But the autocorrelation of inflation and the cross correlations of inflation with the interest rate and output are radically different.

The autocorrelation function of the inflation rate dies out much more rapidly in the nominal contracting model than it does in the reduced-form vector autoregression. Furthermore, while the reduced-form cross correlations between inflation and the other two variables are substantial in magnitude and plausible in sign, they are estimated to be virtually zero in the structural model.

Figure 3 shows the response of the inflation rate, the bill rate, and output to a unit standard deviation shock in each structural equation. The response of inflation to an inflation shock dies out within a year. The response of inflation to shocks in the bill rate and output cannot be detected in the plots. This small response depends primarily on the functional form of the nominal contracting equation, not on estimated parameter values.

The small estimated value of the output-gap coefficient in the nominal contracting equation, γ, effectively decouples the contracting equation from the I–S curve. But even when γ is increased by a factor of one thousand, the response of inflation to inflation shocks is unchanged, and the response of inflation to bill rate and output shocks remains quite small.

2.3.2 The real contracting model

Allowing agents to negotiate nominal contract prices in real terms rather than nominal terms appeals to our intuition, and it greatly enhances the model's ability to mimic the stylized facts of the inflation process. [9]

Let v_t be the index of real contract prices that were negotiated on the contracts currently in effect,

$$v_t = \sum_{i=0}^{3} f_i(x_{t-i} - p_{t-i}) \tag{10}$$

Now suppose that agents set nominal contract prices so that the current real contract price equals the average real contract price index expected to prevail over the life of the contract, adjusted for excess demand conditions. Equation 8 becomes

$$x_t - p_t = \sum_{i=0}^{3} f_i E_t(v_{t+i} + \gamma \tilde{y}_{t+i}) + \epsilon_t \tag{11}$$

Substituting equation 10 into equation 11 yields the real version of Taylor's contracting equation,

$$x_t - p_t = \sum_{i=1}^{3} \beta_i(x_{t-i} - p_{t-i}) + \sum_{i=1}^{3} \beta_i E_t(x_{t+i} - p_{t+i}) + \gamma^* \sum_{i=0}^{3} f_i E_t(\tilde{y}_{t+i}) + \epsilon_t \tag{12}$$

[9]Buiter and Jewett (1981) analyzed a similar model, but they did not explore its implications for inflation persistencee.

where the β_i and γ^* are defined as in equation 9.

In their contract price decisions, agents compare the current real contract price with an average of the real contract prices that were negotiated in the recent past and those that are expected to be negotiated in the near future; the weights in the average measure the extent to which the past and future contracts overlap the current one. When output is expected to be high, the current real contract price is high relative to the real contract prices on overlapping contracts.

We estimate the slope and excess demand parameters in equation 11 by maximum likelihood, taking as given the parameters in the I–S curve, the reaction function, and the long-term real rate equation. Table 12 displays the parameter estimates.

Table 12: Real contracting estimate

Coefficient	Value	Standard error
s	−.07972	.01162
γ	.00454	.00176
Residual s.e.	.0047	
$Q(12)$	27.2	

Some residual autocorrelation remains in the contracting equation. The error has an MA(1) component with an autocorrelation coefficient of −.34 at lag 1. The standard error of the real contracting equation is about half that of the nominal contracting equation, and the estimated effect of aggregate demand on contract prices is three orders of magnitude larger in the real contracting model.

The empirical implications of bargaining in terms of relative real contract prices instead of relative nominal prices are striking. Figure 4 presents the vector autocorrelation function for inflation, the bill rate, and the output gap implied by the real contracting model. Comparing figures 1, 2, and 4, the vector autocorrelation function of the real contracting model mimics the stylized facts much more closely than the autocorrelation function of the nominal contracting model does. The inflation autocorrelation function dies out slowly in the real model, and the cross correlations between inflation and the bill rate and output have the appropriate signs and magnitudes.

Figure 5 presents the impulse-response function of the real contracting model, drawn to the same scale as figure 3. Again, the contrast between the first row and column of figures 3 and 5 is remarkable. The magnitude and persistence of the response of inflation to each structural shock, the first row of the figures, is much greater in the real contracting model. The response of all three variables to an inflation shock, the first column of the figures, is also larger and more persistent.

2.3.3 A formal hypothesis test

Although the qualitative results shown in figures 1, 2, and 4 are compelling evidence that the nominal contracting model cannot generate enough inflation persistence to be consistent with the data—while the real contracting model can—a formal test of the real versus the nominal model is desirable. Such a test can be constructed by embedding both models in a more general framework. A variation on equations 10 and 11 that encompasses both the real and the nominal contracting models is

$$v_t = \sum_{i=0}^{3} f_i(x_{t-i} - \delta p_{t-i}) \tag{13}$$

$$x_t - \delta p_t = \sum_{i=0}^{3} f_i E_t(v_{t+i} + \gamma \tilde{y}_{t+i}) + \epsilon_t \tag{14}$$

where $0 \leq \delta \leq 1$. The parameter δ indexes the degree to which contracts are negotiated in real terms: $\delta = 0$ in the nominal contracting model, while $\delta = 1$ in the real contracting model.

We estimate δ and γ by maximum likelihood, constraining the contract slope parameter to 0.08 and again holding fixed the parameters of the I–S curve, the reaction function, and the long-term real rate equation. The estimated value of δ is almost exactly 1, so the p-value of the likelihood-ratio test of the the single restriction imposed by the real contracting model, $\delta = 1$, is essentially unity.

The likelihood ratio test statistic for the single restriction imposed by the nominal contracting model, $\delta = 0$, is 11.6, with $\chi^2(1)$ probability of 6.6×10^{-4}. The data decisively reject the nominal contracting model, and they fail to reject the real contracting model. [10]

3 Policy experiments

We perform a battery of policy experiments designed to explore the properties of the real contracting model and to evaluate the effectiveness of monetary policy in recent years. Because the tactics of monetary policy have changed so frequently, we cannot estimate a stable monetary policy reaction function over the entire sample from 1965 through 1990. Furthermore, the sample since the end of the nonborrowed reserves operating procedure in late 1982 is so short that we cannot estimate a policy reaction function in recent data with much precision. Nevertheless, we think that a simplified policy reaction

[10] While it is natural to think of testing the contracting models by comparing their likelihood values with that of the unconstrained vector autoregression in section 1, neither of the structural contracting models is nested within the vector autoregression. The fundamental price series in the vector autoregression is the inflation rate, while the fundamental price series in the structural models is the log of the price level.

function that plausibly characterizes monetary policy over the last decade is

$$\Delta r_t = \alpha_\pi(\pi_t - \bar{\pi}) + \alpha_y \tilde{y}_t \tag{15}$$

where $\bar{\pi}$ is the target inflation rate and $\alpha_\pi = \alpha_y = 0.1$. We use equation 15 as the baseline of our policy experiments. Since we vary the size of the policy parameters α_π and α_y over two orders of magnitude in the experiments, we are not too concerned about the lack of precision in the point estimates of the policy parameters.

For each setting of the policy parameters, we examine five characteristics of the system. The first two characteristics are associated with a deterministic thought experiment. We start the system in its steady state with a positive rate of inflation. At the beginning of the experiment, we lower the target inflation rate to zero, and we compute the output sacrifice ratio and the system's speed of convergence to its new equilibrium. The output sacrifice ratio is the cumulative annual deviation of output from trend, discounted at 3 percent per year. The speed of convergence is one minus the size of the largest root in the reduced form of the model, the quarterly rate of decay of the solution trajectory toward its long-run equilibrium. The other three system characteristics are the unconditional variance of inflation, output, and the bill rate as the model is repeatedly shocked by disturbances drawn from the estimated distribution of the structural residuals.

In the policy experiments we vary α_π and α_y over a logarithmic grid centered on the baseline value of 0.1 and ranging from 0.01 to 1.0. Figures 6–10 show model solution trajectories in the disinflation experiment when the policy parameters are first set at their baseline values and then set at the four corners of the (α_π, α_y) grid.[11] Table 13 shows the system characteristics

[11]Except for figure 7, these graphs are all drawn to the same scale.

for the same settings of the policy parameters. We examine the system characteristics and solution trajectories at the baseline parameter settings and compare them with the cases at the four corners of the policy grid.

Table 13: System characteristics

Policy			Convergence	Sacrifice	Variance		
α_π	α_y	Fig	rate	ratio	Inflation	Bill rate	Output
.10	.10	6	.094	2.39	.00223	.00157	.00137
.01	.01	7	.048	11.42	.01959	.00051	.01930
1.00	1.00	8	.125	1.81	.00177	.01277	.00192
1.00	.01	9	.113	3.59	.00094	.01996	.01054
.01	1.00	10	.022	0.27	.01339	.01405	.00040

$\alpha_\pi = .1$, $\alpha_y = .1$: In figure 6, α_π and α_y are set at their baseline values of 0.1. At the beginning of the disinflation experiment, the model is at its steady state with a constant inflation rate of 5.2 percent per year. At quarter zero the target inflation rate, $\bar{\pi}$, is lowered to zero.

The bill rate, the dashed line in the upper panel, rises by 50 basis points over three quarters at the beginning of the experiment before gradually falling to its new equilibrium after about four years. The inflation rate, the solid line in the upper panel, reaches its target of zero in two years, turns slightly negative, and then gradually converges to its equilibrium value from below. Output, shown in the lower panel of figure 6, falls five percent below trend after about six quarters. The output sacrifice ratio, discounted at three percent per year, is 2.4 in this experiment. This sacrifice ratio is somewhat smaller than the value of 3.9 estimated by Gordon (1985), but it is six times greater than the value of 0.42 that is generated when we perform the same experiment in the nominal contracting model.

The size of the dominant root in the reduced-form model of section 1 is

0.94, a convergence rate of 0.06 per quarter. Since we believe that monetary policy has been more aggressive in recent years than it was in the early part of the sample, we think that the 0.09 convergence rate of the baseline model fairly reflects the vigor of recent monetary policy.

$\alpha_\pi = .01$, $\alpha_y = .01$: Policy is responsible for stabilizing inflation and output fluctuations in this model. When both of the baseline policy parameters are reduced by a factor of 10, the variance of inflation and output increase by an order of magnitude, and the variance of the bill rate falls by a factor of 2/3. The large output fluctuations in figure 7 are driven by large swings in the real rate of interest. The real-rate fluctuations, in turn, are dominated by huge swings in the inflation rate, reaching a deflation rate of 21 percent per year after three years. The bill rate actually *falls* for the first 6.5 years of the simulation. This timid policy rule produces an enormous sacrifice ratio of 11.4.

In a mechanical sense, this policy eventually achieves its objective of zero inflation. However, the key assumption that policy is fully credible is quite dubious under this policy rule. To be considered credible, we believe that policymakers must be seen to be fighting inflation, raising interest rates in response to deviations of inflation from its target.

$\alpha_\pi = 1.0$, $\alpha_y = 1.0$: Compared with the baseline simulation, the primary effect of this very strong targeting of inflation and output in figure 8 is to drive up the variance of the bill rate by an order of magnitude. The sacrifice ratio improves a bit and the model converges slightly faster than it does in the baseline case.

$\alpha_\pi = 1.0$, $\alpha_y = .01$: While it controls the inflation rate very closely, this combination of strong inflation targeting and weak output targeting in figure 9 drives up the variance of the bill rate and output by an order of magnitude compared to the baseline case.

$\alpha_\pi = .01$, $\alpha_y = 1.0$: This combination of weak inflation targeting and strong output targeting in figure 10 shares the credibility problems of the simulation in figure 7. After rising by 5 basis points at the beginning of the experiment, the bill rate falls throughout the simulation, and the inflation rate has not yet converged to zero after 20 years. As one might expect, output hardly deviates from trend, and the sacrifice ratio is extremely low in this experiment.

The upper panels of figures 11–15 plot the five system characteristics as surfaces above the (α_π, α_y) plane. The lower panels are contour plots of the same surfaces. The point (.01, .01) lies in the bottom-left corner of each contour plot. To gain clear views of the surfaces in the upper panels, we rotate the plots about the vertical axis by varying amounts. The viewpoint can be determined by inspecting the policy coordinates at the corners of the surfaces.

If our characterization of recent monetary policy is approximately correct, $\alpha_\pi = \alpha_y = 0.1$, then policy has been striking a good balance among competing policy objectives. Given policymakers' concern for the sacrifice ratio and the variance of inflation, interest rates, and output, movement from the center toward any corner of the policy parameter grid entails a substantial deterioration in at least one measure of system performance without substantial improvement in any of the other measures.

More aggressive targeting of inflation and output yields little or no improvement in the sacrifice ratio, inflation variance or output variance, but it produces higher bill rate variance. Figures 12–15 depict this result graphically. Starting in the center of the plots, increases in both α_π and α_y correspond to movements along the level contours of the sacrifice ratio, inflation variance, and output variance functions and uphill movement on the bill-rate variance function.

Weaker targeting of inflation and output yields a small improvement in the bill-rate variance at the expense of a substantial deterioration in the sacrifice ratio and the variance of inflation and output.

Movements toward the other two corners of the policy grid yield predictable results. If policy emphasizes inflation at the expense of output, then output variance rises; if policy emphasizes output at the expense of inflation, then inflation variance rises. Each of these policy changes is associated with movement across a flat region of the sacrifice ratio function, and each is accompanied by a substantial increase in the variance of the bill rate.

4 Conclusion

As measured by its autocorrelation function and its cross correlations with the Treasury bill rate and output, the inflation rate is quite persistent. The inflation autocorrelation function reaches zero only after a lag of about four years, and inflation is strongly correlated with the bill rate and output at lags and leads of two to four years.

The nominal contracting model of Phelps and Taylor cannot replicate these prominent features of the data. The inflation autocorrelation function dies out within a year in that model, and the cross correlations of inflation with the bill rate and output are virtually zero. These properties are implied by the functional form of the model, and they are insensitive to our particular parameter estimates. When we increase the response of the contract price to excess demand by a factor of one thousand times its estimated value, the inflation autocorrelation function remains the same, and the cross correlations of inflation with the bill rate and output remain very small.

When nominal contracts are negotiated in real terms rather than nominal terms, these properties change dramatically. The real contracting model can mimic the vector autocorrelation function of inflation, the bill rate, and output quite nicely. In addition to this graphical evidence of the superiority of the real contracting model, a likelihood ratio test decisively rejects the nominal contracting model in favor of the real model; the p-value of the test is 6.6×10^{-4}.

In conjunction with the estimated I-S curve, the real contracting model implies significant tradeoffs among monetary policy goals—the output sacrifice ratio and the variance of inflation, interest rates, and output. Given our parameter estimates and our characterization of monetary policy in recent years, we conclude that policymakers have been striking a good balance among competing monetary policy objectives.

A Computations

Each of our forward-looking models can be cast in the format

$$\sum_{i=-\tau}^{0} H_i x_{t+i} + \sum_{i=1}^{\theta} H_i E_t(x_{t+i}) = \epsilon_t \qquad (16)$$

where τ and θ are positive integers, x_t is a vector of variables, and the H_i are conformable square coefficient matrices. The expectation operator $E_t(\cdot)$ denotes mathematical expectation conditioned on the process history through period t,

$$E_t(x_{t+i}) = E(x_{t+i} | x_t, x_{t-1}, \ldots)$$

The random shock ϵ_t is independently and identically distributed $N(0, \Omega)$. The covariance matrix Ω is singular whenever equation 16 includes identities.

We represent constants in the model of equation 16 with a device analogous to the column of ones that represents the constant in an ordinary least squares data matrix. Each model includes an identity for the number one,

$$\mathtt{ONE}_t = \mathtt{ONE}_{t-1}$$

Constants are coded as a coefficient times the variable `ONE`, and `ONE` is initialized at unity in the estimation and simulation exercises.

Because ϵ_t is white noise, $E_t(\epsilon_{t+k}) = 0$ for $k > 0$. Leading equation 16 by one or more periods and taking expectations conditioned on period-t information yields a deterministic forward-looking equation in expectations,

$$\sum_{i=-\tau}^{\theta} H_i E_t(x_{t+k+i}) = 0, \qquad k > 0 \qquad (17)$$

We use the generalized saddlepath procedure of Anderson and Moore

(1985) to solve equation 17 for expectations of the future in terms of expectations of the present and the past. For a given set of initial conditions, $\{E_t(x_{t+k+i}) : k > 0, i = -\tau, \ldots, -1\}$, if equation 17 has a unique solution that grows no faster than a given upper bound, that procedure computes the vector autoregressive representation of the solution path,

$$E_t(x_{t+k}) = \sum_{i=-\tau}^{-1} B_i E_t(x_{t+k+i}), \qquad k > 0 \tag{18}$$

In the models we consider here, the roots of equation 18 lie on or inside the unit circle.

Using the fact that $E_t(x_{t-k}) = x_{t-k}$ for $k \geq 0$, equation 18 is used to derive expectations of the future in terms of the realization of the present and the past. These expectations are then substituted into equation 16 to derive a representation of the model that we call the ***observable structure***,

$$\sum_{i=-\tau}^{0} S_i x_{t+i} = \epsilon_t \tag{19}$$

Equation 19 is a structural representation of the model because it is driven by the structural disturbance, ϵ_t; the coefficient matrix S_0 contains the contemporaneous relationships among the elements of x_t. It is an observable representation of the model because it does not contain unobservable expectations.

To generate the initial estimate of the long-term real rate, ρ_t, in section 2.1, the reduced-form vector autoregression for inflation, the bill rate, and output is combined with the intertemporal arbitrage condition in equation 3 to form a system in the format of equation 16. Next, the observable structure of the system is computed. Finally, the observable structure is simulated over the sample period, with the vector autoregression residuals exogenous, to generate the sample path of ρ_t.

For maximum likelihood estimation of the contracting equations, the estimated I–S curve, the reaction function, and the long-term real rate equation are combined with the contracting equations in the format of equation 16. For a given set of contracting parameters, the likelihood function of the model is evaluated using the observable structure and the realization of the data. The likelihood function is maximized with a sequential quadratic programming algorithm using numerical derivatives.

Impulse-response functions of the estimated models are computed by simulating the observable structure with appropriate settings for the exogenous shock term, ϵ_t.

Computing the vector autocorrelation function of the various models requires a few more steps. Premultiplying the observable structure by $-S_0^{-1}$, we have the *reduced form* of the structural model,

$$x_t = \sum_{i=-\tau}^{-1} B_i x_{k+i} + B_0 \epsilon_t \tag{20}$$

The coefficient matrices $\{B_i : i = -\tau, \ldots, -1\}$ in equation 20 are identical to those in equation 18, while B_0 is simply S_0^{-1}.

The companion system of the reduced form is

$$\begin{bmatrix} x_t \\ x_{t-1} \\ \vdots \\ x_{t-\tau+1} \end{bmatrix} = \begin{bmatrix} B_{-1} & B_{-2} & \cdots & B_{-\tau} \\ I & & & 0 \\ & \ddots & & \vdots \\ & & I & 0 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t-2} \\ \vdots \\ x_{t-\tau} \end{bmatrix} + \begin{bmatrix} B_0 \epsilon_t \\ 0 \\ \vdots \\ 0 \end{bmatrix} \tag{21}$$

In a more compact notation, the companion system is

$$y_t = A y_{t-1} + \eta_t \tag{22}$$

where $y_t = [x_t, \ldots, x_{t-\tau+1}]'$, and $\eta_t = [B_0\epsilon_t, 0, \ldots, 0]'$. Recursively substituting equation 22 into itself,

$$y_{t+k} = A^k y_t + \sum_{i=1}^{k} A^{k-i}\eta_{t+i} \tag{23}$$

Because η_t is uncorrelated over time, the covariance matrix of the k-period ahead forecasts of y_t is

$$V_t(y_{t+k}) = \sum_{i=0}^{k-1} A^i \Psi (A^i)' \tag{24}$$

where Ψ is the covariance matrix of η_t. In a stationary model, as k goes to infinity the conditional covariance matrix $V_t(y_{t+k})$ converges to Γ_0, the unconditional covariance matrix of y_t.

While the vector autoregressive model in section 1 is stationary, the structural models include the log price level, an I(1) variable. In the structural models we compute successive terms of $V_t(y_{t+k})$ until the conditional variances of the I(0) variables converge to constants. At this point the conditional variances of the I(1) variables are increasing at a linear rate. When the conditional variances of the stationary variables converge, we treat the sum in equation 24 as if it were Γ_0, the unconditional covariance matrix of y_t. The vector autocovariance function of y_t is then computed recursively according to

$$\Gamma_k = A\Gamma_{k-1}, \qquad k > 0 \tag{25}$$

This procedure correctly computes the autocovariance function of the stationary variables.

Finally, dividing each row and column of Γ_k, $k \geq 0$, by the square root of the corresponding diagonal element of Γ_0 yields the model's vector autocorrelation function.

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Figure 1
Autocorrelation function, vector autoregression

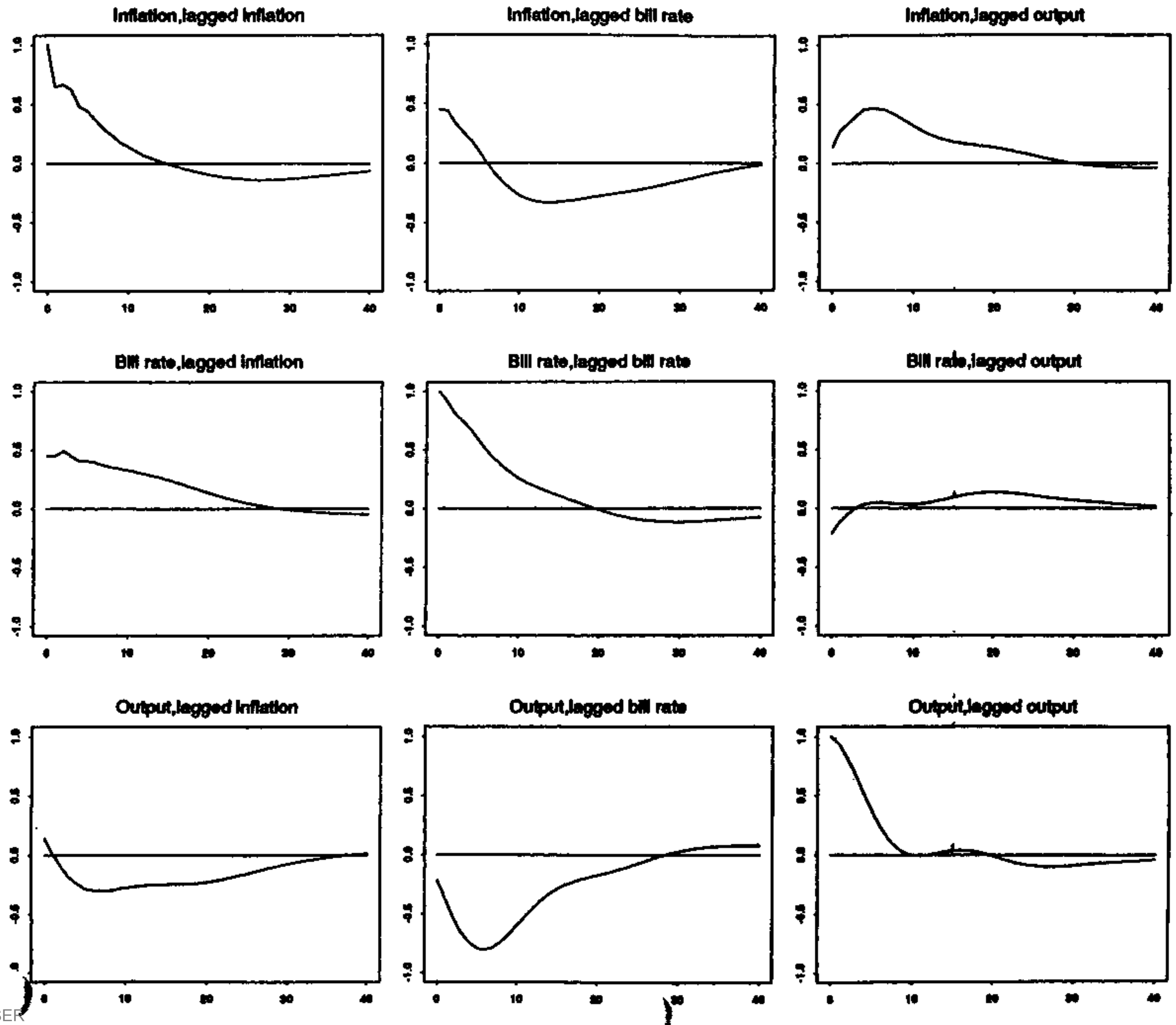


Figure 2
Autocorrelation function, nominal contracting model

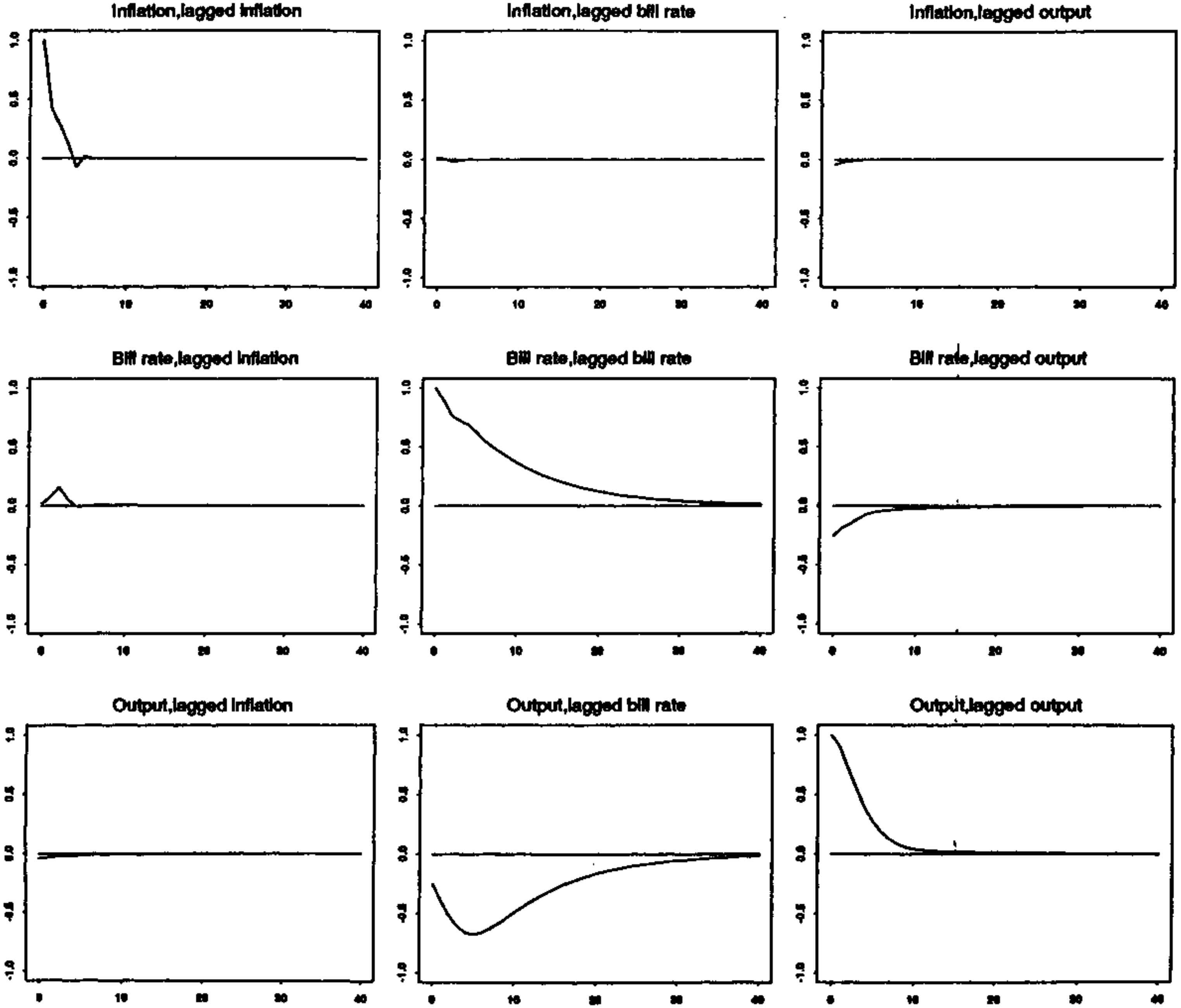


Figure 3
Impulse response function, nominal contracting model

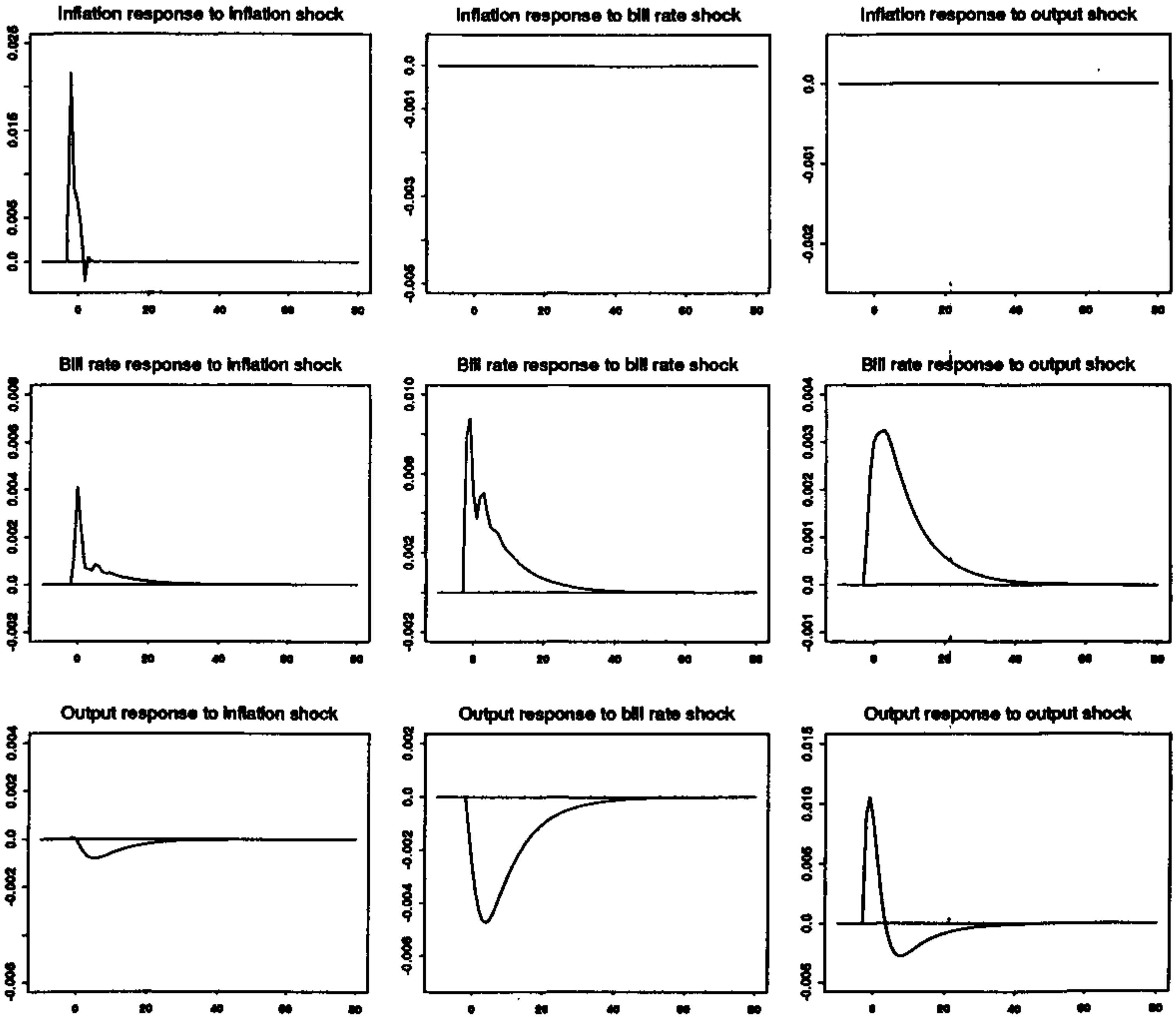


Figure 4
Autocorrelation function, real contracting model

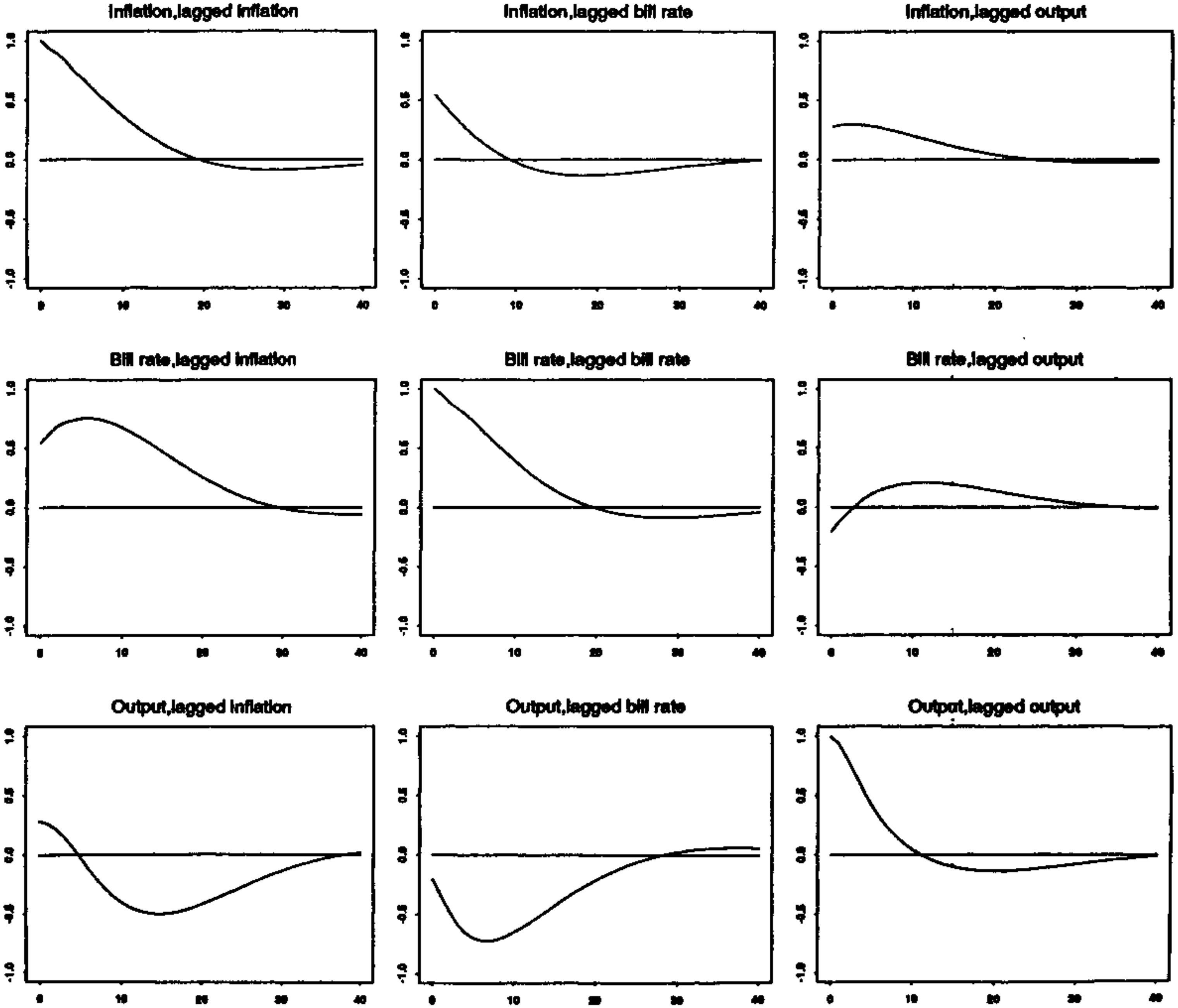


Figure 5
Impulse response function, real contracting model

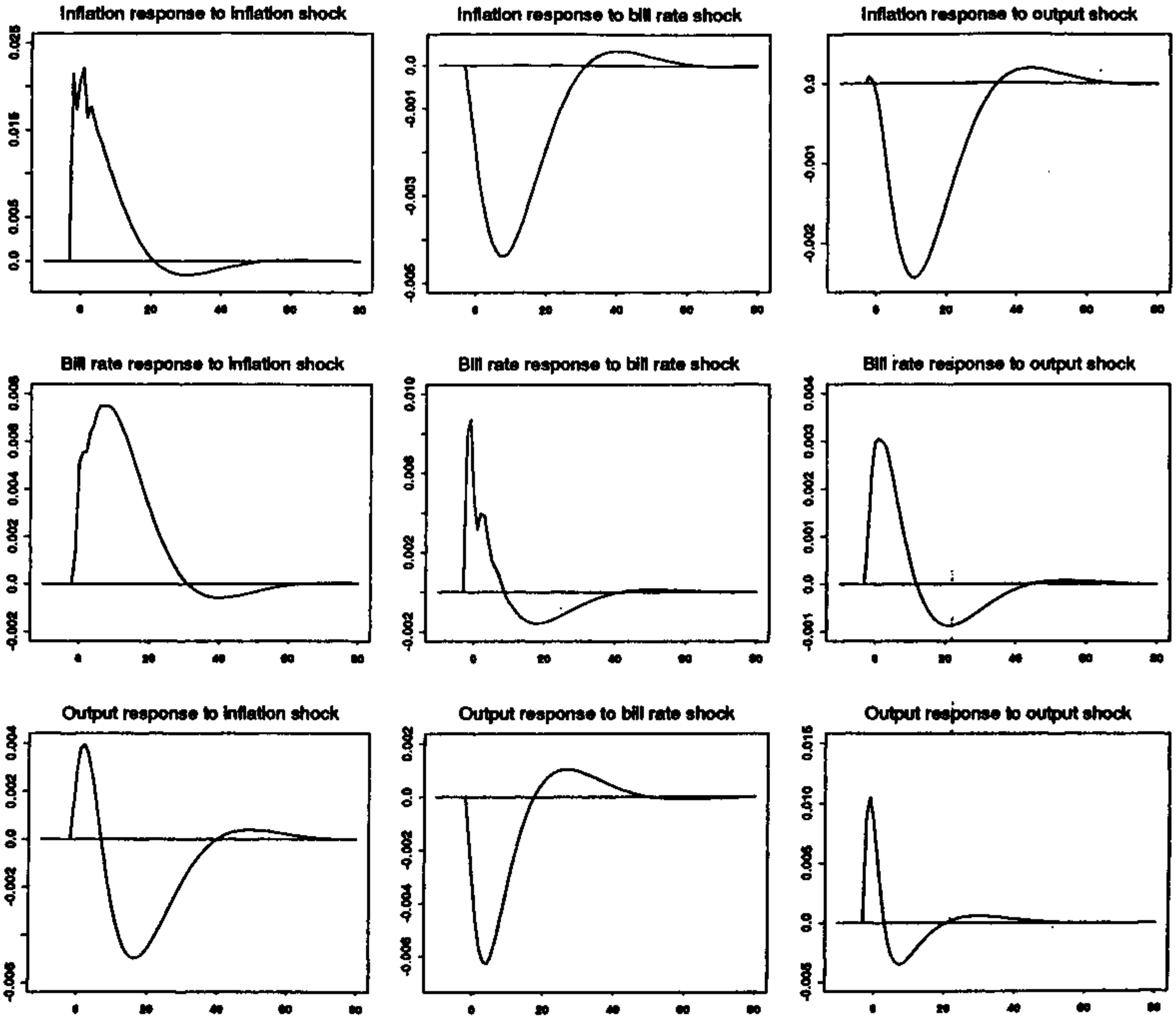


Figure 6
Disinflation: alphapi = .1, alphay = .1

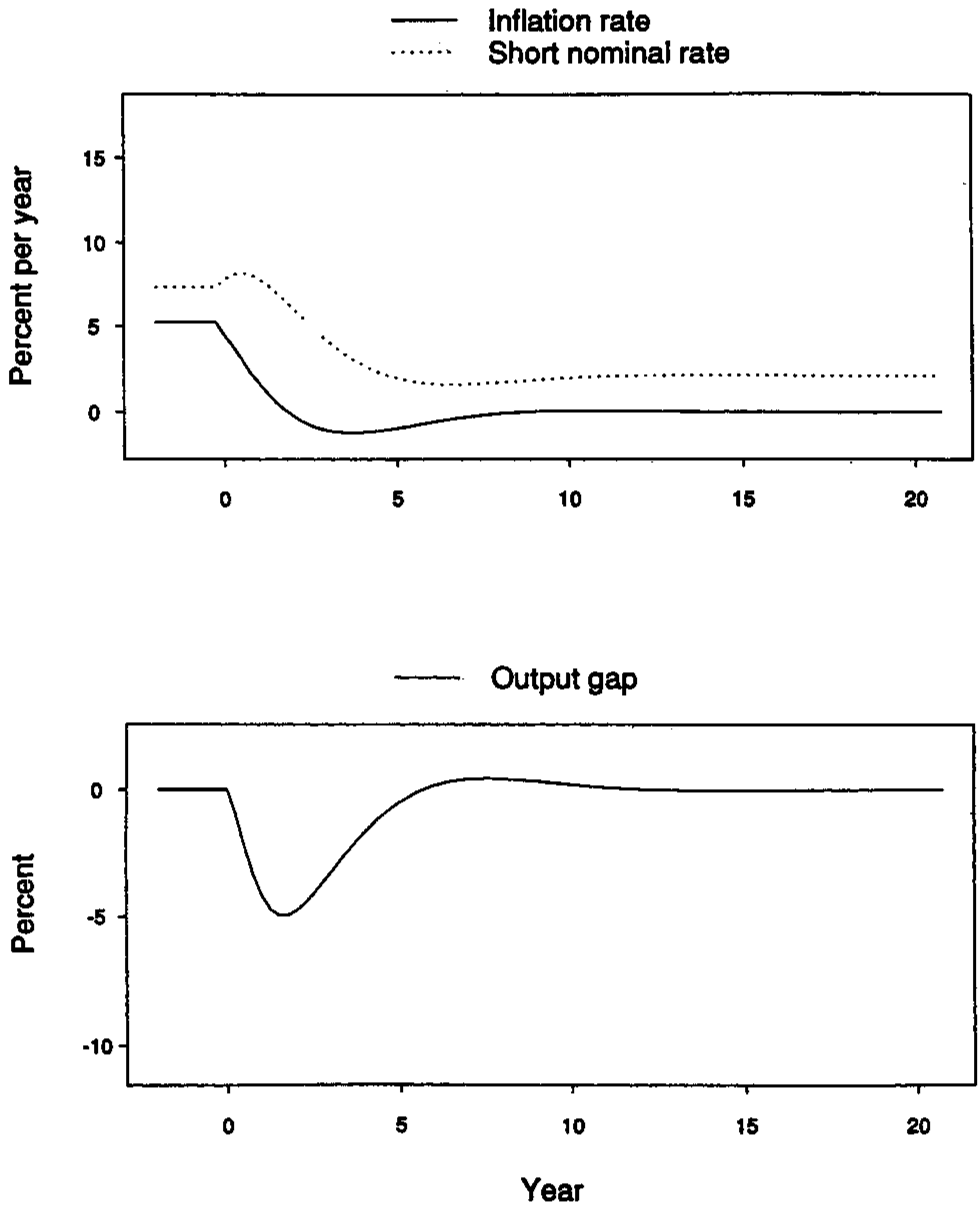


Figure 7

Disinflation: alphapi = .01, alphay = .01

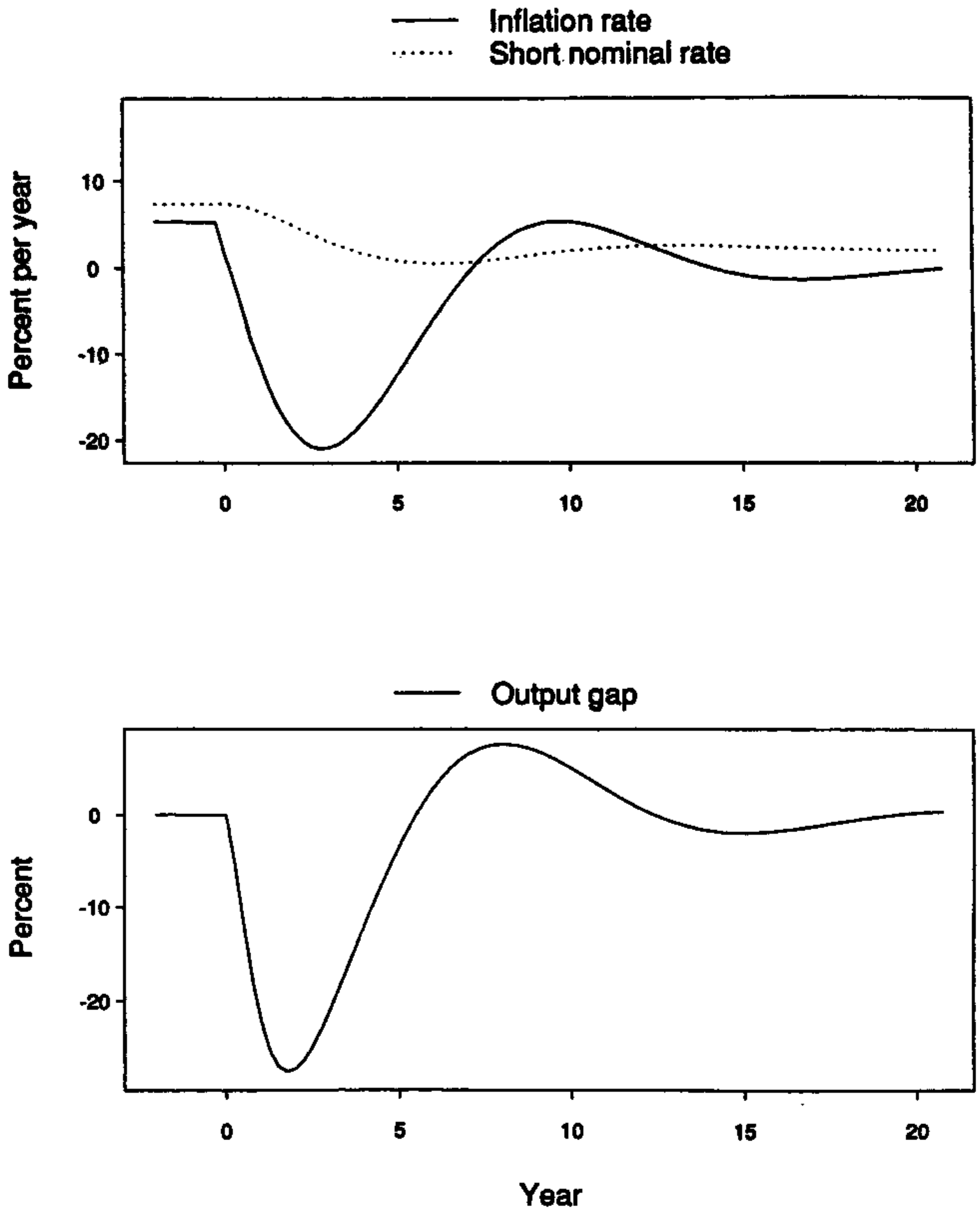
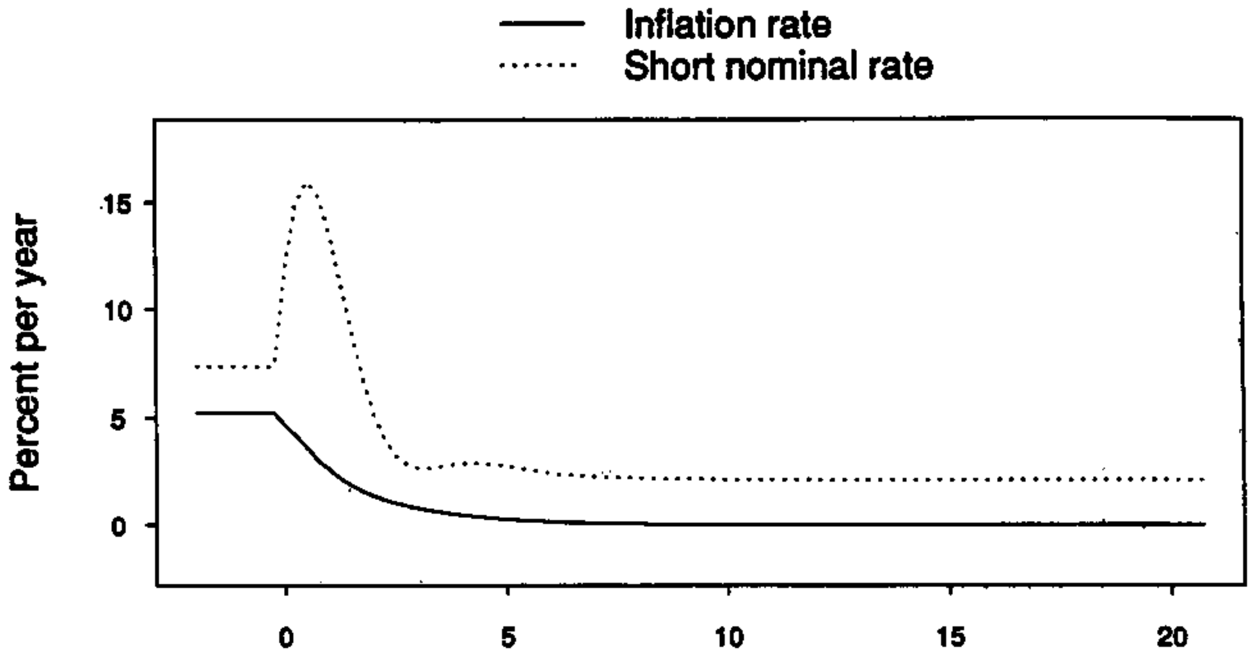


Figure 8
Disinflation: alphapi = 1, alphay = 1



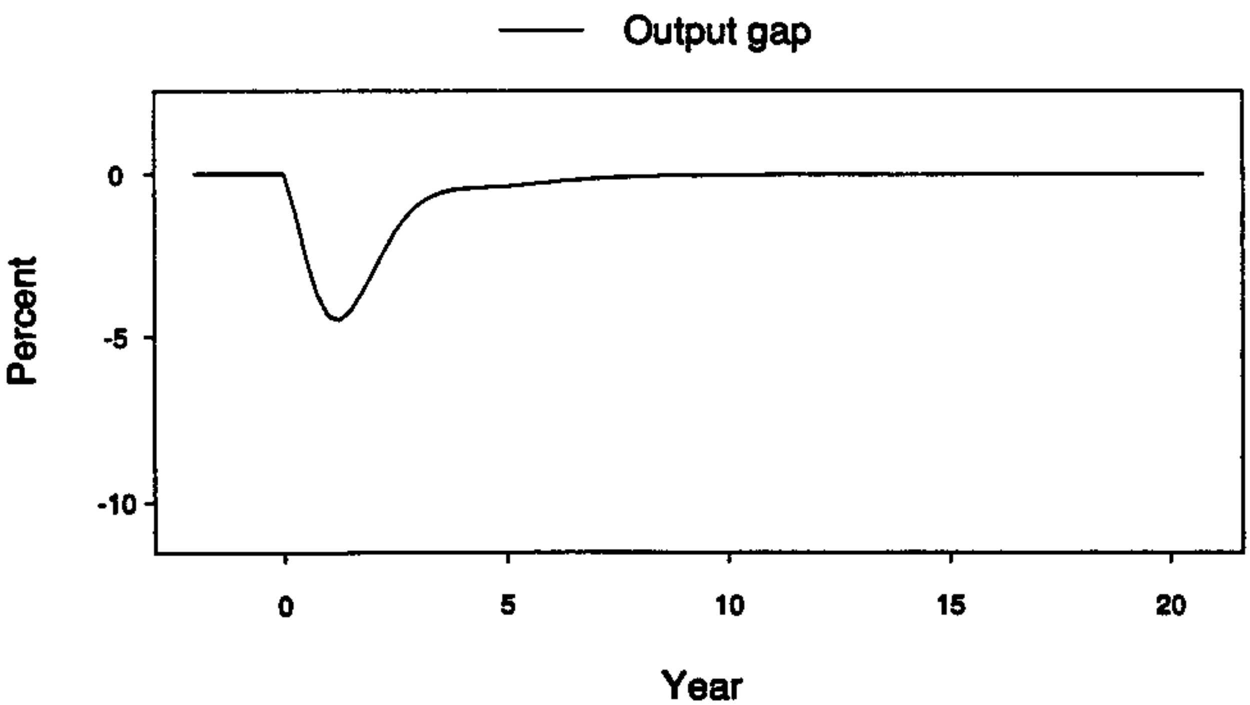


Figure 9

Disinflation: alphapi = 1, alphay = .01

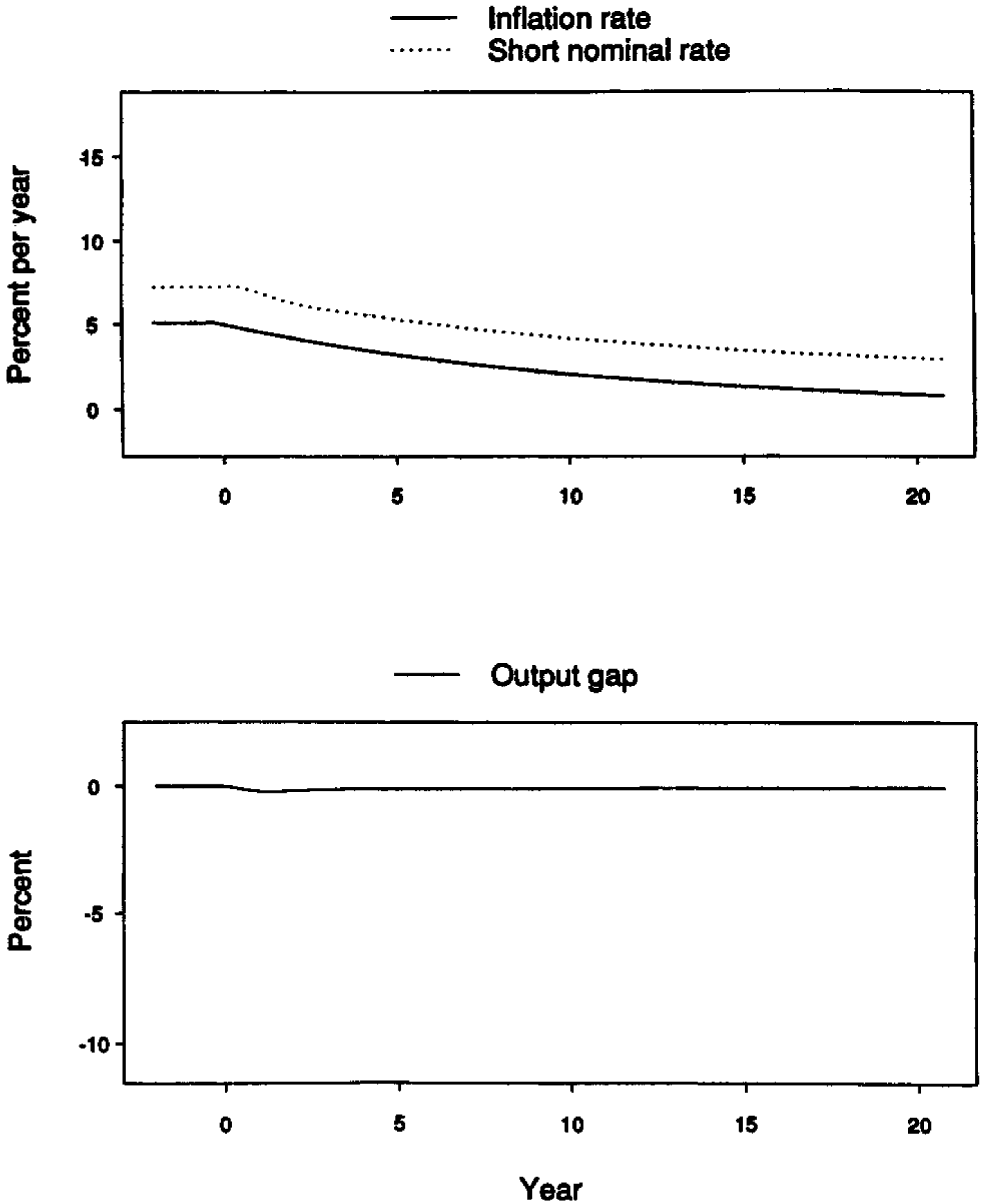


Figure 10

Disinflation: alphapi = .1, alphay = .1

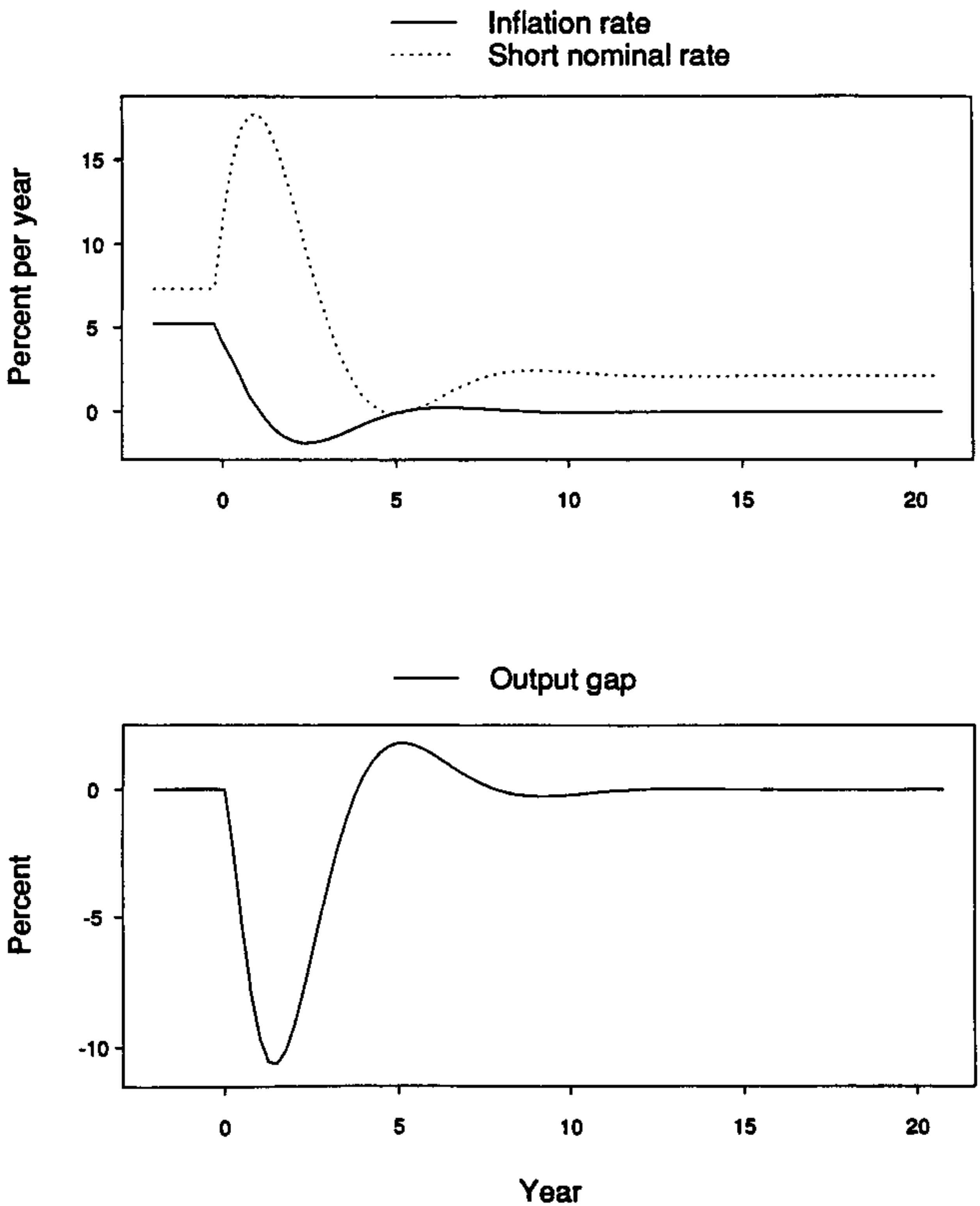


Figure 11
Speed of convergence

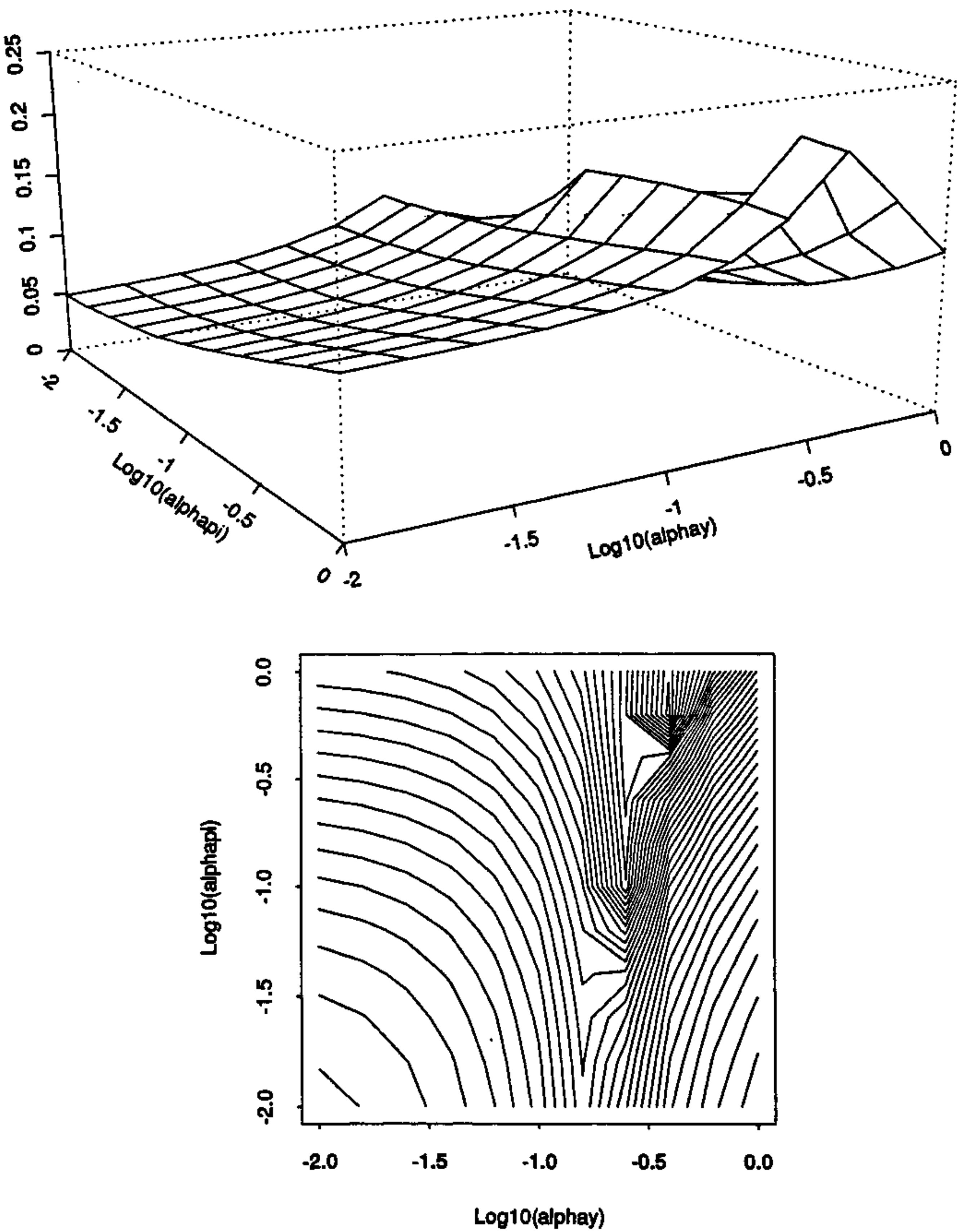
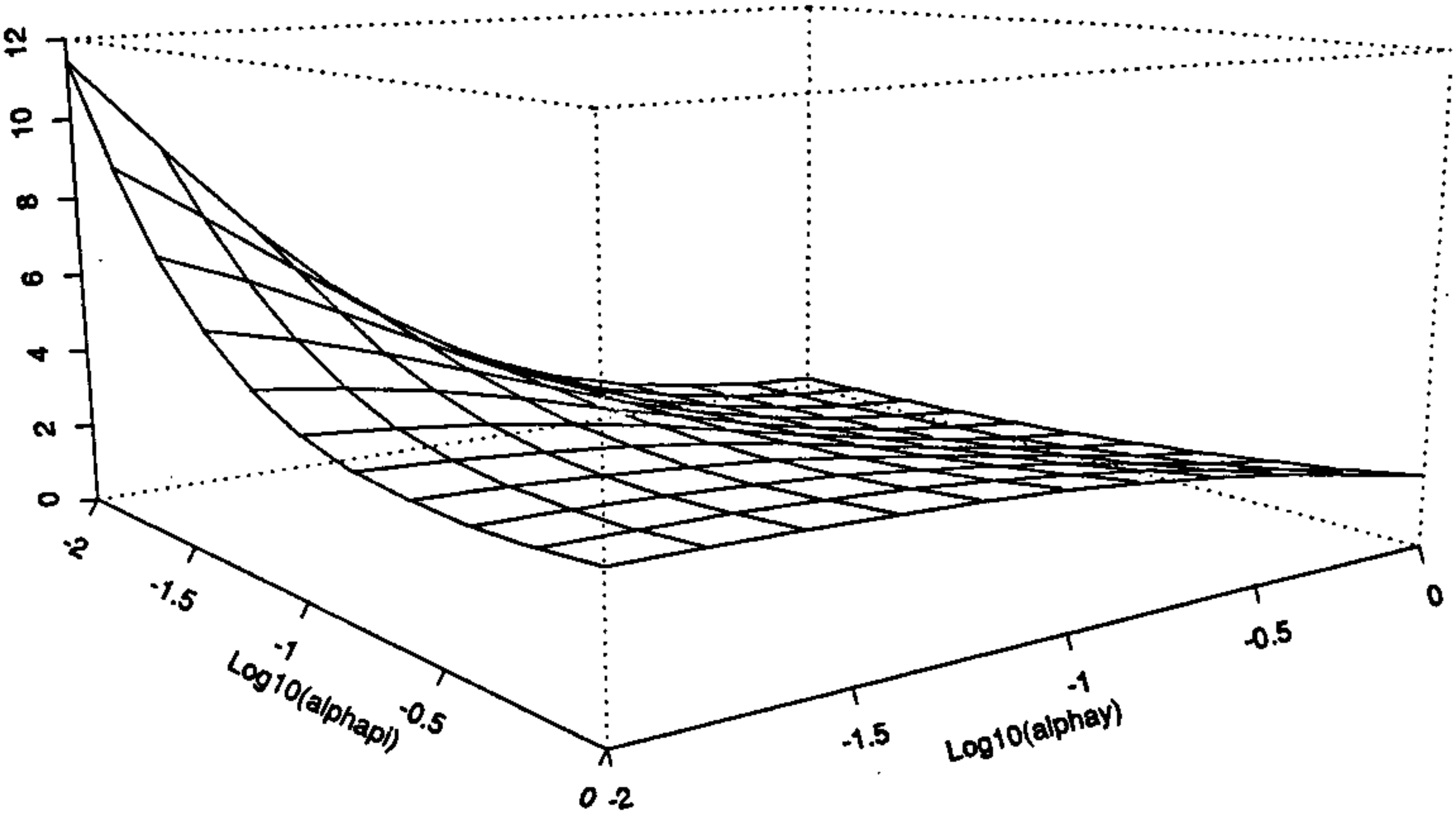


Figure 12
Sacrifice Ratio



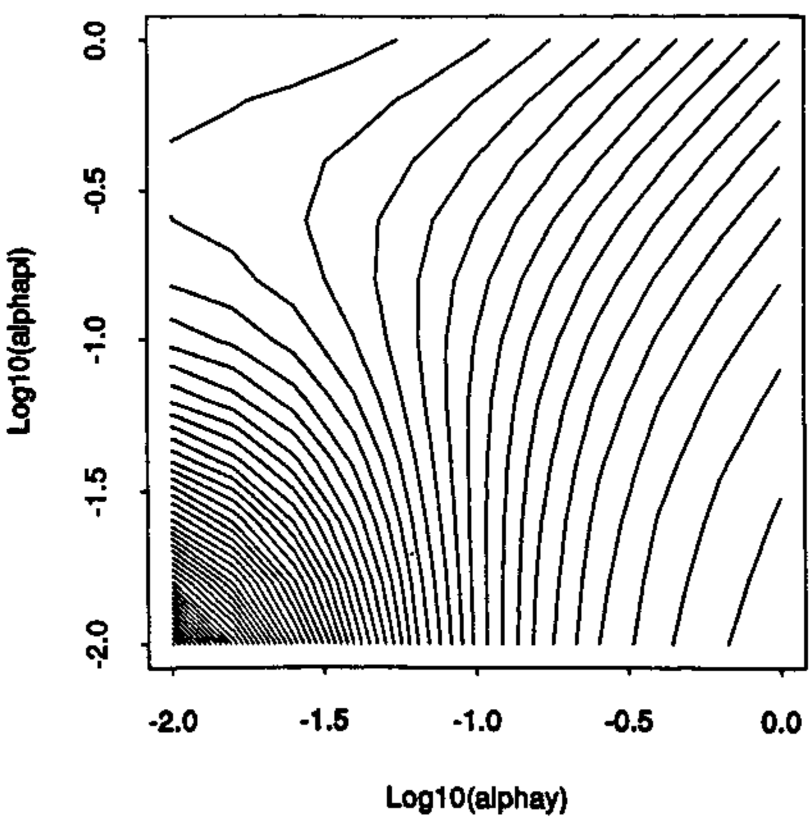


Figure 13
Inflation variance

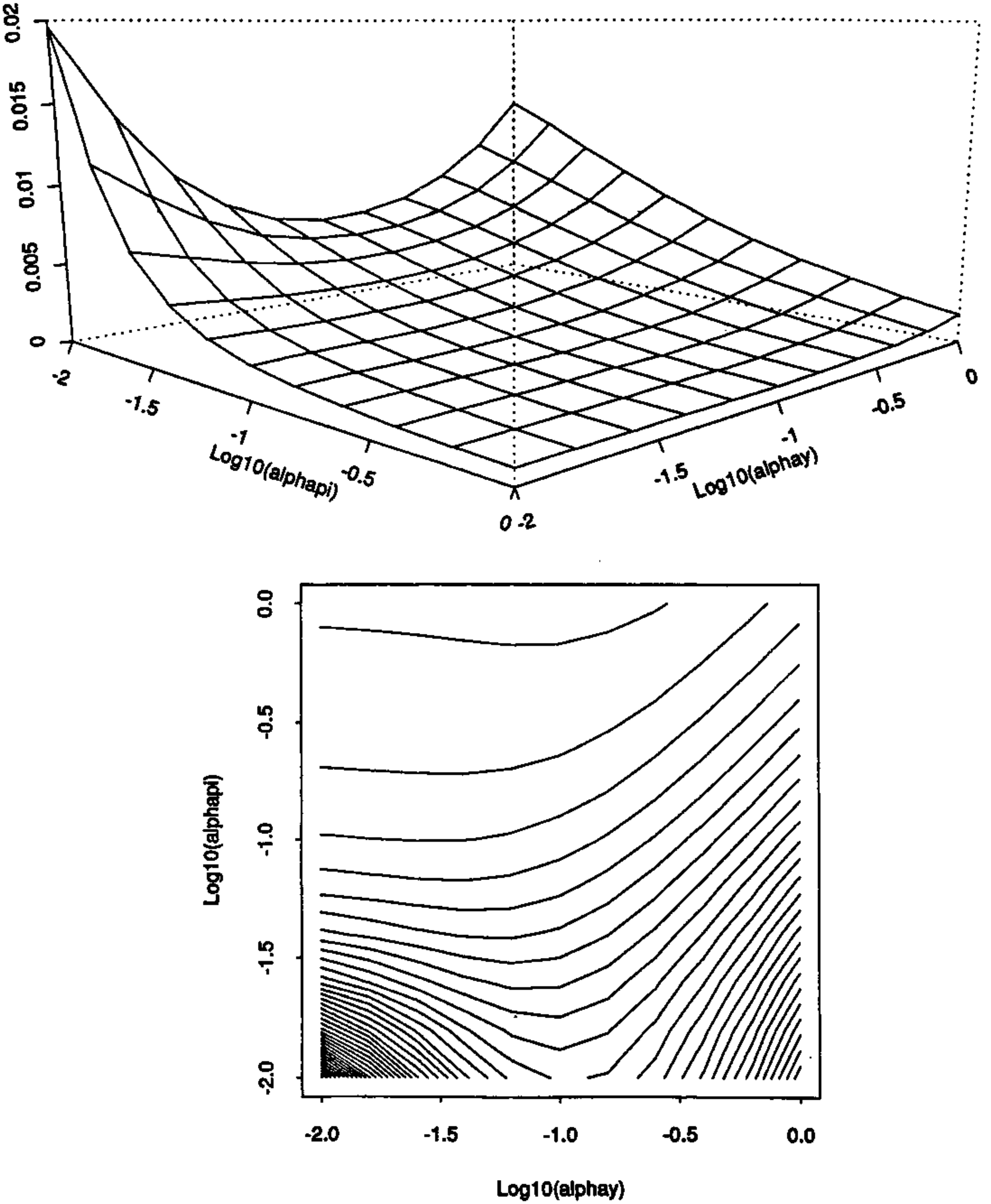


Figure 14
Bill rate variance

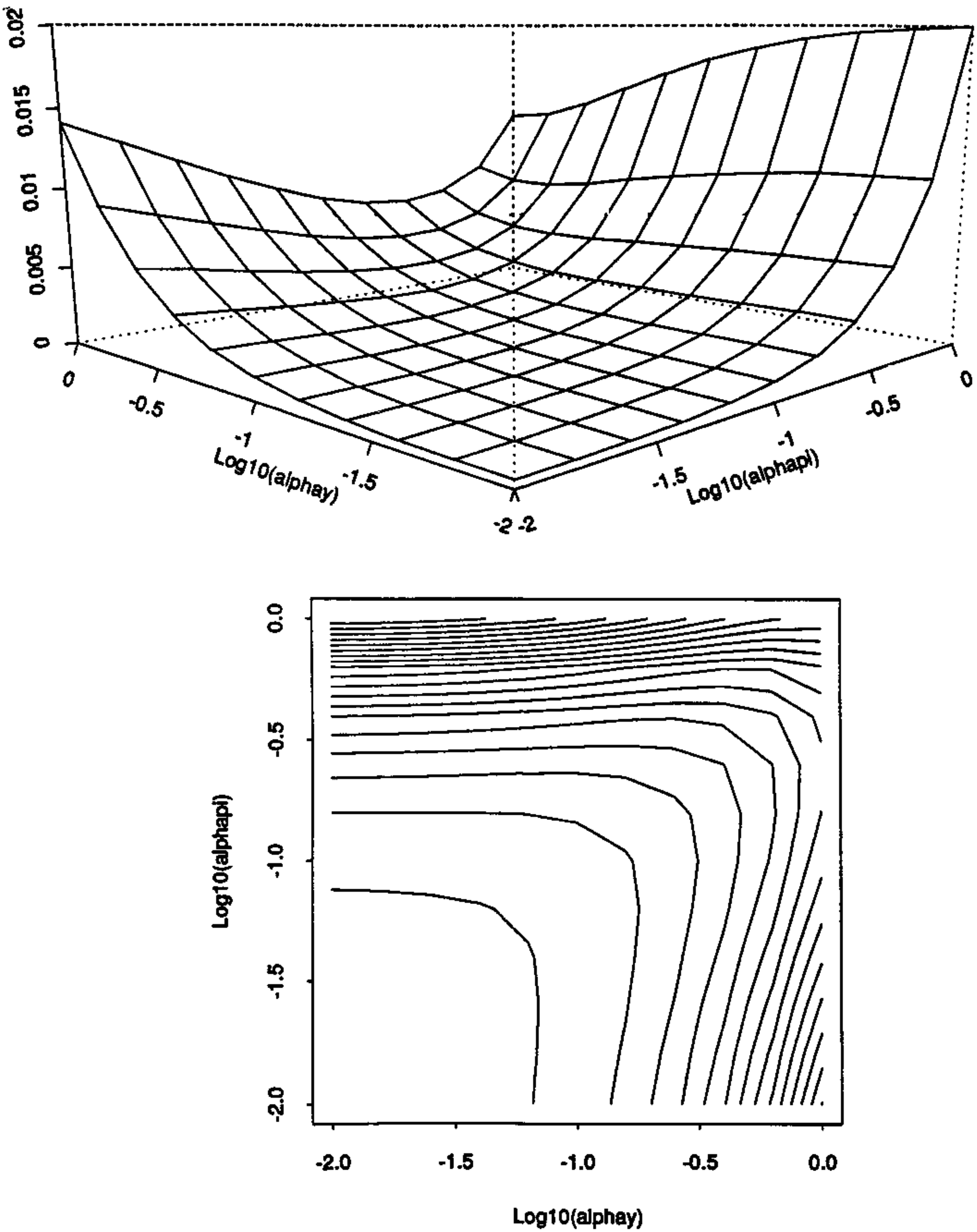
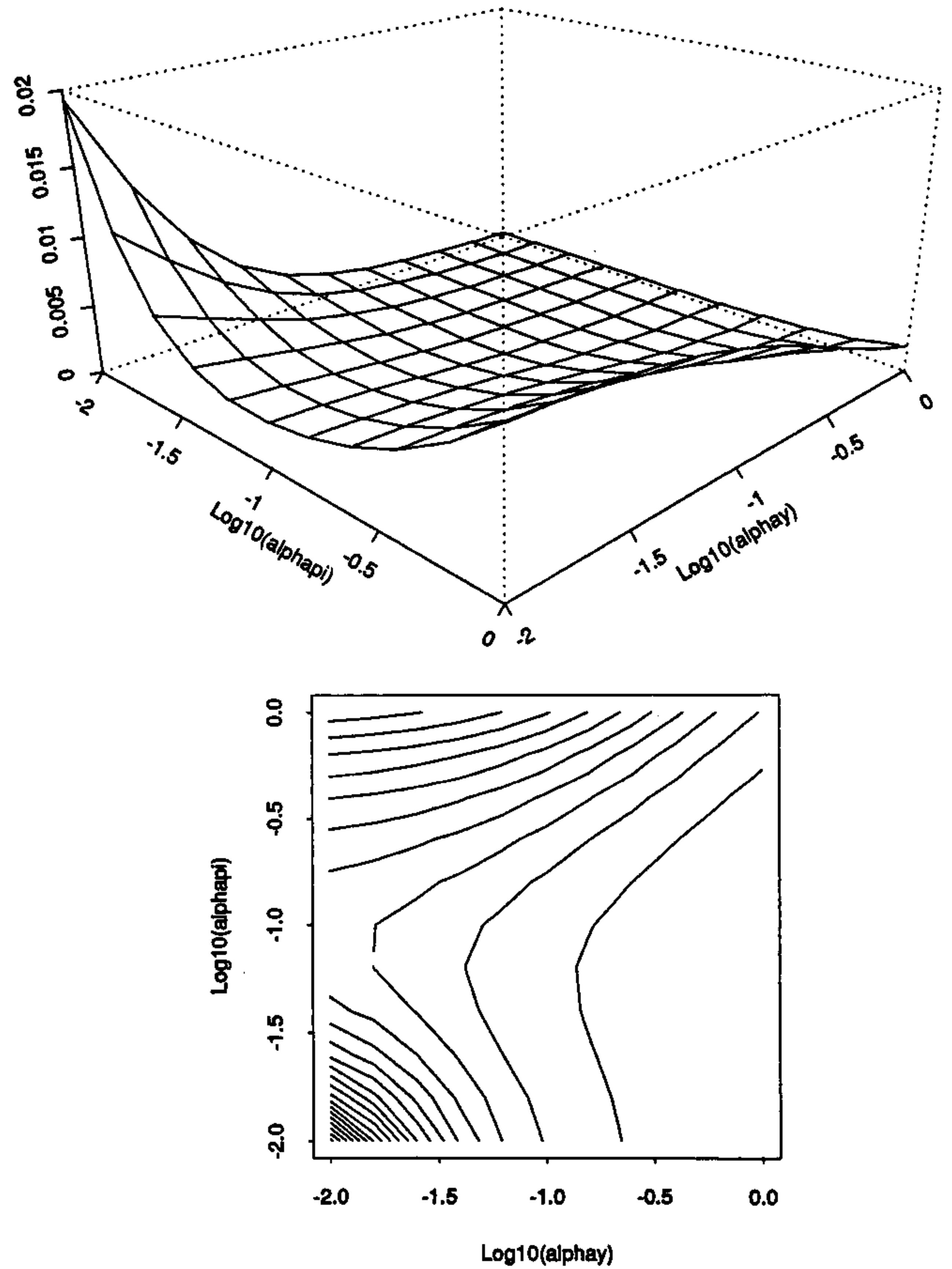


Figure 15
Output variance



COMMENTS ON "INFLATION PERSISTENCE" BY JEFF FUHRER AND GEORGE MOORE

John B. Taylor[1]

This paper makes an important contribution to the methodology of monetary policy formulation. In three ways the paper advances in a practical direction a new approach to macroeconomics.

First, the authors specify a structural model with rational expectations. Their model takes account of the Lucas Critique very much along the lines that Lucas suggested in his famous paper. Lucas emphasized the forward-looking nature of price setting, consumption and investment by showing how reduced-form parameters would change when policy changes. The authors' model builds in such parameter changes in the price-setting equations and in aggregate-demand equations.

Second, they estimate their structural model using full-information maximum-likelihood methods. For practical policy evaluation an estimated model is much better than a calibrated model, where the parameters are chosen to give a rough fit of empirical variances and covariances. That the model fits the data as well as it does is impressive.

Third, they use the estimated model to evaluate alternative policy rules. They do not focus on the impact of one-time changes in the instruments of policy such as the money supply or the federal funds rate--a traditional exercise with econometric models. Rather, they look at the response of the economy to a policy <u>rule</u> which they write algebraically, arguing that the general functional form comes close to what the Federal Reserve has been using in practice. They evaluate monetary policy by optimizing across the parameters of the policy rule to find parameters that give the best performance of the economy in terms of volatility of prices, volatility of output, and volatility of interest rates, though they do not use a formal optimization procedure.

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Their results, taken literally, are quite striking. They find that a policy rule that is a fairly close representation of Fed policy for the last eight or 10 years is nearly optimal. The rule entails changing the federal funds rate, according to whether the inflation rate is on a target and whether output is on a target. Their results are not very sensitive to the choice of a welfare function. Basically, as long as price stability and output stability are given some weight, movements too far away from this particular rule worsen performance. This is a remarkable result and deserves further research.

What are the implications for policy? The literal implication is to keep following that rule. What does that mean for the staff? They should find ways to give advice that results in the Federal Open Market Committee (FOMC) following that rule. This should certainly not be viewed as formal instruction to follow a mechanical formula. If Fuhrer and Moore had found instead that it is better to adjust interest rates by a larger amount or a smaller amount in response to the changes in inflation, then the implication would be to try to advise the FOMC to modify the rule. It is perhaps too abstract for policymakers to think in terms of a policy rule, but it seems to me that this is the only way to think of implementing or taking seriously the policy implication of this paper.

Another thing I like about this paper is the way they try to match up the theory with data as summarized in the auto-correlation functions. Their model explains the positive delayed impact of output on inflation as well as the reverse negative delayed impact of inflation on output. These facts are true not only of the United States but also of almost every country I have looked at.

Fuhrer and Moore emphasize how they have had to modify the standard staggered-contracts model to get the results. One of the nice things about the original staggered-contracts model in my view is that it could explain such autocorrelations. However, inflation was detrended in a different way. In my work, for example, I looked at the deterministically detrended price level rather than the first difference: the inflation rate. For example, my 1980 paper in the *Journal of Economic Dynamics and Control* was based on logs of price levels rather than percentage price changes. This is true of all the estimates that I have done using staggered-contract models for the United States, as well as for other countries in my multi-country model. There is a very nice paper by Andrew Levin which reports on estimates of the standard staggered-contracts model for the United States. He finds that the model fits the data. He can't reject it using the same type of tests that Fuhrer and Moore use. The main difference is that Levin focuses on levels rather than changes.

I think that levels are a better way to think about the microeconomics of this model. From a microeconomic foundations perspective, it makes more sense to me to assume that workers and firms are concerned about the level of wages of other workers. The same is true of prices. When a price is being set, a price survey is generally performed. In deciding what price to set for a textbook, for example, publishers look at what other textbooks are selling for. They don't think about it in rates of change.

By focusing their model in real terms and making this adjustment, Fuhrer and Moore are effectively doing the detrending within the model. I think that is a very reasonable modification, especially given that it seems to fit the first differenced data. And it is certainly in the spirit of the original staggered-contract model.

I have some doubts, however, about the empirical distribution of contracts found by Fuhrer and Moore. Andrew Levin finds the distribution is one with more wage contracts that are four quarters long than two quarters long. The least frequent is one quarter long. Fuhrer and Moore seem to have the opposite distribution with more one-quarter contracts than four-quarter contracts. For wage data this does not seem possible. Levin finds a peak in the distribution of wage changes at about four quarters. He finds about 65 percent of the wage adjustments occur annually, 25 percent occur semi-annually, and 9 percent occur quarterly.

Finally, I would encourage the authors to compare their policy evaluation with other work. I have thought it useful to compute a tradeoff between the variance of inflation and the variance of output. (See Taylor (1979), for example). The tradeoff can be drawn as a simple curve. There is now much research in the literature about such tradeoff curves. Fuhrer and Moore have a table in their paper that gives two points on such a tradeoff curve. Filling out the remaining points could make for some useful comparisons.

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IMPLEMENTING SHORT-RUN MONETARY POLICY WITH LOWER RESERVE REQUIREMENTS

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In late 1990, the Federal Reserve eliminated reserve requirements on nonpersonal time deposits and required reserves fell by about $10 billion, an almost 20 percent reduction. In early 1992, reserve requirements against transaction accounts were lowered to 10 percent from 12 percent, releasing an additional $3.5 billion of required reserves.[2] These reductions in required reserves have raised concerns that lower total reserve balances will result in increased reserve market volatility, which could impede the implementation of monetary policy. Moreover, this increased volatility could, in principle, spill over into other markets.

This paper examines the effects of reserve requirements on market volatility and on the central bank's ability to achieve short-run policy objectives. Although a number of earlier studies examined the effects of reserve requirements, our approach differs in two important respects. First, previous studies, such as Kaminow (1977), Siegel (1981), Baltensperger (1982), Froyen and Kopecky (1983), and Horrigan (1988), focused on longer-term objectives of monetary policy. In contrast, we focus on the use of short-run control procedures, such as reserve requirements and open market operations, to achieve short-run policy objectives.

As illustrated in Figure 1, the implementation of monetary policy can be viewed as consisting of a hierarchy of instruments, targets, and

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1. Board of Governors of the Federal Reserve System and Federal Reserve Bank of New York, respectively. We would like to thank Michael Boldin, Jim Clouse, Josh Feinman, Gregg Hess, Ann-Marie Meulendyke and Ed Stevens for useful comments on earlier versions of this paper. We would also like to thank Jeff Brown and Mark Flaherty for research assistance.

2. The Federal Reserve has the authority to lower reserve requirements on transaction deposits to 8 percent; any further reduction would require congressional approval.

indicators.[3] This hierarchy is necessary because the central bank cannot directly achieve its long-run objectives of output and price stability (shown on the far right of the figure). Instead, the central bank uses <u>policy rules</u> to set short- and intermediate-run targets consistent with achieving long-term economic goals. The nature of these policy rules has changed over time, as the central bank has shifted its focus between targeting quantities and targeting prices.

The optimal choice of a policy rule has been studied extensively.[4] These studies, however, assumed that the central bank could control short- or intermediate-run targets, such as a monetary aggregate or an interest rate. In reality, of course, the central bank cannot perfectly control these variables and must rely on a set of <u>operational rules</u>. Operational rules are used to set instruments (such as reserve requirements, the discount rate, and open market operations) in order to achieve the longer-term objectives of monetary policy. Although operational rules have been studied independently of each other -- for example, by Goodfriend (1983) and Feinman (forthcoming) -- we focus on how these instruments can be used conjunctively to achieve short-run policy objectives.

The second objective of this paper is to provide estimates of the impact that changes in reserve requirements are likely to have on volatility in the money market. In contrast, previous studies were largely theoretical. Such an approach can usually only be used to show that the impact of a change in policy depends on various unknown parameters of a particular model. In this paper, we quantify the impact of changes in required reserves using estimates from a money market model.

The analysis is based on a simple, short-run aggregate model of the reserves market that includes three sectors: households, banks and

3. This terminology is an slight extension of the terminology used by McCallum (1990), which assumed that the central bank can control either the federal funds rate or the quantity of reserves.

4. For early examples, see Tobin and Brainard (1963), Brainard (1964), Poole (1970), and Holbrook and Shapiro (1970).

the central bank. Households operate in the deposit market, while banks and the central bank operate in the deposit and reserve markets. The model predicts that a reduction in reserve requirements generally increases the variability of reserves, the federal funds rate, and deposits. This result depends, however, on the magnitude of various elasticities, on the relative variance of economic shocks that buffet the reserve and deposit markets, and on the type of operating rule used by the central bank.

Our empirical results indicate that banks are likely to respond to a drop in required reserves by increasing their holdings of excess reserves. In addition, we find that banks are likely to become more responsive to changes in the federal funds rate under a lower required reserve regime. Consequently, while variability of nonborrowed reserves increases slightly with lower required reserves, the federal funds rate becomes somewhat less volatile.

These findings are consistent with a view that banks, in response to an increased probability of an overdraft with lower required reserves, substantially increase their holdings of excess reserves. With more excess reserves and a decrease in required reserves, the probability of a reserve deficiency also drops. As a result, banks become less concerned about their reserve balances and more responsive to changes in the funds rate.

This view contrasts somewhat with the conventional view, which predicts that the funds rate is likely to become more volatile with lower reserves. This view holds that an increased probability of an overdraft is not sufficient to encourage banks to significantly raise the level of excess reserves. Instead, banks manage their reserve accounts more closely and become less interest rate sensitive. In this case, for example, banks are more likely to "bid up" the funds rate when reserves are seen to be in short supply relative to a higher required reserve regime.

The remainder of the paper is organized as follows. The next section presents our model of the reserves market and the third section uses the model to examine the effects of changes in reserve requirements. The fourth section contains the results and a discussion of our empirical work. Finally, we offer some concluding remarks.

A BASIC MONEY MARKET MODEL

In this section, we outline a short-term model of the money market; a complete analysis of equilibrium in the money market can be found in the next section. The model focuses on two markets -- bank reserves and transactions deposits -- and includes three sectors -- households, banks and a monetary authority. Households primarily hold bank deposits for transactional purposes and, since transactional deposits are reservable, banks hold reserves at the central bank. In addition to required reserves, banks may hold excess reserves. The central bank supplies reserves according to an operational rule, which may include a reserve target, an interest rate target, or a combination of both.

Households

In each period, households allocate their financial wealth between bonds and deposits. Deposits are held primarily for transactional services and yield a below-market return of r_D. Bonds, however, do not provide transactional services but yield a market return of r_B. For simplicity, we assume that the opportunity cost of holding bank deposits (r_B-r_D) is proportional to the federal funds rate. Furthermore, the demand for (log) transactions deposits, D^D, is assumed to be:

$$(1) \qquad D_t^D = \alpha_0 - \alpha_1 \cdot r_{f,t} + \alpha_2 \cdot S_t + \epsilon_{D,t},$$

where α_0, α_1 and α_2 are constants and assumed to be greater than zero; $r_{f,t}$ is the federal funds rate; S_t is a scale variable, such as (log) retail sales or personal consumption expenditures; and $\epsilon_{D,t}$ represents an aggregate shock to deposit demand with mean of zero and variance of σ^2_D. Since deposits and the scale variable are measured in logs and the federal funds rate is measured in percentage points, α_1 is a semielasticity with respect to the funds rate, and α_2 is an elasticity with respect to the scale variable.

Banks

The primary role of banks is to provide transactional services for households, and deposits represent banks' only liability. Banks hold bonds and reserves as assets.[5] Total reserves held at the central bank consist of required reserves and excess reserves. While total reserves are held for interbank clearing needs, excess reserves are held to avoid reserve requirement deficiencies and overdrafts in the event of an unexpectedly large outflow of reserves. This reserve identity can be written as follows:

$$(2) \qquad tr_t = rr_t + er_t,$$

where, in levels, total reserves are denoted by tr_t, required reserves by rr_t, and excess reserves by er_t.

Total reserves also can be categorized by the aggregate sources of these funds, as either nonborrowed reserves obtained through open market operations or reserves borrowed from the discount window. This identity can be written as:

$$(3) \qquad tr_t = nbr_t + br_t,$$

where, in levels, nbr_t is the amount of nonborrowed reserves and br_t is the amount of borrowed reserves.

The decision to hold reserves can be viewed as four separate decisions -- rr_t, er_t, nbr_t, and br_t -- subject to the constraint that total uses for reserves must equal total sources of funds -- i.e., equations (2) and (3) are satisfied. Alternatively, equation (3) can be substituted into (2) to obtain:

5. Bank loans are assumed to be perfect substitutes for bonds and therefore can be omitted from the analysis.

$$\text{(4)} \qquad nbr_t^D = rr_t^D + er_t^D - br_t^D.$$

In this form, the demand for nonborrowed reserves is derived as a residual once the demands for required, excess and borrowed reserves are calculated.

We make the following assumptions about the demand for reserves. First, required reserves are simply the reserve requirement ratio on transactions deposits (τ) multiplied by the current level (as opposed to the log) of transactions deposits (d_t).[6] We also suppress the demand for borrowed reserves and instead model the demand for free reserves, which is defined as excess reserves less borrowed reserves. We can therefore rewrite equation (4) as follows:

$$\text{(5)} \qquad nbr_t^D = \tau \cdot d_t^s + fr_t^D,$$

where fr_t^D is the demand for free reserves, in levels.

Taking logs of both sides of equation (5) and rewriting yields:

$$\begin{aligned} \log(nbr_t^D) &= \log[\ \tau \cdot d_t^s + fr_t^D\ ] \\ &= \log[\ \tau \cdot d_t^s \cdot (1 + fr_t^D/(\tau \cdot d_t^s))\ ] \\ &= \log(\tau) + \log(d_t^s) + FRR_t^D \\ \text{(5')} \qquad NBR_t^D &= \tau' + D_t^s + FRR_t^D \end{aligned}$$

where $\tau' = \log(\tau)$ and FRR_t^D is the free reserve ratio, the ratio of free reserves to required reserves. Finally, we assume that the desired free reserves ratio is:

$$\text{(6)} \qquad FRR_t^D = \beta_0 - \beta_1 \cdot \tau - [\beta_2 + \beta_3 \cdot \tau] \cdot r_{f,t} + \epsilon_{FR,t},$$

6. Although legal reserve requirements vary over time, we assume that τ is constant in this section of the paper.

where β_0, β_1, β_2 and β_3 are constants and assumed to be greater than zero; and ϵ_{FR} is an aggregate shock to the free reserve ratio with mean of zero and variance of σ^2_{FR}.

This specification for the ratio of free to required reserves is motivated by Brunner (1992), which derived a similar relationship from an optimization model of bank reserve management. Several aspects of equation (6) deserve discussion. First, the desired ratio is a function of the federal funds rate, the opportunity cost of holding reserves at the central bank rather than lending these funds to another bank. Assuming that $[\beta_2 + \beta_3 \cdot \tau]$ is greater than zero, an increase in the federal funds rate leads to a decrease in the demand for free and nonborrowed reserves.

Second, equation (6) also implies that the reserve requirement (τ) plays a crucial role in the demand for free and nonborrowed reserves. Assuming that β_1 is positive, a reduction in the reserve requirement will induce banks to increase their ratio of free to required reserves. If banks allow total reserves to fall dollar for dollar with a reduction in required reserves, the probability of an overdraft will increase. In order to offset the increased probability of an overdraft, reserve managers are likely to increase their levels of free reserves. The extent of this increase will depend on the perceived probabilities and costs of reserve deficiencies and overdrafts under the new regime. This effect is illustrated in Figure 2 by a shift to the right in the demand curve for free reserves, from FRR_0^D to FRR_1^D. Assuming that the shift in free reserves does not offset the decrease in required reserves, the demand for nonborrowed reserve shifts to the left, from NBR_0^D to NBR_1^D.

Finally, equation (6) suggests that a lower required reserve ratio will also induce a change in banks' responsiveness to movements in the federal funds rate ($\beta_2 + \beta_3 \cdot \tau$). If β_3 is greater than zero, lower required reserves lead to a decrease in responsiveness to the funds rate. Expressed somewhat differently, reserve managers may be more willing to "pay up" in the funds market for a given amount of reserves under the new regime. This would occur if banks view the expected costs of deficiencies and overdrafts as being higher under the new regime and respond by managing their reserve accounts more closely. This outcome is shown in Figure 2 by an increase in the slopes of the demand curves for both free and nonborrowed reserves. On the other hand, if β_3 is negative, the responsiveness to changes in the federal funds rate will increase. This could occur if banks, after raising their levels of free reserves, view the expected costs of deficiencies and overdrafts as being lower.

Combining equations (5') and (6), the demand for (log) nonborrowed reserves can be written as:

$$(7) \quad NBR_t^D = \tau' + D_t^s + \beta_0 - \beta_1 \cdot \tau - [\beta_2 + \beta_3 \cdot \tau] \cdot r_{f,t} + \epsilon_{FR,t}.$$

Note that equation (7) can be rewritten to show that the supply of bank deposits is positively related to the level of nonborrowed reserves and the federal funds rate, but negatively related to the reserve requirement ratio.

Central Bank

As discussed in the introduction, the primary role of the central bank in this model is to influence conditions in the reserve market in accordance with established operational (short-run) procedures. Establishing operating procedures for implementing short-run monetary policy can be viewed as comprising two steps, both taken in view of the longer-term objectives of monetary policy. These steps are summarized in Figure 3.

The first step in establishing operational procedures involves setting values for several policy instruments and short-run operating targets at the beginning of each period. Some policy instruments, such as the required reserve ratio and the discount rate, may be left unchanged for several periods. Still, the setting of these instruments pins down the demand for nonborrowed reserves, equation (7), in each period.

As illustrated in the left panel of Figure 3, short-run targets for the level of nonborrowed reserves and the federal funds rate must be consistent with each other; with other policy instruments, such as the required reserve ratio; and with any longer-term objectives. For example, suppose that at the beginning of period t, the central bank's policy objectives included an intermediate target for deposits, D_t^T. Consistent with equation (1), the central bank would establish operational targets for the federal funds rate and for nonborrowed reserves as follows:

$$(8a) \qquad r_{f,t}^T = [\ D_t^T - \alpha_0 - \alpha_2 \cdot S_t\ ] \ / \ \alpha_1$$

$$(8b) \qquad NBR_t^T = \tau' + D_t^T + \beta_0 - \beta_1 \cdot \tau - [\beta_2 + \beta_3 \cdot \tau] \cdot r_{f,t}^T.$$

Alternatively, in an interest rate targeting regime, the central bank would set the federal funds rate target directly. In that case, the operational target for nonborrowed reserves is still described by equation (8b), and the expected level of deposits, consistent with equation (1) and the funds rate target, is:

$$(8c) \qquad D_t^T = \alpha_0 - \alpha_1 \cdot r_{f,t}^T + \alpha_2 \cdot S_t\ .$$

The second step involves choosing an operational rule for supplying reserves to the banking system, the primary instrument for implementing monetary policy. This rule is used to address any deviations in short-run variables from their targeted levels. In this model, the central bank can choose to target the funds rate, the level of nonborrowed reserves or a combination of both. This choice is embodied in the following rule for supplying nonborrowed reserves (NBR_t^S) to the banking system:

$$(9) \qquad NBR_t^S = NBR_t^T + \gamma \cdot (r_{f,t} - r_{f,t}^T) + \epsilon_{NB,t},$$

where NBR^T and r_f^T are operational targets for nonborrowed reserves and the federal funds rate, respectively; γ is a constant greater than zero; and ϵ_{NS} is an aggregate shock to the supply of nonborrowed reserves with mean of zero and variance of σ^2_{NS}.

According to the operating rule in equation (9), the central bank supplies a nominal amount of reserves (NBR^T) in the absence of any shocks to the reserve market. Additional reserves are supplied, however, in response to deviations in the observed federal funds rate from its expected (targeted) level. In addition, as illustrated in the right panel of Figure 3, γ determines both the degree to which the central bank tolerates a deviation in the funds rate and the type of operational regime pursued by the central bank. If γ is zero, then the monetary authority is following a pure nonborrowed reserve target. At the other extreme, if γ is equal to infinity, the supply of nonborrowed reserves is infinitely elastic at the targeted interest rate.

CHANGES IN REQUIRED RESERVES

In the previous section, we presented a simple model of the money market. In this section, we examine the equilibrium conditions implied by the model and investigate the changes in volatility that occur when reserve requirements are reduced. We find that both the equilibrium values and the variability of deposits, reserves, and the funds rate depend critically on the required reserve ratio, as well as on the variance of exogenous shocks and various elasticities in the model.

Equilibrium in the money market occurs when both the reserve market and the deposit market clear; that is, when equations (1), (7) and (9) are simultaneously satisfied. The equilibrium solutions for r_f, NBR, and D in any time period are:[7]

7. To simplify notation, time subscripts will be dropped since all variables are dated at time t.

$$(10a) \qquad r_f - r_f^T = \frac{\epsilon_D + \epsilon_{FR} + \epsilon_{NS}}{(\alpha_1 + \beta_2 + \beta_3 \cdot \tau + \gamma)}$$

$$(10b) \qquad NBR - NBR^T = \frac{\gamma \cdot \epsilon_D + \gamma \cdot \epsilon_{FR} + (\alpha_1 + \beta_2 + \beta_3 \cdot \tau) \cdot \epsilon_{NS}}{(\alpha_1 + \beta_2 + \beta_3 \cdot \tau + \gamma)}$$

$$(10c) \qquad D - D^T = \frac{(\beta_2 + \beta_3 \cdot \tau + \gamma) \cdot \epsilon_D - \alpha_1 \cdot \epsilon_{FR} - \alpha_1 \cdot \epsilon_{NS}}{(\alpha_1 + \beta_2 + \beta_3 \cdot \tau + \gamma)}$$

where r_f^T, NBR^T and D^T are expected levels, as defined by equations (8a) through (8c). Note that the equilibrium values of the variables depend on the required reserve ratio, as well as on various elasticities (α_1, β_2 and β_3) and variances of exogenous shocks (σ_D^2, σ_{FR}^2 and σ_{NS}^2), and the central bank's measured response (γ) to deviations in the federal funds rate from its expected level.

There are several features of the equilibrium conditions in equations (10a) through (10c) worth noting. First, the central bank can always achieve its short-run targets on average. This is true whether the central bank pursues a nonborrowed reserve target, a funds rate target or a combination of the two targets, as long as the targets are consistent with each other.

Consider, for example, the effects of a lower required reserve ratio, illustrated in Figure 4. Suppose that initially the central bank has chosen policy instruments such that the demand for nonborrowed reserves is denoted by NBR_0^D and has chosen D^T, r_f^T and NBR_0^T as its set of operational targets. As discussed in the previous section, a decrease in τ both shifts and steepens the nonborrowed reserve demand curve, yielding NBR_1^D. This reduction in demand can be "sterilized" by lowering the reserve target to NBR_1^T. As a consequence, a reduction in reserve requirements leads to a change in the composition of bank assets, with a decrease in reserves exactly offset by an increase in bonds.

Second, it is important to note that, although the central bank can offset the shift in demand by reducing the nonborrowed target, a reduction in reserve requirements still leads to changes in volatility in the money market. Consider, for example, the effects of a deposit shock with a lower reserve requirement, illustrated in Figure 5. As shown in the top panels, an unexpected increase in the demand for deposits increases the equilibrium levels of deposits and nonborrowed reserves and pushes the equilibrium funds rate higher. Recall from equation (7) that a reduction in the reserve requirement ratio (τ) decreases the interest rate elasticity of nonborrowed reserves, as illustrated in the bottom left panel of Figure 5. With this decreased sensitivity, banks desire more reserves with the same deposit shock and are more willing to "pay up" in the funds market. As a consequence, the equilibrium funds rate and level of nonborrowed reserves are relatively higher under the lower required reserve regime. The equilibrium level of deposits is relatively lower, however, since the opportunity cost of holding deposits is somewhat higher under the lower required reserve regime.

Consequently, although the central bank can still achieve its operational targets on average with a reduction in reserve requirements, variability around those targets is likely to change. Table 1 summarizes the effects of lower reserve requirements on volatility in the money market. While it is impossible to determine analytically whether the variance of any single variable will increase or decrease with lower reserve requirements, it is possible to determine the change in the <u>contribution</u> of each exogenous shock. Accordingly, each row of the table shows the weighted contribution (column 3) of each exogenous shock (column 2) to the total variance of each economic variable (column 1). The fourth column of the table lists the change in the contribution of each shock when τ is lowered.

As discussed earlier and illustrated by Figure 5, with a lower reserve requirement, the contribution of deposit shocks to variability in the funds rate and nonborrowed reserves increases (lines 1 and 2), while its contribution to variability in deposits decreases (line 4). The effects of a nonborrowed reserve supply shock with a reduction in reserve requirements are shown in Figure 6. Again, with lower reserve requirements, banks are less responsive to movements in the funds rate; in reaction to the reserve supply shock, banks hold relatively fewer reserves (line 3 of Table 1) and the funds rate falls somewhat further (line 1) under the new regime. In addition, since the opportunity cost of deposits also drops somewhat more in the lower required reserve regime, deposits are more variable (line 5).

The effects of a shock to the desired free reserve ratio are similar to other shocks. With a decrease in banks' interest rate-sensitivity, a free reserves ratio shock has the same effect on the funds rate and nonborrowed reserves as a deposit shock, which also shifts the demand curve for nonborrowed reserves. On the other hand, since a free reserve ratio shock changes the federal funds rate, its effect on deposits is similar to a reserve supply shock.

Overall, the federal funds rate is likely to become more volatile under a lower required reserve regime, since the effects of all three exogenous shocks on the funds rate become amplified under a new regime as banks become less interest rate-sensitive. The net change in variability of deposits and nonborrowed reserves, however, is unclear and depends critically on several policy instruments, such as the required reserve ratio, and on the variance of exogenous shocks and various elasticities in the model.

Finally, it is important to note that the central bank could improve its control of the federal funds rate, at the expense of other operational targets, by increasing its response to deviations in the federal funds rate (γ) from its targeted level. As an example, Figure 7 illustrates the effects of a deposit shock under two scenarios, γ less than infinity and, the extreme case, γ equal to infinity. As shown in the bottom panels, under the extreme case, deposit shocks would have no impact on interest rate volatility, but would have a large impact on reserve and deposit volatility. In addition, if the central bank "pegs" the federal funds rate, shocks to the free reserve ratio, which shift the nonborrowed reserve demand curve, would have no impact on either the funds rate or deposits.

It is perhaps unrealistic to assume that the central bank could or would want to perfectly control the federal funds rate. The central bank may not be able to "peg" the federal funds rate, since it would require continuous open market operations to keep the rate at its targeted level. Such a regime would require a radically different set of institutional arrangements compared to those currently in place. Moreover, while there are some advantages to smoothed interest rates, the central bank may not wish to tolerate the increased volatility in quantity variables that would accompany such an approach.

In summary, we have shown that lower reserve requirements alter the volatility of deposits, reserves and the federal funds rate. While the federal funds rate is likely to become more volatile with lower required reserves, it is unclear whether deposits and reserves become more or less volatile, as these variables depend critically on other parameters of the model. In the next section, we estimate the model in order to determine the parameter values and the likely change that lower required reserves would have on deposit and reserve volatility.

EMPIRICAL RESULTS

In this section, we quantify the relationships between reserves, deposits and the federal funds rate by estimating the money market model we developed in the previous sections. For econometric reasons, our empirical model differs slightly from our theoretical one, but the basic structure of both models is the same.

Money market models have been developed and studied by Thomson, Pierce, and Parry (1975); Farr, Roberts, and Thomson (1976); Tinsley and others (1982); and Anderson and Rasche (1982). While our econometric approach is similar to these earlier models, we use more recent econometric techniques and place more emphasis on the role of reserve requirements and operating rules for open market operations in achieving short-run policy objectives in the money market.

The Econometric Model

The econometric model consists of a system of three equations similar to those in the theoretical model. The demand for transaction deposits is reformulated within an error-correction framework similar to Moore, Porter, and Small (1990). The most general form of the deposit equation in the econometric model is:

$$(1') \qquad \Delta D_t = \rho \cdot (D_{t-1} - \alpha_0 + \alpha_1 \cdot r_{f,t-1} - \alpha_2 \cdot S_{t-1}) + \sum_{i=1}^{I} \phi_i \cdot \Delta D_{t-i} + \sum_{j=0}^{J} \theta_j \cdot \Delta r_{f,t-j} + \sum_{k=0}^{K} \delta_k \cdot \Delta S_{t-k} + \epsilon_{D,t}$$

where $1-\rho$ is the rate of adjustment of the deposit demand to its long-run relationship -- equation (1) -- in response to a deposit shock. The remaining coefficients -- ϕ_i, θ_j, and δ_k -- capture short-run dynamics.

The most general form of the demand equation for free reserves is:

$$(7') \qquad FRR_t = \beta_0 + \sum_{i=1}^{I} \mu_i \cdot FRR_{t-i} - \sum_{j=0}^{J} \beta_{1j} \cdot \tau_{t-j} - \sum_{k=0}^{K} \beta_{2k} \cdot r_{f,t-k} - \sum_{l=0}^{L} \beta_{3l} \cdot \tau_{t-l} \cdot r_{f,t-l} + \epsilon_{FR}.$$

where $FRR_t = NBR_t - \tau' - D_t$. The supply equation for nonborrowed reserves in the econometric model is the same as equation (9). Finally, we allow for time trends and seasonal dummies.

Since the federal funds rate and the required reserve ratio interact nonlinearly, equations (1'), (7') and (9) form a set of nonlinear simultaneous equations. Following Gallant (1987, pgs. 465-486), we can rewrite the nonlinear system as:

$$(11) \qquad Q_t\,(\,y_t\,,\,x_t\,,\,\Phi\,) \;=\; \eta_t\,,$$

where $y_t = [\,D_t \;\; NBR_t \;\; r_{f,t}\,]'$, a 3x1 vector of endogenous variables; x_t is a kx1 vector of predetermined variables, including exogenous and lagged dependent variables; Φ is a px1 vector of parameters to be estimated; $\eta_t = [\,\epsilon_{D,t} \;\; \epsilon_{FR,t} \;\; \epsilon_{NS,t}\,]'$, a 3x1 vector of exogenous shocks; $E[\eta_t] = 0$; and $E[\eta_t \cdot \eta_t'] = \Sigma$, a 3x3 matrix with σ^2_D, σ^2_{FR}, and σ^2_{NS} along the diagonal and zeros elsewhere.

Assuming that an analytical solution exists for y_t in terms of x_t, η_t, and Φ, the conditional (negative) log-likelihood function for (11) is:

$$(12) \qquad -llf(\Phi,\,\Sigma) \;=\; T\cdot\log(2\pi) \;+\; T/2\cdot\log|\Sigma| \;+\; \sum_{t=1}^{T}\left(\,1/2\cdot\eta_t'\cdot\Sigma^{-1}\cdot\eta_t \;-\; \log|J_t|\,\right),$$

where J_t is the Jacobian matrix of Q_t. For this application,

$$(13) \qquad J_t \;=\; \begin{bmatrix} 1 & 0 & -\theta_0 \\ -1 & 1 & -(\beta_2+\beta_3\cdot r_t) \\ 0 & 1 & -\gamma \end{bmatrix}.$$

Estimates for Φ and Σ are obtained by minimizing equation (12) subject to equations (11) and (13). Two-stage least squares estimates are used as starting values for the maximum likelihood routine.

The model is estimated using monthly data from 1984:2 through 1992:3. This time period was chosen because it provides the most consistency with regard to operational procedures. Time series for transaction deposits (demand deposits plus other checkable deposits), nonborrowed reserves, required reserves against transaction deposits, the effective federal funds rate, and retail sales (the scale variable) were obtained from the Federal Reserve's FAME data base.[8] A time series for the reserve requirement ratio for transaction deposits was calculated by dividing required reserves against transaction deposits by transaction deposits. Expected levels of nonborrowed reserves and the federal funds rate were obtained from the Federal Reserve Bank of New York's biweekly report to the FOMC.

Results and Discussion

We experimented with several specifications of the system of equations, using up to four lags for each of the endogenous and predetermined variables. Our choice of specification to present was based on a variety of diagnostic tests, including F-tests for the omission of certain lagged variables and Q-tests for serial correlation. Table 2 presents the maximum likelihood estimates of the parameters in the optimal specification.[9]

The results can be summarized as follows. First, although changes in policy have important effects on the demand for transaction deposits, the full impact of these changes takes several months to occur. The long-run response of deposit growth to a change in the federal funds rate (-.083) is fairly large. However, the central bank has no immediate influence on deposits, as evidenced by insignificant coefficients on the contemporaneous and first lag values of changes in the funds rate. Moreover, the error-correction coefficient (-.028) is

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8. We experimented with other scale variables, including industrial production and personal income, with similar results.

9. It has often been suggested that the elasticity with respect to the scale variable (α_2) is close to one. We found that this hypothesis could not rejected, and our results impose this restriction.

quite small, which implies that full adjustment to a change in the funds rate takes several months.[10]

Second, the results suggest that both the required reserve ratio and the federal funds rate play a statistically important role in banks' demand for free reserves. Most importantly, the interest rate elasticity changes with shifts in policy. Recall that the elasticity with respect to the funds rate is $-(\beta_2+\beta_3 r)$. As shown in Table 3, the average reserve requirement on transaction deposits has been about 8 percent between 1984 and 1992. Using this value for r and using parameter estimates from Table 2, the elasticity is -.002, which is quite small. Although the elasticity increases somewhat with lower reserve requirements, the increases are fairly modest. For example, with an average reserve requirement on transactions deposits of 7 percent, the (absolute) elasticity increases to only -.004.

Third, with respect to the supply of nonborrowed reserves, the estimates suggest that the central bank has pursued a combination policy over the sample period. The coefficient on the funds rate deviation (.111) is significant and indicates that an additional $1.5 billion of reserves would be injected in the money market if federal funds were trading 25 basis points above their expected level. This estimate, based on our system of simultaneous equations, is about twice as large as Feinman's estimate of roughly $780 million, which is based on a single-equation representation of central bank behavior.

Overall, these results indicate that banks are likely to become somewhat more responsive to changes in the federal funds rate under a lower required reserve regime ($\beta_3<0$). These findings are consistent with a view that banks view the expected probability of reserve deficiencies and overdrafts as being lower under the new regime. This could occur, for example, if banks significantly increase their levels of excess reserves in response to the change in required reserves. With

10. These results for deposit demand are very similar to those obtained by Moore, Porter and Small, although they used a disaggregated model of M2 over a different sample period.

the increase in excess reserves and a decrease in required reserves, the probability of a reserve deficiency also drops dramatically. As a consequence, banks become more concerned about the level of the federal funds rate and less concerned about their reserve balances.

In addition, these estimates have important implications for volatility in the money market with lower required reserves. Since deposit demand is contemporaneously insensitive to changes in the funds rate, variability of deposits is unaffected by a policy change. On the other hand, the federal funds rate becomes less variable and nonborrowed reserves becomes more variable with lower required reserves. Still, according to our estimates, these changes are likely to be very small. Table 4 presents two hypothetical regimes based closely on current reserve market relationships. These estimates indicate that if the reserve requirement was lowered from 8.5 percent to 7.5 percent, the standard deviation of the funds rate around its expected level would drop by a mere 1/2 of a basis point. Similarly, the standard deviation of nonborrowed reserves would increase only by about .01 percent.

Although these predicted changes are small, they are noteworthy because their direction contrasts somewhat with the conventional view. As we have pointed out, conventional wisdom holds that the funds rate will become more volatile as reserve requirements are lowered. This is because, with lower reserve requirements, an increase in the expected probability of reserve overdrafts is not sufficient to encourage banks to significantly raise the level of excess reserves. Banks will, instead, manage their reserve accounts more closely, becoming less interest rate sensitive and more likely to "bid up" the funds rate when reserves are seen to be in short supply.

CONCLUSION

In this paper, we examined both theoretically and empirically the impact of lower reserve requirements on the variability of reserves, interest rates and deposits. Our work is novel both because of its detailed modelling of the operational (short-run) procedures of monetary policy, and because of our empirical estimation of those procedures. Our theoretical model predicted that interest rate volatility would likely increase with lower reserve requirements, while the change in the volatility of reserves and deposits would depend on the type of disturbance that occurred. This result depended, however, on the magnitude of various elasticities, on relative variances, and on the central bank's rule for supplying reserves.

Our empirical results, however, indicated that lower required reserves would lead to a decrease in interest rate volatility and increase in reserve volatility, although both of these volatility changes would be quite small. We found no evidence that short-run deposit volatility would change with lower reserve requirements, since the funds rate only affects deposits with a lag.

There are a few caveats to our results. First, our empirical work is based on monthly data, which allowed us to examine both volatility in the reserve market and the relationship between changes in the reserve market and the deposit market. While daily data yield a better insight to behavior in the reserve market, high frequency observations would likely obscure conclusions about longer-term relationships. On the other hand, quarterly data would miss the shorter-term dynamics of the reserves market.

Second, we estimated our model over a particular time period and did not allow parameter coefficients to vary during that period. Even the time period was chosen because it provided the most consistency with respect to operational procedures, subtle changes in these procedures could have had an impact on our estimates. We plan to explore this issue in subsequent research.

With these cautions in mind, our work nevertheless suggests that lower reserve requirements are unlikely to have much impact on volatility in the reserve market. Although there may be other reasons for maintaining a certain level of reserve requirements, a significant increase in volatility of reserves and the funds rate does not appear to be one of them.

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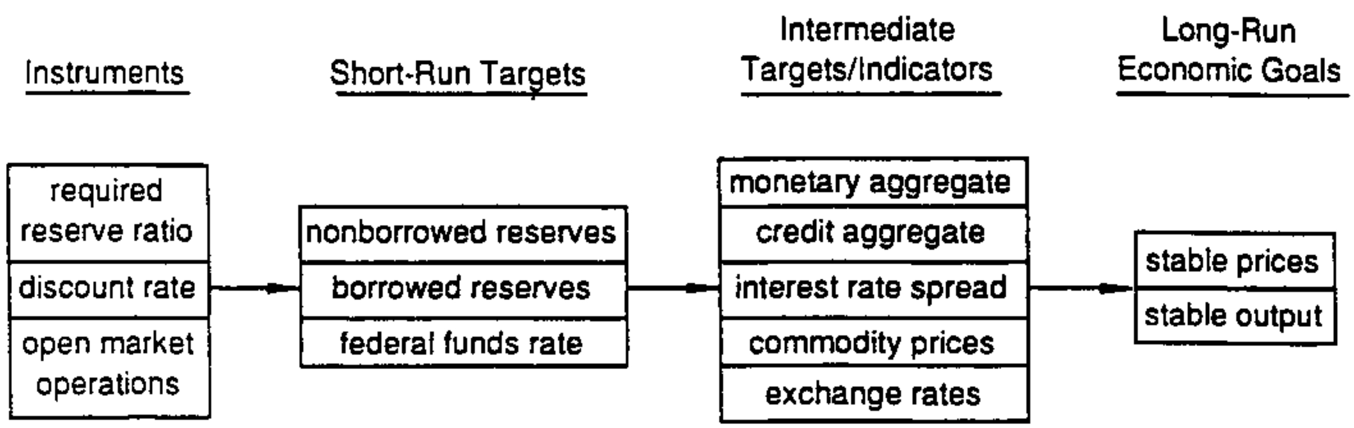
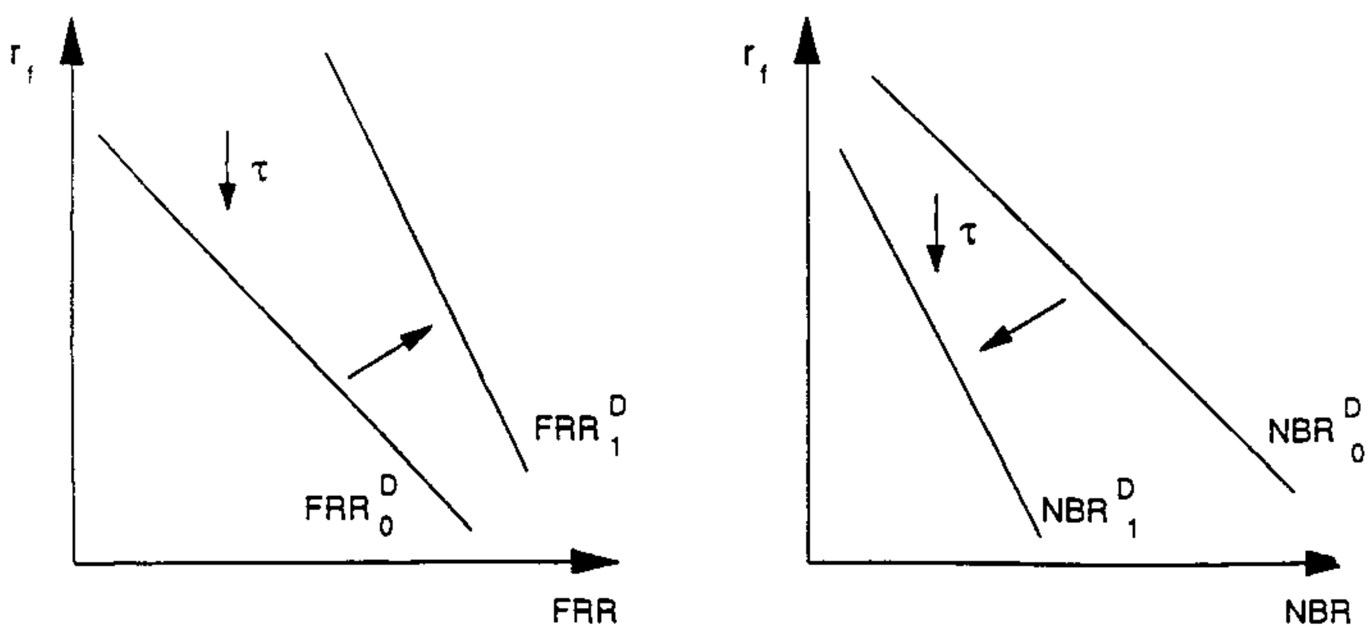
1. Implementing Monetary Policy: A Hierarchy of Instruments, Targets, and Indicators



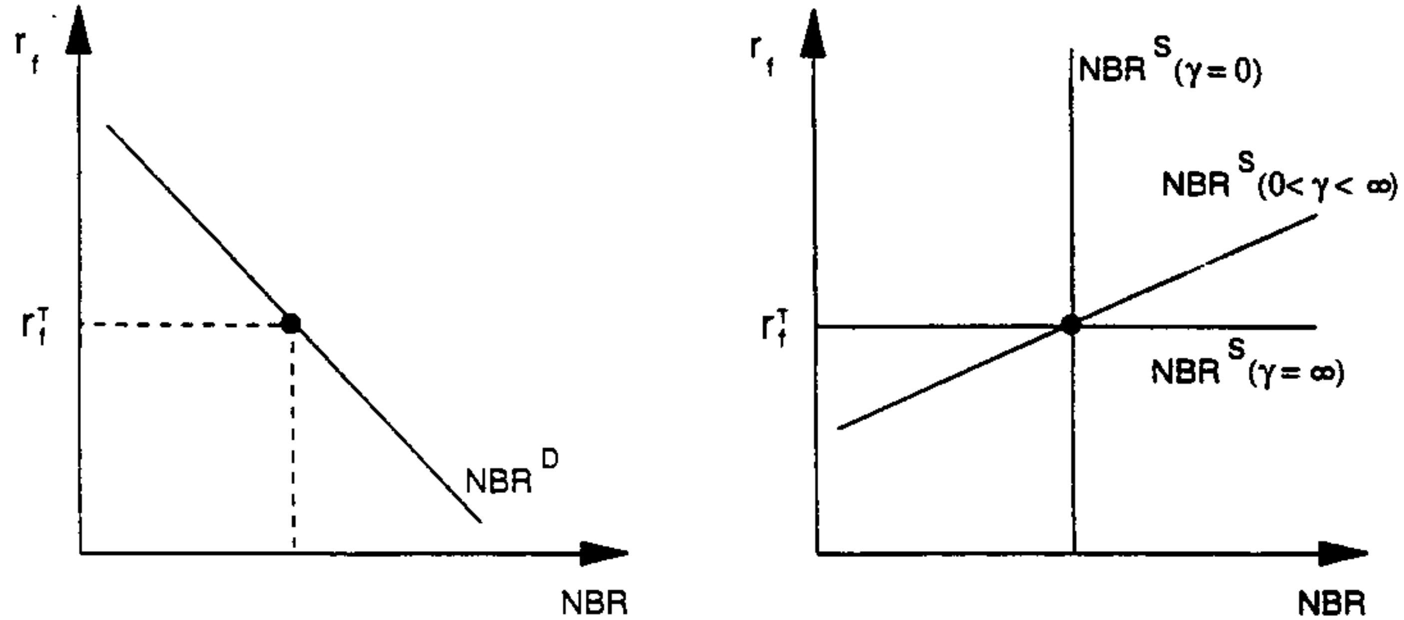
2. Effects of Lower Reserve Requirements on the Demand for Free and Nonborrowed Reserves



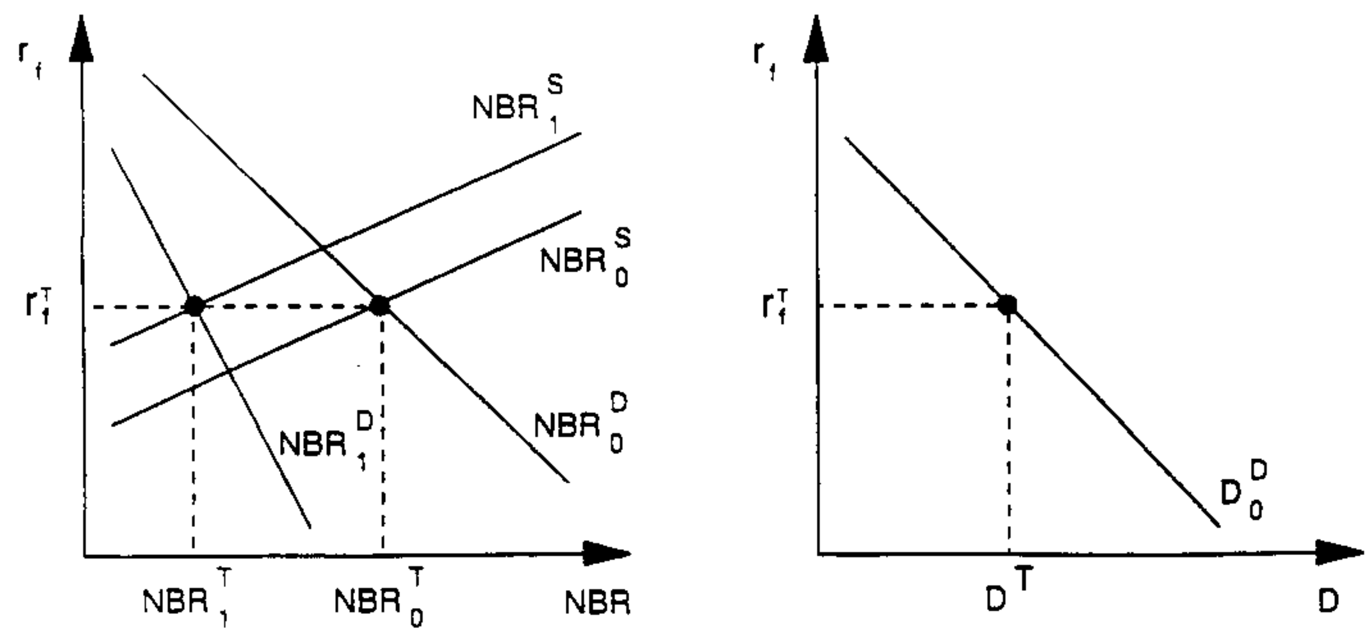
3. Operational Procedures for Implementing Short-term Monetary Policy

Choosing Operational Targets

Choosing an Operational Rule

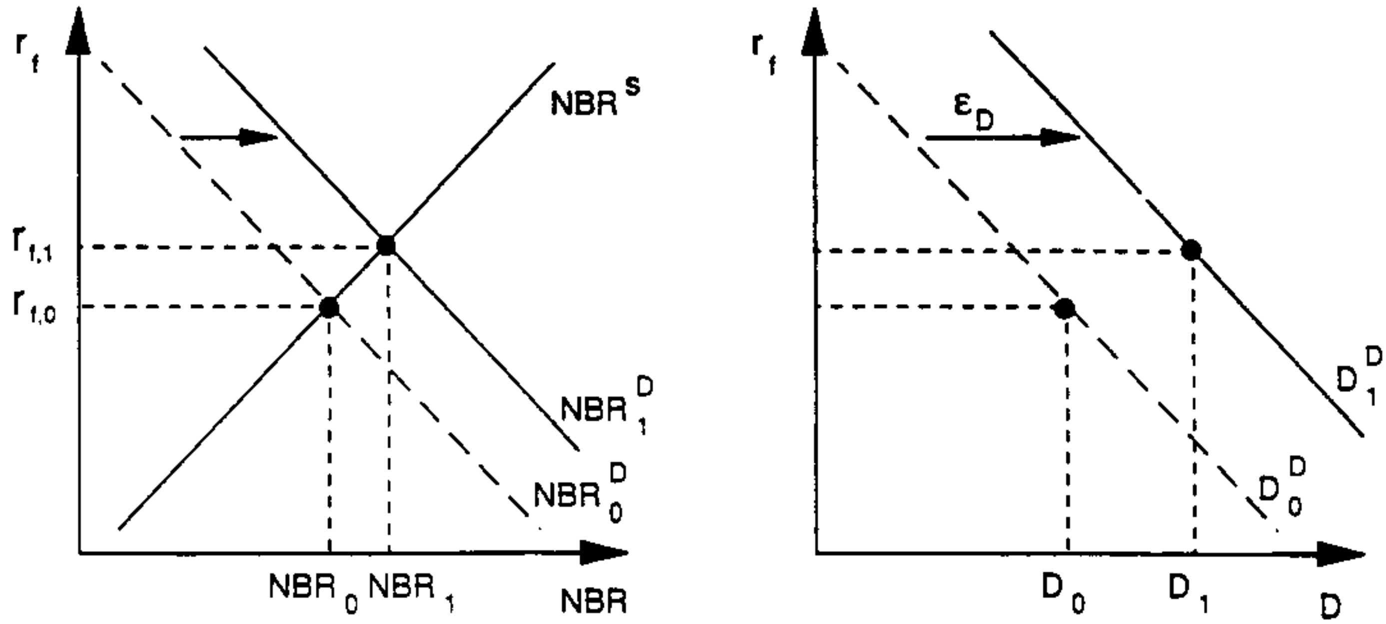


4. Sterilization of a Decrease in Reserve Requirements

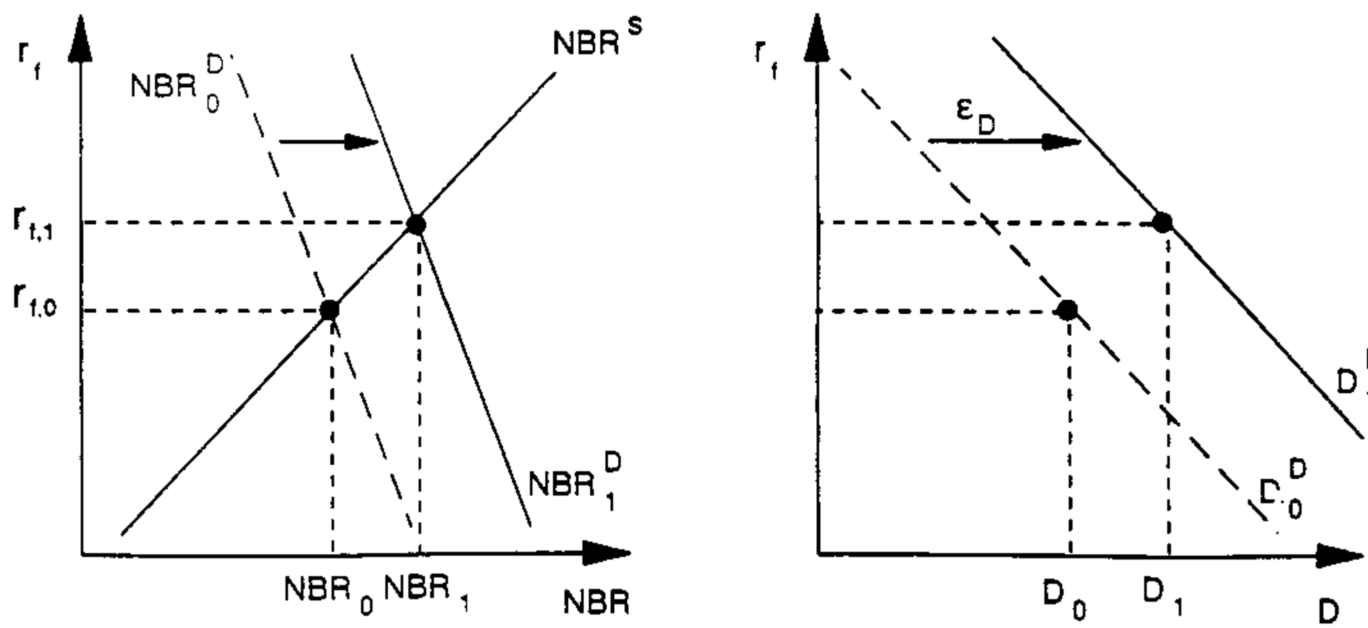


5. Effects of a Deposit Shock with a Lower Reserve Requirement

Baseline Case

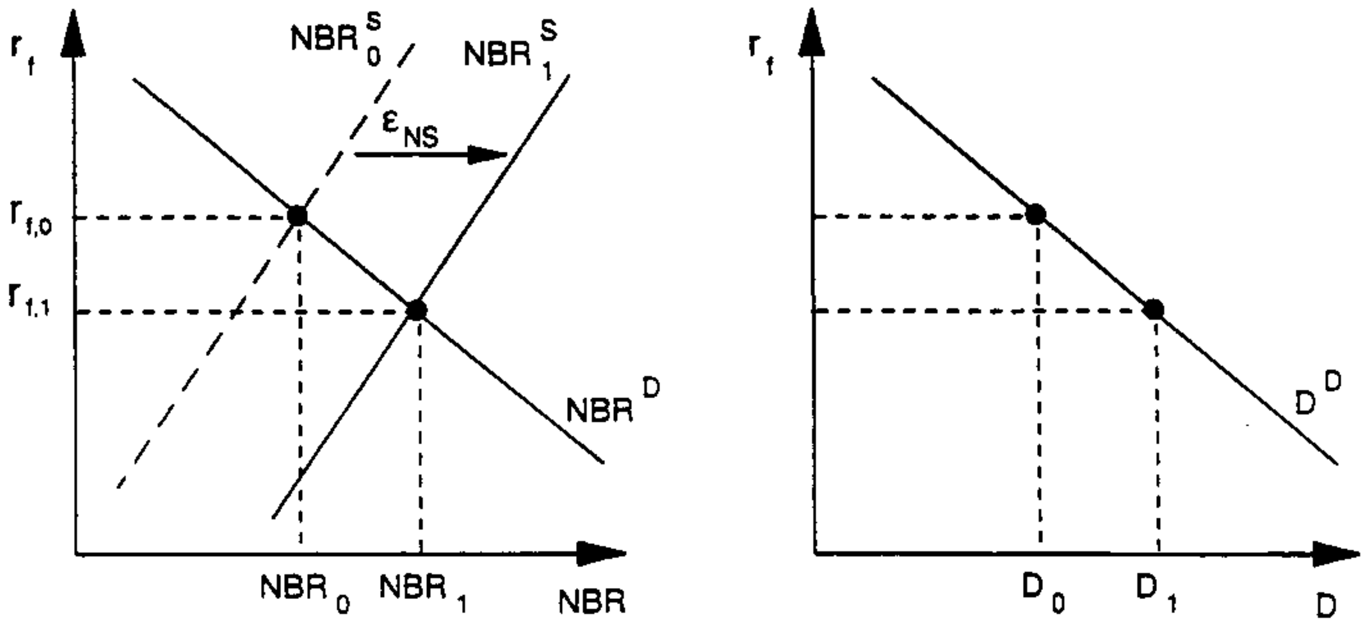


Lower Reserve Requirement

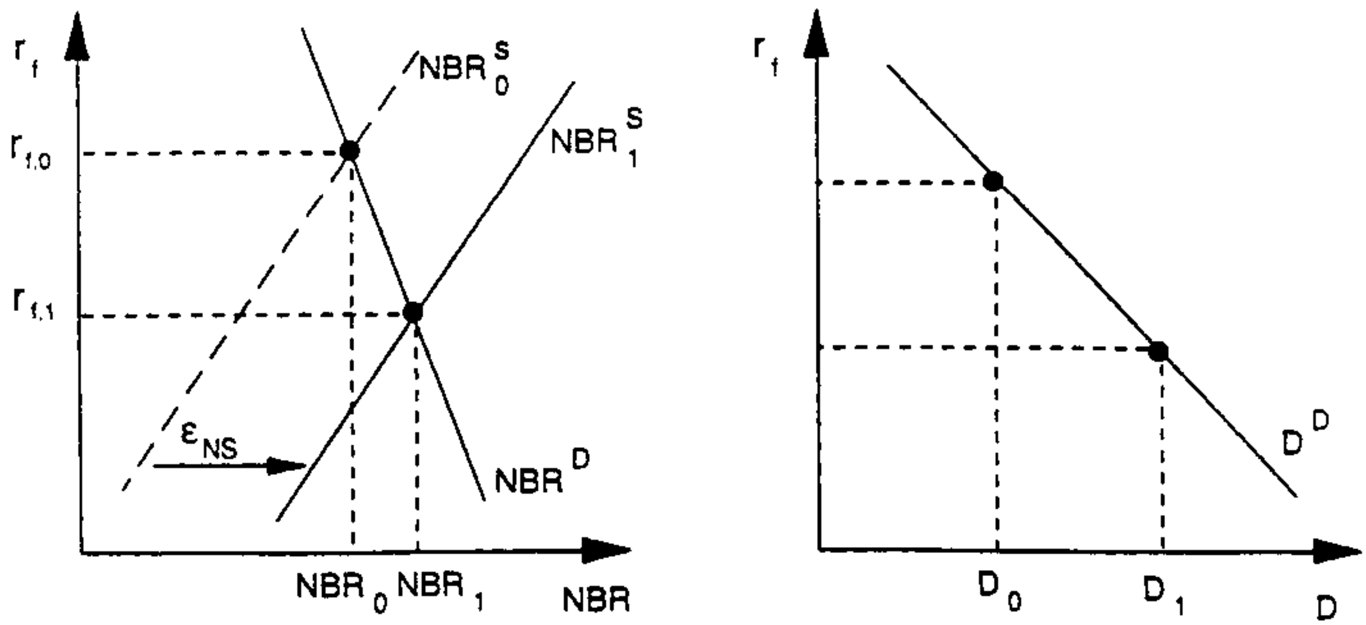


6. Effects of a Reserve Supply Shock with a Lower Reserve Requirement

Baseline Case

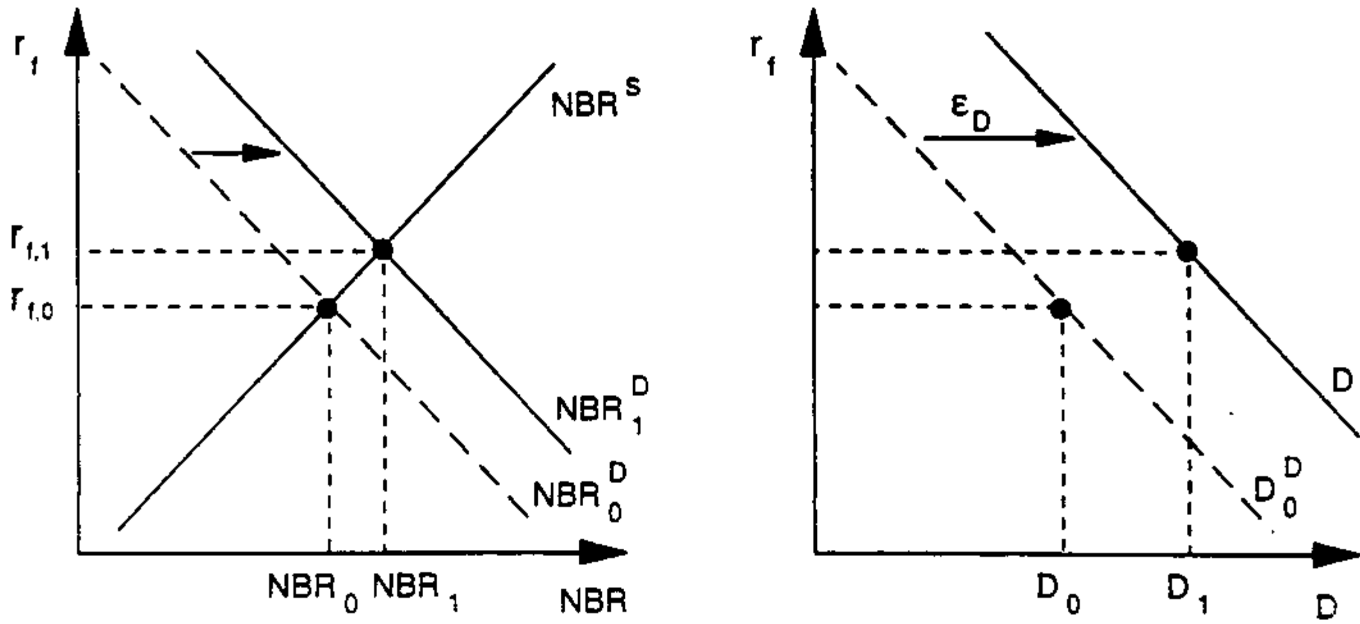


Lower Reserve Requirement

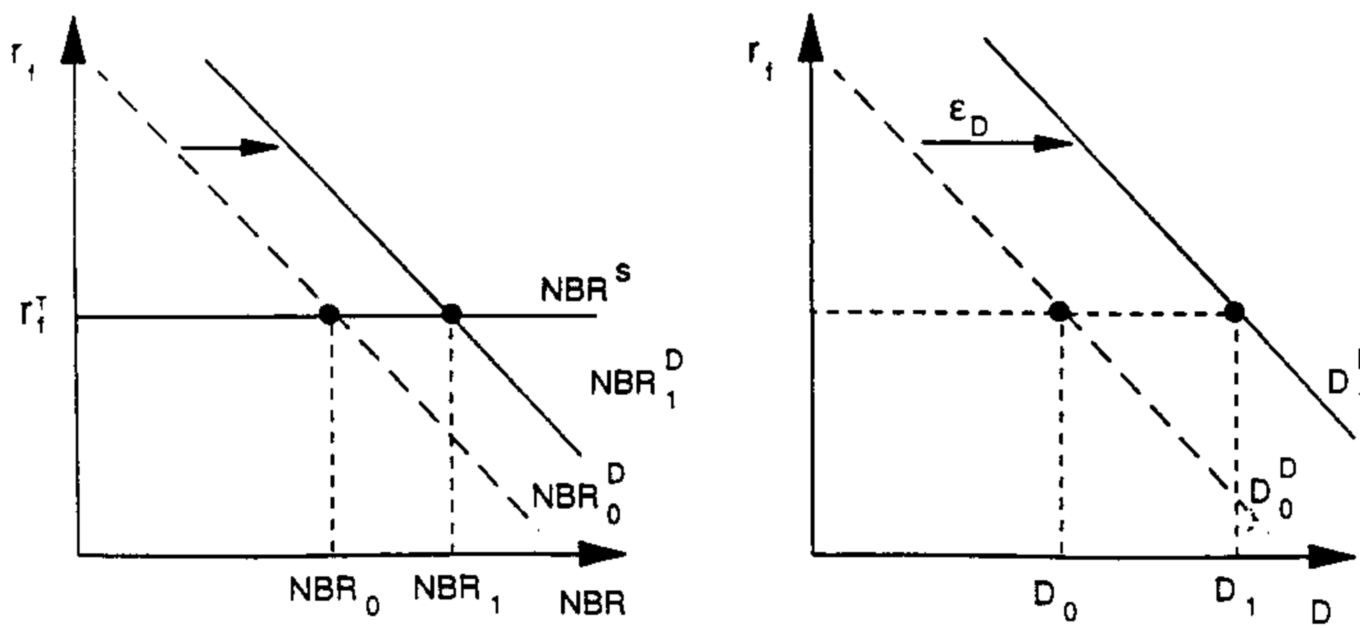


7. Effects of a Deposit Shock When Central Bank Pegs Federal Funds Rate

Baseline Case



Central Bank Pegs Rate



1. **The Effects of Lower Reserve Requirements On Volatility In the Money Market**

Variable	Shock	Contribution of Shock to Variance of Variable:	Change in Contribution with a Decrease in τ:
$r_f - r_f^T$	ϵ_D, ϵ_{FR}, ϵ_{NS}	$\dfrac{1}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^2}$	$\dfrac{2\beta_3}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^3} > 0$
$NBR - NBR^T$	ϵ_D, ϵ_{FR}	$\dfrac{\gamma^2}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^2}$	$\dfrac{2\beta_3\gamma^2}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^3} > 0$
$NBR - NBR^T$	ϵ_{NS}	$\dfrac{(\alpha_1+\beta_2+\beta_3\tau)^2}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^2}$	$\dfrac{-2\gamma\beta_3(\alpha_1+\beta_2+\beta_3\tau)}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^3} < 0$
$D - D^T$	ϵ_D	$\dfrac{(\beta_2+\beta_3\tau+\gamma_2)^2}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^2}$	$\dfrac{-2\alpha_1\beta_3(\beta_2+\beta_3\tau+\gamma)}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^3} < 0$
$D - D^T$	ϵ_{FR}, ϵ_{NS}	$\dfrac{\alpha_1^2}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^2}$	$\dfrac{2(\alpha_1)^2\beta_3}{[\alpha_1+\beta_2+\beta_3\tau+\gamma]^3} > 0$

2. Summary of Empirical Results[1]

Coefficient	Estimate[2]		Coefficient	Estimate	
Deposit Demand			**Desired Free Reserve Ratio**		
ρ	-.028	(-2.30)	β_0	.139	(1.99)
α_0	1.703	(6.15)	μ_1	.262	(4.38)
α_1	-.083	(-2.66)	β_1	1.402	(1.69)
ϕ_1	.152	(1.49)	β_2	.020	(2.35)
ϕ_2	-.145	(-1.58)	β_3	-.224	(-2.22)
ϕ_3	.323	(3.34)			
θ_0	-.001	(-0.21)	σ_{FR}	$.474 \times 10^{-2}$	(14.36)
θ_1	.001	(0.23)			
θ_2	-.005	(-2.34)			
θ_3	-.005	(-2.13)	**Nonborrowed Reserve Supply**		
δ_0	.013	(1.38)	$r_f - r_f^T$	.111	(2.29)
δ_1	-.021	(-1.58)			
δ_2	-.017	(-1.44)	σ_{NS}	1.870×10^{-2}	(2.30)
δ_3	-.012	(-1.29)			
σ_D	$.556 \times 10^{-2}$	(13.24)			

[1] Coefficients correspond to those in equations (1'), (7') and (9).

[2] Numbers in parenthesis are t-statistics.

3. **Selected Reserve Market Statistics: 1984 - 1992**

Variable	Mean	Standard Deviation
τ	8.06 %	0.34 %
FRR	0.88 %	1.36 %
$r_t - r_t^T$	0.07 %	0.16 %
$NBR - NBR^T$	-0.10 %[1]	0.94 %

[1] Mean is insignificant from zero.

4. **Estimated Standard Deviations Under Various Regimes**

Variable	$\tau = 8.5\%$	$\tau = 7.5\%$
$r_t - r_t^T$	0.181 %	0.175 %
$NBR - NBR^T$	1.540 %	1.552 %

DISCUSSION: IMPLEMENTING SHORT-RUN MONETARY POLICY WITH LOWER RESERVE REQUIREMENTS

E. J. Stevens[1]

The intent of Brunner and Lown is to "examine the effects of reserve requirements on market volatility and on the central bank's ability to achieve short-run policy objectives", something that has interested many of us since early 1991. A surprise reduction in reserve requirements in December 1990 was followed by several months of unusual volatility in the federal funds rate. Post hoc, ergo propter hoc? The startling estimated implication of this model is that a cut in reserve requirements should reduce, not increase, volatility. Can it be so?

The conceptual model is appealing. Short-run shocks to demands for deposits and free reserves, and to the Fed's supply of nonborrowed reserves influence the market for bank reserves without lasting effects. In this sense, the model is not designed to explain serious matters like deviations of the price level or output or money from policy targets. Rather, it models very short-run noise in deposits, reserves, and the interbank overnight interest rate. Perhaps such noise could obscure policy signals and have longer-lasting effects, but that is not the issue here.

The authors have dealt with most of my comments on the original version of their paper, which lacked the empirical sections of the current version. Therefore, I will focus my comments on the way in which they have married their simple conceptual model to the more complicated data series used in estimating the model.

MONTHLY DATA

Estimating the model with monthly data is good practice with the estimation methodology, but is not likely to produce the most relevant results. Perhaps there are important mean-zero shocks at a monthly frequency, but it was volatility of the funds rate at much higher frequencies -- during a single day, from day to day, and between settlement days and other days of a reserve maintenance period -- that vexed the Fed early in 1991. The possibility of volatility at these higher frequencies is, I believe, one

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stumbling-block to further reductions in reserve requirements.

A monthly frequency seems even longer than the authors envisioned in their conceptual model of bank reserve management, which is couched in terms of reserve deficiencies, which occur at a two week frequency, and of overdrafts, which occur at frequencies ranging from a few minutes to overnight. Monthly averages of daily aggregate data surely must obscure a great deal of the phenomenon we want to know about, as the authors acknowledge in their concluding discussion. Armed with estimates suggesting that feedback from the deposit market to the reserves market is relatively unimportant even at a monthly frequency, I would hope that one of their next steps would be to estimate the model at maintenance period and daily frequencies

DEFINITIONS OF VARIABLES

A second aspect of marrying model to data that deserves further scrutiny is the choice of empirical counterparts to the conceptual variables. The conceptual model includes transactions deposits and total reserves. The latter are allocated between required reserves against transactions deposits and excess reserves. Excess reserves are viewed as an inventory of balances yielding insurance against reserve deficiencies and supplemental protection against overdrafts. Total reserves have two sources, nonborrowed and borrowed, but the demand for borrowing is said to be "suppressed" by defining a single demand for free reserves, which is excess reserves minus borrowed reserves. Total reserves thus are identical to nonborrowed reserves, conceptually.

The empirical counterpart of total reserves used in estimating the model is actual reported nonborrowed reserves of the U. S. banking system, including reserve balances and applied vault cash, net of adjustment and seasonal discount window borrowing. [As is usual, extended credit borrowings are treated as nonborrowed.] The empirical counterpart of conceptual free reserves is reported nonborrowed reserves minus required reserves against transactions deposits. Free reserves therefore include reported excess reserves net of borrowed reserves, <u>plus</u> <u>reserves</u> <u>against</u> <u>non</u> <u>transactions</u> <u>deposits</u>, a novel definition.

Several issues arise from these definitional leaps. Defining free reserves to include required reserves against non transactions deposits implies that they play the same role as excess reserves in protecting against overdrafts, which they do, but they certainly don't protect against reserve deficiencies. Recently, of course, this component of the measure of free reserves should be negligible or zero, but it must have dominated the measure prior to 1991, or for 79 of the 94 months in the sample period. What is puzzling is that the estimated free reserves relationship implies that banks held fewer non transactions deposit liabilities and their associated required reserves when interest rates were higher than when rates were lower.

Subtracting borrowed from excess reserves and working with a single demand for free reserves also has its problems. One is that seasonal borrowing has a seasonal pattern that is large enough to swamp variations in excess reserves and adjustment borrowing at the monthly frequency. This may help to explain why the estimated coefficient on lagged free reserves is relatively large. A second problem with using free reserves is what to do about the level of the discount rate, which is not included in the model. More excess reserves can be held by buying or refraining from selling federal funds, at the cost of the funds rate. Less borrowing at the discount window might serve the same purpose, keeping a bank's "powder dry", in a sense, at the cost of the margin between the discount rate and a market rate such as the funds rate. However, only the funds rate enters the estimations.

Vault cash and clearing balances also present problems. Reported total reserves for a maintenance period include both deposit balances at the Fed and vault cash held by bound banks four weeks earlier. Two identical pairs of total and excess reserve levels with substantially different levels of vault cash will allow entirely different degrees of overdraft protection. Reported total and excess reserves do not include clearing balances that banks contract to maintain at the Fed. These balances, which now are the equivalent of 25% of reserve deposit balances, may be an important source of overdraft protection that is not incorporated in the model estimation.

I wonder how much confidence to place in the model's estimated coefficients, particularly those in the free reserves relationship, given the number of difficulties involved in measuring free reserves. This doubt, in addition to the question about the relevance of estimates at a monthly frequency, makes me eager to see further refinement of the work before I could be convinced of the surprising implication that reducing reserve requirements reduces volatility in the funds rate.

I hope that Brunner and Lown will continue along the lines their paper sets out. The conceptual model nicely captures critical aspects of the day-to-day interaction of policy implementation, banks' reserve management, and the larger financial world within which banks do business. Their initial results seem intuitively plausible in finding little feedback from the market for transactions deposits to the short-run determination of reserves and the funds rate, and finding significant interaction between the funds rate and the supply of nonborrowed reserves. Using higher frequency data and improving their treatment of free reserves are two items I would hope the authors place high on their agenda for future work.

PRECISION OF POLICY IMPLEMENTATION

Finally, note that this model incorporates three sectors. One includes the entire non-bank public, a second includes all banks, but the third consists of only one agent, the central bank. The model begins with the plausible assumption that the behavior of each sector is subject to an exogenous mean-zero random shock. However, in the case of the central bank, shocks to the supply of nonborrowed reserves are not necessarily exogenous. They might be altered by changing the way the Fed does its business.

While the present paper doesn't focus special attention on this reserve supply shock, it strikes me as a very useful aspect of the model to investigate from the perspective of lower reserve requirements, especially if the model is reestimated with higher frequency data. As required reserves decline, demand for reserves will decline, albeit perhaps not proportionally. If the size of reserve supply shocks remain unchanged as the trend level of reserves declines, the central bank will be responsible for a relatively larger source of deposit and interest rate variability. Delicate reserve supplying techniques with an average absolute error of, say, 1% of reserve balances when reserve requirements are high, will be clumsy indeed when reserve balances are far lower.

Shocks to reserve supply are the only source of noise that the Fed might expect to change directly, by changing the mechanics of policy operations. The Desk long has operated once a day, just before noon, to control the supply of nonborrowed reserves, based on reserve projections made early in the day. Other central banks operate differently: The Bank of England, with no reserve requirements, may operate as frequently as four times during a day as it gains successively more up-to-date estimates of reserve supply and demand; the Bank of Canada does draw downs or re deposits of Treasury balances at the end of the day, based on end of the day estimates of reserve supply; the Bank of Japan operates twice a day.

This model highlights, but doesn't deal directly with, a serious question: If the central bank can achieve its targets on average, why does it bother trying to damp short-run shocks to either deposits or the interest rate? One possible answer is that it can perform a low cost public service by sterilizing predictable seasonal shocks to the financial system. If that is all that the shocks to deposit demand and free reserve demand represent, perhaps not too many people would object to this effort to provide an elastic currency. However, if the shocks emanate from the central bank's own reserve supplying operation, then surely the central bank has a duty, not to dampen the effects of, but to eliminate the source of the shocks, up to the point at which the real resource costs of gaining better control of reserve supply are equal to the real resource costs to the banking system of coping with such shocks.

Perhaps a useful empirical result of this line of research will be estimates of the size of reserve supply shocks. Such estimates could give us some indication of the possible need to modify the Fed's reserve supplying techniques under a lower or zero reserve requirement regime.

FEDERAL RESERVE OPERATING PROCEDURES AND INSTITUTIONAL CHANGE

John Wenninger and William Lee[1]

> So, all things considered, I would conclude -- at last -- with the hope that our worst fears about money and institutional behavior under deregulation are wrong and policy can be conducted in a simpler world where something like our old friend M1 will reemerge -- reviving Phoenix-like from its ashes -- and serve yet another day.[2]

Thus far, it just has not happened. Over the past 10 to 15 years, institutional changes (innovation and deregulation) have continued to create operating and tactical problems for the Federal Reserve. No single monetary variable has emerged from the ashes (or elsewhere) to serve as a guide for policy.[3] As a result, currently there is no automatic feedback from changes in economic conditions to the federal funds rate in the short run, and reserves have become largely an endogenous, demand-determined variable. At the intermediate level, the Federal Reserve no longer sets targets for "our old friend M1" even though many of the institutional features of the current operating procedures were formulated specifically to control M1. Rather, the Federal Reserve places more emphasis on longer run control of M2, while acknowledging M2's shorter run limitations.

More recently, some additional institutional changes have occurred that could affect the way monetary policy is implemented both in the short-run and over the longer run:

(1) Institutional changes, affecting both the supply of and demand for M2, have raised the issue of whether M2 needs to be redefined in light of its recent weakness.

(2) The so-called "credit crunch", or a reduced willingness of some institutions to lend, has resulted in part from

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1. Federal Reserve Bank of New York.

2. Stephen H. Axilrod, "Defining the Issues -- Monetary Aggregates and Monetary Policy in a Deregulated Financial World", *Interest Rate Deregulation and Monetary Policy*, Federal Reserve Bank of San Francisco, Asilomar Conference, November 28-30, 1982, p. 12.

3. Some analysts argue that not just M1 but all financial quantity aggregates have become of little use. See Benjamin Friedman, "Monetary Policy Without Quantity Variables", *American Economic Review*, Papers and Proceedings, May 1988, pp. 440-45.

institutional changes that have disrupted the credit intermediation process.

(3) The reduction in credit flows through the banking system more generally as this industry downsizes could be another important institutional change for policy over the longer run.

(4) The closing of a large number of insolvent depository institutions has raised the question of whether it would be better to use reserves or the funds rate as the instrument variable to avoid undesired monetary side effects.

In this paper, we will assume a fairly broad definition of operating procedures and tactics in reviewing the implications of institutional change. That is, we will view institutional changes as relevant if they affect the question of reserves versus the funds rate as the Federal Reserve's instrument variable in the short run, or the choice, definition, and interpretation of intermediate monetary and credit aggregates in the longer run. The purpose of this paper is to provide a list of potentially relevant institutional changes that may affect the implementation of monetary policy.

The remainder of this paper reviews in more detail how institutional changes have affected, or could affect, the Federal Reserve's operating tactics and procedures. The first section reviews the institutional setting of the 1979-82 procedures in the short run. The second section summarizes the more intermediate problems as well as some proposals for institutional reforms that might improve the Federal Reserve's procedures. The third section discusses the implications of the four institutional issues noted above that have developed more recently.

SHORT-RUN PROCEDURES 1979-82

In the late 1970s and the early 1980s, the Federal Reserve's operating procedures were often discussed in terms of a chart like Chart 1.[4] The

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4. This section and the next draw on earlier work contained in the following documents. Stephen Axilrod, "U.S. Monetary Policy in Recent Years," *Federal Reserve Bulletin*, January 1985; Henry C. Wallich, "Recent Techniques of Monetary Policy," Federal Reserve Bank of Kansas City *Economic Review*, May 1984. See also Stephen Axilrod, "Monetary Policy, Money Supply and the Federal Reserve's Operating Procedures," *Federal Reserve Bulletin*, January 1982; Stephen Axilrod and David Lindsey, "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach," *American Economic Review*, vol. 71, no. 2 (May 1981), and Donald Kohn, "Monetary Policy in an Era (continued...)

demand for reserves increased as the Federal funds rate fell because of the negative interest rate elasticity in the demand for money and the presumption the banks would hold more excess reserves at lower levels of the funds rate.

The supply of nonborrowed reserves (equal to the supply of total reserves when the funds rate was less than the discount rate) was viewed as being policy determined and therefore as completely interest inelastic at levels of the funds rate less than the discount rate. If the demand for total reserves exceeded the level of nonborrowed reserves provided through open market operations (that is, the funds rate exceeded the discount rate), banks would borrow from the discount window in the short-run to make up the difference. The slope of the supply function above the discount rate was determined by the banking system's reluctance to borrow and discount window administration.

If an increase in the demand for reserves (D1 to D2 in the chart) was due to an undesired increase in money relative to target, there would be automatic upward pressure on the funds rate. The more reluctant banks are to use the discount window, the greater would be the automatic upward pressure on the funds rate. Higher interest rates, in turn, would eventually slow economic activity and reduce the demand for money, bringing the money supply and reserves back toward target. If the Federal Reserve desired to speed the process up somewhat, it could reduce the supply of nonborrowed reserves and cause the funds rate to increase even more (NB1 to NB2 in the chart). The Federal Reserve could also speed up the process by increasing the discount rate.

In either case, it was viewed as an advantage that deviations of money from target resulted initially in some automatic response in the funds rate. This outcome was viewed as superior to the earlier procedure in which the Federal Reserve set the funds rate and deviations of money from target were fully accommodated in the short-run. In terms of Chart 1, the supply function was a horizontal line at the desired level of funds rate.

4(...continued)
of Change", *Federal Reserve Bulletin*, February 1989. For an international perspective, see *Changes in Money Market Instruments and Procedures: Objectives and Implications*, Bank for International Settlements, March 1986. For a historical perspective, see Ann-Marie Meulendyke, "A Review of Federal Policy Targets and Operating Guides in Recent Decades," Federal Reserve Bank of New York *Quarterly Review*, Autumn 1988. A review of the Federal Reserve's new operating procedures following the October 1979 change can be found in Board of Governors of the Federal Reserve System, *New Monetary Control Procedures*, Staff study, February 1981.

For operating procedures that focused on controlling money through the supply of reserves with automatic pressure on the funds rate, it was necessary to assume an institutional setting that would validate the following two assumptions:

(1) Shifts in the demand for reserves should have some economic content, that is, the concept of money to which reserves are linked must have some predictable and stable relationship to the economy. Ideally, deviations of money and reserves from target would reflect changes in the level of economic activity and not underlying instability in the demand for money.

(2) The relationship between borrowed reserves and the spread between the funds rate and the discount rate should also be reasonably stable for two reasons: (1) to set the funds rate at the desired level at the beginning of the operating period by establishing an initial borrowing assumption, and (2) to have shifts in the demand for reserves of a given size produce "predictable initial impacts" on the funds rate.

These two assumptions, as most analysts are well aware, did not work out in practice because of the substantial changes in the institutional environment that have taken place since the mid-1970s. These institutional changes will be outlined in the next section.

INSTITUTIONAL CHANGE AND THE OPERATING PROCEDURES AT THE INTERMEDIATE LEVEL

Several institutional changes have occurred since the mid-1970s that not only resulted in little or no automatic change in the funds rate in response to changes in the economic conditions after October of 1982, but also resulted in a shift in the focus of policy at the intermediate level (from M1 to M2). To briefly recapitulate some of these institutional changes:

-- In the mid-to-late 1970s, the demand for M1 appeared to shift downward probably as a result of increased emphasis by corporations on cash management in a high interest rate environment. Hence, even as the October 1979 operating procedures were being put into place, there was some reason to doubt the underlying stability of the demand for M1 based on recent history.

-- By the early 1980s, a deregulation process had begun that blurred the distinction between transactions balances and savings balances, raising issues about the interpretation of

M1 growth and the definition of transactions money. Large flows of funds took place between types of deposits as new types of deposits were introduced or when large volumes of these new deposits subsequently matured.[5]

-- The deregulation of the interest rates on most consumer deposits, contrary to the expectations of many analysts, appeared to result in a large increase in the interest elasticity of the demand for M1, making it difficult to set reasonable targets for M1 particularly in the disinflationary environment of the mid-1980s.[6] As a result, the Federal Reserve began to focus more on a broader monetary aggregate, M2. Targets for M1 have not been set for a number of years.

-- The larger interest rate elasticity for the demand for M1 in a deregulated banking system resulted in part from the shifting of funds by consumers among the components of M2 as banks changed time deposit rates more quickly than the rates on M1 deposits in response to movements in market rates.

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5. For more detail on this process, see Courtenay Stone and Daniel Thornton, "Solving the 1980s' Velocity Puzzle," Federal Reserve Bank of St. Louis *Review*, August-September 1987, pp. 5-23; and W. Michael Cox and Harvey Rosenblum, "Money and Inflation in a Deregulated Financial Environment: An Overview," Federal Reserve Bank of Dallas *Economic Review*, May 1989, pp. 1-19. For some interesting work on the effects of deregulation using regional statistics, see Peter Ireland, "Financial Evolution and the Long-Run Behavior of Velocity: New Evidence from U.S. Regional Data," Federal Reserve Bank of Richmond *Economic Review*, November-December 1991, pp. 16-26.

6. Not all analysts, however, took the view that M1 would become less interest elastic if the interest rate on M1 deposits was deregulated. For example, James Pierce in his panel discussion at the Federal Reserve Bank of San Francisco Asilomar Conference in November 1982 (p. 218) argued:

> It is important to note that the assertion that the LM curve becomes steeper depends heavily on the assumption that the interest elasticity of money demand does not increase when money pays a market interest rate. This is unlikely. When it earns a market rate of return, money is held not just as a medium of exchange, but also as an asset whose return is competitive with the returns on other assets. The portfolio demand for money is likely to be highly interest elastic. In this case, small changes in the interest rate on money, relative to other interest rates, produce large changes in the quantity of money demanded. With a sufficiently high interest elasticity of money demand the LM curve is flatter rather than steeper when money pays a market interest rate. In this case, the economy is more sensitive to IS shifts and less sensitive to LM shifts.

Because reserves were primarily related to M1 deposits, the growth of reserves could increase or decrease sharply in response to changes in market interest rates with little or no affect on M2. As a result, the reserve base was not linked to the more reliable nominal anchor for policy (M2) in a practical way for operating purposes.[7]

-- In addition, since the demand for reserves was dominated by the demand for M1, there was no reason to believe that the relationship between reserves and GDP would be any more reliable than the one between M1 and GDP. Hence, it did not appear possible, at a practical level, to ignore the intermediate monetary target and set a path for the reserve base consistent with GDP.[8]

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7. The problem is the well-known one of using reserves to control a monetary aggregate when reserve requirements are not universal and uniform on its components. For example, suppose M2 had two components, reservable transactions deposits (D) and nonreservable time deposits (T), and that the desired ratio of T to D was (t). If the reserve ratio was (r), the following relationship between M2 and the reserve base (R) would hold: $M2= (1/r) R + (t/r) R$. Hence, to control M2 with R, it is necessary to project (t) fairly accurately. If (t) depends on interest rates, it would be necessary to use an interest rate assumption. In any case, it is not sufficient to hold R constant to attain a desired M2; rather it is necessary to adjust R to changes in (t). In recent years, (t), calculated as the ratio of nonreservable M2 to reservable M2 has varied in a range of 4.2 to 5.1, with a standard deviation of 0.24. It is not clear that the movements in the funds rate associated with offsetting these movements in (t) would be acceptable to policy makers especially if there were any doubts about the stability of the demand for M2.

8. Benjamin Friedman has argued that adding currency to reserves to arrive at the monetary base also would not be a solution. Currency has long been an endogenously determined variable, (Federal Reserve provides an elastic currency), and its demand is driven by forces other than GDP, such as criminal activity, tax evasion and the underground economy, as well as its use in foreign countries. For more detail, see "Conducting Monetary Policy by Controlling Currency Plus Noise", Carnegie - Rochester Conference Series on Public Policy, no. 29. The Shadow Open Market Committee has also deemphasized the monetary base in recent years because of the increased dominance of the base by its currency component. For more detail, see William Poole, "Choosing a Monetary Aggregate: Another Look", Report Prepared for the Shadow Open Market Committee Meeting of September 29-30, 1991. In any case, the sharply differing views expressed by Allan Meltzer and Donald Kohn on this subject of the Federal Reserve's using the monetary base as a policy variable suggests that perhaps the monetary base should be reviewed in more detail than is being done in this paper. For more detail, see Michael T. Belongia (ed), *Monetary Policy on the 75th Anniversary of the Federal Reserve System*, Federal Reserve Bank of St. Louis, October 19-20, 1989, pp. 96-103 and pp. 104-107.

-- And by the mid-1980s, the demand for borrowed reserves appeared to become less stable as banks became more reluctant to borrow because of the perception that weak banks were being supported by discount window loans.

With the increased uncertainty about the interpretation of both the supply of and demand functions for reserves, the Federal Reserve, for all practical purposes gradually reverted to operating again by setting targets for the Federal funds rate. As a result, there now is no automatic response in the funds rate to changes in economic conditions.

In a sense, we should not be too surprised with the way the current approach to policy has evolved; that is, with the emphasis largely on the federal funds rate. Even as early as 1981, when the Federal Reserve was successfully using operating procedures that focused primarily on setting targets for reserves and money, some analysts seemed to be predicting that, given the way the institutional setting was likely to develop, the Federal Reserve could well end up with little choice but to use the federal funds rate as its instrument variable. In commenting on the experience with the new operating procedures through 1980, Stephen Axilrod and David Lindsey noted:[9]

> Experience to date suggests an affirmative answer for the economic conditions since October 1979. But a reserve targeting procedure linked to predetermined money growth rates assumes a more or less stable demand function for money. However, as more and more substitutes for money evolve, as different forms of money develop, and as financial technology becomes more and more computerized and transfers for payments out of almost any and all assets can be made rapidly by electronic means, it may become increasingly difficult to detect - indeed, to believe in - a stable demand function for money. This raises the question of whether we will not eventually reach a point where interest rates will have to be given more consideration in policy, in the absence of a clear notion about what is "really" money and in view of the possibility that the velocity of whatever we happen to define as money may come to develop the capacity for varying sharply from period to period.

Thus, while the demand for M1 turned out to be unstable as they predicted, the institutional structure of the current operating procedures still remains unchanged, in a sense out of step with the institutional changes that have occurred thus far. The demand for reserves is derived largely from the demand for a discredited monetary aggregate (M1 with its unstable demand function and high interest rate elasticity), and the supply function of reserves seems to have been made

9. Axilrod and Lindsey, "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach".

less predictable by the crisis in the banking system that has increased the reluctance of banks to use the discount window.

This outcome naturally seems to raise the question of what types of regulatory changes could be made to make the current procedures more consistent with the current institutional setting. A convenient place to start this discussion is to review the regulatory changes that were frequently cited as necessary for making the 1979 to 1982 operating procedures more effective in order to determine whether any of these changes, on variations there on, would be applicable today. In October of 1981, David Lindsey listed the following seven regulatory changes in what he called his "immodest proposal for reform":[10]

1. Repeal of the prohibition of interest payments on demand deposits

2. Phase-out of interest rate ceilings on all deposits

3. Payment of interest on required reserve balances at the Federal Reserve at a rate equal to the return on the Federal Reserve's security portfolio in the preceding calendar quarter

4. Continued phase-in of reserve requirements under the Monetary Control Act

5. Extension of reserve requirement coverage to all transactions-type balances, regardless of issuer

6. Return to essentially contemporaneous required reserve accounting on transactions deposits, combined with a limited liberalization of the carryover privilege

Another possible reform deserves further study:

7. Establishment of a graduated marginal discount rate that depends on adjustment borrowing as a percent of the institution's lagged required reserve balance plus required clearing balance at the Federal Reserve, with elimination of administrative pressure and arbitrage restrictions but with the basic discount rate and the gradient set at the Board's discretion

In the context of the Lindsey proposal, it might be interesting to discuss (1) which of these regulatory changes have occurred and which ones remain to be done, and (2) whether any of these regulatory changes might be adopted or modified to make the current procedures more effective (in terms of adapting them more for M2 control, or making the borrowed reserves function more stable).

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10. David Lindsey, "Nonborrowed Reserves Targeting and Monetary Control", *Improving Money Stock Control*, Laurence H. Meyer (Ed), Boston: Kluwer - Nijhoff, 1983.

Prohibition of Interest on Demand Deposits
This prohibition still remains in force, affecting primarily the corporate sector since consumers have the alternative of NOW accounts for transactions purposes. Hence, corporations still must spend resources for cash management techniques even though all the other components of M2 earn market rates of interest. It is doubtful that monetary control in terms of M2 would be much improved by allowing banks to pay interest on demand deposits (since demand deposits are only a small part of M2), but it still seems more efficient economically to relax this prohibition. If the Federal Reserve was still setting M1 targets, however, it would perhaps be more important to allow interest payments on demand deposits because they comprise a larger fraction of M1.

Phase-out Interest Rate Ceilings on All Deposits
Other than for demand deposits, this proposal has been largely carried out for M2, and it seems unlikely that a new system of interest rate ceilings will be imposed on consumer deposits.

Pay Interest on Required Reserve Balances
Banks still do not earn interest or their required reserve balances at the Federal Reserve, although they do earn implicit interest, within limits, on their required clearing balances. For depositors to receive a full market rate of return on their transactions deposits, it would be necessary for the Federal Reserve to pay a market rate on reserves so that banks would not need to pass back the cost of the reserve requirement tax to depositors. With market rates on both reserves and demand deposits, the rates on transactions balances could follow market rates quite closely resulting in a demand for M1 function with a low interest rate elasticity. The word "could" is emphasized because our experience with NOW accounts suggests it would not necessarily turn out that way.

Given the way in which reserve requirements are now structured, however, it is unlikely that paying interest on reserves and demand deposits would have much of an affect on monetary control at the M2 level, or on the issue of a federal funds rate versus a reserves instrument. The remaining elements of Lindsey's proposal, however, may still have some implications, especially if we view them in terms of M2 rather than M1.

Continued Phase in of Reserve Requirements
One purpose of the Monetary Control Act was to establish uniform reserve requirements on deposits at member and nonmember banks. Clearly, this could reduce the error in the money multiplier when targeting reserves,

assuming the reserves are required to be held against a monetary aggregate (M2, most likely) that the Federal Reserve has at least some confidence in.

Extension of Reserve Requirements to All Issuers of Transactions Balances
This proposal combined with the previous one (uniform reserve requirements on the liabilities in the targeted aggregates) seems to be a key consideration at this time if we believe that it is necessary to refocus the shorter run procedures toward more automatic response in the funds rate to deviations of M2 from target. If extended to M2, time and savings deposits, money market mutual funds, money market deposit accounts, overnight RPs and Eurodollars would all become reservable, probably at some very low percentage requirement.

Contemporaneous Required Reserve Accounting
Contemporaneous reserve accounting is largely in place for transactions balances. If a case can be made to set uniform reserve requirements for the components of M2, it would probably be desirable to keep the reserve requirements contemporaneous. Paying interest on reserve balances -- when uniform, universal and contemporaneous reserve requirements are in place on the components of M2 -- would probably be desirable, as would allowing the payment of interest on demand deposits (items 1 and 3 above).

Graduated Marginal Discount Rate
Given the way the discount window (borrowed reserves) has deteriorated both as an effective safety valve for the banking system as well as a guide for monetary policy, it seems worthwhile to consider changing the discount window. Recently, however, the problem with the discount window seems to come not so much from administration pressure and arbitrage restrictions, but rather the potential funding difficulties that could be created for a bank if it is (correctly or incorrectly) identified as a troubled bank when market participants learn that the bank needed to rely on the window. In any case, for a reserves targeting approach to work for M2, it would seem necessary to re-examine the structure of the discount window in the current institutional setting as well as the reasons for Lindsey's "graduated marginal discount rate".

In sum, a large part of the regulatory reform that seemed important in the early 1980s has now been accomplished. The main problem that remains is that these institutional reforms were largely geared to M1, not M2. Relaxing the prohibition of interest payments on demand deposits still seems desirable. Payment of interest on reserves, however, would probably not be politically popular (especially if not linked to a broader restructuring of reserve requirements to improve M2 control). Restructuring reserve requirements so that they are uniform, universal, and contemporaneous on the M2 components is worth considering if the Federal Reserve was committed to allowing deviations in M2 growth to generate automatic responses in the funds rate.[11] However, given the unusually weak M2 growth in 1990-91, it is not clear that the Federal Reserve would be willing to adopt this approach (more on the weakness in M2 in the next section).[12] Reforming the discount window to make it a more effective safety valve for the banking system might be worthwhile considering quite independently of monetary control issues.

THE IMPLICATIONS OF OTHER INSTITUTIONAL CHANGES FOR OPERATING TACTICS

In this section, we look at four more recent institutional developments that may have implications for the Federal Reserve's operating tactics: (1) the definition of M2 now that consumers appear to be more willing to use close substitutes for M2, and banks use small time deposits more as managed liabilities (2) the "credit crunch" or disruption in the credit intermediation process, (3) reduced credit flows through the banking system as the industry downsizes more generally, and (4) the closing of a large number of depository institutions by the regulatory authorities.

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11. At the other extreme, perhaps it could be argued that, rather than setting uniform reserve requirements on M2, reserve requirements should be eliminated altogether. That is, the reserve balances that banks would hold voluntarily for clearing purposes would be sufficient for the Federal Reserve to implement policy. Moreover, it could be argued that the demand for these reserve balances would not be destabilized because of instability in the demand for some arbitrary concept of money containing a mixture of savings and transactions balances. Nevertheless, it would still be necessary to study carefully what the demand for reserves would depend on. Clearly, with access to daylight overdraft credit at the Federal Reserve, it is not certain that the demand for clearing balances would increase as GDP grew more rapidly because higher reserve balances would not necessarily be needed for banks to process a larger volume of payments. In addition, a large fraction of the transactions made through the reserve accounts banks hold at the Federal Reserve is related to financial transactions. This is especially true for the accounts of the large money center banks. For both these reasons, the demand for reserves probably would not have a stable relationship to GDP. In any case, a careful study of the relationship between fedwire volume and GDP would be necessary before this approach could be considered.

12. Some analysts who have been concerned about the weakness in M2 have argued that the Federal Reserve should change its operating procedures to obtain better control of M2 by (1) making all bank liabilities reservable, and (2) paying interest on reserves. For more detail, see Martin Feldstein, "Reasserting Monetary Control at the Fed," *The Wall Street Journal*, June 10, 1991, p. A10.

The Definition of M2

In the preceding sections, we took the position that for reserve targeting to work effectively, reserves must be linked to a definition of money that had a stable relationship with GDP. In this section, we briefly review the question of whether M2 could serve as this variable given the institutional changes that seem to be contributing to its unusual weakness over the past 2 to 3 years. To put the weakness in M2 in some perspective, the M2 equation developed by Moore, Porter, and Small overpredicted M2 by $200 billion or 5.9 percent by the fourth quarter of 1991 (Chart 2).[13] Alternatively, if we compare M2's growth to its average growth rate over past cycles, it is about 6.5 percent weaker than the average (Chart 3).[14]

The weakness in M2, however, has not been reflected uniformly across its components. As can be seen from Charts 4 and 5, the recent weakness in M2 can be traced to its small time deposit component. Small time deposits are currently about 27 percent below the usual cyclical pattern, while M2 less small time deposits has displayed a fairly typical cyclical pattern.[15]

This period of unusually weak growth in M2 and small time deposits appears to stem from both supply and demand considerations. On the supply side, a sharp curtailment of depository lending has occurred, what some analysts have referred to as a "credit crunch".[16] As of the fourth quarter of 1991, depository lending had fallen about 11 percent

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13. The M2 equation used in this exercise was taken from George Moore, Richard Porter and David Small, "Modeling the Disaggregated Demands for M2 and M1: The U.S. Experience in the 1980s", *Financial Sectors in Open Economies: Empirical Analysis and Policy Issues*, Board of Governors of the Federal Reserve System 1990, pp. 21-105, Table 11.

14. In these charts and the ones that follow, the averages over the past four recessions include the 1960-61, 1969-70, 1973-75, and 1981-82 recessions. The 1980 recession was excluded due to the unique circumstances associated with the 1980 credit controls, and the overlap with the data for the 1981-82 recession.

15. In real terms, the cyclical comparisons tell a slightly different story. M2's level would be about 3 percent below the pattern of past cycles as of the fourth quarter of 1991, while small time deposits would be roughly 23 percent below and M2 less small time deposits about 3.5 percent above.

16. See Ronald Johnson, "The Bank Credit Crumble", Federal Reserve Bank of New York *Quarterly Review*, Summer 1991, pp. 40-51. In the Johnson article, it is argued that the sharp curtailment in bank lending resulted primarily from a deflation in asset prices and a broad shortage of bank capital.

below the typical cyclical pattern (Chart 6).[17] This reduced lending by depository institutions has probably contributed to the weakness in M2 from the supply side because, since the phase-out of Regulation Q, banks have had more freedom to use small time deposits as managed liabilities. Thus, with curtailed lending, banks have had less need to pursue small CDs as a source of loanable funds.

At the same time on the demand side, it appears that there has also been a decline in the demand for small time deposits and, for M2 as a whole. Consumers have become more willing to switch to instruments outside M2 now that the yields on small time deposits have fallen to very low levels and a wide spread between long and short term rates has developed. Also from the demand side, the closing of thrift institutions by the Resolution Trust Corporation (RTC) may have resulted in some consumers moving funds out of thrift institutions into mutual funds and market instruments.[18]

These unusual circumstances, reducing both the supply of and demand for small time deposits and therefore the growth of M2 as a whole, raise the question of whether redefining M2 to exclude these deposits might result in a better measure of money for policy purposes.[19] In practice, however, a monetary aggregate measured as M2 less small time deposits would appear to pose significant problems for monetary targeting. Unlike M2, this aggregate does not seem to have a strong and stable long-run relationship with GDP, a desirable feature for achieving long-run policy objectives through monetary targeting (Chart 7 and Table 1).[20] Moreover, it appears to respond strongly to changes in interest rates, making it difficult to set targets in the shorter run. This conclusion can be illustrated by comparing the growth

17. In this paper, we use the terms "bank lending" and "depository lending" interchangeably to mean total lending by depository institutions, both banks and thrift institutions.

18. For more background and econometric evidence, see John Carlson and Susan Bryne, "Recent Behavior of Velocity: Alternative Measures of Money", Federal Reserve Bank of Cleveland *Economic Review*, QI-1992, pp. 2-10; and John V. Duca, "The Case of the Missing M2", Federal Reserve Bank of Dallas *Research Paper No. 9202*, March 1992.

19. A more elaborate case for removing small time deposits from M2 can be found in Brian Motley, "Should M2 be Redefined" Federal Reserve Bank of San Francisco *Economic Review*, Winter 1988. Motley also reviews the evidence on the increased use of small time deposits as managed liabilities by banks.

20. This chart was adapted from one contained in an article by Susan Black and William Gavin, "Monetary Policy and the M2 Target", Federal Reserve Bank of Cleveland *Economic Commentary*, December 1, 1989.

of M2 less small time deposits to the growth of M1 during the 1980s. Except for a brief period in the early 1980s when the introduction of MMDAs attracted a large amount of money into M2 less small time deposits, the growth rates of M1 and M2 less small time deposits have moved together quite closely since the phase-out of Regulation Q began (Chart 8). The growth rates have also been of about the same order of magnitude, including the 1985-87 period when the FOMC decided to stop setting targets for M1 because of its unusually rapid growth as interest rates fell in response to lower rates of inflation.[21] Hence, it is not clear that M2 less small time deposits would have worked any better for policy purposes than M1 during the 1980s, and these longer-run similarities between the growth rates of M1 and M2 less small time deposits make it difficult to create a strong case to redefine M2 to exclude small time deposits based on the unusual weakness in M2 over this most recent business cycle.[22]

In sum, it appears that the recent instability in the demand for M2 would argue against using it as a variable that would contribute to automatic pressure on the funds rate in the short run. At the same time, however, M2 still appears to have some desirable long-run properties that could be useful for policy purposes and it is therefore difficult to argue for an alternative M2 definition.

The Recent Credit Crunch

Monetary policy was complicated in recent years not only by questions concerning the interpretation of money but also by an institutional change of another type -- a disruption in the bank credit extension process, often referred to as a credit crunch. In the second part of this section, we will review at a rather abstract level the implications of credit crunches for the Federal Reserve's operating tactics.

Analytic Framework. A convenient analytic framework for analyzing the implications of credit crunches for the Federal Reserve's operating tactics is the extended IS-LM model of Bernanke and Blinder (1988), (B-

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21. Econometric evidence that the demand for M2 less small time deposits probably has a large enough interest rate elasticity to cause problems for monetary targeting was also found in Brian Motley, "Should M2 be Redefined?"

22. For a more detailed analysis of the institutional changes affecting M2 growth in recent years, see John Wenninger and John Partlan, "Small Time Deposits and the Recent Weakness in M2", Federal Reserve Bank of New York *Quarterly Review*, Spring 1992. The above discussion was largely based on the more detailed analysis contained in this article.

B), which distinguishes between bank loans (intermediated credit) and bonds (auction market credit).[23] The two types of credit are not perfect substitutes in the model, thereby allowing credit crunches to have a role. Furthermore, there is sufficient detail in this model to analyze the differences in operating characteristics between using the interest rate or reserves as the instrument variable in a setting with explicit credit market shocks. We will first briefly review the structure of the model and then turn to the implications of the credit crunch for monetary policy operations.

In the B-B model, the nonbank public holds (non-interest paying) bank deposits, (D), and bonds, (B), in its portfolio of financial assets with bank loans serving as liabilities. Money demand is assumed be an increasing function of income (y), and a decreasing function of the interest rate on bonds (i): $D(y,i)$. The demand for bank loans is increasing in income and the bond rate while being a decreasing function of the lending rate (r): $L(r,i,y)$.

Banks hold reserves, bonds, and loans as assets while issuing deposits. Required reserves are determined by the reserve ratio, τ, while the share of excess reserves, ER, and loans, L^S, are determined by relative rates of return: $ER = \varepsilon(i)D(1-\tau)$, $\varepsilon_i<0$, $L^S = \lambda(r,i)D(1-\tau)$, $\lambda_r>0$, $\lambda_i<0$. Using the identity that total reserves, R, equal required reserves, τD, plus excess reserves, $\varepsilon(i)D(1-\tau)$, deposits can be solved as a function of the level of reserves, R, and a multiplier: $D = [\tau+\varepsilon(i)(i-\tau)]^{-1} R$ or $D = m(i)R$, $m_i>0$.[24] Income, (Y), is assumed to be a decreasing function of both the loan rate, r, and the bond rate, i. The price level is assumed to be exogenous in this exercise.

Appealing to Walras' Law to eliminate the bond market, market equilibrium can be characterized by equilibrium in the remaining three markets:

23. Ben Bernanke and Alan Blinder, "Credit, Money, and Aggregate Demand," *American Economic Review*, May 1988, p. 435-39. For more background on the recent credit crunch, see Ronald Johnson, "The Bank Credit Crumble," Federal Reserve Bank of New York *Quarterly Review*, Summer 1991, p. 40-51; and Ben Bernanke and Cara Lown, "The Credit Crunch," *Brookings Papers on Economic Activity*, 2:1991, p.205-27.

24. In order to distinguish bank loans from bonds for banks as well as the nonbank public, the loan rate is assumed not to affect their respective demand functions. This way, the usual properties of the LM curve are preserved while allowing bank loans to be imperfect substitutes for bonds.

Money Market: $D(i,y) + e_D = m(i)R$
Loan Market: $L(r,i,y) + e_{LD} = \lambda(r,i)D(1-\tau)) + e_{LS}$
Goods Market: $Y = Y(r,i) + e_Y$

The terms e_i, i=D, LD, LS, and Y denote exogenous shift parameters for money demand, loan demand, loan supply, and output respectively. In this setting, monetary policy can be conducted by targeting a path for reserves, R, or the bond rate, i. For the three equilibrium conditions, there are three endogenous variables: the loan rate, r, income, Y, and either the level of reserves, R, or the bond rate, i. Table 2 shows the comparative- statics results for this model under the alternative assumptions of the Federal Reserve using the interest rate or reserves as its instrument variable.[25]

Theoretical Effects of a Credit Crunch. At a theoretical level, a credit crunch could shift the "IS curve" (C-C curve in the B-B paper) to the left along a fixed LM curve for three different reasons: (1) a tightening of lending standards by banks; (2) an increased demand for bank credit by borrowers who are resorting to taking down their lines of credit because of reduced access to the bond market resulting from concerns over credit quality; and (3) a general decreased demand for credit due to the wealth effects from a sharp fall in asset (collateral) values which would shift the goods market equation. In the context of this simple model, the consequences of these three sources of credit market shocks are shown in the second, third, and fourth rows of the top and bottom panels in Table 2. All three types of credit crunch shocks reduce output (Chart 9), and under reserve targeting also result in a lower bond rate (Chart 9, panel 1). As is well known, however, the impact on output will be greater when the Federal Reserve operates by setting the interest rate because the Federal Reserve will lower the supply of reserves to stabilize the interest rate, (Chart 9, panel 2), thereby shifting the LM curve to the left (and the C-C curve further to the left in the B-B model). Hence, when credit crunches are a problem, output would be more stable if the Federal Reserve used reserves rather than the interest rate as its instrument variable, all other things equal.

Looking next at the indicator value of the money and credit market variables (loans and the loan rate), money gives the correct

25. Bernanke and Blinder (1988) assume R to be exogenous when reporting their set of comparative statics results. The lower panel of table 2 reproduces their results with the addition of the loan rate response in column 1.

signal about the reduction in output stemming from a credit crunch regardless of the type of credit crunch shock or whether the Federal Reserve is using the interest rate or reserves as its instrument variable. Likewise, the credit market variables -- loans and the loan rate -- give the same signals whether the Federal Reserve uses reserves or the interest rate as its operating variable. However, the signals differ depending on the nature of the credit crunch shock. A reduction in loan supply would produce higher loan rates and a lower level of loans, an increase in loan demand would also produce higher loan rates but a higher level of loans, and a reduction in asset (collateral) values (wealth) would result in both lower loan rates and a lower level of loans. These varied outcomes (or varied ways in which credit crunches could develop) make it difficult to detect a credit crunch by looking for an unique set of signals from the behavior of bank loans and the bank lending rate, although the appropriate policy response for stabilizing output may be much the same in all three cases.

In addition, in the B-B model when the Federal Reserve is using the interest rate as its instrument variable, it is also possible to mistake a reduction in money demand with a reduction in loan supply (rows 1 and 2 in the top panel of Table 2). In both cases, the shocks affect the endogenous variables in the same directions. Chart 9, panel 3 illustrates why this occurs. It shows the initial effect of a decrease in money demand is for the LM curve to shift right to LM' and the economy moves from point A to point B. In order to maintain the initial bond rate, the Federal Reserve reduces reserves and the LM curve begins to shift back to the left. However, the reduction in reserves also results in a decreased supply of bank loans and therefore shifts the IS curve down to IS' (recall that in the B-B model both the IS (C-C) and LM functions shift when reserves change). To restore the original bond rate, the LM curve must shift to LM" (beyond the original equilibrium) and the final equilibrium is at point C, a lower level of income than initially (at point A). This similarity between money demand and loan supply shifts could be quite important for monetary policy tactics, especially in a period like the most recent episode when both credit crunches and downward money demand shifts apparently took place. That is, the reduction in economic activity resulting from the credit crunch could be amplified by the Federal Reserve attempting to stabilize the interest rate in response to a reduction in money demand.

Clearly, the results outlined above are highly theoretical and depend entirely on the model chosen. Nonetheless, the results do point out the possibility of policy problems when the interest rate is the instrument variable during credit crunches or when credit crunches and downward shifts in money demand occur simultaneously and tend to reinforce one another. Under these circumstances, maintaining the supply of reserves could well be the superior strategy.

Reduced Credit Flows

The importance of money in the policy process is based in part on the role played by financial intermediaries (primarily commercial banks but also thrift institutions) in gathering and consolidating deposits and making loans. Financial intermediaries offer depositors a safe place to keep their money balances and provide transactions services. In turn, banks lend money to a broad range of customers, some of which would not have direct access to the money markets. During the 1980s, however, there were three major institutional developments that have contributed to change in the intermediation process (securitization and asset sales, off balance sheet activities, and insurance companies, mutual funds and other institutions engaging in bank-like activities). These developments, especially if they continue or accelerate, could have implications for the interpretation of the monetary aggregates because relatively less credit appears to be reflected directly on the books of depository institutions.[26] At the extreme, some analysts are already asking the following question:[27]

> It does not take a visionary to imagine a world without banking. As this survey has shown, nonbanks are doing more banking and banks are doing less. If the trend continues (never, admittedly, a safe assumption), banks will not disappear, though traditional banking will wither. What would take its place?

Our analysis will not attempt to answer this question, but rather the more limited question of what the implications of this institutional change might be for the Federal Reserve's operating tactics. Chart 10 shows the sharp increases in total debt outstanding relative to M2 and

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26. Clearly, we are taking a credit or financial intermediation view of the monetary policy transmission mechanism in which money growth is an indicator of the ability of banks to make loans and therefore the ability of firms and others to make debt-financed expenditures. There are also interest rate channels in which changes in the money stock cause interest rates to change as portfolios are adjusted to accommodate the availability of money. The changes in interest rates, in turn, affect interest-sensitive components of spending. For more detailed discussion, see Ben Bernanke and Alan Blinder, "The Federal Funds Rate and the Channels of Monetary Transmission," *NBER Working Paper 3487*, 1990; and Mark Gertler, R. Glenn Hubbard and Anil Kashyap, "Interest Rate Spreads, Credit Constraints and Investment Fluctuations: An Empirical Investigation", *NBER Working Paper 3495*, 1990.

27. Brooke Unger, "World Banking Survey," *The Economist*, vol. 323, no. 7757, May 2, 1992, p. 49.

depository credit since the early 1980s. Both ratios, after declining through much of the 1970s, have reached the highest levels over the period shown in Chart 10 (since 1959). Moreover, Chart 11 suggests that the recent slowdown in depository lending is being reflected at least to some extent in M2, as discussed earlier. It appears, therefore, that more credit is being extended outside the banking system with possible implications for the interpretation of M2.[28]

A very simple textbook model can be used to illustrate the potential problems for the choice of operating procedures that could be created by more credit extension taking place outside the banking system. It will be shown that the effects on money and credit could depend on whether the Federal Reserve is targeting reserves or interest rates in the short-run as the process occurs. In the longer run, it is unclear what the overall effects will be for economic activity because the Federal Reserve could adjust its long-run targets for money and credit in light of these developments. Nonetheless, exploring the short-run effects gives some flavor of the potential problems that could be created for interpreting the monetary aggregates.

The easiest case to understand is the one in which the banking system sells assets to deposit holders.[29] Assume that the banking system has the highly simplified balance sheet shown below and that the required reserve ratio on deposits is ten percent.

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28. The increased credit flows outside the banking system resulted from a complex set of forces including problems in the banking system that forced banks to conserve capital and generate greater fee income. In addition, some bank customers have obtained better credit ratings than the banks, creating incentives to tap the money markets directly. Finally, the creation of junk bonds allowed some less highly rated firms to enter the debt markets directly. For a detailed discussion of the profound changes in the financial and banking system, see Thomas D. Simpson, "Developments in the U.S. Financial System," *Federal Reserve Bulletin*, January 1988, pp. 1-13, and M.A. Akhtar and Betsy Buttrill White, "The U.S. Financial System: A Status Report and a Structural Perspective", C. Imbriani, P. Roberti, A. Torrisi (editors), *Il Mercato Unico Del 1992: Deregolamentazione E Posizionamento Strategico Dell' Industria Bancaria in Europa*, Bancaria Editrice S.p.A., Rome 1991, pp. 515-42.

29. If the asset sales are to other banks, deposits and assets are redistributed within the banking system and there would be no effects at the aggregate level for credit and money. Likewise, if the result is simply a swapping of one type of asset for another (for example investors hold more bank loans by reducing their level of securities which in turn are held by banks), there would be no effect on money and bank credit. This process becomes important only when the asset sales result in a substitution between reservable deposits and bank loans in investors' portfolios and when bank credit is extinguished at least in the short run.

Figure 1.

Assets		Liabilities
Required Reserves	= 10	Deposits = 100
Loans	= 50	
Securities	= 40	

If the banking system sells 50 of loans to bank depositors, its balance sheet immediately after the sale will appear as below.

Figure 2.

Assets		Liabilities
Required Reserves	= 5	Deposits = 50
Excess Reserves	= 5	
Loans	= 0	
Securities	= 40	

Initially there would be downward pressure on the funds rate as the banks attempt to sell the excess reserves. If the Federal Reserve is targeting the federal funds rate, it would sell government securities to stabilize the federal funds rate, which would absorb the excess reserves. The balance sheet of the banking system would appear as shown below.

Figure 3.

Assets		Liabilities
Required Reserves	= 5	Deposits = 50
Loans	= 0	
Securities	= 45	

In this case, the overall size of the banking system has been reduced. Total loans outstanding remain at 50, but the loans are now held outside the banking system (by former depositors). If, in the longer run, the Federal Reserve is concerned about the lower level of deposits or loans held by banks, it will move to an easier policy. If, on the other hand, the Federal Reserve focuses on total loans as an indicator of credit availability in the economy, it would not necessarily ease policy.

Alternatively, if the Federal Reserve had been controlling the level of reserves in the short run rather than the federal funds rate, the outcome would be different. In this case, the Federal Reserve would not absorb the excess reserves and the funds rate would fall. Banks would begin to make additional loans, and with a reserve ratio of ten percent, the balance sheet of the banking system could return to its original position (Figure 1). With excess reserves of 5 and a reserve ratio of ten percent, loans and deposits could expand by 50 until all the excess reserves were absorbed.

In this case, in contrast to the first case, the level of deposits and bank loans outstanding would not be affected in the longer run. However, the total volume of loans, those held by banks plus those now held directly by former depositors, would be 100. Here again, the policy implications depend upon what is viewed as the important variable, the level of deposits and bank loans, which are unchanged, or total loans outstanding (which have doubled in size in this example).

Once the example of the loan sales is understood, the effects of back-up credit lines for commercial paper and increased intermediation by nonbank firms are quite obvious in the context of this simple model. Again using Figure 1 as a starting point, assume that the banking system provides back-up lines of credit for 50 in commercial paper for existing loan customers. These firms, in turn, issue commercial paper which is purchased by bank depositors and the proceeds are used to pay off bank loans. Immediately after the transactions take place, the banking system would be in the same position as in Figure 2. Here again, the impacts on money and credit would depend on whether the Federal Reserve was targeting reserves or the funds rate in the short run, and the longer run policy implications would depend on whether bank loans and deposits are important or the level of total loans outstanding.

Likewise, if a mutual fund or insurance company can attract deposits away from the banking system and end up in effect holding the assets and deposits the banking system would otherwise have held, the implications for total loans, deposits, and bank loans are the same as in the above examples. That is, the effects are the same as the sale of bank loans to deposit holders except that the mutual fund or the insurance company in a sense intermediates the process.[30]

The banking system, the loan sale process, the guarantees of private credit by banks, and new forms of intermediation are all much

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30. In addition to contributing to the growth of credit extension outside the banking system, guaranteed investment contracts (GICs) offered by insurance companies and mutual funds (bonds, equity and others) provide large and small dollar substitutes for time deposits at banks and thrifts. Just as the savings and transactions features of money market mutual funds led to the judgement that these funds should be included in M2 because they were close substitutes for the liquid components of M2, it may become necessary to consider at some point whether these other deposit like instruments should be included as well because they are close substitutes for time deposits. Indeed, one of the reasons often cited for the development of GICs by insurance companies was the elimination of Regulation Q ceilings on bank and thrift deposits which caused life insurance policies to lose their competitive advantage in attracting savings.

more complex than outlined in the above model.[31] The only point we were trying to make, however, is that when credit flows to a significantly larger extent outside the banking system, there is the potential for the relationship between money and total credit to change in ways that depend in part on the Federal Reserve's operating procedures in the short and longer run.

Because M2 contains small time deposits, which banks appear to use as a managed liability, it is difficult to argue that this broad monetary aggregate would not be affected by changes in credit flows through the banking system, as might be argued for M1 as a measure of transactions balances.[32] Under these circumstances, the level or growth rate of M2 may not be a reliable policy indicator, especially if viewed in isolation. However, it is also not clear that any simple definitional changes for M2 would help the policy process, given how complex the financial system has become. Rather, it would appear important for monetary policy to monitor additional indicators of financial developments.

Finally, the reduced importance of bank lending can also be analyzed in terms of the Bernanke-Blinder model used earlier to explore the implications of credit crunches. If firms begin to use commercial paper and junk bonds to a larger extent than in the past, a reduction in the demand for bank credit would occur. As a result, the IS curve would shift to the right, causing output and the interest rate to increase. To stabilize output, it appears that the appropriate policy response would be to lower the money stock (adjust the monetary target downward), while allowing for the consideration that the IS curve (C-C curve) will also shift to the left as reserves are lowered.

Closing of Weak Institutions

In recent years, many weak depository institutions have been closed by the regulatory authorities. In this section, we review the implications, if any, of this institutional change for the Federal Reserve's operating procedures.

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31. For example, banks are likely to adjust the liabilities side of their balance sheet by reducing nonreservable managed liabilities. In which case, there would be no short-run affects in the market for reserves and the policy response would only be in terms of the longer run targets for money and credit.

32. For a review of the evidence that banks use small time deposits as managed liabilities, see Brian Motley, "Should M2 be Redefined?", Federal Reserve Bank of San Francisco, *Economic Review*, Winter 1988, pp. 33-51.

Some analysts have noted that bank closings have the potential for reducing the money supply because these closings could have the same reserve impact as an open market sale of government securities, that is, a move to a more restrictive monetary policy.[33] This occurs because the Federal Reserve, when targeting the federal funds rate, absorbs the excess reserves that accompany the deposit transfer (otherwise the acquiring bank would put downward pressure on the funds rate as it sells the reserves in the market). However, we will attempt to show that in some cases there would be no impact on money and in other cases the impact does not seem to be of substantial economic significance.

Table 3 contains a numerical example. The first section shows the initial conditions in the banking system. The banking system is divided into three groups: the failing bank, the acquiring bank, and all other banks. In addition, the Federal Reserve's balance sheet is shown. All the balance sheets "balance" except for the failing bank. Its assets and reserves are worth 50 less than its deposits.[34] The money supply, or the sum of deposits at all the banks, is 1300, and reserves are equal to 25 percent of deposits and amount to 325 (far right column).

Next, the regulatory authority (called RTC in the Table) sells 50 in debt to resolve the failing bank (2A in the Table). The debt is sold to the depositors of the "all other" banks. Deposits and reserves each fall by 50 and the Treasury's balance at the Federal Reserve increases by 50 and total reserves fall by 50. An increase in the Treasury's balance, however, would be treated by the open market desk as a factor absorbing reserves, whether it was targeting the funds rate or reserves, and the desk would purchase 50 in government securities to offset the reserve drain resulting from this flow into the Treasury's account (2B in Table). As a result, the deposits and reserves of the "all other" banks would be increased to their original levels. The former holders of the securities that were sold to the Federal Reserve would deposit the proceeds into their bank accounts. Hence, the money supply remains at 1300 and reserves at 325 after: (1) the RTC completes its debt sale to resolve the failed institution and (2) the Federal Reserve performs its "defensive open market operations".

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33. Paul Kasriel, "How the Fed Subverts Its Rate Cuts", *Wall Street Journal*, December 23, 1991.

34. It is perhaps easiest to view this shortfall of 50 as being "bad assets" of unknown value that the government will need to acquire and "workout" somehow.

Next, the RTC proceeds to close the failed bank. It transfers the assets, reserves and deposits of the failed bank to the acquiring bank and gives the acquiring bank 50 in cash to complete the transfer (3A in Table). As a result, the banking system has 50 in excess reserves and total reserves of 375 (50 above the initial conditions). The open market desk would view the 50 reduction in the Treasury's balance as a factor supplying additional reserves (and thereby potentially lowering the funds rate) and would sell 50 in securities to offset the reserve impact (3B in Table). Again, when the RTC transaction and the "defensive open market operation" are completed, the money stock remains at 1300 and reserves at 325. Hence, it would not appear that the closing of a large number of thrift institutions would necessarily have an impact on the money stock that depends on the Federal Reserve's operating procedures. Indeed, it is likely to have no impact on the money supply or on reserves in this context. The end result appears to be that the private sector has 50 more in government securities, 50 less in "bad assets" and the same level of money balances; while the RTC has 50 in "bad assets" funded by government securities.

The critical assumption in making this work is that the Open Market Desk correctly interprets the increases and decreases in the Treasury's balance at the Federal Reserve as absorbing and supplying reserves as the transactions take place and then offsets the impacts on reserves with open market operations. Of course, the other way the Desk could handle this would be to maintain the Treasury balance at the Federal Reserve at a given level as the transactions take place. Under this approach, the money never leaves the banking system but rather shifts from private deposits in M2 to government deposits outside of M2 and finally into excess reserves. In which case, it is possible to work out an example where M2 could be reduced if the Federal Reserve absorbs the excess reserves that accompany the deposit transfer before the acquiring bank can invest the money in Treasury securities purchased from the public. But even in this case, the banking system as a whole can still fund the same level of good assets, while the Treasury ends up funding the bad assets, and the nonbank public has Treasury securities instead of government-insured time deposits.

Conclusions

If, at some point, the Federal Reserve desires to have operating procedures with a more automatic response of policy to changes in economic conditions, it will be necessary to restructure the procedures in light of important institutional changes that have occurred. The demand for reserves needs to be related to a monetary aggregate (or some other concept) that gives accurate feedback information on the performance of the economy. Until recently, M2 might have been a good candidate, but instability in the demand for M2 in 1990-1991 raises some doubts about M2. If the problems with M2 prove not to be just transitory, this process may involve finding alternative definitions of money with stable demand functions and perhaps relatively low interest rate elasticities. If such an aggregate cannot be found, perhaps the operating procedures should be reviewed to see what changes could be made to make the Desk most effective in attaining the desired level of the funds rate (for example, return to lagged reserve accounting). Over the longer run, the tactics of monetary policy may be affected by the reduced importance of the banking system in providing credit to the economy and shifts in the willingness of depository institutions to lend. However, it does not appear that the closing of weak depository institutions would have important economic implications that depend on the Federal Reserve's operating procedures.

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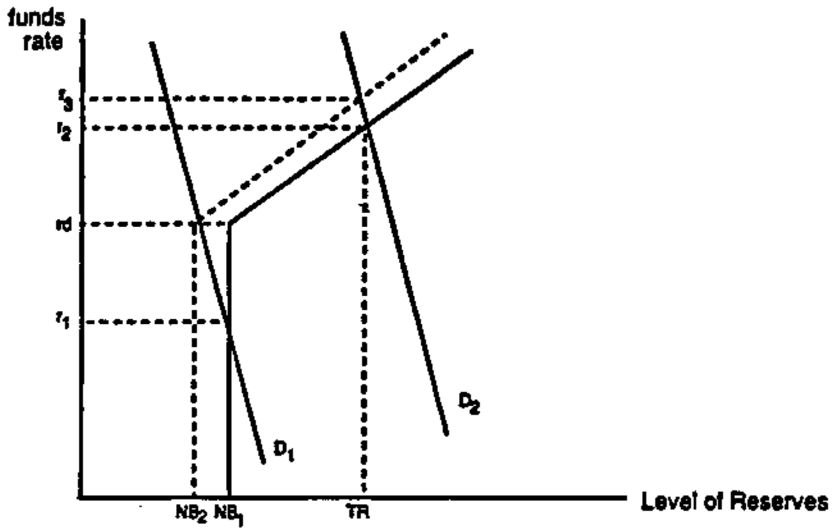
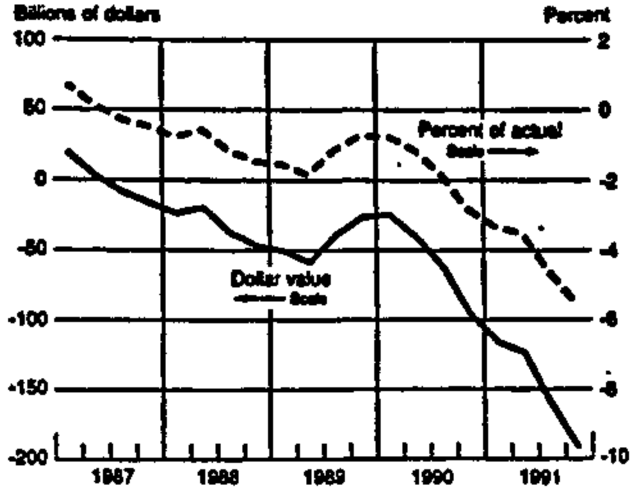
1. Operating Procedures with a Nonborrowed Reserves Target



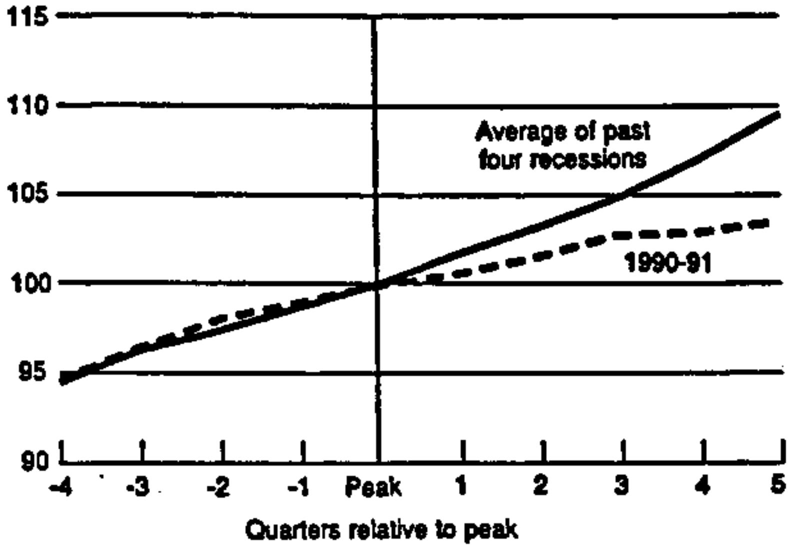
D_1, D_2 = demand for reserves
r_1, r_2, r_3 = levels of funds rate
rd = discount rate
$NB_1 \cdot NB_2$ = levels of nonborrowed reserves supplied
TR = total reserves, TR-NB = borrowed reserves

2. Cumulative Errors from M2 Demand Equation

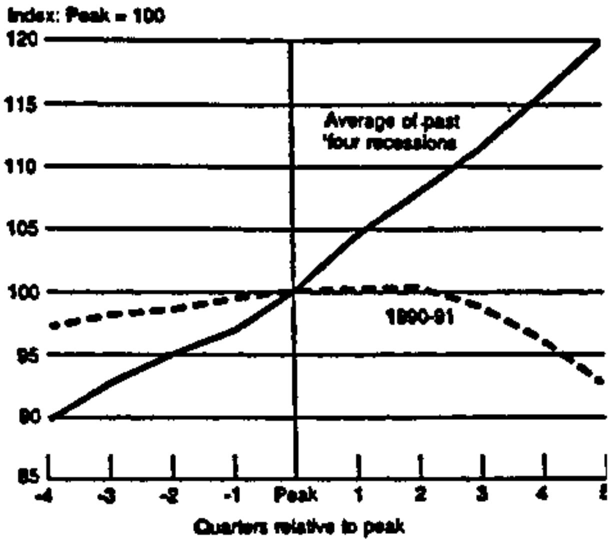


3. M2

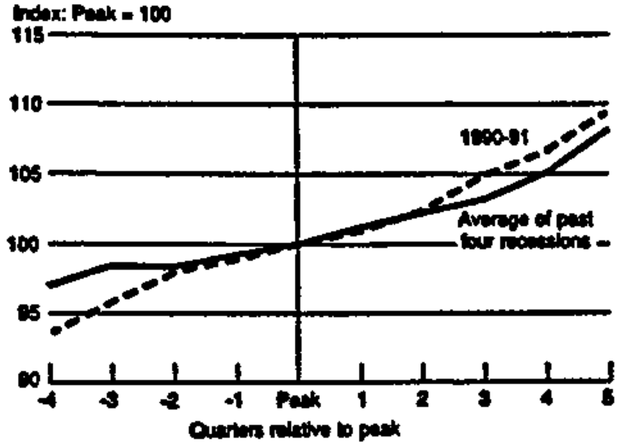
Index: Peak = 100



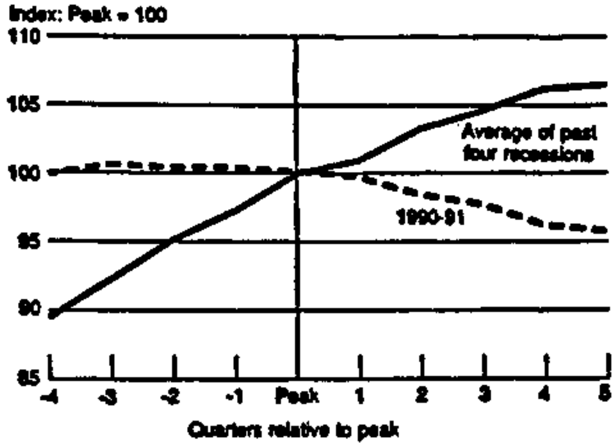
4. Small Time Deposits



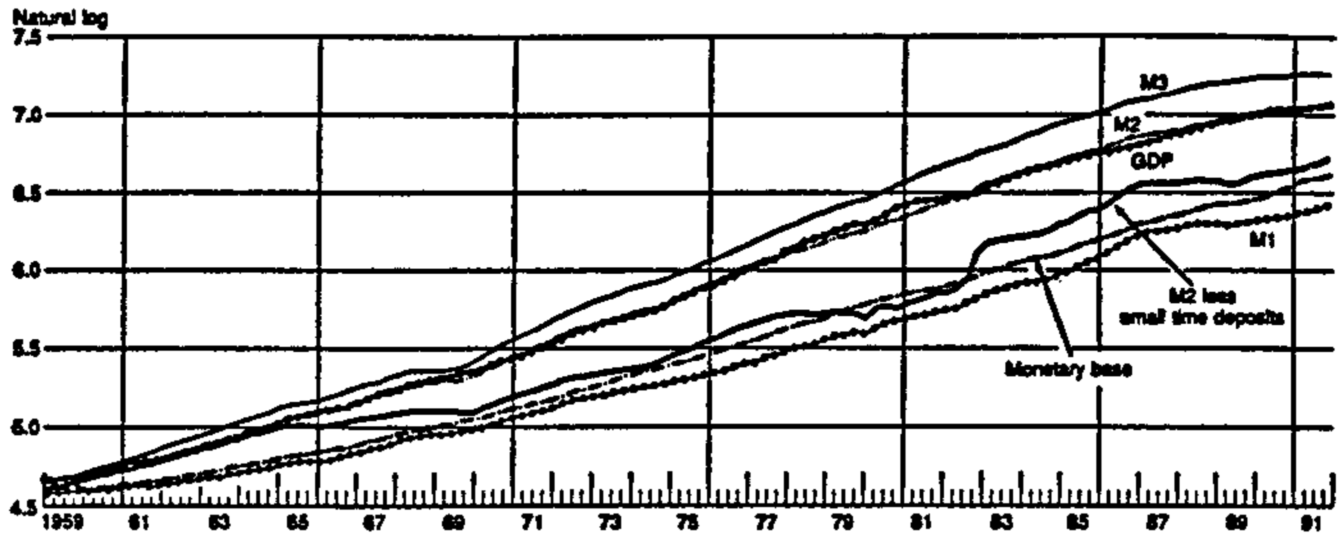
5. M2 less Small Time Deposits



6. Depository Lending



7. Nominal GDP and the Monetary Aggregates



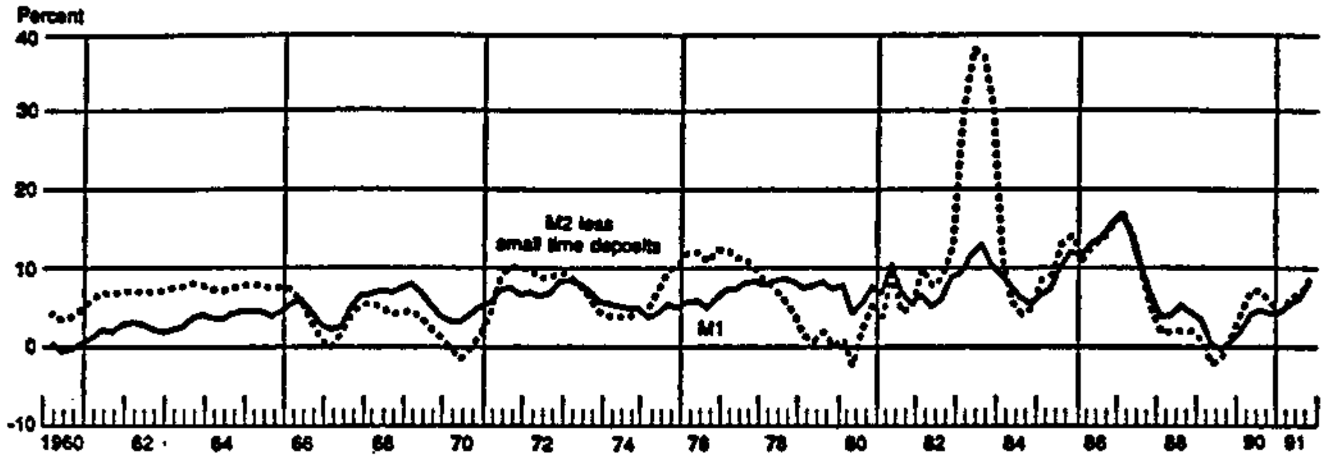
Note: The various monetary aggregates and GDP are normalized to 100 in the first quarter of 1959.

1. GDP Growth Less Money Growth
(Change from Four Quarters Earlier)

	Monetary Base	M1	M2 Less Small Time Deposits	M2	M3
Averages					
1960 to 1991	1.5	2.1	1.1	0.0	-0.7
1960 to 1975	2.5	3.1	2.1	-0.2	-1.2
1976 to 1991	0.5	1.1	0.0	0.1	-0.2
Standard Deviations					
1960 to 1991	3.0	3.7	6.8	2.8	2.8
1960 to 1975	1.8	1.6	3.1	2.4	2.8
1976 to 1991	3.6	4.7	9.0	3.2	2.7

8. Growth of M1 and of M2 less Small Time Deposits

Change from Four Quarters Earlier

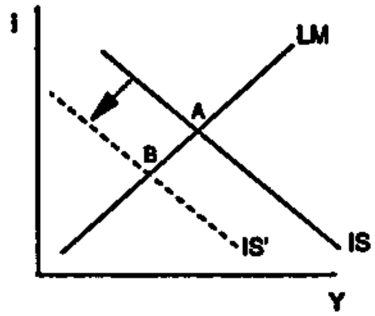


2. Effects of Exogenous Shocks on Money, Credit, and Activity

Interest rate (i) Targeting					
Effects on: Exogenous shocks:	Loan rate r	Income Y	Reserves R	Money D	Credit L
Decreased Money Demand (e_D falls)	+	−	−	−	−
Decreased Loan Supply (e_{LS} falls)	+	−	−	−	−
Increased Loan Demand (e_{LD} rises)	+	−	−	−	+
Decreased Goods Demand (e_Y falls)	−	−	−	−	−
Decreased Bond rate (i falls)	−	+	+	+	+
Reserve (R) Targeting					
Effects on: Exogenous shocks:	Loan rate r	Income Y	Bond rate i	Money D	Credit L
Decreased Money Demand (e_D falls)	−	+	−	−	+
Decreased Loan Supply (e_{LS} falls)	+	−	−	−	−
Increased Loan Demand (e_{LD} rises)	+	−	−	−	+
Decreased Goods Demand (e_Y falls)	−	−	−	−	−
Increased Reserves (R)	−	+	−	+	+

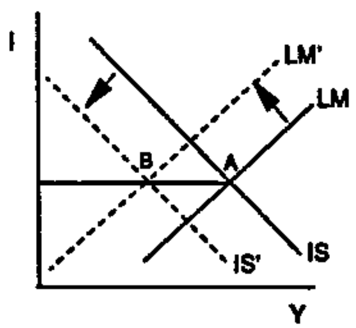
9. Credit Crunches and Reduction in Money Demand in the Bernanke-Blinder Model

Reserve Targeting

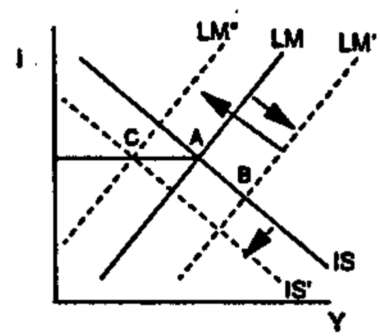


Drop in loan supply, increase in loan demand, or drop in aggregate demand.
Panel 1

Bond Rate Targeting

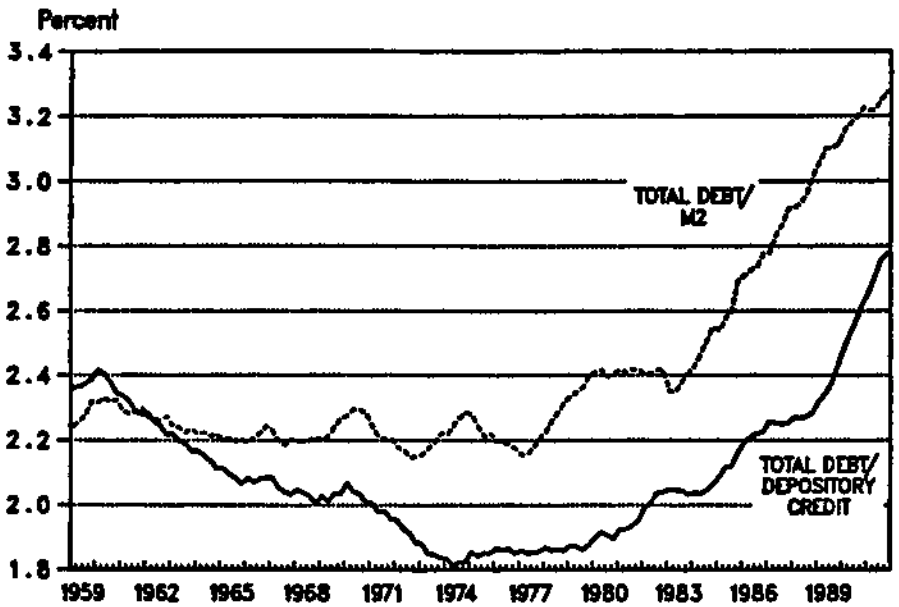


Drop in loan supply or increase in loan demand
Panel 2

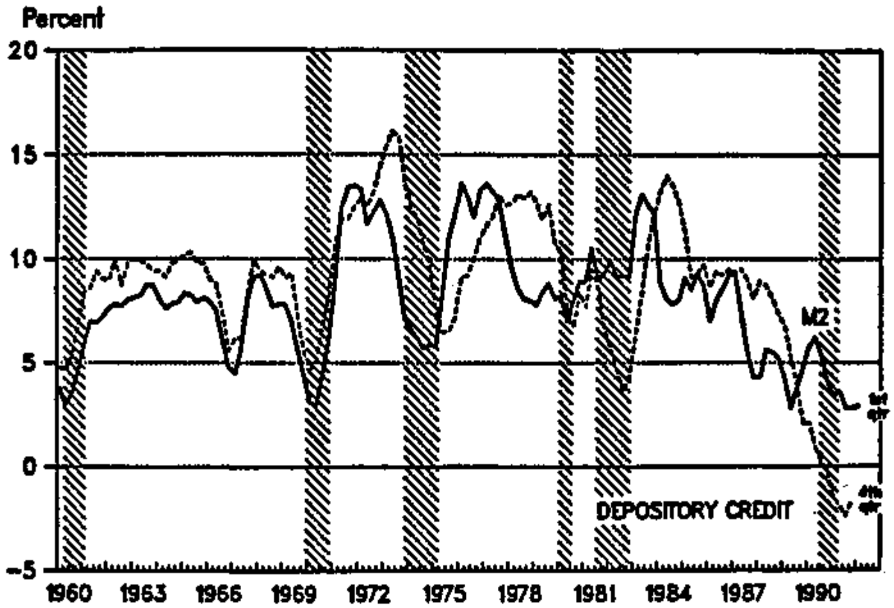


Drop in money demand
Panel 3

10. Ratio of Total Debt to Depository Credit and Ratio of Total Debt to M2



11. Growth of M2 and Depository Credit*
Change from Four Quarters Earlier



* Total loans and investments of banks and all thrift institutions.

3. Reserve Impacts of Bank Closing

	All Other Banks		Failing Bank		Acquiring Bank		Federal Reserve		D	R
(1) Initial Conditions	D=1000	A=750 R=250	D=100	A=25 R=25	D=200	A=150 R= 50	T=0 R=325	A=325	1300	325
(2A) RTC sells debt of 50	D=950	A=750 R=200					T=50 R=275	A=325		
(2B) Fed offsets reserve impact of increase in T (buys securities)	D=1000	A=750 R=250					T=50 R=325	A=375	1300	325
(3A) RTC Closes Failing Bank			D=0	A=0 R=0	D=300	A=175 R=75+ 50	T=0 R=375	A=375		
(3B) Fed Offsets reserve impact of lower T (sells securities)					D=300	A=225 R=75	T=0 R=325	A=325	1300	325

D = deposits
A = assets
R = reserves = .25 deposits
T = Treasury balance at Federal Reserve

COMMENTS ON
"FEDERAL RESERVE OPERATING PROCEDURES AND INSTITUTIONAL CHANGE"
by
Daniel L. Thornton

The paper by John Wenninger and William Lee (1992) on the effects of financial innovation and institutional change on the Federal Reserve's operating procedure is very good. There is much more in the paper that I agree with than I disagree with. Nevertheless, since the role of a discussant is to take a somewhat contrary position, I will focus my comments on areas of disagreement. I will start with some nit-picking and finish with a couple of substantive issues.

The authors assert that borrowing is less predictable since depository institutions have become more reluctant to use the discount window. This seems unlikely to me. Since around mid-1986, borrowings have been relatively small, much less interest-sensitive and relatively stable. While, like Wenninger and Lee, I offer no evidence to support my assertion, it seems likely that these changes have made borrowing more rather than less predictable. True, the marked decline in its interest sensitivity has reduced significantly the ability of traditional models that rely on the spread between the federal funds rate and the discount rate in forecasting the level of borrowing. But this does not imply that *ipso facto* borrowing is less predictable. The fact that borrowing has been relatively stable suggests to me that it may be more predictable as well. This seems even more likely because, as Wenninger and Lee concede, the traditional borrowing function was unstable.[1]

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1. See Thornton (1988) for an example of this instability.

They also argue that, for a "reserve targeting approach to work for M2, it would seem necessary to re-examine the structure of the discount window..." Historically, the discount window has been viewed either as a safety valve for monetary policy or an impediment to monetary control, depending on one's point of view. Both views stemmed from the interest sensitivity of borrowing. Currently, borrowing's low level, relative stability and lack of interest sensitivity lessens its ability to serve in either capacity. I always believed that the importance of borrowing in monetary policy was exaggerated. Variation in borrowing may contribute to "high frequency" variation in M2 under a reserves targeting approach; however, it is unlikely to contribute much to "low frequency" variation. Hence, borrowing should not make it substantially more difficult to hit an M2 target at the frequency that should be of interest to policy makers. I argued in the early 1980s [Thornton (1982)] that issues like monetary base targeting, returning to contemporaneous reserve accounting and removing the interest sensitivity of borrowing by tying the discount rate to market interest rates, were relatively unimportant in the then-great controversy over M1 control. What really mattered was the resolve to seriously target the M1 aggregate. Alton Gilbert (1981) used then-confidential data to show that errors in hitting money targets often reflected the choices of policy makers, not problems with the operating procedure. The problem was the lack of commitment, not the interest sensitivity of borrowing, lagged reserve accounting or the non-borrowed reserves operating procedure. Gilbert must be gratified that his view is now the conventional wisdom.

I was also concerned by the apparent implication in the paper that, in order to effectively control M2 using a reserves targeting approach, reserve requirements must be extended to all of the non-transaction components of M2. Such a recommendation is both undesirable and unnecessary.

It is undesirable because extending reserve requirements to non-depository institutions would introduce inefficiency into a market where it does not already exist. It would also raise the question of whether federal deposit insurance should be extended to such institutions and whether they should have access to the discount window. None of these outcomes seems desirable.

It is unnecessary because the monetary control gains from extending reserves requirements to these institutions likely will be small. Including in M2 a non-reservable component would undoubtedly increase the high frequency control error. This would not be a serious problem, however, because such deposits account for only about 10 percent of M2 and because they should be relatively easy to predict. Consequently, not extending reserve requirements to these deposits should not impair significantly the Fed's ability to control M2 over policy-relevant time horizons. Moreover, short-run M2 control itself is undesirable because it is inconsistent with the historical behavior of M2 velocity.

While the above issues are interesting and fun to debate, I consider them unimportant compared with the policy issues to which I now turn. Wenninger and Lee suggest that the "credit crunch" or reduced credit flows through depository institutions may have repercussions for the Fed's operating procedure. While I endorse their conclusion that if the Fed is concerned with credit flows, it should target a monetary or reserve aggregate rather than interest rates, I disagree with the assumptions implicit in their analysis. Tightening credit standards by depository institutions would likely have real effects. But I fail to see the implications of such actions for monetary policy. The Fed's role in the credit market is independent of bank lending standards. Depository institutions do not create credit, they merely allocate it. They take the savings of one economic emity and lend it to another. Nominal credit is created by open market purchases or, in a much smaller quantity, by extending credit at the discount window and accommodating a larger "float." Policy actions have the same effect on the supply of credit whether depository institutions make loans to individuals and businesses or simply buy government securities. The effect of monetary policy on the supply of credit, and hence interest rates, is independent of lending standards of depository institutions.

If depository institutions and, hence, the Fed are to play a more significant role in the credit market, depository institution leading must be somehow unique. Wenninger and Lee assume this uniqueness by invoking the Brenanke and Blinder (1988) assumption that depository institution loans and bonds are not perfect substitutes, as would be the case if individuals who cannot obtain credit from depository institutions simply cannot obtain credit. According to this view, a restrictive monetary policy not only prices debtors out of the market by rising interest rates, but it truncates the demand for a significant segment of the credit market. This argument, however, is less valid today than ever before. In a modern banking system, depository institutions accommodate increases in loan demand by issuing time and savings deposit liabilities. Since these deposits are no longer reservable, such actions are not constrained by the

Federal Reserve's actions. Furthermore, such deposits now are free of interest rate ceilings. Of course, an easier monetary policy would increase the supply of nominal credit by initially increasing the availability of credit from depository institutions, while a restrictive monetary policy would reduce it. It is difficult to see, however, how a restrictive monetary policy--even a highly restrictive one that reduced the supply of base money--would prevent depository institutions from accommodating strong loan demand.

The financial innovation and deregulation of the 1970s and 1980s, which reduced significantly the role of depository intermediaries in the allocation of credit, are welfare-enhancing. I believe they are part of an evolutionary process that will to continue to erode the relative importance of depository institutions in the allocation of credit. But this is not a symptom of market imperfection; rather, like the marked rise in the importance of depository institutions in years past, it is a sign of increased financial market efficiency.

I have saved my most serious concern for last. At several places in their paper, Wenninger and Lee suggest that, if a monetary aggregate that is reliably related to inflation or output cannot be found, the Fed should target the federal funds rate. This proposition, which seems to be pervasive in the Federal Reserve System, appears to be without justification. First, there is no theoretical or empirical evidence to suggest that the link between between the nominal interest rate and, say, inflation or output is "better" than the link between some money or reserve aggregate and these variables. The empirical evidence does not appear to provide unequivocal support for using either aggregates or interest rates as intermediate policy targets. While I come down decidedly on one side of the theoretical debate, its seems fair to say that the theoretical "evidence" depends strongly on one's point of view. Consequently, the evidence (theoretical or empirical) cannot be called on to justify the conclusion that, faced with such uncertainty about the relationship between aggregates and variables of interest to policy makers, the Fed should default to targeting the federal funds rate.

If the objective evidence about the relationship between these variables and the ultimate objectives of policy makers cannot support the choice of an interest rate or monetary aggregate target, it seems reasonable that the choice should be made on the basis of which variable is most readily controlled. Certainly, the Fed should not target something it cannot control! Hence, the essential issue in monetary policy today is the extent to which the Fed can control interest rates, i.e., how much can the Fed influence the (real) interest rate and for how long?

What concerns me is the apparent acceptance of the idea that the Fed controls interest rates through its direct control of the federal funds rate. This view is clearly stated in the paper presented here by Marvin Goodfriend. Goodfriend (1992) asserts that the Fed sets the federal funds rate and that other short-term interest rates are tied to it through the expectations theory of the term structure of interest rates.[2] This view

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2. As I understand it, the expectations theory of the term structure is <u>not</u> a theory of interest rate determination. It is merely an expectational consistency requirement. That is, I would not accept a long rate that was inconsistent with my expectations of future short rates. If all market participants have the same expectations or if expectations converge in some sense, then the term structure should provide information about the market's expectations for future short-term interest rates. Recent evidence, however, suggests that there is little evidence in the term structure about future short-term interest rates. See Shiller, Campbell and Schoenholtz (1983), for example.

may be correct; however, theory suggests that it should not be true in the long run, and a considerable volume of empirical literature suggests that the Fed's ability to influence interest rates is both relatively weak and short-lived.

Despite these facts, and for reasons that I confess I do not understand, extraordinary power appears to be associated with the funds rate and the Fed's control over it. One cannot help but wonder whether there is something unique about the federal funds rate that makes other interest rates "key" off of it? To answer this question, first consider the nature of the federal funds market. The market for federal funds was created by selecting some items from the asset side of the balance sheets of depository institutions and calling them "reserves"--currently vault cash and deposit balances with Federal Reserve Banks. A demand for reserves was created by requiring depository institutions to meet certain reserve requirements, stated as a percentage of their deposit liabilities. Deposit and reserve flows creates reserve excesses and deficiencies among depository institutions. These distribution effects are mitigated in the federal funds market where the temporary excess reserves of one institution are lent to offset the temporary deficiencies of another.

To see if there is something unique about the federal funds market so that changes in the federal funds rate tend to move other market interest rates, the following experiment is undertaken. Taking the existing institutional environment as given, I assume that the Fed refrains from all policy-related activities. That is, it does not engage in open market operations and makes no loans to depository institutions. Under these conditions, the federal funds rates fluctuates with shifts in deposit and reserve flows among depository institution. Such shocks have no effect on other interest rates, however. Shocks that are idiosyncratic to the funds market are ignored, like the sharp swings in the funds rate that frequently occur now just before and on settlement Wednesdays, and at other times. Even permanent changes in the distribution of deposits and reserves have no effect on other interest rates. The affected depository institutions merely make compensatory changes in their balance sheets. In this environment, changes in the federal funds rate do not cause changes in other interest rates! Changes in other rates, however, would be translated into changes in the funds rate. For example, an increase in loan demand would raise loan rate prompting depository institutions to raise the rates they pay for funds, even overnight funds.

If there is nothing inherent in the federal funds market to make it play such a central role in determining the level of the interest rate structure, the view that the federal funds rate is pre-eminent must be related to monetary policy's effect not only on the funds rate, but on interest rates in general. Certainly, an open market purchase affects the federal funds rate by affecting the distribution of deposits and reserves as the "checks" associated with such transactions flow among depository institutions. More important, however, such actions directly affect the total quantity of reserves. Because of this, the Fed should exercise considerable influence over the funds rate.

I grant that this is true. What concerns me is the possibility that view that the Fed controls other interest rates is based on this fact alone. In short, I am concerned that the view that the Fed controls interest rates is based more on form than on substance. Hence, I want to construct an experiment that is identical in substance, but different in form. For this experiment, I eliminate reserve requirements. I further assume that the Fed plays no role in clearing or processing checks or making wire transfers--this may be the outcome if the Fed ever decides to eliminate reserve requirements. In this world, a market analogous to the federal funds market may or may not exist. The point is that the Fed's influence on the supply of credit and, thus, on interest rates should be the same in this world as it is today. The Fed would engage in open market operations by issuing or redeeming notes. The effect of open market operations on the supply of credit would be exactly the same as now; hence, so too should be the effect of such actions on interest rates. It seems to me, however, that in this world, people would be less quick to conclude that the Federal Reserve has a significant and long-lasting effect on short-term interest rates. In this world, the Fed controls no interest rate directly. Consequently, people might be much less willing to conclude that it exercises much control over interest rates at all.

Lest you think that I don't believe that the Fed can have a significant effect on the federal funds rate, the table below presents a period in which I believe the Fed's influence on the federal funds rate was demonstrated clearly. Between the end of March and the end of June 1989, the 91-day T-bill and 90-day CD rates declined by about 100 basis points. Over the same period, the federal funds rate declined only about 30 basis points. Both total reserve and non-borrowed reserve growth were negative over this period, as the Fed wanted to keep the funds rate from falling with other market interest rates. It did so because it was fighting inflation and was concerned that a declining funds rate would give the impression that it was "easing" monetary policy. Indeed, the discount rate was raised 50 basis points as late as February 24 because new data suggested increased inflationary pressures. Furthermore, the

FOMC voted to maintain the existing degree of reserve pressure, i.e., keep the funds rate at its existing level, at the February, March and April meetings. At the February and March meetings, the Committee adopted asymmetric language toward restraint.[3] Despite the vote of the Committee to keep the funds rate constant and the negative reserve growth, the funds rate declined by 30 basis points. At the July meeting, the Committee voted to reduce "slightly" the degree of reserve pressure. Reserve growth swung from negative to positive, and the funds rate fell sharply to bring it more in line with other short-term interest rates.

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3. See Garfinkel (1990) for a discussion of these policy actions.

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Basis-Point Change in Interest Rates From the Week Ending March 31, 1989 to the Week Ending June 30, 1989

3-mo TBR	90-day CD	FF
-97	-100	-30

Growth Rate of Total and Non-borrowed Reserves
April through June 1989

TR	NBR
-9.0%	-6.9%

CONTROLLING INFLATION WITH AN INTEREST RATE INSTRUMENT

John P. Judd and Brian Motley[1]

ABSTRACT: In this paper we examine the effectiveness in controlling inflation of feedback rules for monetary policy that link changes in a short-term interest rate to an intermediate target for either nominal GDP or M2. We conclude that a rule aimed at controlling the growth rate of nominal GDP with an interest rate instrument could be an improvement over a purely discretionary policy. Our results suggest that the rule could provide better long-run control of inflation without increasing the volatility of real GDP or interest rates. Moreover, such a rule could assist policymakers even if it were used only as an important source of information to guide a discretionary approach.

In Congressional testimony on monetary policy, Chairman Greenspan and other Federal Reserve officials have made it clear that price stability is the long-run goal of American monetary policy.[2] At the same time, reducing fluctuations in real economic activity and employment remains an important short-term goal of the System. However, the desire to mitigate short-term downturns inevitably raises the issue of whether this goal should take precedence over price stability at any particular point in time. At present, the Federal Open Market Committee (FOMC) resolves this issue on a case-by-case basis, using its discretion to set policy after analysis of a wide array of real and financial indicators covering the domestic and international economies.

Economic theory suggests that monetary policy tends to have an

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[1] The authors are Vice President and Associate Director of Research, and Senior Economist, respectively at The Federal Reserve Bank of San Francisco. They would like to thank Evan Koenig, Bennett McCallum, Ronald Schmidt, Bharat Trehan, Adrian Throop, Carl Walsh and participants in the Conference on Operating Procedures at the Federal Reserve Bank of St. Louis, June 18-19, 1992 for helpful comments on an earlier draft, Andrew Biehl for his efficiency and diligence in computing the many regressions and simulations used in this paper, and Erika Dyquisto for preparing the document.

[2] See Greenspan (1989) and Parry (1990).

inflationary bias under such a discretionary system. This bias can be eliminated by the monetary authority pre-committing itself to a policy rule that would ensure price stability in the long run (Barro 1986). Even if the monetary authority is not willing to adhere rigidly to a rule, a discretionary approach could benefit from the information provided by a properly designed rule. For example, the instrument settings defined by the rule at any time could be regarded as the baseline policy alternative that would serve as the starting point for policy discussions. At its discretion, the FOMC could select a policy that was easier, tighter or about the same as that called for by the policy rule. Under such an approach, the rule could provide information that would help to guide short-run policy decisions toward those consistent with the long-run goal of price stability.

In this paper, we assess the effectiveness of so-called nominal feedback rules of the type suggested by Bennett McCallum (1988a, 1988b). These rules specify how a policy instrument (a variable that is under the direct control of the central bank) responds to deviations of an intermediate target variable from pre-established values. Earlier work (Judd and Motley 1991) suggests that a rule in which the monetary base is used as the instrument and nominal GDP is used as the intermediate target could produce price level stability with a high degree of certainty.

Over many years, the Fed has shown a strong preference for conducting policy using an interest rate instrument, as opposed to a reserves or monetary base instrument. In the present paper, we examine rules that use an interest rate instrument in conjunction with nominal GDP as the intermediate target. In addition, since the mid-1980s, the Fed has used a broad monetary aggregate, M2, as its main intermediate target or indicator. Hence, we also assess the usefulness of a rule that combines an interest rate instrument with M2 as the intermediate target variable.

Evaluating the effects of policy rules in advance of actually using them is an inherently perilous task. First, the effects of a rule will depend on the structure of the economy, including several features -- such as the degree of price flexibility and the way in which expectations are formed -- that remain subjects of debate and disagreement among macroeconomists (Mankiw 1990). This lack of consensus about issues that crucially affect the working of the economy means that, in order to be credible, any proposed rule must be demonstrated to work well within more than one theoretical paradigm. Second, implementation of a rule could alter key behavioral parameters affecting price setting and expectations formation. This means that history may not be a good guide in evaluating rules that were not implemented in the past, and that the robustness of empirical results to alternative parameter values also must be examined.

In order to assess their effectiveness under alternative macroeconomic paradigms, we conduct simulations of two different macroeconomic models (a Keynesian model and an atheoretic vector autoregression or error correction system) that have significant followings among macroeconomists.[3] To assess the risks of adopting different rules, we examine the dynamic stability of these models under alternative versions of the rules. In addition, we use stochastic simulations to determine the range of outcomes for prices, real GDP and a short-term interest rate that we could expect if these rules were implemented and the economy experienced shocks similar in magnitude to those in the past. Finally, to test for robustness, we re-examine all of the results under plausible alternative values for key estimated parameters in the models.

[3] Our earlier paper (Judd and Motley 1991), in which the policy instrument was the monetary base, also examined the effects of a rule within the context of a very simple real business cycle (RBC) model. However, with an interest rate instrument, the price level cannot be determined in the context of that RBC model (see McCallum 1988b, pp. 61-66). Thus we did not use the RBC model in this paper.

Using these simulations we evaluate the effectiveness of the rules at controlling the price level. We also examine the effect of the rules on the volatility of real GDP and a short-term interest rate. We find that the interest rate rules do not fare well compared with base-oriented rules. However, one form of the interest rate rule may offer an improvement over a purely discretionary approach. Finally, we suggest a way to use a feedback rule with an interest rate instrument as an important source of information that could contribute to the effectiveness of a discretionary policy.

The remainder of the paper is organized as follows. Section I presents a brief overview of the theoretical advantages and disadvantages of alternative targets and instruments. Section II discusses the nominal feedback rules to be tested. In Section III, we present the empirical results. The conclusions we draw from this work are presented in Section IV.

I. CONCEPTUAL ISSUES

In this section, we discuss briefly the basic conceptual issues determining the effectiveness of alternative intermediate targets and instruments of monetary policy. To illustrate certain basic ideas, we introduce a generic form of the feedback rule that links the *instrument* variable with the *intermediate target* variable. This generic feedback rule may be written in the form:

$$\Delta I_t = \psi + \lambda [Z^*_{t-1} - Z_{t-1}] .$$

The variable I represents the policy instrument, which is a variable under the direct control of the monetary authority. Z represents the intermediate target variable of policy. The rule specifies that the change in the policy instrument should be equal to the change desired in steady-state equilibrium, ψ, plus an adjustment term, $\lambda [Z_{t-1} - Z^*_{t-1}]$. This latter term describes the monetary authority's response to deviations between the actual level of the intermediate target variable (Z) and its desired level (Z^*). The strength of the monetary authority's response to such deviations is defined by λ. Thus, the rule permits policy to incorporate varying degrees of aggressiveness in pursuing the intermediate target.

The policy instrument, I, responds only to lagged, and hence *observed*, values of the intermediate target Z. Hence, the rule can be implemented without reference to any particular model. This is an advantage in view of the current disagreement about the "correct" model of the economy. Nominal feedback rules may gain wider appeal because it may be possible to agree about the effectiveness of a particular rule, while disagreeing about how the economy actually works.

Alternative Intermediate Targets

The appeal of nominal GDP as an intermediate target lies in the apparent simplicity of its relationship with the price level, which is the ultimate long-term goal variable of monetary policy (Hall, 1983). As shown by the following identity, the price level (p) is equal to the difference between nominal GDP (x) and real GDP (y), where all variables are in logarithms:

$$p = x - y.$$

This identity means that there will be a predictable long-term relationship between nominal GDP and the price level as long as the level of steady-state real GDP is predictable.

According to some economists, the level of real GDP has a long-run trend, called potential GDP, which is determined by slowly evolving long-run supply conditions in the economy, including trend labor force and productivity growth (Evans 1989). To the extent that this view is correct, it is straightforward to calculate the path of nominal GDP required to achieve long-run price stability.

However, other research suggests that real GDP does not follow a predictable long-run trend, and is stationary only in differences (King, Plosser, Stock and Watson 1991). If this were the case and nominal GDP were to grow at a constant rate under a rule, the price level would evolve as a random walk, and thus could drift over time. Unfortunately, statistical tests are not capable of distinguishing reliably between random walks and trend-stationary processes with autoregressive roots close to unity (Rudebusch 1993). This uncertainty over the long-run behavior of real GDP means that there is corresponding uncertainty over how the price level would behave under a nominal GDP target.[4]

Another potential problem is that the lags from policy actions to nominal GDP are relatively long, and thus targeting nominal GDP might induce instrument instability. Shorter lags tend to exist between policy actions and monetary aggregates. Hence, using an aggregate as an intermediate target could reduce the likelihood of producing instrument instability compared to a nominal GDP target.

Since the velocity of M1 began to shift unpredictably in the early 1980s, M2 has been the main intermediate target used by the Fed and so is a prime candidate for use in a feedback rule. M2 also has been identified as a potential intermediate target because its velocity (in levels) has been stationary over the past three decades (Miller 1991, Hallman, Porter and Small 1991). Its short-run relationship with spending, however, has not been very reliable. These problems have intensified in recent years, with accumulating evidence of instability in M2 velocity in 1990-92 (Judd and Trehan 1992, Furlong and Judd 1991). Nonetheless, it may be possible to exploit its long-run relationship with prices to achieve price stability.

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[4] In part because of this concern, a number of authors have argued that the Federal Reserve should target prices directly (Barro 1986, and Meltzer 1984). No matter what time series properties real GDP displays, direct price level targeting obviously could avoid long-term price-level drift. The major disadvantage of price level targeting is that in sticky price models, the feedback between changes in the instrument and the price level is very long (and, in fact, longer than for nominal GDP). Thus, attempts by monetary policy to achieve a predetermined path for prices are liable to involve instrument instability (i.e., explosive paths for the policy instrument) and undesirably sharp movements in real GDP. Our earlier empirical results (Judd and Motley 1991) confirm this conjecture.

For present purposes, the important implication of the preceding discussion is that the choice of an intermediate target variable cannot be determined from theory alone. This choice depends on empirical factors such as the time series properties of real GDP, the degree of flexibility of prices, and the predictability of the velocity of money. Clearly an empirical investigation is needed.

Alternative Instruments

Instruments of monetary policy fall into two basic categories: aggregates that are components of the Federal Reserve's balance sheet, such as the monetary base or the stock of bank reserves, and short-term interest rates, such as the federal funds rate. Either category qualifies as a potential instrument since either can be controlled precisely in the short run by the central bank and each is causally linked to output and prices.

The monetary base has the advantage that, in principle, it is the variable that determines the aggregate level of prices, and thus would appear to be a natural instrument to use in a rule designed to achieve price stability. However, it has a number of potential disadvantages. First, using the base as an instrument could cause interest rates to become excessively volatile, and thereby impair the efficiency of financial markets. Second, the base is made up mainly of currency in the hands of the public (currently, about 85 percent), and concern for efficiency in the payments system argues for supplying all the currency the public demands. This means that controlling the base requires operating on a small component of it (bank reserves). Hence, relatively small changes in the base might require large proportional changes in reserves, which could disrupt that market. Third, along with M1, the demand for the base has become relatively unstable in the 1980s compared with prior decades. The deregulation of deposit interest rates and increased foreign demand for U.S. currency apparently have induced permanent *level* shifts in the demand for the base, and possibly a change in its *steady-state growth rate*.

In Appendix C, we examine the stability of the demand for base money and the issue of whether the need to supply currency on demand would seriously inhibit the use of the base as a policy instrument. We conclude that although these problems are legitimate reasons for concern whether a base rule would work well, they probably are not fatal. Nonetheless, it is worthwhile to explore the possibility of using a short-term interest rate as the instrument in the context of the feedback rule since the FOMC has shown a preference over the years for a short-term interest rate (the funds rate) as its instrument.[5] This is our main purpose in this paper.

It is well-known that using an interest rate as an intermediate target would not work, because the economy would be dynamically unstable in the long run (i.e., the price level would be indeterminate) if nominal interest rates were held steady at a particular level and not permitted to vary flexibly in response to shocks. However, this argument does not rule out its use as an *instrument*. If interest rate movements are linked to changes in a nominal variable (such as nominal GDP, a monetary aggregate, or the price level itself) through a rule, the price level may be determinate (McCallum 1981). Thus the question of whether an interest rate instrument would function effectively within a feedback rule cannot be answered by theory alone. Empirical work is required.

II. NOMINAL FEEDBACK RULES

We examine two rules in which the interest rate is used as the instrument and one that uses the monetary base. We use the following symbols throughout:

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[5] Apparently, this preference is based in part on the view that this approach avoids imparting unnecessary volatility to financial markets that would arise if policy were conducted using a reserves or monetary base instrument.

b = log of the monetary base, R = the three-month Treasury bill rate, $m2$ = the broad monetary aggregate, M2, x = log of nominal GDP, y^f = log of full-employment real GDP, and "*" denotes a value desired by the central bank.

Equation 1 employs nominal GDP as the intermediate target and the interest rate as the instrument.

$$
\begin{aligned}
\Delta R_t &= -\lambda_1[x^*_{t-1} - x_{t-1}] + \lambda_2[x^*_{t-2} - x_{t-2}] \\
\text{(1)} \qquad &= -\alpha[x^*_{t-1} - x_{t-1}] - \beta[\Delta x^*_{t-1} - \Delta x_{t-1}] \\
&\text{where } \alpha = (\lambda_1 - \lambda_2),\ \beta = \lambda_2 .
\end{aligned}
$$

Equation 2 is similar but uses M2 as the target.

$$
\text{(2)} \qquad \Delta R_t = -\alpha[x^*_{t-1} - \overline{V2}_{t-1} - m2_{t-1}] - \beta[\Delta x^*_{t-1} - \Delta\overline{V2}_{t-1} - \Delta m2_{t-1}] ,
$$
$$
\text{where } \overline{V2}_t = \sum_{i=0}^{15}(x_{t-i} - m2_{t-i})/16 .
$$

In order to provide a standard of comparison, we also examine a rule in which a base instrument is used to reach a nominal income target.[6]

$$
\text{(3)} \qquad \Delta b_t = [\Delta y^f_t + \Delta p^*_t] - \Delta\overline{VB}_t + \alpha[x^*_{t-1} - x_{t-1}] + \beta[\Delta x^*_{t-1} - \Delta x_{t-1}] ,
$$
$$
\text{where } \Delta\overline{VB}_t = \left(\frac{1}{16}\right)[(x_{t-1} - b_{t-1}) - (x_{t-17} - b_{t-17})] .
$$

The left hand sides of these equations represent the change in the policy instrument, either the annualized growth rate of the monetary base or the percentage point change in the short-term interest rate. Since in steady-state the rate of interest is constant, the left hand

[6] In our earlier paper (Judd Motley 1991), we also tested the following two rules:

$$
\Delta b_t = \left[\Delta y^f_t + \Delta p^*_t\right] - \Delta\overline{VB}_t + \alpha\left[p^*_{t-1} - p_{t-1}\right]
$$
$$
\Delta b_t = \left[\Delta y^f_t + \Delta p^*_t\right] - \Delta\overline{VB}_t + \alpha\left[(y^f_{t-1} - y_{t-1}) + (\Delta p^*_{t-1} - \Delta p_{t-1})\right].
$$

The price level target produced instability in the Keynesian model, while the second rule, suggested by Taylor (1985), produced dynamic instability in the vector autoregression.

sides of (1) and (2) are zero in equilibrium. Hence, the interest rate rules contain only a feedback component, which specifies how the interest rate is adjusted when the target variable (nominal GDP or M2) diverges from the path (in levels or growth rates) desired in the previous quarter. In (2), the target level of M2 (in logarithms) is defined as the target level of nominal income less the average level of M2 velocity over the past 16 quarters. The terms α and β define the proportions of a target "miss" (in levels and growth rates, respectively) that the central bank chooses to respond to each quarter. In equilibrium, there are no misses and hence the interest rate is constant.

The monetary base rule is more complicated. The first term on the right-hand side of (3) represents the growth rate of nominal GDP that the central bank wishes to accommodate in the long-run, which is equal to the sum of the desired inflation rate (Δp^*) and the steady-state growth rate of real GDP (Δy^f). The second term, $\Delta \overline{VB}$, subtracts the growth rate of base velocity over the previous four years, and is designed to capture long-run trends in the relation of base growth to nominal GDP growth.[7] The third term specifies the feedback rule determining how growth in the base is adjusted when there is a target miss in the previous quarter. In steady-state, this feedback term drops out, so that the rule simply states that $\Delta b_t = \Delta p_t^* + \Delta y_t^f - \Delta \overline{VB}_t$.

In all three rules, we use two lags on the levels of the intermediate target variables. As shown in (1), this specification is equivalent to including one lag on the level and one lag on the growth rate of the target variable (McCallum, 1988b). Thus the instrument is subject to both "proportional" (response to levels) and "derivative" (response to growth rates) feedback. The addition of derivative

[7] The 16-quarter average was designed to be long enough to avoid dependence on cyclical conditions. As a consequence, the term can take account of possible changes in velocity resulting from regulatory and technological sources.

feedback can improve the performance of proportional feedback rules in some circumstances (Phillips 1954). In any event, we evaluate the performance of the rules under all three possible categories of control: proportional only ($\alpha>0$, $\beta=0$), derivative only ($\alpha=0$, $\beta>0$), and both proportional and derivative ($\alpha>0$, $\beta>0$).

III. EMPIRICAL RESULTS

For each of the rules tested, we performed a number of dynamic simulations within the context of two types of models: a simple structural model based on Keynesian theory, and theoretically agnostic vector autoregression or error correction models.

The models are described in detail in Appendix A. The Keynesian model embodies four equations, each representing a basic building block of this framework. First, there is an aggregate demand equation, relating growth in real GDP to growth in real M2 balances (or the monetary base). Second, there is a Phillips-curve equation, relating inflation to the GDP "gap" (i.e., the difference between real GDP and an estimate of its full-employment level), and a distributed lag of past inflation. This latter variable reflects the basic Keynesian view that prices are "sticky," and means that there are long lags from policy actions to price changes. Third, full-employment real GDP (in levels) is assumed to have a deterministic trend. Thus the supply of real GDP in levels is unaffected by business cycle developments. Finally, the model includes an equation defining the demand for (real) money (or the monetary base) as a function of real GDP, and the nominal interest rate.

To simulate this model with a base instrument, this last equation is replaced by the equation describing the policy rule (3). In simulations with an interest rate instrument, (1) and (2), the policy rule determines the interest rate, which feeds into the M2 or base demand equation to determine the monetary aggregate. Under both instruments, the simulation model includes the aggregate demand and supply equations and the Phillips curve to determine y, y^f and p.

In addition to the Keynesian model, we also use either a vector autoregression (VAR) or vector error correction (VECM) framework. To simulate the effects of a rule with a base instrument, we use a four-variable VAR system, including real GDP, the GDP deflator, the monetary base, and the three-month Treasury bill rate. In these simulations, the estimated equation for the base is replaced by the policy rule (3). For the interest rate rules, we use a somewhat different system of equations. Since the second interest rate rule (2) involves M2 as the intermediate target, we replace the base with M2 in the above list of variables. We use this same system to simulate the effects of (1), which uses nominal GDP as the intermediate target. In simulating the interest rate rules, the estimated interest rate equation is replaced by the appropriate policy rule.

In estimating these systems, we used standard statistical techniques as described in Appendix A to test for stationarity, cointegration, and lag length. In the system that includes M2, we found one cointegrating relationship, which we interpret as an M2 demand function. This cointegrating vector was imposed in estimating the resulting VECM. No cointegrating vector was found in the system that includes the monetary base, and hence this system was estimated as a VAR.

The simulation results fall into three categories. First, we examine the dynamic stability of each macroeconomic model when the rules are used to define monetary policy. For a policy rule to be considered, it must produce a model that has sensible steady-state properties. In the long run, a feedback rule will make the price level follow the desired path, as long as it does not make the economy dynamically unstable and induce explosive paths for the endogenous variables. Given the uncertainty about the true structure of the economy, a rule must produce dynamic stability in both types of models examined, and with a range of alternative values of α and β, in order to be considered reliable. We conduct numerous simulations to see if the rules meet this test.

Second, we conduct repeated stochastic counterfactual simulations of the alternative models and rules over the 1960-1989 sample period to see how the principal macroeconomic variables might have evolved if the rules had been followed. In these simulations, we assume that the shocks in each equation have the same variance as the estimation errors. This procedure allows us to construct probability distributions of alternative outcomes for each rule and each model, and to calculate (95 percent) confidence intervals for long-run inflation rates as well as for short-run real GDP growth rates and for interest rate changes. This enables us to compare different rules in terms of the full range of alternative outcomes that each might produce. To compare the simulated results under the rules with the results of the policies actually pursued, we report the means and 95 percent confidence bands of the actual data over 1960-89.

Third, we tested the robustness of these results by repeating many of the above simulations under alternative values of key parameters in our estimated models.

Dynamic Stability

The results of our analysis of the dynamic stability of the models under the various rules are shown in Table 1. To detect whether a particular combination of model, rule, and pair of α and β was dynamically stable, we computed a nonstochastic simulation covering 300 quarters. The size of the simulation's last cycle for the price level (peak-to-trough change) was divided by the size of its first cycle to form a ratio that we call s. If s is greater than 1.0, the simulation is unstable since the swings in the endogenous variable become larger as time passes, while a value of s less than 1.0 shows dynamic stability.[5] For each combination of model and rule, we performed a grid search over various combinations of α (to measure proportional control) and β (to measure derivative control). The grid extended from $\alpha = \beta = 0.0$ to $\alpha = 0.8$ and $\beta = 1.1$ (in units of 0.1 for both α and β). Excluding the combination in which $\alpha = \beta = 0.0$, which represents the no-rule case, each grid search generated 107 values of s. Although the exact specification of these searches is somewhat arbitrary, they do appear to present an accurate picture of the stability properties being investigated.

Table 1 provides a count of stable simulations as a proportion of total simulations for each rule under each model. As shown, the nominal GDP/base rule is dynamically stable in every simulation for both models. Thus the conclusion that an economy guided by a nominal GDP/base rule would have desirable steady-state properties is quite robust across models and choices of α and β. In fact, in the case of a base instrument, the simple approach of proportional control (only) would seem to make sense. In any event, the risk of inducing unstable cycles by using this rule appears to be small.

The same cannot be said for the interest rate instrument, using either nominal GDP or M2 as the intermediate target. Under the vector error correction model, the rule produces only 21 stable cases out of 107 trials when nominal GDP is the intermediate target, and only 19 stable cases when M2 is used. The results are considerably better in the Keynesian model (81 and 98 stable trials, respectively, for nominal GDP and M2 targets). However, the important characteristic of robustness across alternative models is lacking when the full range of combinations of proportional and derivative control is considered.

It is not entirely surprising that there is a tendency for the models to produce more cases of dynamic instability when an interest

[5] Nearly all of the simulations we observed exhibited cycles. However, the method used for detecting dynamic instability also works for simulations that do not exhibit cycles.

rate instrument is used than when the base is used. As noted above, economic theory predicts that the price level would be determinate in the long run and the economy dynamically stable if the monetary authority were to peg the base, but that the price level would be indeterminate and the economy dynamically unstable if the authority were to peg a nominal interest rate at a constant level. Although the feedback rules attempt to avoid this problem by tying interest rate changes to intermediate targets for nominal quantities, the underlying tendency toward instability shows through in our results.

However, in the case of an interest rate rule that exerts derivative control only -- so that policy responds only to the growth rates, and not the levels, of nominal GDP and M2 -- there does not appear to be a problem with instability. As Table 1 shows, the model is dynamically stable in all 8 trials when the intermediate target is M2, and in almost all trials (7 out of 8) when nominal GDP is the target.

Counterfactual Simulations

In this section we present the results of simulations that attempt to assess how the macroeconomy might have evolved over the past three decades if the various feedback rules had been in use. In these "counterfactual experiments," the paths for the target variables were set to hold the price level constant at its level in 1960. We chose values for α and β that produced stable simulations across the two models. For each combination of rule and model, we calculated 500 stochastic simulations.[9] The random shocks in each equation were drawn from probability distributions that had the same mean and variance as the estimation error terms. Each set of 500 simulations is called an experiment.

In presenting the results of these experiments, we focus on two

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[9] There are nine alternative rules (i.e., three combinations of intermediate targets and instruments, and three combinations of α and β) and two models. Thus eighteen sets of 500 stochastic simulations were computed.

measures of economic performance that should reflect the concerns of policymakers -- the price level and the short-run growth rate of real GDP. Ideally, a policy rule should deliver price stability without causing unacceptable fluctuations in real GDP growth. To address possible concerns about the short-run variability of the interest rate under the rules, we also examine quarter-to-quarter changes in the interest-rate instrument of policy.

We measure the price level performance of each rule in terms of the average inflation rate that it produced over the 30-year simulation period. The volatility of real GDP is measured in terms of the four-quarter growth rate of real GDP. For each experiment, we calculated 95 percent confidence intervals for both of these variables. In the case of the simulations using the interest rate instrument, we also calculated 95 percent confidence intervals for the quarterly changes in the interest rate.

Table 2 shows the performance of the various rules in stabilizing the price level.[10] Using the monetary base as the instrument, adoption of the nominal-GDP feedback rule could have stabilized prices in the long run within narrow limits. For example, under the base rule with both proportional and derivative control (α = 0.25 and β = 0.50), average inflation (with 95 percent probability) would have been between -0.4 and +0.3 percent in the Keynesian model and between -0.8 and +0.7 percent in the VAR. Under the policies actually followed during this period, average inflation was 5.4 percent.

The rules in which the interest rate is used as the instrument also are able to produce confidence bands that generally are centered near an average inflation rate of zero. However, these bands are wider than when the monetary base is used as the instrument. For example, the bands under the interest rate instrument with some proportional control

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[10] The average inflation results in Table 2 are not qualitatively changed if alternative horizons, such as five, ten or twenty years, are used for the stochastic simulations.

(either alone or with derivative control also) range in width from 1.1 to 4.2 percentage points compared with band widths of 0.7 to 1.5 percentage points when the base is the instrument. Thus although both instruments produce confidence bands for average inflation that are centered on zero, use of the base as the policy instrument reduces price level uncertainty more than use of the interest rate.

The confidence bands on average inflation are considerably wider under the interest rate rules if policy exerts only derivative control (see the right-hand column of Table 2). When policy attempts to control only the *growth rate* of the intermediate target, misses in the level in effect are "forgiven" each quarter. Not surprisingly, the widths of the resulting confidence bands on long-run inflation increase to between 3.4 and 7.2 percentage points. However, it is important to note that even at the top ends of these confidence bands, average inflation is below the actual inflation rate over 1960-89.

Finally, the results suggest that there is little to distinguish the nominal GDP target from the M2 target under an interest rate instrument. However, our use of a sample period that ends in 1989 abstracts from the widely discussed problems with instability in the demand for M2 that have occurred in 1990-92 (Furlong and Judd 1991, Judd and Trehan 1992). Since 1989, the velocity of M2 has been roughly constant, whereas historical relationships suggest that it should have declined rather sharply in response to declining nominal interest rates. This apparent shift in M2 demand raises concerns that the future performance of M2 as an intermediate target may be worse than it was in the past.

Table 3 shows the effects of the rules on the volatility of real GDP. For each model, it reports 95 percent confidence intervals for four-quarter growth rates of real GDP under the alternative rules.[11]

[11] We also looked at the volatility of the two-quarter and eight-quarter growth rates of real GDP. The conclusions were qualitatively the same as for the four-quarter growth measures.

The table compares the simulation results with the distribution of the actual historical data, which is a measure of the volatility of real GDP during the sample period under the discretionary policies actually followed by the Federal Reserve.

In nearly every case, the confidence bands are wider under the rules that use some proportional control (either alone or in combination with derivative control) than they were in the actual sample period, though in some cases the differences are small. For example, in the Keynesian model, use of the nominal GDP/base rule with both proportional and derivative control is estimated (with 95 percent confidence) to yield four-quarter real GDP growth rates of between -4.0 and +10.3 percent, which is wider than the -1.9 to +7.9 percent band in the historical data. In the VAR, the corresponding confidence interval is +0.4 to +9.3 percent, which has about the same width as the historical measure.

Table 3 suggests that use of an interest rate instrument, with at least some proportional control, would lead to larger fluctuations in real GDP growth than a base instrument. The confidence bands are substantially wider under rules that use an interest rate instrument than with a base instrument, especially in the VAR and VECM models. There appears to be a slight tendency for the confidence bands to be narrower under an M2 rule than a nominal GDP rule, but the difference is small.

However, *if only derivative control is exerted*, the width of the confidence bands on real GDP growth is noticeably narrower than when there also is a significant element of proportional control (see the right-hand column of Table 3). In most cases, derivative control leaves the volatility of GDP at about the same level as it was historically. This is true whether an interest rate or a monetary base instrument is used.

In Table 4, we present evidence on the quarter-to-quarter volatility of the short-term interest rate that might result from following the two rules that use the interest rate as the instrument. When at least some proportional control is used, the rules result in an increase in short-run interest rate volatility compared with that experienced under the discretionary policy pursued in our sample period. Thus the width of the 95 percent confidence intervals varies from 6.0 to 16.9 percentage points under the rules, compared with a width of 4.0 percentage points in the actual data. However, use of derivative control only is estimated to reduce interest rate volatility compared with history. As shown in the right-hand column, the confidence bands range in width from 1.3 to 2.4 percentage points compared with the 4 point width in the actual data.

In summarizing the results in Tables 2, 3 and 4, it is useful to compare the simulations under an interest rate instrument both with those under a base instrument and with the historical record. Compared to the base-instrument results, we conclude:

1. Use of the interest rate permits much more drift in the price level in the long-run than use of the base.

2. An interest rate instrument also results in more volatility of real GDP, except in the case of derivative control only, when the interest rate instrument leads to less volatility.

Comparing the results under an interest rate instrument with historical experience, we can make the following generalizations:

1. If at least some proportional control is used, the interest rate rule would hold inflation well below its historical average, but would result in greater volatility in real GDP and interest rates than experienced in the past.

2. If derivative control only is used, then the interest rate rules would hold inflation somewhat below historical experience, maintain real GDP volatility at about its historical level, and result in less interest rate volatility than actually occurred in the past.

Robustness

One problem with attempting to evaluate empirically the likely effects of monetary policy rules that were not actually followed during the period for which data are available is that the estimated behavioral parameters of models might have been different if the rule had actually been used (Lucas, 1973). In a crude attempt to deal with this issue, we have recalculated many of the simulations discussed above under alternative assumptions about key coefficients in our estimated models. We ran these simulations under the assumption that selected coefficients varied (one at a time) from their estimated levels by plus and minus two standard deviations. The results of these alternative simulations are shown in Appendix B.

The coefficients that were varied in these tests included the following:

1. In the Keynesian model, we altered the slope of the Phillips curve, the elasticities of real GDP with respect to both real M2 and the real base in the aggregate demand equations, and the interest elasticities of the demand for both M2 and the base. In addition, we varied the length of the lags on past inflation in the Phillips curve, restricted the sum of these coefficients on past inflation to unity, and introduced a unit root in potential GDP.

2. In the VECM, we varied the interest rate, GDP and price elasticities of M2 in the cointegrating vector that appears in the M2 and price equations.

There are too many results in Appendix B to review in detail. However, several general points stand out. First, the results for average inflation are quite robust for all of the rules within all of the models. When the monetary base is the instrument, the results for real GDP growth also are robust, although somewhat less so than for inflation.

As shown in Tables B.2 and B.4, the width of the confidence bands for four-quarter real GDP growth is relatively sensitive to coefficient variations when the interest rate is used as the instrument and the rule involves some proportional control. In a few cases the bands become somewhat narrower, but in many more they become considerably wider. On the other hand, interest rate volatility is relatively less sensitive to the changes in the models' coefficients. However, as shown in Tables B.3 and B.5, when the interest rate rule involves derivative control only, the simulation results are highly robust.

One issue of special concern is the restriction in the Phillips curve that the coefficients on lagged inflation sum to unity (point 2 in Tables B.1, B.2, and B.3). This restriction ensures that monetary policy is neutral with respect to real GDP in the long run (i.e., it makes the Phillips curve "vertical" in the long run), and is a central feature of the theory underlying the Phillips curve. Although the restriction is rejected by the data in our sample (see the *F*-test under equation A.2′ in the Appendix), we imposed it in our sensitivity analysis because of its theoretical importance. In most cases, the imposition of this restriction leads to dynamic instability.

IV. CONCLUSIONS

In this paper, we have examined the effectiveness of nominal feedback rules that link short-run monetary policy actions to an intermediate target with the ultimate goal of controlling inflation in the long-run. Two subsidiary goals are that the rules not induce unacceptably large variations in real GDP or in interest rates. Given uncertainties about the structure of the economy, these rules are designed to be model-free in the sense that the monetary authority does not need to rely on a specific model of the economy in order to implement them. In addition, the rules are operational in that they define specific movements in an instrument that can be controlled precisely by the central bank.

We have focused mainly on rules that use a short-term interest rate as the policy instrument, and either nominal GDP or M2 as the intermediate target. As a standard of comparison, we also have looked at a rule in which the monetary base is the instrument and nominal GDP is the intermediate target. This rule has been shown to have desirable properties in earlier research. In addition, we compare the results from the rules with actual experience over the past three decades.

Our empirical results suggest that all of the feedback rules examined, so long as they do not produce explosive paths, would be highly likely to hold inflation below the average rate experienced in the U.S. over 1960-89. When comparing rules with alternative instruments, the interest rate rule does not measure up to rules with the monetary base as the instrument and nominal GDP as the intermediate target. The latter rule provides much tighter control of the price level and induces somewhat less volatility in real GDP than rules using an interest rate as the instrument. Moreover, rules using the base as the instrument are consistent with dynamic stability in the economy under a wide range of assumptions, whereas the same cannot be said for rules with interest rate instruments. In a number of cases, the latter rules induced explosive paths in the economies simulated.

Despite the strong results obtained for rules with a base instrument, there are reasons to be concerned that their performance in the future would not measure up to the results obtained in our counterfactual simulations covering the past three decades. The prime example is that the increase in foreign demand for U.S. currency in recent years may have made the overall demand function less stable than in the past. So, what conclusions can be reached about the effectiveness of rules defined in terms of an interest rate instrument? First, within such rules, nominal GDP and M2 were found over our 1960-1989 sample period to function about equally well as intermediate targets. Given this result, and the evidence that the relationship between M2 and spending may have broken down during 1990-1992, rules defined in terms of nominal GDP would appear to be less risky.

Second, based upon our simulations, interest rate rules that involve some proportional control of nominal GDP (or M2) do not appear to be viable alternatives for monetary policy. We found a large number of cases in which these rules produced explosive paths for the simulated economy. Thus use of such a rule in the real world, where we do not know with any precision the structure and size of parameters of the pertinent behavioral relationships, would run a significant risk of inducing dynamic instability.

However, feedback rules with an interest rate instrument that focus on the growth rate, rather than the level, of nominal GDP (or M2) lead to dynamic stability in the various models. Naturally, such rules automatically accommodate past misses of the level of the intermediate target, and thus allow the possibility that the price level may drift over time. Such drift would occur only when there were a prolonged series of positive or negative shocks. However, it should be noted that even after allowing for such drift, the worst case simulation that we obtained still held the simulated average inflation rate over 1960-1989 well below the historical average. Moreover, such an approach is estimated to involve about the same level of volatility in real GDP and a reduction in interest rate volatility compared with historical experience, with a very high probability.

This conclusion suggests that, although a rule that aimed at controlling the growth rate of nominal GDP with an interest rate instrument is far from ideal, it might be an improvement over a purely discretionary interest rate policy. It would seem to offer the likelihood of lower long-run inflation without increasing the volatility of real GDP or interest rates. A simple version of such a rule can be written[12].

$$\Delta R_t = -0.50[\Delta x^*_{t-1} - \Delta x_{t-1}].$$

Such a rule could make a contribution to policy, even if it were used only to modify the Fed's traditional discretionary approach. When using an interest rate instrument within the context of a purely discretionary policy, it is natural for the policymaker to evaluate

[12] As noted above, Δx refers to a change in the log of nominal GDP, while ΔR refers to a change in the interest rate expressed as a percent. Thus when nominal GDP growth deviates from its target by 1 percent (4 percent annual rate), the rule calls for a change in the interest rate of .005, or 50 basis points.

alternative policy actions relative to a status quo policy of leaving the interest rate (currently the federal funds rate) unchanged. As a result, the debate tends to focus on a decision about whether the funds rate should be raised or lowered from its recent level. This approach may be misleading, since a policy of leaving the funds rate unchanged does not necessarily imply that the future thrust of policy relative to key macroeconomic variables will remain unchanged.

However, the instrument setting given by the feedback rule at any point in time *does* provide a sensible way to define no change in monetary policy, since it represents a consistent policy regime, incorporating the long-run goal, the intermediate-run target and the short-run instrument. A debate that focused upon whether policy should ease, tighten, or remain the same *relative to what the feedback rule calls for*, would seem to be more informed than one that focused upon whether the short-term interest rate should be changed from recent levels. Occasional adjustments to the nominal GDP target could be used to offset drift in the price level that may arise from exercising derivative control (only) of nominal GDP.[13]

The approach outlined above could be considered as one possible step to improve a purely discretionary interest rate policy. In effect, the rule would be used to provide policymakers with information that could help them make short-run discretionary decisions without losing sight of the long-run goal of controlling inflation.

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[13] If, for example, the level of prices were to drift significantly upward or downward despite following the rule, an offsetting adjustment could be made to the path of the nominal GDP target. Of course, the central bank would have to guard against the temptation to make frequent adjustments to the target path, since this could undermine the value of the feedback rule. One way to do this would be to define in advance the amount of drift in the price level that would be tolerated before a level adjustment would be made to the nominal GDP target.

1. Dynamically Stable Simulations by Type of Control

Rule Intermediate Target/Instrument	Proportional Only (10 trials)	Proportional and Derivative (89 trials)	Derivative Only (8 trials)	Total (107 trials)
Nominal GDP/Interest Rate				
Keynesian Model	6	68	7	81
VECM	1	13	7	21
M2/Interest Rate				
Keynesian Model	8	82	8	98
VECM	0	11	8	19
Nominal GDP/Monetary Base				
Keynesian Model	10	89	8	107
VAR	10	89	8	107

Note: The number of trials is the total number of pairs of α and β for each combination of rule and model.

Proportional Only: $\alpha > 0; \beta = 0$
Proportional and Derivative: $\alpha > 0; \beta > 0$
Derivative Only $\alpha = 0; \beta > 0$

2. Simulated Average Annual Inflation Rate 1960-1989

Rule	95% Confidence Limit		
Intermediate Target/Instrument	Proportional Only	Proportional and Derivative	Derivative Only
Nominal GDP/Interest Rate	(α=0.75, β=0.00)	(α=0.25, β=.50)	(α=0.00, β=0.50)
Keynesian Model	-0.6% to 0.5%	-1.3% to 0.9%	-2.3% to 4.9%
VECM	Explosive	-1.0% to 2.5%	-0.3% to 3.1%
M2/Interest Rate	(α=0.75, β=0.00)	(α=0.60, β=0.25)	(α=0.00, β=0.50)
Keynesian Model	-0.8% to 1.0%	-0.9% to 1.0%	-1.5% to 3.2%
VECM	Explosive	-1.2% to 3.0%	-0.2% to 3.5%
Nominal GDP/Monetary Base	(α=0.50, β=0.00)	(α=0.25, β=0.50)	(α=0.00, β=0.50)
Keynesian Model	-0.4% to 0.3%	-0.4% to 0.3%	-0.2% to 0.7%
VAR	-0.8% to 0.7%	-0.8% to 0.7%	-0.5% to 1.0%
Actual Data:		5.4%	

3. Simulated Four-Quarter Real GDP Growth Rates

Rule	95% Confidence Limits		
Intermediate Target/Instrument	Proportional Only	Proportional and Derivative	Derivative Only
Nominal GDP/Interest Rate	(α=0.75, β=0.00)	(α=0.25, β=0.50)	(α=0.00, β=0.50)
Keynesian Model	-16.7% to 20.6%	-6.3% to 19.7%	-1.3% to 8.2%
VECM	Explosive	-11.7% to 19.8%	0.6% to 10.2%
M2/Interest Rate	(α=0.75, β=0.00)	(α=0.60, β=0.25)	(α=0.00, β=0.50)
Keynesian Model	-7.2% to 13.6%	-4.7% to 10.6%	-1.6% to 8.3%
VECM	Explosive	-16.4% to 15.3%	0.8% to 10.0%
Nominal GDP/Monetary Base	(α=0.50, β=0.00)	(α=0.25, β=0.50)	(α=0.00, β=0.50)
Keynesian Model	-3.4% to 10.0%	-4.0% to 10.3%	-3.5% to 10.2%
VAR	-0.4% to 9.9%	0.4% to 9.3%	0.6% to 9.0%
Actual Data:		-1.9% to 7.9%	

4. Simulated Quarter-to-Quarter Changes in the Short-Term Interest Rate (percentage points)

Rule	95% Confidence Limits		
Intermediate Target/Instrument	Proportional Only	Proportional and Derivative	Derivative Only
Nominal GDP/Interest Rate	(α=0.75, β=0.00)	(α=0.25, β=0.50)	(α=0.00, β=0.50)
Keynesian Model	-8.3% to 8.6%	-3.7% to 3.8%	-1.1% to 1.3%
VECM	Explosive	-2.5% to 2.7%	-0.9% to 1.1
M2/Interest Rate	(α=0.75, β=0.00)	(α=0.60, β=0.25)	(α=0.00, β=0.50)
Keynesian Model	-5.7% to 6.0%	-3.0% to 3.0%	-0.8% to 0.9%
VECM	Explosive	-3.5% to 3.7%	-0.6% to 0.7%
Actual Data:		-2.0% to 2.0%	

APPENDIX A: MACROECONOMIC MODELS

We employed two alternative sets of assumptions about the structure of the economy: a Keynesian (or Phillips-curve) model and a vector autoregression (VAR) or vector error correction model (VECM). As will become apparent, the models are not attempts to describe the structure of the economy as precisely as possible. Rather, the Keynesian model incorporates the fundamental features of this macroeconomic paradigm. The VAR/VECM system is an atheoretic model that captures the statistical relations among various macroeconomic time series. These models are meant to illustrate the basic nature of the responses of the economy to the implementations of the monetary policy rules tested.

All of the equations below are estimated over 1960.1 to 1989.4. The variables in the regressions below are defined as follows:

b	=	log of monetary base (adjusted for reserve requirement changes)
cc	=	1 in 1980.2, and 0 elsewhere
g	=	log of government purchases
$m2$	=	log of M2
mm	=	1 in 1983.1 and 0 elsewhere
p	=	log of GDP deflator
R	=	3-month treasury bill rate
T	=	time trend; y = log of real GDP
x	=	log of nominal GDP
y'	=	log of real GDP trend

Keynesian Model

The Keynesian, or "sticky price" model, consists of four equations. First, the real aggregate demand equation embodies the direct effects of monetary and fiscal policy on macroeconomic activity. In one version, it specifies the growth rate of real GDP as a function of current and lagged growth rates of the real monetary base, real government spending, and its own lagged values:

$$\text{(A.1)}\quad \Delta y_t = \underset{(4.45)}{0.0045} + \underset{(2.06)}{0.17}\,\Delta y_{t-1} + \underset{(4.41)}{0.47}\,(\Delta b_{t-1} - \Delta p_{t-1}) + \underset{(2.52)}{0.016}\,\Delta g_t - \underset{(-2.52)}{0.016}\,\Delta g_{t-1}$$

$$R^2 = 0.21$$
$$SEE = 0.0083$$
$$Q = 21.34$$
$$D.F. = 116$$

An alternative version uses M2 as the monetary policy variable:

$$(\text{A.1}')\ \Delta y_t = \underset{(3.18)}{0.0033} + \underset{(1.84)}{0.15}\ \Delta y_{t-1} + \underset{(5.09)}{0.41}\ (\Delta m2_{t-1} - \Delta p_{t-1}) + \underset{(2.36)}{0.14}\ \Delta g_t - \underset{(2.36)}{0.14}\ \Delta g_{t-1}$$

$$R^2 = 0.25$$
$$SEE = 0.081$$
$$Q = 27.26$$
$$D.F. = 116$$

The supply side of the Keynesian model is a simplified Phillips curve, which embodies the essential "sticky price" characteristic of the paradigm. It specifies that the current inflation rate depends on past inflation and the gap between actual and full-employment real GDP $(y - y^f)$. Theory suggests that the coefficients on lagged inflation should be constrained to sum to 1, thus ensuring that, in steady state, real GDP will be equal to its full-employment level, and inflation will be constant. However, the data over the sample period used reject this restriction at the 3.3 percent marginal significance level. Our basic model does not incorporate this restriction, but we also show results in which it is imposed.

$$(\text{A.2})\ \Delta p_t = \underset{(1.89)}{.0014} + \underset{(2.78)}{0.022}\ (y_t - y_t^f) + \underset{(3.02)}{0.28}\ \Delta p_{t-1} + \underset{(3.20)}{0.30}\ \Delta p_{t-2} + \underset{(2.72)}{0.25}\ \Delta p_{t-3} + \underset{(0.58)}{0.05}\ \Delta p_{t-4}$$

$$R^2 = 0.70$$
$$SEE = 0.0037$$
$$Q = 22.05$$
$$D.F. = 113$$

$$(\text{A.2}')\quad \Delta p_t = \underset{(2.62)}{0.021}\ (y_t - y_t^f) + \underset{(3.44)}{0.32}\ \Delta p_{t-1} + \underset{(3.51)}{0.33}\ \Delta p_{t-2} + \underset{(2.98)}{0.28}\ \Delta p_{t-3} + \underset{(0.86)}{0.07}\ \Delta p_{t-4}$$

RESTRICTION : In $\sum_{i=1}^{4} \delta_i \Delta p_{t-i}$, $\sum_{i=1}^{4} \delta_i = 1$. $F(1,113) = 4.63$.

$R^2 = 0.69$
$SEE = 0.0038$
$Q = 23.20$
$D.F. = 115$

Equation (A.3) defines y^f, the log of full-employment real GDP, as the fitted values of a log linear time trend (T) of real GDP. This equation incorporates the idea, common to Keynesian models, that real GDP is trend stationary.

$$\text{(A.3)} \qquad y^f_t = \underset{(846.15)}{7.56} + \underset{(98.9)}{0.007928}\, T_t$$

$R^2 = 0.97$
$SEE = 0.0045$
$Q = 1662.32$
$D.F. = 119$

To test for the robustness of the results under a unit root in real GDP, we also estimate the following equation:

$$\text{(A.3')} \qquad \Delta y_t = \underset{(4.00)}{0.0051} + \underset{(2.56)}{0.24}\, \Delta y_{t-1} + \underset{(1.50)}{.014}\, \Delta y_{t-2}$$

$R^2 = 0.065$
$SEE = 0.0091$
$Q = 27.31$
$D.F. = 116$

Equations (A.4) and (A.5) represent the financial sector of the model, respectively defining the demands for the monetary base and M2 as functions of the aggregate price index, real GDP and a short-term nominal interest rate. As in Miller (1991), we find that M2 is cointegrated with these arguments, whereas the base is not. Thus the base demand equation is specified in first differences, while the M2 demand equation has an error correction form.

$$\text{(A.4)} \quad \Delta b_t - \Delta p_t = \underset{(0.42)}{0.00029} + \underset{(1.15)}{0.064}\, \Delta y_{t-1} + \underset{(3.40)}{0.17}\, \Delta y_{t-2} - \underset{(-7.86)}{0.42}\, \Delta R_{t-1} + \underset{(7.61)}{0.50}\, (\Delta b_{t-1} - \Delta p_{t-1})$$

$R^2 = 0.54$
$SEE = 0.0050$
$Q = 22.83$
$D.F. = 115$

TABLE A.1

Marginal Significance Levels of Dependent Variables

	Δy	Δp	ΔR	Δb
Δy	.509	--	.000332	--
Δp	.018	.000	.168	--
ΔR	.00192	.0152	.898	.000
Δb	.666	.0366	--	.000
R^2	0.36	0.71	.039	.063
SEE	0.0080	0.0036	.0077	0.0035
Q	26.55	26.60	43.18	27.85
D.F.	101	109	102	110

The VAR embodies no theoretical restrictions and therefore is agnostic about the structure of the economy. In simulating this model with the nominal GDP/Base rule, the estimated equation for the base was replaced by equation (3) defining the policy rule. This produced:

Nominal GDP/Monetary Base Simulation:

Equation 1, together with the VAR equations for y, p and R.

To evaluate the rules in equations 1 and 2, which use the interest rate as the instrument, we incorporated the following variables: real GDP, the price level, M2, and the treasury bill rate. In this case, the Johansen-Juselius tests detected one cointegrating vector, which was statistically significant in the M2 and price equations. Given the signs and magnitudes of the coefficients in this vector, it appears to be a money demand equation. Moreover, the Johansen-Juselius test failed to reject the hypothesis that the coefficients on y, p and $m2$ were equal. The estimation results are summarized in Table A.2.

In simulations to evaluate equations 1 and 2, the interest rate equation above was replaced by the rule. This yielded:

Nominal GDP/Interest-Rate Simulation:

Equation 1, together with VECM equations for y, p and R.

M2/Interest-Rate Simulation:

Equation 2, together with VECM equations for y, p and R.

$$(A.5)\ \Delta m2_t = \underset{(-2.49)}{-0.079} - \underset{(-3.27)}{0.89}\ m2_{t-1} + \underset{(3.27)}{0.89}\ p_{t-1} + \underset{(3.27)}{0.95}\ y_{t-1} - \underset{(-3.71)}{0.14}\ R_{t-1} + \underset{(11.28)}{0.70}\ \Delta m2_{t-1}$$

$$+ \underset{(1.93)}{0.17}\ \Delta p_t - \underset{(-1.42)}{0.074}\ \Delta y_t - \underset{(-4.56)}{0.26}\ \Delta R_t - \underset{(-2.83)}{0.016}\ cc_t + \underset{(5.78)}{0.029}\ mm_t$$

$$\begin{array}{lcl} R^2 & = & 0.61 \\ SEE & = & 0.0049 \\ Q & = & 28.16 \\ D.F. & = & 110 \end{array}$$

The above equations were combined with the various feedback rules to form three simulation models that were used to generate results discussed in the text.

Nominal GDP/Interest Rate Simulation:

Equation 1, with equations A.1′, A.2, A.3 and A.4.

M2/Interest Rate Simulation:

Equation 2, with equations A.1′, A.2, A.3, and A.5.

Nominal GDP/Monetary Base Simulation:

Equation 3, with equations A.1, A.2 and A.3.

Vector Autoregression-Error Correction Models

In addition to the model just discussed, we also conducted simulations using an atheoretic framework. For the case in which the monetary base is used as the instrument, we used the following variables: real GDP, the price level, the base and the nominal short-term interest rate. Following Johansen and Juselius (1990) we tested for cointegrating vectors in this system of variables. Finding none, we estimated a VAR with all variables in first differences. We selected lag lengths using the Final Prediction Error procedure (Judge, et al., 1985). The estimation results are summarized in Table A.1.

TABLE A.2

Vector Error Correction Model

Dependent Variables

	Δy	Δp	$\Delta m2$	ΔR
y_{t-1}	--	-0.033[a] (-1.66)	0.13[a] (3.80)	--
p_{t-1}	--	-0.033[a] (-1.66)	0.13[a] (3.80)	--
$m2_{t-1}$	--	0.033[a] (1.66)	-0.13[a] (-3.80)	--
R_{t-1}	--	0.028 (0.26)	-0.11 (-3.55)	--
(Marginal Significance Levels)[b]				
Δy	.585851	.332590	.237394	.003320
Δp	.004468	.000000	.225075	.168222
$\Delta m2$	.037828	.585279	.000000	--
ΔR	.063848	.004459	.000037	.898220
R^2	0.31	0.69	0.66	0.32
SEE	0.0078	0.0036	0.0046	0.0077
Q	34.13	17.44	28.60	43.18
D.F.	95	103	97	102

[a] Restriction of coefficient equality imposed.

[b] Lags chosen by Final Prediction Error procedure (Judge, et al., 1985).

APPENDIX B: SENSITIVITY ANALYSIS; 1960-1989

B.1 Rule/Instrument: Nominal GDP/Monetary Base
Model: Keynesian

	Dynamic Stability[a]	95% Confidence Limits[b] Average Inflation	Four-Quarter Real GDP Growth
1. Basic Model	107	-0.4% to 0.3%	-3.4% to 10.0%
Modifications			
2. (A.2′):			
ln $\sum_{i=1}^{n} \delta_i \Delta p_{t-i}$, $\sum_{i=1}^{n} \delta_i = 1$	80	-1.1% to 0.4%	-8.9% to 12.6%
3. (A.2):			
One lag of Δp_N	107	-0.4% to 0.3%	-6.0% to 12.7%
Eight lags of Δp_N	107	-0.3 to 0.3	-2.8 to 9.6
4. (A.2):			
$\partial\Delta p/\partial\Delta(y-y^f)$			
+ 2σ	106	-0.4% to 0.1%	-4.3% to 11.0%
- 2σ	107	-0.1 to 1.3	-3.1 to 9.8
5. (A.1):			
$\partial\Delta y/\partial(\Delta b - \Delta p)$			
+ 2σ	94	-0.4% to 0.6%	-3.7% to 10.3%
- 2σ	81	-0.5 to 0.6	-9.9 to 11.0
6. (A.3):			
Use (A.3′)	107	-0.4% to 0.2%	-3.6% to 10.0%

[a] This column reports the number of combinations of α and β that produced dynamically stable simulations out of a total of 107 combinations tried.

[b] Simulations use $\alpha = 0.50$ and $\beta = 0.00$.

B.2 Rule/Instrument: Nominal GDP/Interest Rate
Model: Keynesian

		95% Confidence Limits[b]		
	Dynamic Stability[a]	Average Inflation	Four-Quarter Real GDP Growth	One-Quarter Interest Rate Change
1. Basic Model	82	-1.3% to 0.9%	-6.3% to 19.7%	-3.7% to 3.8%
Modifications				
2. (A.2'):				
In $\sum_{i=1}^{n} \delta_i \Delta p_{t-i}$, $\sum_{i=1}^{n} \delta_i = 1$	14	Explosive	Explosive	Explosive
3. (A.2):				
One lag of Δp_N	77	-1.4% to 2.0%	-26.5% to 23.8%	-6.5% to 7.1%
Eight lags of Δp_N	77	-0.6 to 1.0	-5.7 to 10.3	-2.5 to 3.0
4. (A.2):				
$\partial \Delta p / \partial (y - y')$				
$+ 2\sigma$	70	-1.4% to 3.0%	-38.3% to 17.5%	-6.0% to 6.8%
$- 2\sigma$	81	-0.5 to 1.6	-3.9 to 11.5	-2.4 to 3.1
5. (A.1):				
$\partial \Delta y / \partial (\Delta b - \Delta p)$				
$+ 2\sigma$	38	-0.7% to 0.6%	-7.5% to 15.4%	-2.7% to 3.2%
$- 2\sigma$	95	-1.2 to 2.7	-13.4 to 12.4	-5.6 to 6.3
6. (A.4):				
$\partial (\Delta b - \Delta p) / \partial \Delta R$				
$+ 2\sigma$	49	-1.5% to 1.4%	-8.4% to 19.7%	-4.7% to 5.2%
$- 2\sigma$	101	-1.0 to 0.7	-5.7 to 15.8	-3.1 to 3.2
7. (A.3):				
Use (A.3')	72	-1.1% to 0.8%	-9.1% to 16.1%	-3.8% to 4.0%

[a] This column reports the number of combinations of α and β that produced dynamically stable simulations out of a total of 107 combinations tried.

[b] Simulations use $\alpha = 0.25$ and $\beta = 0.50$.

B.3 Rule/Instrument: Nominal GDP/Interest Rate
Model: Keynesian; Derivative Control Only

	Dynamic Stability[a]	95% Confidence Limits[b] Average Inflation	Four-Quarter Real GDP Growth	One-Quarter Interest Rate Change
1. <u>Basic Model</u>	7	-2.3% to 4.9%	-1.3% to 8.2%	-1.1% to 1.3%
<u>Modifications</u>				
2.(A.2′):				
$\ln \sum_{i=1}^{n} \delta_i \Delta p_{t-i}, \sum_{i=1}^{n} \delta_i = 1$	1	-6.6% to 6.3%	-2.6% to 11.7%	-1.8% to 1.8%
3. (A.2):				
One lag of Δp_M	7	-1.9% to 4.9%	-2.2% to 8.9%	-1.4% to 1.7%
Eight lags of Δp_M	7	-1.9 to 5.2	-2.7 to 9.3	-1.0 to 1.3
4. (A.2):				
$\partial \Delta p / \partial (y-y')$				
$+ 2\sigma$	7	-2.9% to 4.2%	-1.7% to 8.2%	-1.3% to 1.5%
$- 2\sigma$	7	1.0 to 5.7	-1.5 to 7.2	-0.8 to 1.5
5. (A.1):				
$\partial \Delta y / \partial (\Delta b - \Delta p)$				
$+ 2\sigma$	5	-0.7% to 4.8%	-2.3% to 9.3%	-1.0% to 1.5%
$- 2\sigma$	8	-4.3 to 5.3	-0.9 to 7.4	-1.3 to 1.3
6. (A.4):				
$\partial (\Delta b - \Delta p) / \partial \Delta R$				
$+ 2\sigma$	8	-2.4% to 6.3%	-8.0% to 3.3%	-1.1% to 1.5%
$- 2\sigma$	6	-1.6 to 4.0	-1.7 to 8.3	-1.1 to 1.3%
7. (A.3):				
Use (A.3′)	7	-2.0% to 4.9%	-1.9% to 8.1%	-1.1% to 1.4%

[a] This column reports the number of values of β that produced dynamically stable simulations out of a total of 8 trials.

[b] Simulations use $\sigma = 0.00$ and $\beta = 0.50$.

B.4 Rule/Instrument: Nominal GDP/Interest Rate
Model: Vector Error Correction

	Dynamic Stability[a]	95% Confidence Limits[b]		
		Average Inflation	Four-Quarter GDP Growth	One-Quarter Interest Rate Change
1. Basic Model	21	-1.0% to 2.5%	-11.7% to 19.8%	-2.5% to 2.7%
Modifications				
2. ΔM2 Equation: Coefficients on M2, p and y				
+ 2σ	10	-0.8% to 5.1%	-49.7% to -3.8%	-2.3% to 3.6%
- 2σ	13	-6.4 to -1.6	42.2 to 199.2	-8.5 to 6.3
3. Δp Equation: Coefficients on M2, p and y				
+ 2σ	0	Explosive	Explosive	Explosive
- 2σ	14	-3.0% to 0.1%	-79.9% to 11.6%	20.4% to 21.2%
4. ΔM2 Equation: Coefficient on R				
+ 2σ	7	-5.0% to 3.3%	3.4% to 40.8%	-3.0% to 2.5%
- 2σ	17	-1.3 to 1.9	-23.9 to 33.0	-4.0 to 4.0

[a] This column reports the number of combinations of α and β that produced dynamically stable simulations out of a total of 107 combinations tried.

[b] Simulations use $\alpha = 0.25$ and $\beta = 0.50$.

B.5 Rule/Instrument: Nominal GDP/Interest Rate
Model: Vector Error Correction; Derivative Control Only

	Dynamic Stability*	95% Confidence Limits: Average Inflation	95% Confidence Limits: Four-Quarter GDP Growth	95% Confidence Limits: One-Quarter Interest Rate Change
1. Basic Model	7	-0.3% to 3.1%	0.6% to 10.2%	-0.9% to 1.1%
Modifications				
2. ΔM2 Equation: Coefficients on M2, p and y				
+ 2σ	8	8.8% to 12.5%	2.1% to 11.3%	-0.4% to 1.6%
- 2σ	8	-5.1 to -2.2	-2.2 to 7.9	-1.2 to 0.8
3. Δp Equation: Coefficients on M2, p and y				
+ 2σ	0	Explosive	Explosive	Explosive
- 2σ	8	-6.4% to -3.4%	-0.7% to 8.4%	-1.3% to 0.8%
4. ΔM2 Equation: Coefficient on R				
+ 2σ	8	4.4% to 8.9%	-2.0% to 7.0%	-0.6% to 1.4%
- 2σ	8	-1.0 to 2.2	-0.6 to 9.4	-1.0 to 1.0

* This column reports the number of values of β that produced dynamically stable simulations out of a total of 8 trials.

APPENDIX C: USING THE MONETARY BASE AS AN INSTRUMENT

The monetary base has two components, bank reserves and currency in the hands of the public. Historically, the Federal Reserve has pursued a policy of allowing the public to determine freely how much currency it wishes to hold. This policy assures that the "price" of currency in terms of other forms of money (bank deposits) is always unity, which simplifies transactions. In recent years, the proportion of the total base that consists of currency has risen, as a result both of the reduction and eventual removal of reserve requirements on deposits that do not function as transactions balances, and of the rising demand for U.S. currency abroad. Currently, some 84 percent of the base is held in the form of currency, compared to around 63 percent in the fifteen years prior to 1975. This change in the composition of the base raises two potential problems.

First, the preponderance of currency means that control of the total base really amounts to operating on a relatively small component of it (bank reserves), which might pose operating difficulties. Hafer, Haslag and Hein (HHH), 1992, argue that it might be impossible to implement a base-instrument feedback rule of the type defined by equation 1, because the change in the base required to attain zero inflation could imply negative bank reserves.

The HHH reasoning seems to go as follows. In order for inflation to be zero, nominal GDP must grow at the trend rate of growth or real GDP, which is taken to be 0.00739 per quarter (this estimate was taken from McCallum (1988b). HHH estimate an aggregate demand curve, which expresses growth rates in nominal GDP as a function of a constant and growth in the base. This equation implies that if nominal GDP is to grow at the assumed trend rate, the base would have to decline at a rate of 0.087 per quarter. At the same time, with real GDP growing, the public's demand for currency is likely to grow at some positive rate. Since reserves are only a small percentage of the base, the combination of a decline in the total base and an increase in the currency stock implies that reserves would soon become zero or even negative, which clearly is impossible. Hence, HHH conclude that the feedback rule could not be implemented with a base instrument if currency were supplied elastically.

The problem with this analysis is that the figure used for the long-run (non-inflationary) growth rate of real GDP (0.00739 per quarter) apparently is based upon data covering 1954 to 1985,* whereas the aggregate demand curve is estimated over 1955-69, when average real GDP growth was much higher. It appears to be the inconsistency in these two figures that leads to the implication that the base would have to decline under the feedback rule.

We have produced simulations of the base using the Keynesian model described in Appendix B, in combination with the feedback rule defined in equation 1 in the text. In this exercise, we used the same sample period to estimate the aggregate demand function and to define the growth rate of potential GDP. Using the stochastic simulation technique described in the text, we generated 500 25-year stochastic simulations beginning in 1990. We assumed that the target for the growth of nominal GDP was gradually reduced from the rate prevailing in 1988-89 until it reached the growth rate of potential real GDP five years later. The nominal GDP target grew at the real potential GDP growth rate for the remainder of the 25 year simulation period. We constructed a 95 percent confidence interval for the base from these stochastic simulations. average annual growth rates of the upper and lower bounds of this

* This figure is the same as the one used in McCallum (1988b), which is based upon that data sample.

interval were 3.53 and 0.64 percent, with a midpoint of 2.1 percent.

Since the model used for this simulation does not involve an interest rate, we cannot split the base into its currency and reserves components. It certainly is possible that reserves would decline during the transition from a positive inflation rate to zero, especially if the base were to grow at the lower bound of its 95-percent confidence interval. However, since presumably the demands for both reserves and currency have positive income elasticities, they both would have to grow in steady state when interest rates are constant. Thus as long as the level of reserves did not reach zero during the transition period, it should be feasible to implement the rule with a base instrument while accommodating the public's demand for currency.

It is possible that in certain cases the degree of tightness during the transition period could be limited by the level of reserves. However, if this were to occur, the length of the transition period from positive to zero inflation could be lengthened to accommodate this constraint. Thus, we conclude that this problem is probably less serious than HHH suggested.

The second problem associated with the change in the composition of the base is that it may have caused the demand for the aggregate to become unstable -- either in levels or growth rates. Although, it appears clear that financial and regulatory changes have caused permanent *level* changes in this demand, the evidence for a change in the steady state *growth rate* is less compelling. We have examined the stability of the base demand equation used in our simulations (see Appendix B). This equation is estimated in log changes. Using Monte Carlo methods to generate the appropriate critical values to test for a break over 1960.1 to 1991.4, our tests failed to reject stability at the 10 percent marginal significance level over this period.[8] The most likely point for a break is 1989.1, when the marginal significance level reaches 12 percent. At all other times it is above 25 percent.

It should be emphasized that concern over possible instability in the demand for the base (in levels or growth rates) raises less serious concerns about its use as an *instrument* than they would if the base were proposed as an *intermediate target*. A base rule will continue to push the economy toward the desired long-run position as long as the link between the instrument and the target remains *qualitatively* the same, even if it changes *quantitatively*. Moreover, two features of the rules under investigation tend to mitigate the adverse effects of instability in base demand. First, the rules we examine below include a term capturing the recent growth rate of base velocity. This term causes the central bank to respond automatically to gradual movements in the relationship between base growth and nominal GDP. Second, under a feedback rule, shifts in base velocity are automatically offset by policy. For example, if base velocity unexpectedly rises, nominal GDP will rise relative to the target, which will induce a contraction in base growth under the rule. This contraction will offset the velocity shift and so tend to bring nominal GDP back to its target.

[8] Christiano (1988) used a similar technique to test for a break in GNP.

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CONTROLING INFLATION WITH AN INTEREST RATE INSTRUMENT:
A COMMENT

Evan F. Koenig[1]

Monetary policy rules of the type considered by Judd and Motley specify a target and an instrument. The monetary authority adjusts the instrument in response to deviations of the target variable from its desired path. The instrument must be under the tight control of policymakers and must be predictably related to the target. The target must be readily observable and reliably linked to some measure or measures of economic well-being. In their current paper, Judd and Motley consider two alternative target variables—nominal gross domestic product (nominal GDP) and nominal M2—and two alternative instruments—the monetary base and the federal funds rate. Earlier papers by Bennett McCallum (1990) and Judd and Motley (1991) have compared the performance of rules based on nominal-GDP targets to the performance of rules based on price-level targets. I will begin with some comments on issues that arise out of this earlier literature. Later, I will discuss the appropriate strategy for choosing a policy instrument and the potential role of M2 in the policy-making process.

PRICE-LEVEL STABILITY OR ZERO INFLATION?

Changes in the rate of money growth do not appear to have important long-run effects on the path of real output. Whether one wants to include a measure of real output as a target variable governing the direction of monetary policy, then, depends upon whether or not one believes changes in the money supply have a significant near-term impact on economic activity. Those who believe that the near-term impact of money-supply changes is negligible—or who, like Barro (1986), believe that money-supply changes affect real activity only by interfering with the smooth working of the private economy—typically favor a price-level target. On the other hand, those who take traditional Keynesian models seriously tend to favor a nominal income target. Nominal-income targeting attaches equal weights to the

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1. Federal Reserve Bank of Dallas. John Duca and Jerry O'Driscoll provided helpful comments.

price level and real output as guides to the direction of monetary policy. Simulations suggest that policy rules that target nominal income stabilize inflation nearly as well as rules that target the price level directly. Further, if the economy is assumed to be Keynesian, nominal-income targeting yields a smoother path of real output than does price-level targeting.

Stabilizing inflation is not the same thing as stabilizing the price level, and the desirability of nominal-income targeting has been questioned on the grounds that if real output is not trend-stationary, then targeting a deterministic path for nominal GDP will give rise to a non-stationary price level (Haraf 1986).

I want to suggest that nominal-income targeting may be preferable to price-level targeting, even in a world where wages and prices are completely flexible—so that the usual motivation for a Keynesian analysis is missing—and even in a world where output is subject to permanent supply-side shocks—so that nominal-income targeting yields a non-stationary price level. Briefly, my argument is that price-level targeting substantially increases the vulnerability of a real-business-cycle world to the disruptive effects of financial crises.

For concreteness, suppose that the full-employment level of output falls by one-third. Assuming no Keynesian wage or price rigidities, the usual story would be that actual output also falls by one-third, independent of any action that the monetary authority might or might not take. If the monetary authority chooses to maintain a constant price level, nominal income declines by one-third, matching the decline in output.

Consider the impact of these events on borrowers and lenders. Lenders are completely insulated from the output shock, in the sense that the real value of payments on existing loans is entirely unaffected, so that someone deriving all of her income from interest would not see any change in her standard of living. For borrowers, the situation is quite different. The nominal and, hence, the real value of home-mortgage, auto-loan, credit-card, and other obligations is unchanged. Borrowers' discretionary incomes—the incomes they have available to purchase current output—must, therefore, absorb the full force of the declines in borrowers' gross incomes. For example, an individual who had been devoting 50% of his gross income to fixed obligations would see his discretionary income fall to only one-third of its pre-shock level. A sufficiently large adverse supply shock could easily drive the discretionary income of some borrowers to **zero**. In any case, if aggregate income falls by one-third, but lenders' living standards are unchanged, then the living standards of borrowers must fall by **more** than one-third.

In much the same way, the real-income **gains** resulting from a **positive** supply shock accrue only to borrowers. In general, borrowers bear all the risk related to supply shocks. Lenders bear none of the risk.

While, in theory, it ought to be possible to reallocate risk by making debt contracts contingent upon aggregate supply shocks, such contingencies are rarely observed in practice. Typically, borrowers are offered concessions only if they are facing severe financial distress. Then, loan payments are merely rescheduled, not forgiven. Even rescheduling is difficult to arrange when multiple lenders are involved. In any case, one benefit of price-level stability is supposed to be a **simplification** of debt contracts. If under a price-level-stabilization rule debts must be indexed to real output, this purpose has been defeated.

As a practical matter, then, adverse supply shocks are likely to hit borrowers disproportionately hard under a price-level-stabilization rule. A series of adverse shocks might well drive borrowers into default, threatening the solvency of financial intermediaries and, so, disrupting capital formation and production. Such disruptions are more likely the larger and more highly autocorrelated are deviations of potential output away from trend. So, it is precisely in a real-business-cycle world—where supply shocks are large and have a substantial permanent component—that the negative side effects of price stability are the greatest threat.

In general, an adverse supply shock has much the same effect on the financial health of an economy with a stable price level as a comparably sized deflation has on the financial health of an economy with a constant level of potential output.

Under nominal-income targeting—unlike price-level targeting—the real impact of supply shocks is distributed evenly between borrowers and lenders. A one-third decline in potential real GDP is accompanied by a one-third increase in the price level. Consequently, the real value of debt obligations and interest payments also declines by one-third. Borrowers are less likely to be pushed into default than under a price-level-stabilization rule, and the financial system is less likely to undergo stress.

A minor variation on nominal-income targeting—nominal-consumption targeting—has a nice intuitive rationale. If utility is logarithmic in consumption, then holding the nominal value of consumption constant is equivalent to holding the marginal-utility value of money constant.[2] I find this definition of price-level stability to be more attractive than the conventional definition, which holds constant the value of money measured in units of output.

Interestingly, the consumption-capital-asset-pricing model (consumption-CAPM) suggests that nominal interest rates would be constant if nominal-consumption targeting were successfully implemented.[3] Empirically, the consumption-CAPM seems to perform better at intermediate and long time horizons than at short time horizons, so we could probably expect a nominal-consumption-targeting rule to stabilize intermediate-term and long-term interest rates more than short-term rates.

To recap, I don't think one has to believe that output is trend-stationary or that prices are sticky in order to believe that some variant of nominal-income targeting is desirable. Even if most recessions have their roots in supply-side shocks, the actions of the Federal Reserve influence how such shocks are propagated through the financial markets and, so, help determine whether the real impact of the shocks is amplified by the disruption of credit relationships. Financial crises have historically been an important contributing factor to the most severe of our economic downturns, and the elimination of these crises was one of the principal motivations for

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2. The marginal-utility value of money is $u'(c)/p$, where c is consumption, p is the price level, and $u(\cdot)$ is the utility function. Assuming logarithmic utility, $u'(c)/p = 1/(p \cdot c)$.

3. According to the consumption-CAPM, the utility derived from spending a dollar today must equal the expected utility derived from saving that dollar and spending the proceeds tomorrow. Thus,

$$u'(c(t))/p(t) = E[u'(c(t+1))/p(t+1)](1 + R(t))/(1 + \rho),$$

where $R(t)$ is the nominal interest rate and ρ is the rate of time preference. With logarithmic utility, this condition becomes

$$1 + R(t) = (1 + \rho)/E[p(t)c(t)/(p(t+1)c(t+1))].$$

So, $R(t) = \rho$ if people expect the ratio of current spending to future spending to equal unity, and, more generally, the nominal interest rate is constant if people expect the ratio of current consumption spending to future consumption spending to be held fixed.

establishing the Federal Reserve System.

INSTRUMENTS AND INDICATORS

I have argued that, in selecting a **target** variable, one should use an analytical framework that distinguishes between borrowers and lenders. Likewise, in comparing the performance of various **instruments** it is essential that one distinguish between inside money and outside money, between currency and reserves, between periods of regulated and periods of deregulated deposit interest rates, and between long-term and short-term interest rates.

A distinction between currency and bank reserves is made necessary by the Federal Reserve's commitment to provide currency on demand. As Hafer, Haslag, and Hein (1992) have pointed out, when combined with a feedback rule for the monetary base, the Federal Reserve's commitment to providing currency on demand can lead to a squeeze on bank reserves. If banks face a binding ceiling on deposit interest rates, any squeeze on their reserves would force a sharp curtailment in lending. Without a ceiling, deposit interest rates would rise, putting upward pressure on the general level of rates. These effects can only be satisfactorily analyzed using a model that includes both inside and outside money and that allows, historically, for a binding Regulation Q.

Long-term interest rates affect investment, short-term interest rates are the rates most directly subject to Federal Reserve control, and the spread between short-term and long-term rates is closely related to the opportunity cost of holding inside money. Consequently, one cannot really hope to adequately model the interplay between the real and financial sectors—or to say anything convincing about the merits of one policy instrument compared with another—without carefully modeling the relationship between long-term and short-term interest rates. Among other things, this means recognizing that long-term rates are a weighted average of current and expected future short-term rates. If one models long-term rates as a weighted average of current and **past** short rates, one is leaving oneself open to the Lucas critique.

Before concluding, let me touch upon the potential usefulness of M2 as a target for monetary policy. A case for M2-targeting can be based upon M2's historical tendency to lead movements in income and upon M2's availability on a monthly (even weekly), rather than quarterly, basis. Judd and Motley's analysis captures the first of these considerations but ignores the second.[4] My own suspicion is that M2 is probably best viewed as an indicator variable or supplementary target variable rather than as a replacement for nominal income in the policy rule. As an indicator or supplementary target, information on M2 could help guide adjustments in the Federal Reserve's chosen policy instrument between quarterly GDP reports. In view of the recent deterioration in standard models' ability to explain its movements, however, caution is required before giving M2 even this limited role.

CONCLUSION

I find the idea of an explicit policy rule appealing. The case for some variant of nominal-income targeting is stronger than has generally been recognized. Until we improve our understanding of the linkages between the real and financial sectors, however, we cannot with any confidence say which of its potential instruments the Federal Reserve should use to keep nominal spending on course. Nor can we with any confidence say what the feedback mechanism linking instrument to target should be. In asking some highly stylized macroeconomic models to shed light on the relative merits of alternative instruments and feedback rules, Judd and Motley are, in my opinion, pushing these models beyond the limits of their capabilities.

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4. See also McCallum (1990).

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NOMINAL INCOME TARGETING WITH THE MONETARY BASE AS INSTRUMENT: AN EVALUATION OF MCCALLUM'S RULE[1]

Gregory D. Hess, David H. Small and Flint Brayton [2]

Traditional long-run objectives for monetary policy are low inflation and stable growth of real output at full employment. Nominal income targeting has been proposed as a policy that would strike a reasonable balance between these two goals. Long-run inflation would be restrained by low, stable nominal income growth, and real growth on average would not be affected by the conduct of monetary policy. In the short-run, such a policy would split temporary supply shocks into price and output effects, and pursuing a nominal income target would prevent these shocks from having any long-term effect on inflation. Shocks to the aggregate demand side of the economy, from any source, would be offset by such a policy.

Indeed, Bennett McCallum has set forth an operational proposal for nominal income targeting. [3] Seeking to base his policy rule on a variable that the Federal Reserve can "control directly and/or accurately," McCallum selects the monetary base as the policy instrument.[4] His rule adjusts base growth for

1. With "Estimates of Foreign Holdings of U.S. Currency--An Approach Based on Relative Cross-Country Seasonal Variations" by Richard D. Porter.

2. The authors are, respectively: Economist, Monetary Studies; Section Chief, Monetary Studies; and Section Chief, Macroeconomic and Quantitative Studies, at the Board of Governors of the Federal Reserve System. We would like to thank Richard Porter, Brian Madigan, and George Moore for their comments and Ellen Dykes for editorial assistance. We also gratefully acknowledge the research assistance of Allen Sebrell, Ron Goettler, and Chris Geczy.

3. "Monetarist Rules in Light of Recent Experience," <u>American Economic Review Proceedings</u>, vol. 74 (1984), pp. 388-91; "Robustness Properties of a Rule for Monetary Policy," <u>Carnegie-Rochester Conference Series on Public Policy</u>, vol. 29, (Autumn 1988) pp. 173-204; and "Targets, Indicators, and Instruments of Monetary Policy," <u>Monetary Policy for a Changing Financial Environment</u>, (Washington, D.C.: American Enterprise Institute, 1990), pp. 44-70.

4. McCallum adopts the following terminology. An <u>instrument</u> variable is one that can be directly controlled, a <u>goal</u> variable is the ultimate argument of the monetary authority's preferences, a <u>target</u> is an operational guideline for proceeding from one's instruments to one's goals, and <u>indicators</u> are variables that provide information to the Federal Reserve but are not instruments, targets, nor goals.

changes in trend velocity and for deviations of nominal GNP from its targeted path.

In this paper, we explore McCallum's monetary base instrument rule in the context of several models. The first section uses two models, previously utilized by McCallum, to demonstrate the general properties of his rule and to update through 1992 the empirical support for the rule. The second section uses models that allow a significant role for interest rates in transmitting the effects of changes in the monetary base to aggregate demand. The analysis in these two sections makes two main points: (1) Shifts, or instabilities, in the structural relationship between the base and nominal GNP in the 1980s and 1990s raise questions about the efficacy of the proposed rule; and (2) The ability of McCallum's base instrument rule to control nominal output depends on the response pattern of the target variable, nominal output, to changes in the base. In the sequence of models presented, we lay out these dynamic linkages in successively more detail and examine their implications for nominal income targeting.

RE-EXAMINING MCCALLUM'S RESULTS[5]

McCallum's rule for using the monetary base as an instrument to target nominal GNP is

$$(1) \qquad \Delta b_t = \alpha - (1/N) \sum_{j=1}^{N} \Delta v_{t-j} + \lambda \, [x^*_{t-1} - x_{t-1}] \, ,$$

where: b ≡ log of the St. Louis monetary base
x ≡ log of nominal GNP
v ≡ log of the GNP velocity of the monetary base, x - b.
x^* ≡ target value of x (grows at 3 percent per year)
Δ ≡ first difference operator.

The coefficient α is chosen such that, absent influences from the other terms, the base grows at 3 percent per year (the assumed growth rate of potential real output). The second term in the rule adjusts base growth for recent trends in the GNP velocity of the

5. To make results in this section directly comparable to those presented by McCallum, we use the measure of the monetary base constructed by the Federal Reserve Bank of St. Louis and use GNP as a measure of aggregate output. In the second section we switch to GDP.

monetary base. In computing trend velocity, McCallum sets the length of averaging to sixteen quarters (N = 16). For example, if base velocity had been growing on average by 2 percent over the previous four years, growth of the base would be reduced by this amount to keep nominal GNP growing at 3 percent on average. Historical trends in base velocity that this "velocity adjustment" term would be expected to offset are shown in the upper and middle panels of chart 1. The final term of the rule adjusts base growth in response to deviations of nominal GNP from its targeted level: McCallum typically gives λ a value of 0.25.

In his evaluation of this policy rule, McCallum maintains the hypothesis that the economics profession lacks agreement on the appropriate theoretical and statistical paradigms with which to explain macroeconomic fluctuations. Consequently, he analyzes the base-instrument rule within a range of models. He simulates each model--with the base rule incorporated--subject to estimated historical shocks. The simulations are performed as "counterfactuals"-- that is, given the estimated empirical relationships among the variables of interest, what would have been the paths for these variables had the Federal Reserve followed McCallum's base instrument rule.

A Single-Equation Model of the Economy

To display its general properties, we first examine McCallum's rule in conjunction with a single-equation model of nominal income that relates contemporaneous nominal GNP growth to its lagged value and the growth of the monetary base. McCallum used this model, and we have attempted to replicate his results over the period 1954:Q1 to 1985:Q4 (see column i of table 1). Estimates for the extended time period 1954:Q1 to 1992:Q1 are reported in equation 2 and in column ii of table 1:

$$(2) \qquad \Delta x_t = \underset{(3.93)}{.008} + \underset{(4.70)}{.341}\, \Delta x_{t-1} + \underset{(2.55)}{.306}\, \Delta b_t + \mu_t,$$

$$\bar{R}^2 = .188 \qquad \text{Durbin-h} = -1.45 \qquad \text{SEE} = .0098$$

Sample period = 1954:Q1 to 1992:Q1

where SEE is the standard error of the estimate and (as throughout the paper) heteroskedasticity-robust t-statistics are reported in parentheses.[6] This model, in conjunction with the base rule, produces a root-mean-squared deviation (RMSD) of simulated nominal GNP from the targeted values of 0.0243 for the period from 1954:Q1 to 1992:Q1. This RMSD represents an increase from the value of 0.0197 reported by McCallum when the model is estimated and simulated through 1985:Q4.[7] The top panel of chart 2 displays the targeted and simulated values of nominal GNP.

More detailed observations on the model performance are evident in the middle panel of chart 2 which shows growth rates of the simulated values of nominal GNP and the monetary base, while the bottom panel shows the nominal GNP shocks that are fed into the simulation. Three observations are noteworthy. First, the short-run swings in simulated nominal GNP (dotted line, middle panel) closely follow the historical GNP shocks fed into the model (dotted line, lower panel). Accordingly, the quarterly standard deviations of simulated and actual nominal GNP growth are fairly close at 4.24 percent and 4.42 percent respectively.[8] Second, medium-term swings in nominal GNP growth are damped. For example, the standard deviation of the fourth-quarter to fourth-quarter growth of nominal GNP for the years 1955-91 was 3.55 historically and is reduced to 2.38 in the simulations. And third, the mean growth of simulated nominal GNP over the full sample is 2.91 percent per annum when using McCallum's rule, compared with 7.30 percent growth of nominal GNP observed since 1954.

The particular episodes in which the base rule smooths nominal GNP can be seen by looking first at the two-year moving average of the errors in the bottom panel of chart 2 (solid line). At first, the moving average crosses zero frequently. Subsequently, however, it tends to be positive from 1975 to 1982 and negative on balance from 1982 to 1992. Over the first period, the growth in

6. In this paper we use NIPA data from the Bureau of Economic Analysis' recent 1987-base benchmark. To date, these series go back to 1959:Q1. We extrapolate prior to this date using growth rates from the Bureau's 1982-base benchmark.

7. Using currently published data, we obtain an RMSD of 0.0196 when we attempt to duplicate McCallum's results (see column i of table 1).

8. This lack of quarter-to-quarter improvement results from the monetary base responding to deviations of nominal GNP from target with a one-quarter lag.

simulated base tends to slow (middle panel) and, as a result, the growth of simulated nominal GNP tends to stay centered around 3 percent despite the positive shocks on average. During the later period, however, nominal GNP growth is kept around 3 percent as the negative shocks to nominal GNP are offset by an increase in simulated base growth.

To show how the monetary base would have moved under the rule as compared with actual base supply, in chart 3 we compare the simulated growth of the monetary base with its historical pattern (the mean has been subtracted from each series). McCallum's rule keeps the growth of the base roughly constant through the early 1970s, in contrast to the historical experience of accelerating base growth. Then, from the early 1970s to the early 1980s, simulated base growth falls as the economy is subject to positive aggregate demand shocks. In the early 1980's simulated base growth increases as the trend in velocity growth slows. Of particular interest is 1990-91, when actual base growth spiked during the recession. A rule that simply targeted the base would have led to a tightening of policy to keep base growth on target, but McCallum's rule calls for an acceleration in the growth of the monetary base; an acceleration which tends on average to be greater than which was actually observed.

Chart 4 further illustrates this aspect of McCallum's rule which calls for sharp responses of the monetary base to changes in economic performance. Here we decompose the growth in the base called for by McCallum's rule into the sum of the contributions from the constant 3 percent (not shown), the component due to GNP targeting, and the component due to shifts in long-run velocity. The component due to GNP targeting (the solid line) fluctuates around zero, reflecting the divergences of simulated from targeted nominal GNP. As can be seen, the divergence from zero has been more pronounced in the past ten years than it was in earlier years--reflecting less success by the rule in attaining the GNP target. Furthermore, the short-run swings in base growth (dot/dash line) are driven largely by GNP targeting, whereas the broad swings in the base are driven by changes in velocity growth. In particular, the velocity effect has been relatively stable over the past two years, but the response to the movement of nominal GNP below target has caused nearly all of the acceleration in the simulated base.

A Model of Aggregate Demand and Supply

McCallum also evaluates his rule in the context of a small macro model with an aggregate demand equation and a supply side that incorporates sluggish wage and price behavior similar to that of the MPS model.[9] We present this aggregate demand/aggregate supply model (ADAS) to show that (1) as in the analysis with the single-equation model, performance of the rule deteriorates after 1985 and (2) the main source of deterioration lies in the demand side of the model--where instabilities in base demand, if they exist, would show up.

The aggregate demand curve is similar to the nominal income model above (equation 2) except that GNP and the monetary base are specified in real terms and real government expenditures are added as an explanatory variable. This real aggregate demand equation (see also column ii of the aggregate demand panel of table 2) estimated through 1992:Q1, is

$$(3)\quad \Delta y_t = \underset{(3.51)}{.004} + \underset{(3.75)}{.320}\,\Delta y_{t-1} + \underset{(0.20)}{.025}\,(\Delta b_t - \Delta p_t)$$

$$+ \underset{(2.73)}{.294}\,(\Delta b_{t-1} - \Delta p_{t-1}) + \underset{(3.52)}{.175}\,\Delta g_t - \underset{(-2.98)}{.151}\,\Delta g_{t-1} + e_{yt},$$

$$\bar{R}^2 = .208 \qquad \text{Durbin-h} = -1.03 \qquad \text{SEE} = .0086$$

Sample period = 1954:Q1 to 1992:Q1

where

$g \equiv$ the log of aggregate real government expenditures.

$y \equiv$ the log of real GNP

$p \equiv$ the log of the implicit GNP deflator.

9. For a description of the Federal Reserve's MPS model see Eileen Mauskopf and Flint Brayton, "Structure and Uses of the MPS Quarterly Econometric Model of the United States," Federal Reserve Bulletin, vol. 73 (1987), pp. 93-109; and Flint Brayton and Eileen Mauskopf "The Federal Reserve Board MPS Quarterly Econometric Model of the U.S. Economy," Economic Modelling (July 1985), pp. 170-292.

The aggregate supply side of the model has equations for nominal wages and prices. The wage equation relates the growth in nominal wages to changes in expected inflation and deviations of real GNP from potential. Our specification of this equation estimated through 1992:Q1 is

$$(4)\quad \Delta w_t = \underset{(2.91)}{.001} + \underset{(5.16)}{.230}\,(y_t - y_t^f) \underset{(-3.30)}{- .150}\,(y_{t-1} - y_{t-1}^f) + 1.0\Delta p_t^e + e_{wt}.$$

$\bar{R}^2 = .551$ Durbin-Watson = 1.59 SEE = .0047
Sample period = 1954:1 to 1992:1

where

w_t ≡ the log of the nominal wage rate

y_t^f ≡ the log of full-employment real GNP

Δp_t^e ≡ the expected rate of inflation calculated as the lagged eight-quarter moving-average of inflation.

Our specification of the inflation equation relates inflation to lagged inflation and the lagged growth in wages estimated through 1992:Q1 is:

$$(5)\quad \Delta p_t = \underset{(-1.31)}{-.001} + \underset{(7.70)}{.408}\,\Delta w_t + \underset{(3.01)}{.222}\,\Delta p_{t-1} + \underset{(6.71)}{.371}\,\Delta p_{t-2} + e_{pt}$$

$\bar{R}^2 = .720$ Durbin-h = -1.70 SEE = .0034
Sample period = 1954:Q1 to 1992:Q1

The results for equations 4 and 5 are also reported in column iv of the wage and price panels of table 2.[10] These equations are

10. Column i presents the results for a non-neutral form of the model as presented by McCallum when estimated over the sample period 1954:Q1 to 1985:Q4, and these results are extended to 1992:Q1 in column ii. Column iii presents the results for the neutral model for the sample period 1954:Q1 to 1985:Q4, and these results are extended to 1992:Q1 in column iv.

similar to ones used by McCallum, except that we constrain them to yield a long-run aggregate supply function that is neutral with respect to inflation; those used by McCallum produce a positively sloped long-run aggregate supply curve.[11] To the price equation used by McCallum, we have added the second lag of Δp. With this change in specification, neutrality cannot be statistically rejected.[12] The unrestricted sum of the coefficients on wage growth and lagged inflation is 0.928. The F-test for the restriction that the sum of the price and wage coefficients is unity has a statistic of 2.3. The restriction cannot be rejected at the 5 percent level of significance. A similar test for neutrality in the wage equation tests the hypothesis that the coefficient on the expected inflation term is unity. That coefficient is freely estimated to be 0.876, and an F-test for the restriction of the coefficient being unity has an F-statistic of 3.26. Again, the restriction cannot be rejected at the 5 percent level of statistical significance. In sum, we cannot reject neutrality, and we proceed with the above specification that embodies it.

In the top panel of chart 5, we plot targeted and simulated nominal GNP for this model when estimated and simulated over the period 1954:Q1-92:Q1. The RMSD of 0.0497 for this period is 155 percent higher than the value of 0.0195 when the estimation and simulation period is 1954:Q1-1985:Q4.[13] The bottom panel of

11. This observation should not be taken as a criticism of McCallum's specification. To reiterate, McCallum's approach was essentially agnostic. He was interested in testing the robustness of his rule in context of several models. The fact that he used a non-neutral specification does not imply that he endorsed the specification.

12. If the second lag of inflation were not included in equation 5, the Durbin-h statistic would be equal to -4.27.

13. In his comments on this paper, McCallum questions this result by trying to replicate it and showing a more limited increase in the RMSD than we show when the sample period is extended thorough 1991:Q4 --he shows an increase from .0191 to .0277. He derives this result from a modified version of his aggregate demand and supply model in which the aggregate supply curve is constrained to be vertical in the long run as it is in our model. Based on the following, we believe our results to be valid. In the aggregate demand equation, McCallum estimates a value of .1549 on the contemporaneous real base, while our estimate of .025 indicates a weaker link between the base and real output. We first replicated McCallum's estimate using his data base,

(Footnote continues on next page)

chart 5 shows the growth of simulated nominal income and the simulated base. The standard deviations of the fourth-quarter to fourth-quarter annual growth rate of actual and simulated nominal GNP are nearly the same at the values of 3.55 and 3.75 respectively.

Evidence, presented in table 3, suggests that the underlying cause for the deterioration in the model's performance as the sample is extended is a weakening of the relation between real GNP and the real base--that is, an underlying instability in the aggregate demand side of the model. Each column of the table reports, for a given estimation range and value of λ, a decomposition of the RMSD into the effects due to aggregate demand shocks (e_{yt}), aggregate supply shocks (e_{wt} and e_{pt}), and the model's stability under the rule.[14] The latter is merely the RMSD that would obtain, starting from the particular disequilibrium conditions of 1954:Q4, when the model is not subjected to shocks but is allowed to converge to the steady state using McCallum's rule for base growth.

In column i of table 3 we present the results for 1954:Q1 - 1985:Q4 when $\lambda = .25$. The aggregate demand shocks alone generate an

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(Footnote continued from previous page)
but then substituted the 1987-based NIPA measures of real GNP as discussed in footnote 6 for his 1982-based GNP figures. This substitution causes the estimated coefficient on the contemporaneous base to fall from .1549 to .0488. To measure the empirical importance of this difference in the estimates, we increased the coefficient on the real base in our model to .1549, while leaving all other parameters unchanged. In simulating this version of our model thorough 1991:Q4, the RMSD fell to .024, which is in line with the value of .0277 reported by McCallum in his comments. It appears, therefore, that differences between the 1982-based and 1987-based GNP figures, and in the resulting estimates of the coefficient on the real base in the aggregate demand equation, explains most of the difference between McCallum's and our simulation results.

For our non-neutral specification, the RMSD is 0.0193 for 1954:Q1 to 1985:Q4 and increases to 0.0321 for the estimation and simulation range 1954:Q1 - 1992:Q1. However, there are two peculiar features about this system. First, the level of simulated real GNP lies uniformly below actual real GNP through the simulation period 1954:Q1 - 1992:Q1. Second, the divergence between actual and simulated real wages widens because of the non-neutrality of the wage equation.

14. Since the RMSD is the mean of squared terms, and is therefore nonlinear, the decomposition will not necessarily sum to its total. Also, the various shocks may be correlated with one another. The decomposition was achieved by alternatively zeroing out demand and supply shocks.

RMSD of 0.0200 compared with one of only 0.0058 for the aggregate supply shocks. This difference is, in part, due to the errors that are being fed into the aggregate demand equation having a standard error of 0.0089, whereas those for the wage and price equations are considerably smaller--0.0048 and 0.0036, respectively. But still, the sum of the coefficients on the real base in the aggregate demand equation is relatively high (0.5587), and thereby the rule-induced changes in the base can stabilize aggregate demand and the model converges to its steady state rather quickly, as indicated by the no-shock RMSD of 0.0046.

Column ii of table 3 extends the estimation and simulation ranges to 1992:Q1, but keeps $\lambda = .25$. As noted above, the RMSD for all shocks becomes larger in this case. In part, this increase results from the weaker relationship between the real base and real GNP: Coefficients relating the real base to real GNP sum to 0.3182 (the contemporaneous coefficient is near zero). This is also reflected in the rise of the RMSD to 0.0158 when the economy is not subjected to shocks. The value of $\lambda = .25$ is not as effective in restoring the model quickly to equilibrium even in the absence of shocks.[15] Again, the model has a much higher RMSD when it is confronted with only aggregate demand shocks than when it is confronted with only aggregate supply shocks.

The Changing Relation Between the Monetary Base and GNP

In measuring the performance of the economy, we have followed McCallum in using the RMSD of simulated from targeted nominal GNP. But this statistic measures only the average performance over the entire sample period. If the performance over more recent years has deteriorated relative to that of earlier years, then the case for using this rule currently or in the future is correspondingly weakened.

To address this issue, for the estimation and simulation results reported in charts 6 and 7 we use a "rolling horizon" period fixed at fifteen years and we extend the analysis through 1992:Q1. As can be seen in chart 6 for the nominal income model, the RMSDs are

15. This instability may result from McCallum's selection of 1954:Q1 as the starting date for his estimation and simulation ranges or from the inclusion of the most recent time period, which weakens the relationships between real base growth and real GNP growth (as documented below). However, each of these possible explanations would fundamentally affect McCallum's methodology for evaluating his rule.

relatively low and stable until the early 1980s. Also, the coefficient linking the monetary base to nominal GNP is stable and significant. But this coefficient weakens, and the RMSD grows noticeably as the 1960s are discarded and the 1980s are added to the estimation and simulation ranges. Chart 7 presents a similar story for the ADAS model. Once more, the coefficient on the contemporaneous real base is significant only during the period from the mid-1970s until the early 1980s, at which point the coefficient on the lagged real base becomes significant.

Formal tests for a shift in the coefficient on the base are reported in column iii of table 1 for the nominal income model and in column v of the aggregate demand panel of table 2 for the ADAS model. We test whether a permanent shift in the relation between base growth and GNP growth (nominal or real) has occurred since 1982:Q1. This date is used because, as Robert Rasche has found, it marks a significant break in the growth rate of velocity in estimates of demand equations for narrow money measures.[16] For both models, a shift seems to have occurred because we can reject at the 1 percent level of statistical significance the hypothesis of excluding both an intercept shift and a slope coefficient shift for the base in 1982:Q1. Furthermore, for neither model can we reject the hypothesis that the sum of the coefficients on the base (real or nominal) in the aggregate demand equations (real or nominal) are zero after 1982:Q1. Using Chow tests for instability in all the coefficients, however, we cannot reject the hypothesis that the nominal and real aggregate demand functions are structurally unchanged after 1982:Q1. These results together suggest that, although a Chow test cannot reject that all the coefficients of the aggregate demand equations have changed, a more specific test focused on the relation between base growth and income growth (both real and nominal) finds that a substantial break has

16. Robert Rasche, "Demand Functions for Measures of U.S. Money and Debt," in Peter Hooper and others, eds., Financial Sectors in Open Economies: Empirical Analysis and Policy Issues, (Board of Governors of the Federal Reserve System, 1990). In his comments on Rasche's piece, McCallum cites work that explains the level of velocity as a function of long swings in interest rates rather than of permanent shocks to its growth rate. However, because McCallum considers aggregate demand and supply models where interest rates have been substituted out, these velocity dynamics should already be incorporated into the analysis if the model being used is the correct one.

occurred since 1982. In fact, the relation is not insignificantly different from zero.

Implications for Policymakers of the Shifting Relation Between the Base and GNP

The Monetary authority's response to economic developments is governed in McCallum's rule by two parameters; (1) the speed of response to deviations of nominal GNP from target and (2) the length of the lag used in measuring trend velocity. As we now discuss, the appropriate choice of these parameters may change as the relation between the base and nominal GDP shifts. With such shifts documented above for the last ten years, the best way to implement McCallum's general approach is less certain.

The Choice of the Monetary Authority's Response to Deviations of Nominal GNP from its Target. In general, the appropriate choice for the value of λ depends on the strength of the relation between the base and GNP, and the policymaker may need to change λ as estimates of this relation change. For example, if the relation between GNP and the base weakens, as suggested above, then to achieve a given performance of the economy, as measured by the RMSD, the policy response to deviations from target (λ) must increase.[17]

Indeed, moving the end of the estimation period for the ADAS model from 1985 to 1992 reduces the sum of the estimated base coefficients from 0.56 to 0.32, as shown in columns i and ii of table 3. To at least partially offset this decline in the link between the base and GNP, in column iii we increase the value of λ to 0.50. The value for the RMSD when the model is subjected to all shocks then drops to 0.0260--a value much smaller than the result for λ = .25 over the full sample (reported in column ii), but still 33 percent larger than the result for the original sample considered by McCallum (reported in column i). Also, when the model is subjected to no shocks, the rate at which the initial disequilibrium disappears is in line with McCallum's original results.

The Choice of Measuring Trend Velocity Shifts. Also implicit in implementing this rule is the choice of lag length in the measurement

17. An analogy is that, if the medicine is half as strong, the economy will need twice as much of it.

of velocity shifts. At one extreme, if all shifts in velocity growth are white noise, then the length of averaging changes in velocity (N) should be quite large to average out the errors and obtain a better estimate of long-run velocity growth. At the other extreme, if all changes to velocity growth are permanent, for example if velocity follows a random walk, then N should be equal to one since the most recent observation of velocity is the best predictor of its long-run value.

In chart 8, we plot the RMSD calculated over the 3-year intervals ending in the indicated year when the lag length is sixteen quarters as suggested by McCallum and when the lag length is four quarters. The two panels are for the nominal income and ADAS models when estimated over 1954:Q1 - 1992:Q1. This rolling horizon RMSD is meant to capture the marginal effect of the rule over specific time intervals. As can be seen in both panels, the choice of lag length makes a modest net difference from the early 1960s to the late 1970s.

In both panels of the chart, the sharpest increase and highest level of the RMSD when N=16, however, are realized in the years immediately following the break in the trend of velocity around 1982:Q1 that is evident in chart 1. As we have shown in chart 4 with respect to the nominal income model, during this period the velocity adjustment in the McCallum rule apparently was not quick enough to offset the shift in velocity. This is evident in that a major proportion of the increase in simulated base growth is due to GNP falling below target. In fact, the adjustment to the new trend of velocity is not completed until 1988 (see chart 4).

ANALYZING MCCALLUM'S RULE WHEN POLICY IS TRANSMITTED THROUGH INTEREST RATES

We now turn to models not utilized by McCallum and in which the transmission of monetary policy to the demand for real goods and services works solely through interest rates. We thereby test McCallum's rule for robustness across alternative demand sides much as he tested it against alternative supply-side specifications.[18]

The analysis is conducted with two models, and the examination with each serves distinct purposes. The first model is small-scale

18. Although in this paper we have used only the MPS-style supply side used by McCallum, he also evaluated his rule using real business cycle and monetary misperception supply sides.

and adds IS and LM equations to wage and price equations similar to those presented above. The model is kept fairly small so that the robustness of its performance with respect to key structural features can be examined. Of particular importance are those parameters that affect the response of short rates to the monetary base and the response of long rates to short rates. Alternative specifications of these two relations are examined.

The second model is the large-scale MPS model maintained by the Board's staff. In this model, McCallum's base instrument rule with $\lambda = .25$ leads to instrument instability. After looking at this, we examine using interest rates as the instrument to target nominal GNP in the MPS model.

A Small Macro-Model with Interest Rates

This model consists of a supply side which has wages and prices that are sticky in the short run but which is neutral with respect to inflation in the long run. On the demand side, the IS curve depends, among other variables, on the long real interest rate. These equations are presented in appendix 1 because we do not consider alternative specifications of them.

The demand side also contains the estimated base demand curve given below in equation 6 where a unitary coefficient is imposed on the log of nominal GDP, and a velocity trend that shifts in 1982:Q1 is incorporated. Therefore, the equation, in effect, models the detrended log of base velocity as a function of the Box-Cox transformation of the federal funds rate. (The Box-Cox transformation is explained below.) This shift in trend velocity, evident in chart 1, was previously documented by Rasche.[19] The estimated velocity trend before 1982 is 2 percent per year and thereafter is -0.4 percent. At a funds rate of 4 percent, the interest elasticity of base demand is 0.029.

19. Rasche, "Demand Functions for Measures of U.S. Money and Debt."

$$\text{(6)} \quad \log(\text{Base}) = -2.18 + \underset{(459)}{\log(\text{GDPN})} - \underset{(6.25)}{.027\ \text{BoxCox}(\text{RFFE})}$$

$$\underset{(47.9)}{-.005\ \text{TIME}} + \underset{(21.4)}{.006\ \text{D82T}},$$

$R^2 = .999$
D-W = .306
Std. Error = .0171
Estimation period = 1960:Q1 - 1992:Q1

where:
Base ≡ St. Louis Reserve Bank monetary base
GDPN ≡ nominal GDP
RFFE ≡ federal funds rate (effective yield)
D82T ≡ Shift in time trend, equals zero before 1982 and equal to one in 1982:Q1 and increasing by one per quarter thereafter.

Three aspects of this equation of special note are (1) its specification in terms of the levels of variables and the absence of lags of variables, (2) the shift in trend, and (3) the use of the Box-Cox transformation. First, by modeling the level of velocity as depending on only contemporaneous variables, we assume that the long-run response of base demand to a change in income or interest rates is completed in one period. This specification is advantageous to McCallum's rule in that the large contemporaneous interest elasticity helps to stabilize the model in the presence of base demand shocks--that is, smaller changes in interest rates are needed to re-equilibrate the supply and demand for the base.

An adverse effect of this specification for the simulated performance of McCallum's rule is that the estimated shocks to base demand fed into the simulation may be larger than if a more explicit dynamic specification were chosen. When such specifications were examined, the general results were that over the past ten years, when our base demand equation had its largest and most systematic errors, the errors from the alternatives were not much different from those of the chosen specification.[20] In particular, the errors from equation 6 and those from a base demand equation estimated by Rasche are compared in appendix 2, where we also present changes in U.S. currency held abroad as a possible contribution to recent base demand errors.

Second, by including a shift in the trend of velocity, the estimation errors fed into the simulation are reduced. Nonetheless, in the simulations, this shift in trend growth of base demand will be unexpected and McCallum's rule will try to accommodate it through the 16-quarter moving average of past changes in velocity.

The third aspect of the base demand equation concerns the functional form for interest rates. Two common choices are linear and logarithmic forms. Choosing the linear form has the disadvantage of allowing nominal interest rates to be negative--an outcome that can can easily occur in the zero-inflation paths in these simulations. As a major focus in simulating this model is the behavior of interest rates, this outcome seems unsatisfactory. A logarithmic specification avoids the problem. But the log specification can also lead to very high nominal rates because that specification calls for proportional changes in interest rates as shocks are fed into the simulation.

In the base demand equation 6, our chosen specification for the federal funds rate employs the Box-Cox transformation.[21] This functional form ensures that the interest rate remains positive, as would the logarithmic specification, but tempers increases in the funds rate when it is at a high level. The Box-Cox parameter is set at 0.2.[22]

With this base demand equation and with base supply set by McCallum's rule, short-term interest rates are determined. Changes in short-term interest rates are transmitted to long rates by way of equation 7. Short and long rates move together one for one in the long run, with an equilibrium spread of the long rate over the short

20. These dynamic models led to general problems of convergence of the simulations.

21. The Box-Cox transformation of the variable x is $BC(x) = (x^{\lambda}-1)/\lambda$, for $0 < \lambda \leq 1$. As λ approaches zero the Box-Cox transformation approaches the logarithm. For λ equal to one, it is a linear transformation.

22. Iterating over values of the Box-Cox parameter yields a value of 0.34 that minimizes the sum of squared errors in the base demand equation. The value of .2 was as close as we could get to this and still achieve convergence in the simulations.

rate of 100 basis points.[23] To examine the sensitivity of model simulations to the way long-rate dynamics are modeled, two alternative response patterns are entertained for short-run behavior. In the "quick" response case the full effect of the funds rate on the bond rate is contemporaneous. In the "slow" response case, a change of 100 basis points in the short rate produces current and subsequent quarterly changes in the long rate of 30, 30, 20, and 20 basis points respectively. (After analyzing this model, we make it linear in interest rates and let the bond rate depend on the one-quarter-ahead federal funds rate. The model is then solved assuming perfect foresight.)

$$(7) \quad RTB10Y_t = 1.0 + \sum_{i=0}^{3} \alpha_i \, RFFE_{t-i} \,,$$

$$\text{subject to: } \Sigma\alpha_i = 1$$

A. Quick Response	B. Slow Response
$\alpha_0 = 1$	$\alpha_0 = .3$
$\alpha_1 = 0$	$\alpha_1 = .3$
$\alpha_2 = 0$	$\alpha_2 = .2$
$\alpha_3 = 0$	$\alpha_3 = .2$

where
RFFE ≡ federal funds rate (effective yield)
RTB10Y ≡ 10-year Treasury bond rate

In moving from the nominal bond rate to the real rate that affects spending decisions, the expected inflation rate used to construct the real long-rate is set to zero in the simulations. This is consistent with McCallum's rule which achieves zero long-run inflation, even though there are short-run fluctuations in inflation associated with the shocks being fed in. This way of handling expected inflation in financial markets may be thought of as being consistent with a high degree of credibility that the McCallum rule will continue to be followed.

23. The quick adjustment specification given below and estimated over 1983:Q1 - 1992:Q1 yields a long-run intercept of 100.004 basis points. Extending the sample period back through the early 1980s would incorporate a period of oil shocks and an inverted yield curve--which presumably is not indicative of steady-state behavior.

We examine the robustness of McCallum's policy rule in the context of this model by analyzing the economy's performance under variations in two key structural components--the speed of responses of base demand and of the long rate to changes in the funds rate. In all cases, we conduct simulations by first allowing the model to settle into a steady state and then feeding in the historical shocks.[24] The behavior of the endogenous variables therefore abstracts from all problems associated with a transition to zero inflation associated with implementing the rule.

First we examine effects of the short-run dynamic response of base demand to changes in interest rates by shifting progressively more of the long-run response of base demand to interest rates from the contemporaneous response to a one-period lagged response that was added to the model. The long-run interest rate response is left unchanged--as are all other parameters and the estimated shocks that are fed into the equation. Also, to provide favorable stability conditions, we use the "quick" response of the long rate to the short rate.

When the contemporaneous response of base demand to interest rates reaches as low as 60 percent of the long-run response, swings in simulated interest rates become highly magnified relative to the case of a full contemporaneous response to interest rates. In particular, with only base demand shocks being fed into the simulation, the funds rate frequently (nine times) exceeds 20 percent in the 1960s, and peaks at 27 percent over the 1970s and 1980s and again in the 1990s. In contrast, when the long-run effect of changes in interest rates is realized contemporaneously in the base demand equation, the funds rate fluctuates between 1 percent and 7 percent during the 1960s and peaks at 10 percent in the 1970s and 1980s and at 17 percent in the 1990s.

A second check for robustness is to compare the simulation performance under quick and slow adjustments of the bond rate to the federal funds rate.[25] The results of the simulations are presented in charts 9.A - 9.G. Each chart except the last shows the behavior of

24. Because the model has long lags, its dynamics are affected by the historical values of variables just before the simulation. These dynamics, which are specific to that period, are purged from the results by putting the model into a steady state before subjecting it to shocks.

25. The base demand equation has its full interest response contemporaneously as in equation (6).

the economy when it is subjected to a particular type of shock; in the last chart, all shocks enter the simulations. Each panel of a chart shows the behavior of a given variable when the model has either the quick (solid line) or the slow (dotted line) adjustment of the bond rate to the funds rate.

From these charts one can see that the ability of the base rule to control nominal GDP growth is affected by the response speeds of long rates to short rates. If the long rate responds slowly to short rates, the resulting interest rate variability will be well in excess of historical experience--for example, the funds rate approaches 60 percent at one point in the 1990s. While the lags in the slow response were chosen to accentuate the control problem, what is of interest is the sensitivity of model performance to the way the long rate is modeled. The effect on economic performance is most pronounced for base shocks, but it is also present for IS and wage and price shocks. That volatility feeds through to, and is augmented by volatility in other variables, in particular nominal GDP growth.

The RMSDs from these simulations are not directly comparable to those of the models presented earlier because in these simulations the errors for the IS curve exist only since 1980:Q4 and the simulations start in 1960:Q1 rather than in 1954:Q1. But to give a sense of the way in which the simulations compare, the RMSD with the quick adjustment is 0.025, which is similar to the RMSDs of the earlier models in which the base directly affects aggregate demand. The RMSD increases to .043 with the slow adjusting bond rate.

We carry this analysis one step further by allowing the long rate to depend on future short rates.[26] The model is respecified to be linear in interest rates and then is reestimated. Three specifications of the long-rate equation are examined: (1) weights of 0.5 on both the contemporaneous and first lagged values of the funds rate; (2) a weight of unity on the contemporaneous funds rate; and (3) weights of 0.5 on both the contemporaneous rate and a one-quarter lead

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26. To solve the model we use the methodology developed by Gary Anderson and George Moore in "A Linear Algebraic Procedure for Solving Linear Perfect Foresight Models," Economics Letters, vol. 17 (pp. 247-52.) For a brief overview of this methodology see the appendix to "Inflation Persistence" by Jeff Fuhrer and George Moore, which was prepared for this conference.

of the funds rate.[27] An IS curve shock is used to illustrate the implications of a forward-looking long rate for the ability of the model and McCallum's rule to to stabilize the economy.[28] The behavior of interest rates and nominal and real GDP (deviations from steady-state values) are presented in charts 10.A and 10.B respectively. In both charts, the left-hand panels compare responses when the long rate reacts with a lag and when it reacts fully contemporaneously. The right-hand panels again show the case of a full contemporaneous response but compare it with the specification incorporating the forward-looking long rate.

The general conclusion from charts 10.A and 10.B is that the forward-looking rate provides a little additional smoothing of economic performance.[29] The response of that long rate to the IS shock is sharpest in the case of a full contemporaneous link between the long and short rates (chart 10.A, lower panels). With a lag in the bond rate equation, the response is delayed. The peak response of the forward-looking long rate occurs contemporaneous with the shock; but by incorporating the future decline in the funds rate, the response is not so large as in the case of the full contemporaneous response of the long rate. The paths of nominal and real GDP growth in the alternative cases generally reflect the movements of the long rate: Both are smoothed the most with forward-looking rates because of less-pronounced overshooting of GDP growth.

The dependence of economic performance--shown in Charts 9 and 10--on the manner in which long rates are modeled can be seen as either strengthening or weakening the case for the McCallum rule. The adverse implication is that if in practice rates behave in a sluggish manner then excessive variability, if not instrument instability, may

27. Because the slow response of the long rate to changes in the short rate--as specified in equation 7--is just barely stable, we do not use it.

28. The IS curve is given a one-period shock of 1 percent at an annual rate to the growth of real aggregate demand. Because that equation--A-1 in appendix 1--is an error-correction specification, there is no long-run effect on the level of demand stemming from this growth rate shock.

29. Additional smoothing owing to a forward-looking component in the long rate would be apparent if shocks in the model were positively autocorrelated. In response to a shock, the perfect-foresight solution technique used here would extrapolate the shock into the future and cause the long rate to rise in anticipation of policy's continuing to offset the shock.

well emerge. Furthermore, such sluggish behavior of long rates can be interpreted as indirectly incorporating into the model long lags in the response of spending to changes in interest rates.

A positive interpretation of these results for implementing the McCallum rule also applies to any specific rule for conducting monetary policy. The rule gives the markets a firmer basis on which to interpret changes in the federal funds and with which to form expectations of future Federal Reserve moves. Long rates could be expected to move quickly in response to those shocks that call for persistent moves by the Federal Reserve and such responses would augment these policy moves. While these results suggest that the range of interest rate fluctuations would be moderated by this response of long rates, the potential for volatility induced by the rule would still depend importantly on the strength and patterns of the intertemporal responses of base and spending demands to changes in interest rates.

Analysis Based on the MPS Model.

Although differing considerably in size, the MPS model and the model analyzed in the previous section are similar in one critical respect: The transmission of monetary actions to the rest of the economy occurs through interest rates rather than through direct effects of monetary quantities. An issue addressed in this section is the choice of the policy instrument--the monetary base or the federal funds rate--and how this choice is influenced by the nature of the monetary transmission mechanism. In general terms, the degree of control over a target variable achieved by an instrument depends on the types and magnitudes of shocks that may intervene to affect the realization of the target variable, given the instrument's selected value. [30] As discussed in the previous section, if the base is the policy instrument and monetary transmission is through interest rates, shocks to base demand affect the realized value of nominal output. Nominal output is insulated from this type of shock, however, if the

30. We assume that, even in the case of one target and one instrument, the instrument cannot be varied to offset the influence of all shocks on the target.

policy instrument is the federal funds rate.[31]

The first subsection below briefly describes the structure of the MPS model. The second subsection presents a test of two alternative views of the ways in which monetary actions are transmitted to real output. One view is labeled IR (interest rate) and is represented by the spending block of the MPS model; the other is the DM (direct money) view as specified in equation 3. The latter expresses real GNP growth as a function of lagged GNP growth, and current and lagged values of growth of the real base and real government purchases. Evidence providing some support for the IR view is reported. The final subsections present simulations of the MPS model under alternative policy rules. Compared with McCallum's proposal, the results favor the use of the funds rate as the policy instrument, rather than the base, while considerable support is found for nominal output as a policy target.

The MPS model. The MPS model, which contains roughly 125 estimated equations, 200 identities, and 200 exogenous variables, has been used at the Federal Reserve Board over the past twenty years for forecasting and analyzing alternative economic scenarios. The structure of the model is such that, in the long run, when markets clear and expectations are fulfilled, money is neutral and output is determined by aggregate supply. Short-run properties, however, are quite different: Aggregate demand largely determines the level of output, and the utilization rates of labor and capital may be either below or above their long-run equilibrium values; wages and prices adjust slowly; fiscal policy affects real output directly through the contribution of government spending to aggregate demand and less directly through the effect of tax policy on disposable income and investment incentives; changes in the supply of money affect nominal interest rates and, because inflation expectations are autoregressive, real interest rates, too. There are no direct effects of monetary

31. However, a base-instrument policy may be more effective at tempering the effects of aggregate demand shocks in the short run, because of the response of interest rates necessary to equilibrate base demand and supply. Another issue relevant to the choice of policy instrument is the temporal response of the target to a change in the instrument. Excessive instrument variability may arise if the response pattern grows in magnitude for a period of time, unless the policy rule is carefully designed.

quantities on real spending or prices.[32] Rather, changes in money move interest rates, which in turn affect spending directly as well as indirectly through the value of wealth and the exchange rate.[33]

Also important to the analysis presented below is the specification of the demand for the monetary base in the MPS model, especially the time profile of the interest elasticity of the demand for the base. For these exercises, the base is assumed to equal the currency component of M1 plus a required reserve ratio times deposits currently subject to reserve requirements--demand and other checkable deposits.[34] The structural equations for currency, demand deposits, and other checkable deposits each have estimated contemporaneous interest rate elasticities that are quite low, both in absolute size and in relation to the estimated long-run interest elasticities.[35] As illustrated earlier, the magnitude of the contemporaneous interest rate elasticity of base demand greatly affects how well a policy rule that uses the base as an instrument (or as a target, for that matter) performs if the transmission channel is through interest rates.

Finally, the temporal dynamic structure of the MPS model is much more complex than that of any of the other models examined here or by McCallum. Thus, analysis with the MPS model also provides a test of the robustness of McCallum's rule to the degree of dynamic complexity in economic models. In the models that McCallum examines, variables are expressed as growth rates and, as is typical for these types of models, the dynamic structure is rather simple. The MPS model, however, is specified in levels. This approach tends to find

32. Although wealth is a determinant of spending in the model, its influence cannot be interpreted as a real balance effect. A change in the monetary base, absent any accompanying fiscal action that alters the stock of government debt, affects the composition of wealth but not its magnitude.

33. See note 9 for references to the MPS model. In addition, the model's monetary transmission mechanism is examined in Eileen Mauskopf, "The Transmission Channels of Monetary Policy: How Have They Changed?" Federal Reserve Bulletin, vol. 76 (December, 1990), pp. 985-1008.

34. For simplicity, we exclude vault cash and excess reserves from the measure of the base used.

35. The three equations are revised versions of those reported in Moore, Porter, and Small, "Modelling the Disaggregated Demands for M2 and M1: The U.S. Experience in the 1980s," in Peter Hooper and others, editors, Financial Sectors in Open Economies: Empirical Analysis and Policy Issues (Board of Governors of the Federal Reserve System, 1990), pp. 21-105.

significant dynamic adjustments and interactions at medium and low frequencies, besides those at high frequencies.

A Test of the Monetary Transmission Channel. Because of the importance of the nature of the monetary transmission mechanism to the choice of policy instrument, regression tests using the non-nested J test are conducted to compare the IR and DM specifications.[36] The test regression employed has the form

$$\Delta y = \boldsymbol{\beta}\, X_{dm} + \alpha\, \Delta\hat{y}_{mps} ,$$

where Δy is real GNP growth, X_{dm} is the set of regressors from the DM equation 3, and $\Delta\hat{y}_{mps}$ is predicted real GNP growth from the demand block of the MPS model.[37] $\boldsymbol{\beta}$ (a vector) and α (a scalar) are coefficients to be estimated. In this form, the equation is a specification test of the DM model against the IR alternative. An estimate of α that is not significantly different from zero would be evidence that the particular representation of DM is not misspecified; an estimate significantly different from zero would indicate misspecification. Although carrying out the corresponding specification test with the IR view as the null hypothesis would be desirable, it would be quite involved, because the demand block of the MPS model is a large set of equations.

Estimates of the test regression are shown in table 4 for the period 1970:Q1-1989:Q4, the longest in-sample span over which the full

36. Davidson and MacKinnon, "Several Tests for Model Specification in the Presence of Alternative Hypotheses," Econometrica, vol. 49 (1981), pp. 781-94.

37. The latter is a time series of one-step-ahead forecasts of real GNP growth from the demand block of the MPS model. The demand block includes spending sectors (such as consumption and investment); income, employment and tax equations; and the financial sector (term structure and asset valuation equations). It excludes wage, price, and monetary sectors. Exogenous variables (aside from seasonal factors and fiscal parameters, whose values change only infrequently) are treated as stochastic with values projected using simple time series equations. The one-step-ahead simulations take the value of the federal funds rate as known. This assumption could reduce the variance of the forecasting errors if, historically, the funds rate were adjusted to offset contemporaneous shocks. Given small estimated values of contemporaneous interest elasticities in the model's spending equations, however, problems associated with endogeneity of interest rates cannot be substantial in one-step-ahead forecasts.

set of MPS equations can be simulated. The first column shows the estimates of the DM equation (that is, $\alpha = 0$). Coefficient values are similar to those estimated over other sample periods, shown above in table 2. The J test regression, column ii, estimates α to be significantly greater than zero--the point estimate is 0.60 and the t-statistic is 5.5. Moreover, the base growth coefficients in the regression are jointly insignificant. At a minimum, these results suggest that the IR demand specification in the MPS model provides an alternative to the simple DM equation that cannot be rejected.[38]

The Federal Funds Rate Versus the Base as Policy Instruments: An Illustrative Simulation. To illustrate the properties of the MPS model under alternative policy instruments, while keeping nominal output as the policy target, we conduct two simulations involving a transitory downward shock of $25 billion to real federal government purchases. One simulation incorporates McCallum's proposed base-instrument rule, but omits the velocity adjustment term because the design of the simulation precludes any permanent shifts to velocity. The other uses the federal funds rate as the policy instrument. In each case, the MPS model is adjusted so that it tracks historical values in the absence of shocks, and thus the target for nominal GDP is set equal to its historical path.[39]

In the case of McCallum's rule, instability is quickly apparent, and the model solves for only five quarters. The path for the federal funds rate is (deviations from historical values, in percentage points): -0.53, -1.06, 4.24, -6.71, and 126.40. This instability, we believe, stems from the temporal pattern of the interest elasticity of base demand in the MPS model, described above.

38. Problems with bias and serial correlation of errors are found in the one-step-ahead forecasts of the MPS demand block, however. Although not directly relevant to the present analysis, earlier work indicated that there might be a small omitted direct channel from money (M2) to wages and prices in the MPS model. See Albert Ando, Flint Brayton, and Arthur Kennickell, "Reappraisal of the Phillips Curve and Direct Effects of Money Supply on Inflation," in Lawrence R. Klein, ed., Comparative Performance of U.S. Econometric Models (Oxford University Press, 1991), pp. 201-26.

39. The simulation runs from 1985:Q1 to 1991:Q4. The magnitude of the government purchases shock is equal to 0.6 percent of the baseline value of real GDP in the quarter in which the shock is introduced (1985:Q2).

We conjecture that altering the adjustment parameter (λ) in the policy rule would be unlikely to alter significantly the simulation results. We have not attempted to see if modifications to either the rule or the model would achieve a stable result.

The same shock to government spending is well controlled by a policy that targets the level and growth rate of nominal GDP but uses the federal funds rate as the instrument. (The next section describes the specific form of the rule.) The time profiles of the funds rate, nominal GDP, and its real and price components are plotted in chart 11. The funds rate falls initially as both the level and growth of nominal GDP are below baseline. Subsequently, the growth component of the target turns positive, and pushes the funds rate above baseline for a short period. All significant deviations of the instrument and target are completed within a year or so, although small oscillations in each persist for several years.

Alternative Policy Targets. Although his research has focused on nominal GDP as the target of policy, McCallum has also reported some tests of price level targeting.[40] In this final section, we use stochastic simulations of the MPS model to evaluate the two targets he has examined--nominal output and the price level--as well as M2.[41] Because of the evidence of instability of base-instrument policies in the MPS model, the simulations take the federal funds rate as the policy instrument.

The stochastic simulation procedure used involves the repeated simulation of the model with randomly drawn additive shocks applied in each quarter to all estimated equations and more than 100 exogenous variables. Each policy analyzed is subjected to a sample of 180 twenty-quarter simulations, each differing by only the particular values of the random quarterly shocks that are applied. The shocks

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40. McCallum, "Targets, Indicators, and Instruments of Monetary Policy."

41. In this analysis, nominal output, the price level and the M2 money stock are intermediate policy targets. As discussed below, the ultimate objectives, or goals, of policy are assumed to be stabilization of the price level and real output. Metrics employed to compare different policies are measures of variability of the price level and real output.

are based on actual historical errors.[42]

For each policy, the federal funds rate, r, is adjusted in response to movements of the level and the four-quarter growth rate of the target, t_i:[43]

$$r_t = \alpha_1 \hat{t}_{i,t} + \alpha_2 (\hat{t}_{i,t} - t_{i,t-4}).$$

Values of the instrument and targets are measured as deviations from a deterministic baseline simulation. The '^' denotes that current-quarter values of targets may be estimates, depending on the information lag assumed for each target. For nominal GDP and the GDP deflator, the information lag is assumed to be one-half quarter and, in these instances, $\hat{t}_{i,t}$ is measured as the average of values in the current and immediately preceding quarters. M2 is assumed to be known contemporaneously. For each target, we use a coarse grid search to find the values of the feedback coefficients that minimize a simple policy loss function, constructed as the unweighted average of the variances of the levels of real GDP and the GDP deflator (relative to values in the deterministic baseline).[44]

Table 5 presents a summary of stochastic simulation results. To compare the ways alternative targets would perform over an extended period, we take the reported standard deviations from the fifth, and last, year of the stochastic simulations. Irrespective of whether targets are compared on the basis of standard deviations of real GDP,

42. The simulation procedure used by McCallum, and employed elsewhere in this paper, can be interpreted as one long stochastic simulation in which errors are drawn in their historical sequence. Other analyses of monetary policy rules using the MPS model and the stochastic simulation procedures described in this section are reported in Flint Brayton, William Kan, Peter Tinsley and, Peter von zur Muehlen, "Modeling and Policy Use of Auction Price Expectations," in Ralph Bryant and others, Evaluating Policy Regimes: New Research in Empirical Macroeconomics (The Brookings Institution, forthcoming), and in Flint Brayton and Peter Tinsley, "Interest Rate Feedback Rules of Price Level Targeting," unpublished manuscript, Board of Governors of the Federal Reserve System, Division of Research and Statistics, October, 3, 1991. The material in this section draws heavily on the latter reference.

43. The addition of the growth rate term was found to significantly improve the performance of the policies studied.

44. For the M2 and price level policies, however, the grid search yielded a sort of corner solution: If the policy feedback coefficients were increased beyond those reported, a substantial number of simulations failed to converge.

the GDP deflator or nominal GDP, the ranking of targets places nominal GDP first, M2 second, and price level last.[45] For the nominal GDP and M2 policies, the policy rule appears to be stable: The profile across the simulation interval of standard deviations (not shown) appears to level off in the fifth year. For the price target policy, standard deviations over the simulation horizon tend to increase by ever larger amounts, indicating that the policy is probably unstable.

The dominant performance of the nominal GDP target is relatively straightforward to explain. Nominal GDP has two advantages over an M2 target: First, it is more closely related to the assumed ultimate goals of policy--stability of the price level and of real output; And second, with an interest rate instrument, it is unaffected by shocks to money demand. It performs better than a price level because it requires the policy instrument to respond to deviations of both real output and price from their desired values. If the goal of policy is to control both types of deviations, a target that incorporates elements of each goal is likely to work better than one that does not. Moreover, direct policy responses to offset demand shocks help control prices, because output deviations are an important determinant of subsequent price movements in the MPS model and demand shocks are estimated to be quantitatively more significant than price shocks. Thus, the nominal GDP target provides better control over the price level than does a policy that targets prices directly.[46]

Besides comparing results of alternative policies with each other, we can see how well the policies work in relation to measures of historical volatility. As table 5 shows, only the policy based on the nominal GDP target has a standard deviation of the unemployment rate that is similar in magnitude to the historical variation in this series. This finding seems to imply that stationarity of the price level could be achieved with no more variability of real activity than that observed historically. However, the volatility of quarterly changes in the funds rate, under the reported nominal GDP target policy, is somewhat higher than the historical standard deviation.

45. The policy ranking also is unaffected if the policy feedback parameters are varied over a wide range.

46. This statement holds only for relatively simple policy rules, such as the one examined here. A price target policy with a much more complex dynamic structure should be able to overcome the instability found for the price target rule examined here.

CONCLUSION AND SUMMARY

This paper has examined McCallum's proposed base-instrument rule for targeting nominal output in the context of two classes of economic models. The first class specifies a direct link between the monetary base and spending. In the second, the monetary transmission mechanism operates through interest rates. Within each class, several different models are examined. The paper reaches three main conclusions:

1 The relationship between the monetary base and nominal output seems to have weakened significantly in the past decade. This weakening brings into question the ability of a policy using the monetary base as the instrument to control nominal output effectively. In the sequence of models examined, the deterioration of the link between the base and output is shown to lie mainly within the aggregate demand side of the economy, with the base demand equation exhibiting a shift in the growth rate of velocity and large errors over the past decade.

2 In models in which the transmission mechanism of monetary policy is through interest rates, the ability of McCallum's' base-instrument policy to control nominal output is found to be very sensitive to the lag structure of (a) the interest rate sensitivity of base demand and (b) the speed with which changes in short-term interest rates are transmitted to spending through long rates. In an analysis with a small model, the degree of control over nominal output that McCallum's rule achieves is comparable to that found in the models with a direct link between the base and output only if the interest responsiveness of base demand is nearly contemporaneous and if the lag between the long-term interest rate and the short-term rate is very short. Additional tests in which a forward-looking term structure is introduced show some further improvement in control.

3 In experiments with the MPS model, results favor the use of the federal funds rate as the policy instrument; the lagged responses in the model's structure are such to make McCallum's base-instrument policy unstable. With the funds rate instrument, however, considerable support is found for using nominal income as a policy target, compared with using either M2 or the price level.

Finally, we note that in his comments appearing next in this volume, McCallum indicates that he was unsuccessful in attempting to replicate some of our results. With a version of his original ADAS model that approximates our ADAS model and with his base-instrument rule, McCallum found a less severe deterioration in economic performance as the sample period is extended over the last decade. We believe our results to be correct, and in footnote 13 have discussed them in light of McCallum's comments.

1. McCallum's Nominal Aggregate Demand Function

$$\Delta x_t = \alpha_0 + \alpha_1 \bullet \Delta x_{t-1} + \alpha_2 \bullet \Delta b_t + \alpha_3 \bullet DUMM + \alpha_4 \bullet DUMM \bullet \Delta b_t + e_{xt}$$

	(i)	(ii)	(iii)
α_0	.008***	.008***	.007***
	(.002)	(.002)	(.002)
α_1	.265***	.341***	.260***
	(.082)	(.074)	(.074)
α_2	.476***	.306***	.540***
	(.135)	(.120)	(.150)
α_3			.003
			(.003)
α_4			-.496**
			(.231)
Adj-Rsq.	.219	.188	.237
SEE	.010	.010	.009
RMSD	.020	.024	.057
Durbin's h	-1.43	-1.45	-1.54
F(α:3,4)			11.72***
F(α:2,4)			0.03
Chow	.74	.67	
Est. Range	1954:1-85:4	1954:1-92:1	1954:1-92:1

Adj-Rsq.: Adjusted R-squared.
*,**,***: Significant at or below the 10 percent, 5 percent and 1 percent level, respectively.
RMSD : Root Mean Squared Deviation.
Durbin's h: Test for serial correlation with lagged dependent variables.
SEE: Standard error of the estimate.
Standard errors are heteroskedasticity consistent.
DUMM = 1 from 1982:Q1 to the end of the sample period, = 0 otherwise.
CHOW: Tests for a structural break for all coefficients in 1982:1.
F(α:3,4) is the F-test statistic for the hypothesis that $\alpha_3 = \alpha_4 = 0$.
F(α:2,4) is the F-test statistic for the hypothesis that $\alpha_2 + \alpha_4 = 0$.

2. McCallum's ADAS Model (continued on next page)

Aggregate Demand: $\Delta y_t = \delta_0 + \delta_1 \Delta y_{t-1} + \delta_2 \Delta(b-p)_t + \delta_3 \Delta(b-p)_{t-1} + \delta_4 \Delta g_t + \delta_5 \Delta g_{t-1}$
$+ \delta_6 DUMM + \delta_7\ DUMM \bullet \Delta(b-p)_t + \delta_8\ DUMM \bullet \Delta(b-p)_{t-1} + e_{yt}$

	With Non-neutral supply side		With neutral supply side		
	(i)	(ii)	(iii)	(iv)	(v)
δ_0	.004***	.004***	Same as Column (i)a/	Same as Column (ii)a/	.005*
	(.001)	(.001)			(.001)
δ_1	.263***	.320***			.268***
	(.088)	(.085)			(.083)
δ_2	.160	.025			.223***
	(.132)	(.125)			(.146)
δ_3	.398***	.294**			.408***
	(.120)	(.107)			(.135)
δ_4	.190***	.175**			.184***
	(.055)	(.050)			(.049)
δ_5	-.180***	-.151***			-.154***
	(.054)	(.051)			(.048)
δ_6					-.001
					(.001)
δ_7					-.564**
					(.218)
δ_8					-.067
					(.213)
Adj-Rsq.	.259	.208			.250
SEE	.009	.009			.010
Durbin's h	-1.02	-1.03			-1.11
F(δ:6,7,8))					3.76***
F(δ:2,3,7,8))					.50
CHOW	.54	.60			.60
RMSD	.019	.032	.019	.050	.056
Est. Range	1954:1-85:4	1954:1-92:1	1954:1-85:4	1954:1-92:1	1954:1-92:1

a/ The models of columns iii and iv differ from those of columns i and ii respectively in terms of their wage and price equations.
*,**,***: Significant at or below the 10%, 5% and 1% level, respectively.
RMSD: Root Mean Squared Deviation for the full model.
Standard errors are heteroskedasticity consistent.
DUMM = 1 from 1982:1 to the end of the sample period, = 0 otherwise.
CHOW: Tests for a structural break for all coefficients in 1982:1.
F(δ:6,7,8)): F-test statistic for H0: $\delta_6 = \delta_7 = \delta_8 = 0$.
F(δ:2,3,7,8)): F-test statistic for H0: $\delta_2 + \delta_3 + \delta_7 + \delta_8 = 0$.

2. McCallum's ADAS Model (continued)

WAGES: $\Delta w_t = \beta_0 + \beta_1(y_t - y_t^f) + \beta_2\ (y_{t-1} - y_{t-1}^f) + \beta_3\Delta p_t^e + e_{wt}$

	With Non-neutral supply side		With neutral supply side		
	(i)	(ii)	(iii)	(iv)	(v)
β_0	*** .004 (.001)	*** .002 (.001)	*** .002 (.001)	*** .001 (.001)	Same as Column (iv)[a]
β_1	*** .212 (.047)	*** .217 (.044)	*** .231 (.046)	*** .230 (.041)	
β_2	*** -.141 (.047)	* -.140 (.045)	*** -.155 (.046)	*** -.150 (.058)	
β_3	*** .827 (.067)	*** .876 (.067)	1.0	1.0	
Adj-Rsq.	.542	.549	.544	.551	
SEE	.005	.005	.005	.005	
D-W	1.81	1.62	1.72	1.59	

PRICES: $\Delta p_t = \gamma_0 + \gamma_1\Delta w_t + \gamma_2\Delta p_{t-1} + \gamma_3\Delta p_{t-2} + e_{pt}$

	(i)	(ii)	(iii)	(iv)	(v)
γ_0	-.001 (.001)	.001 (.001)	** -.001 (.001)	-.001 (.001)	Same as Column (iv)[a]
γ_1	*** .428 (.055)	*** .384 (.050)	*** .446 (.058)	*** .408 (.052)	
γ_2	** .180 (.081)	*** .202 (.077)	** .189 (.078)	*** .222 (.074)	
γ_3	*** .350 (.060)	*** .342 (.058)	*** .365 (.058)	*** .371 (.055)	
Adj-Rsq.	.728	.718	.731	.720	
SEE	.004	.003	.004	.003	
Durbin's h	-1.70	-1.24	-2.01	-1.70	
Est. Range	1954:1-1985:4	1954:1-1992:1	1954:1-1985:4	1954:1-1992:1	1954:1-1992:1

a/ The model of column v differs from that of column iv in terms of the aggregate demand function.

3. Decomposition of RMSD for the ADAS Model[a/]

	(i)	(ii)	(iii)
RMSD			
Shocks			
All	.0195	.0497	.0260
Agg. Demand	.0200	.0333	.0251
Agg. Supply	.0058	.0168	.0099
None	.0046	.0158	.0061
Value for λ	.25	.25	.50
Sum of the est. base coefficients (t-statistic)	.5587 (4.294)	.3182 (3.063)	.3182 (3.063)
Estimation Range	1954:1-1985:4	1954:1-1992:1	1954:1-1992:1

a/ Column i uses the model of column iii of table 2; columns ii and iii use the model from column iv of table 2.

4. Tests of the Monetary Transmission Channel

$$\Delta y_t = \beta_0 + \beta_1 \Delta y_{t-1} + \beta_2 \Delta(b-p)_t + \beta_3 \Delta(b-p)_{t-1} + \beta_4 \Delta g_t + \beta_5 \Delta g_{t-1} + \alpha \Delta \hat{y}_{mps,t}$$

	(i)	(ii)
β_0	.004*** (.001)	.007*** (.001)
β_1	.209** (.104)	.009 (.095)
β_2	.162 (.150)	-.069 (.134)
β_3	.400*** (.155)	.185 (.137)
β_4	.147 (.115)	.244*** (.099)
β_5	-.278*** (.116)	-.174* (.100)
α	-	.596*** (.108)
Adj.-Rsq.	.235	.452
SEE	.0089	.0075
Durbin Watson	2.05	1.91
Durbin's h	-.56	.73
F(β:2,3)	7.40***	.92

Est. Range: 1970:Q1 - 1989:Q4
Standard errors in parentheses
Adj.-Rsq: Adjusted R-squared
F(β:2,3): F-test statistic for H0: $\beta_2 = \beta_3 = 0$.

*,**,***: Significant at or below the 10%, 5% and 1% level, respectively.

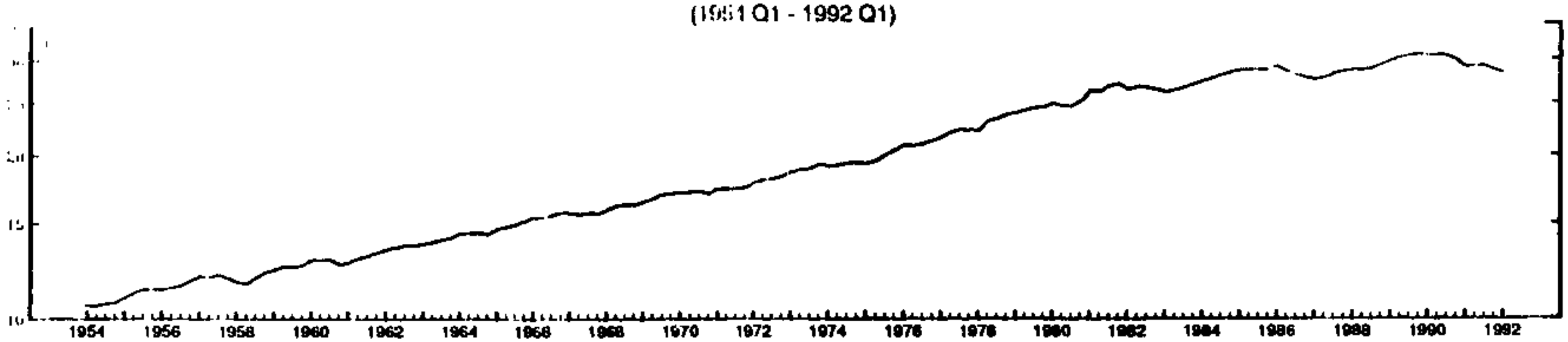
5. Stochastic Simulation of Alternative Policy Targets[a]

	Policy target			Historical standard deviation[b]	
	Nominal GDP	M2	GDP deflator		
Policy feedback coeff's (α_1, α_2)	(25,100)	(150,300)	(5,50)		
Information delay (quarters)	0.5	0	0.5		
Standard deviations:[c] (levels, except as noted)					
real GDP	3.91	5.08	7.11	-	
GDP deflator	4.19	5.78	10.12	-	
nominal GDP	3.03	5.85	12.25	-	
federal funds rate					
quarterly change		2.34	1.44	0.42	1.69
level	4.06	3.18	2.49	-	
unemployment rate	1.47	2.33	3.30	1.57	
M2	4.11	2.09	9.38	-	

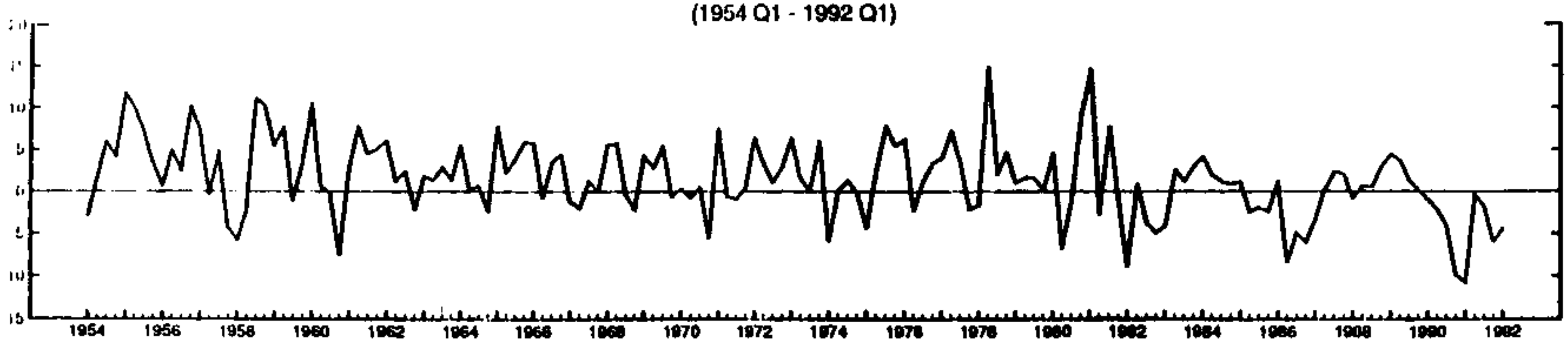
a/ Based on 180 20-quarter stochastic simulations.
b/ Calculated for stationary series only (1960:Q1 - 1992:Q1).
c/ Standard deviations, which are averages of quarterly observations in the fifth year of the simulations, are measured in percent, except for the federal funds rate and the unemployment rate, for which they are measured in percentage points.

Chart 1

Base Velocity
(1954 Q1 - 1992 Q1)



Growth of Base Velocity
(1954 Q1 - 1992 Q1)



Growth of Nominal Income and St. Louis Base
(1954 Q1 - 1992 Q1)

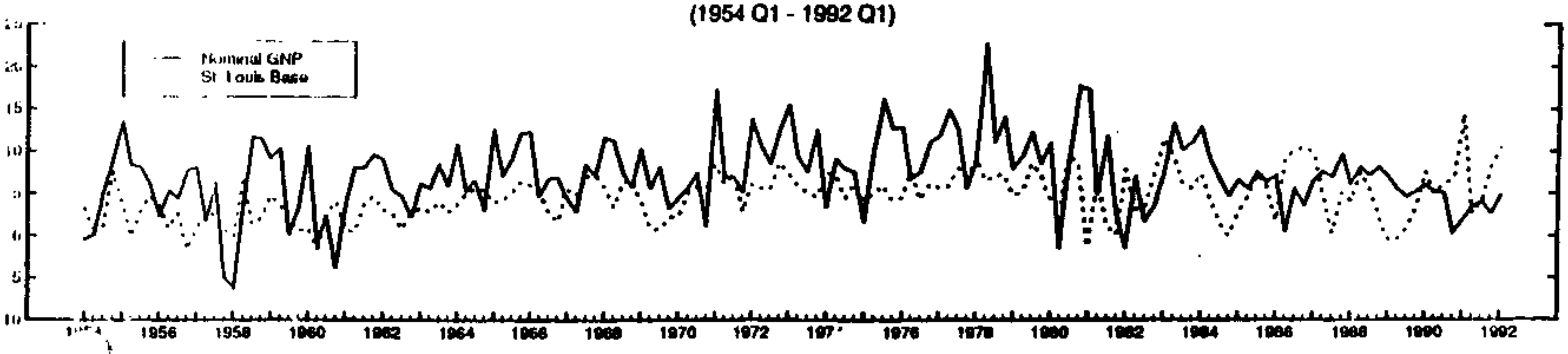
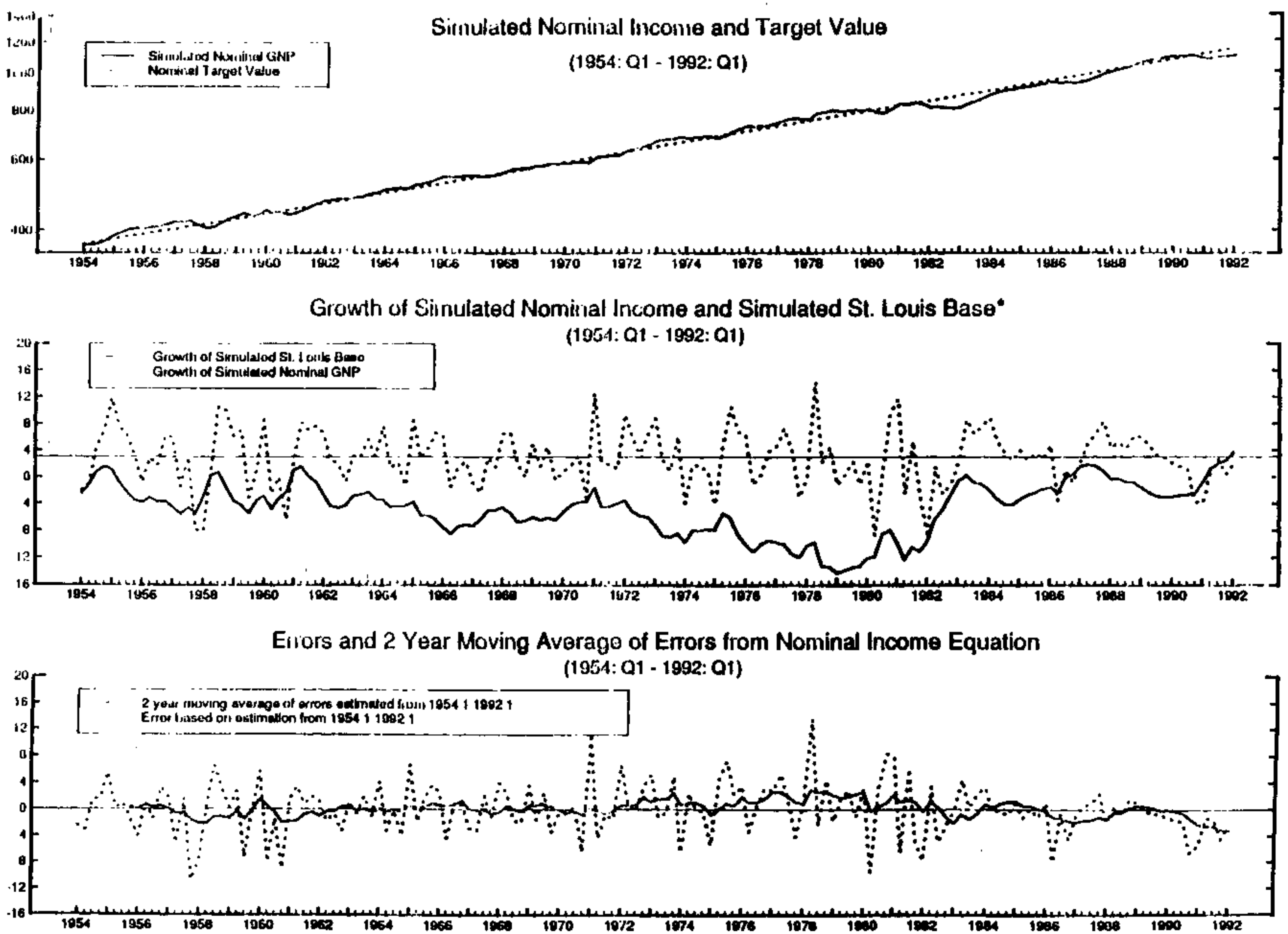


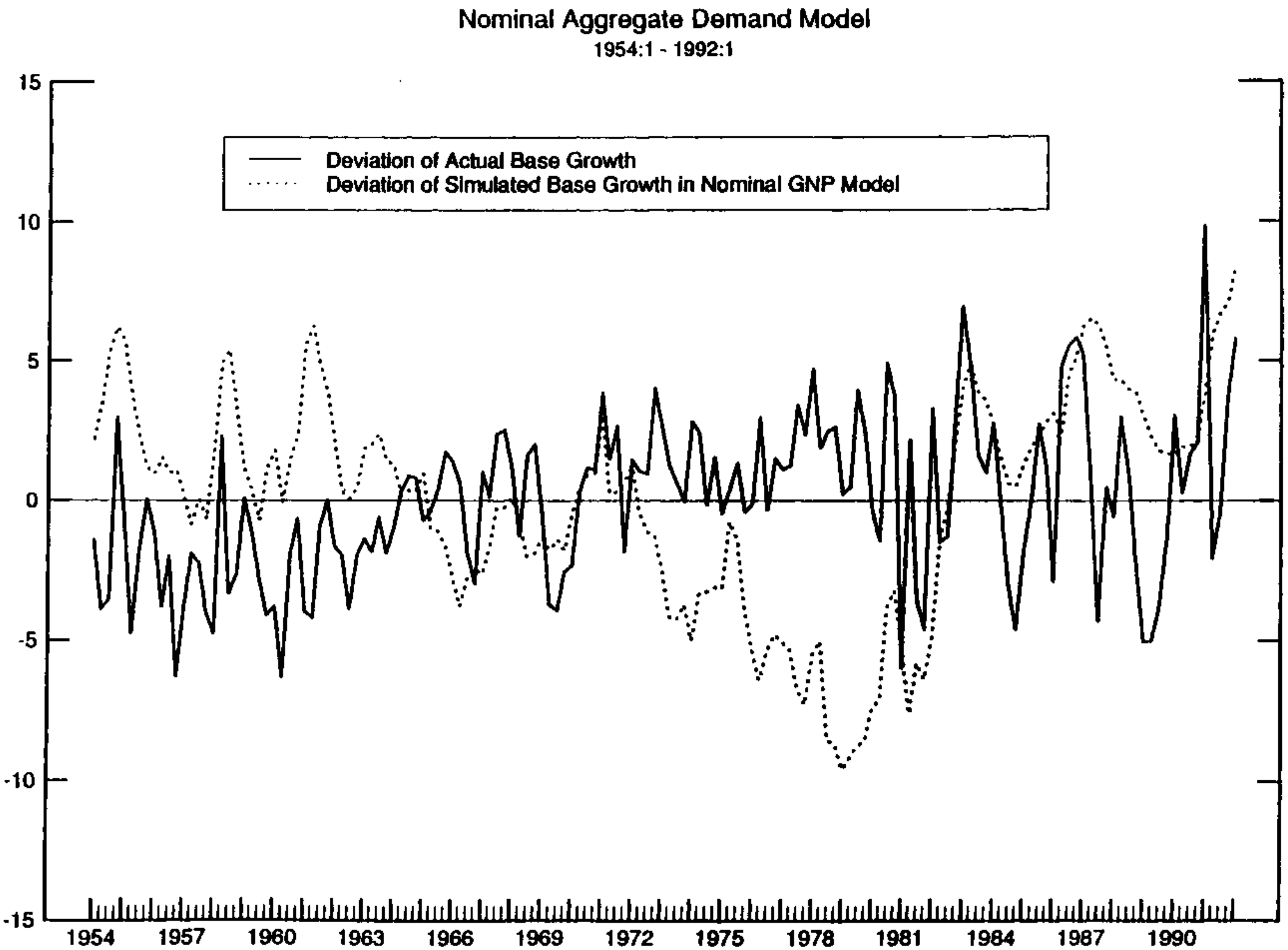
Chart 2

Nominal Aggregate Demand Model



Horizontal line at 3 percent indicates targeted long-run value of Nominal GNP Growth.

Chart 3



Nominal Aggregate Demand Model
1954:1 - 1992:1
Deviation of Actual Base Growth
Deviation of Simulated Base Growth in Nominal GNP Model
15
10
5
0
-5
-10
-15
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990

Chart 4

Nominal Aggregate Demand Model

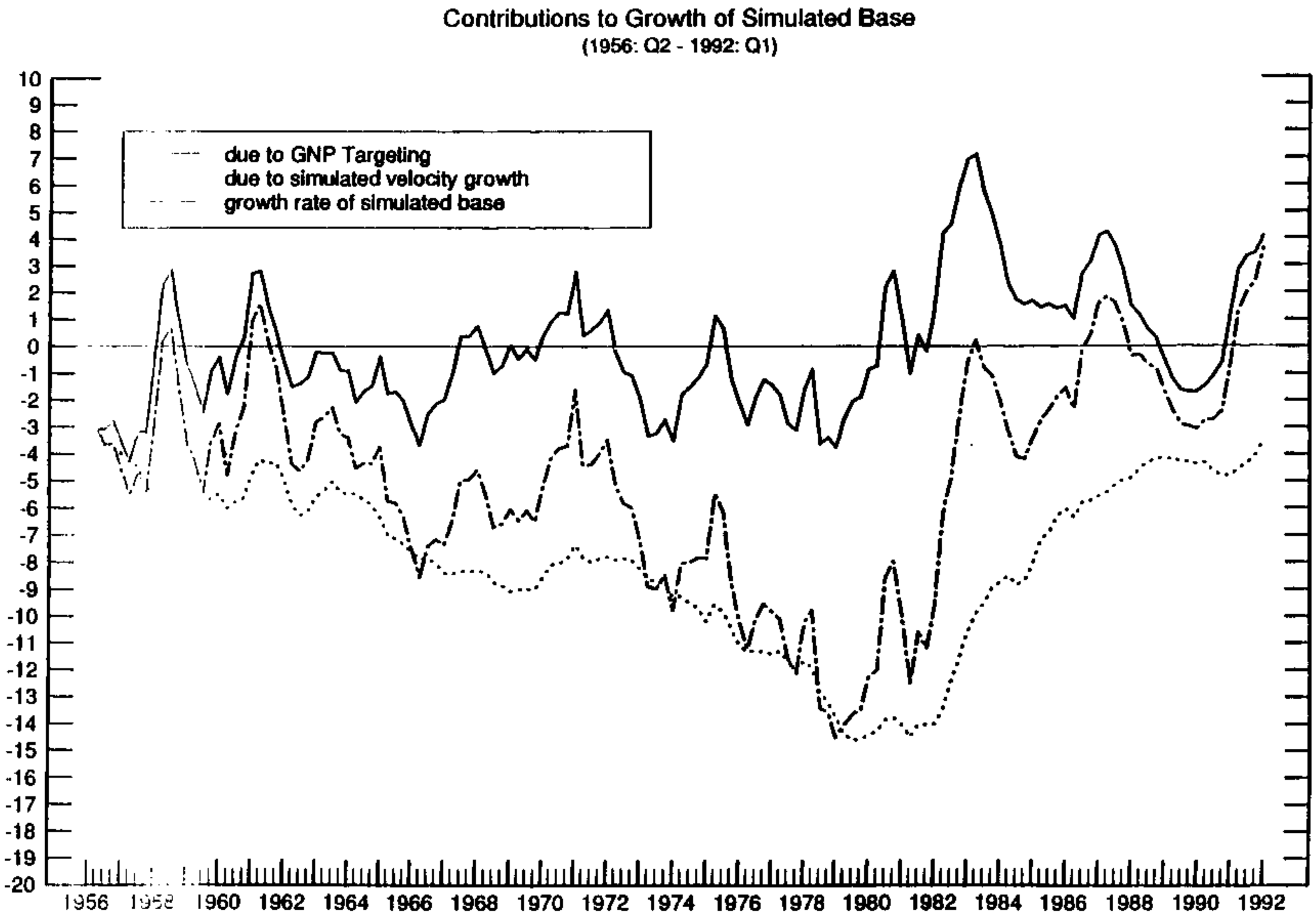
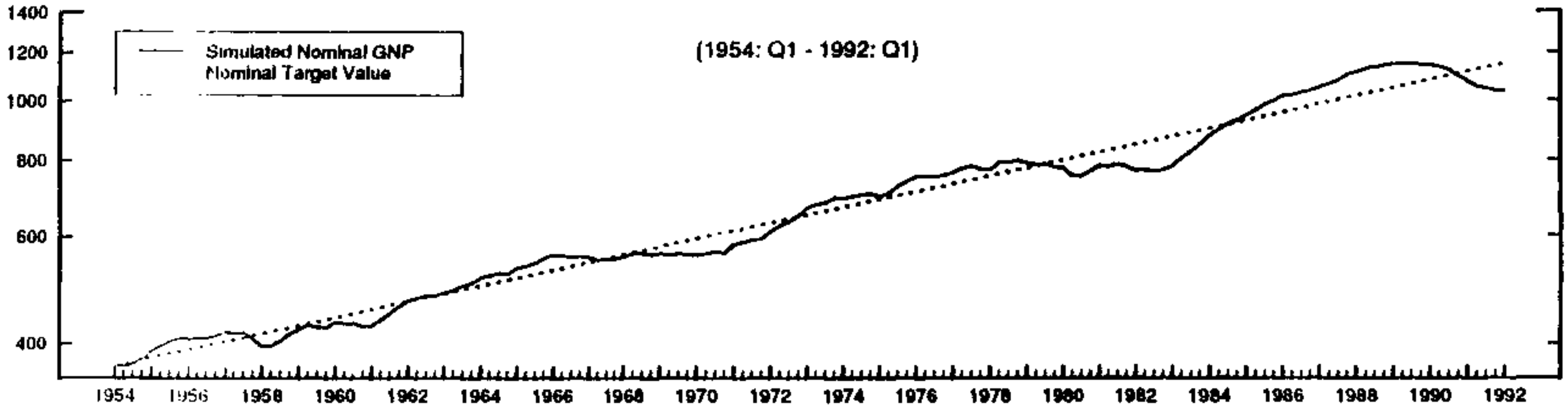


Chart 5

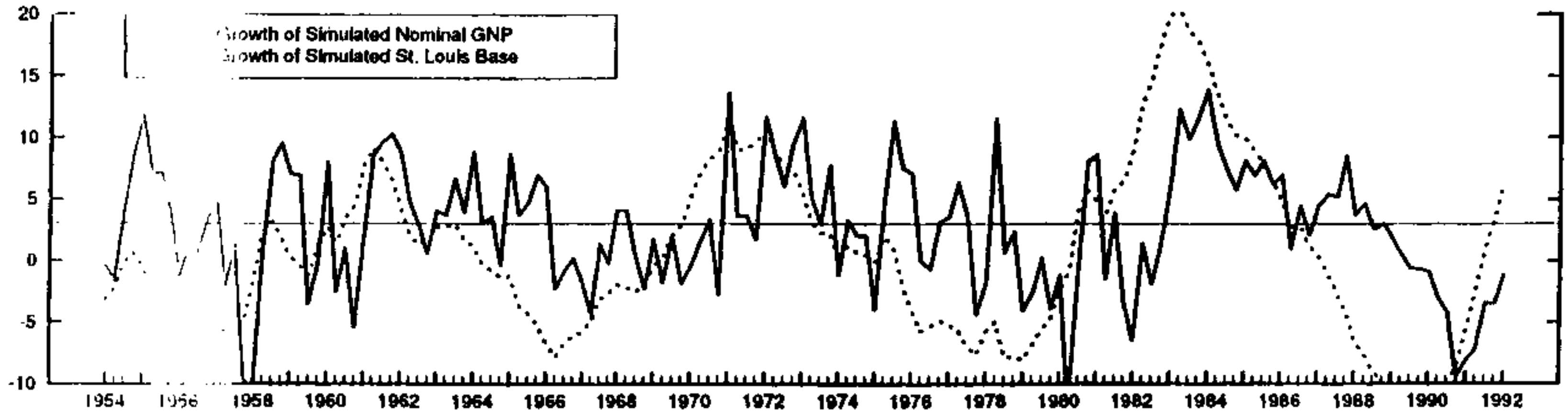
ADAS Model

Simulated Nominal Income and Target Value



Growth of Simulated Nominal Income and Simulated St. Louis Base*

(1954: Q1 - 1992: Q1)

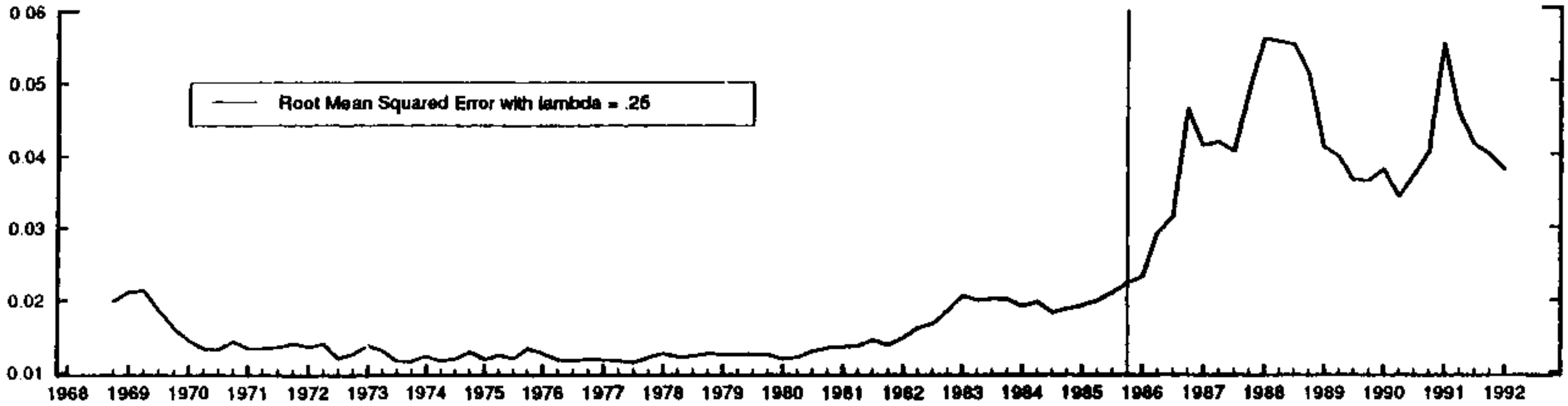


Horizontal line at 3 percent indicates targeted long-run value of Nominal GNP Growth.

Chart 6

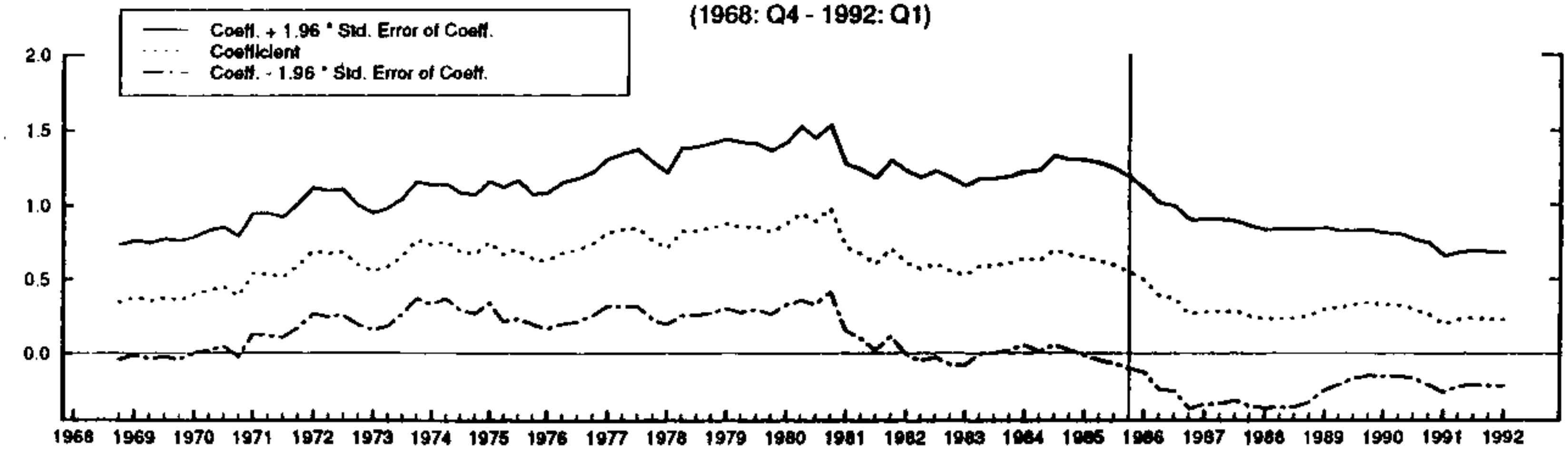
The Nominal Aggregate Demand Model

Root Mean Squared Error
(1968: Q4 - 1992: Q1)



Simulation Results Based on a 15 Year Rolling-Horizon Estimate

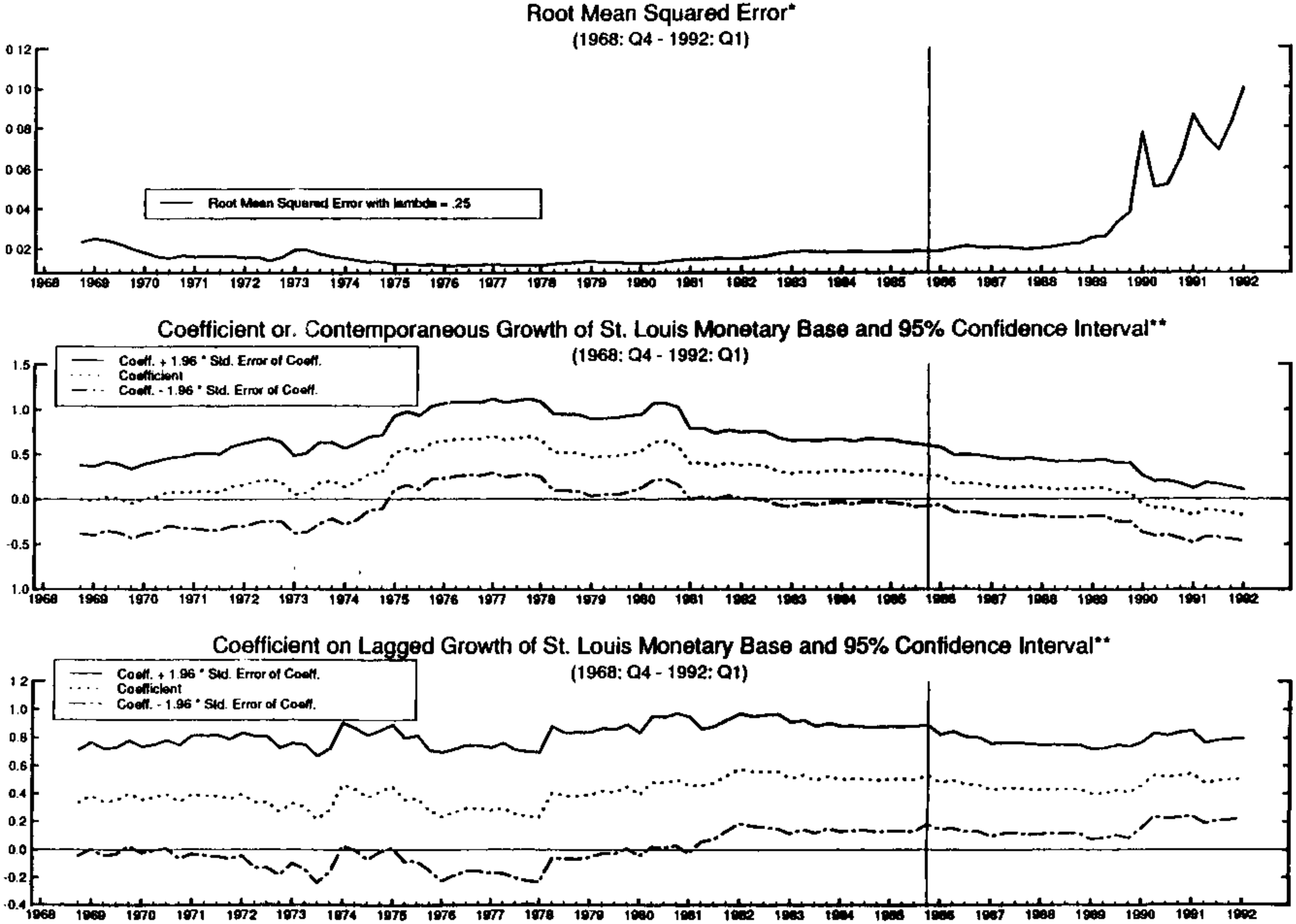
Coefficient on Contemporaneous Growth of St. Louis Monetary Base and 95% Confidence Interval
(1968: Q4 - 1992: Q1)



Regression Results Based on a 15 Year Rolling-Horizon Estimate

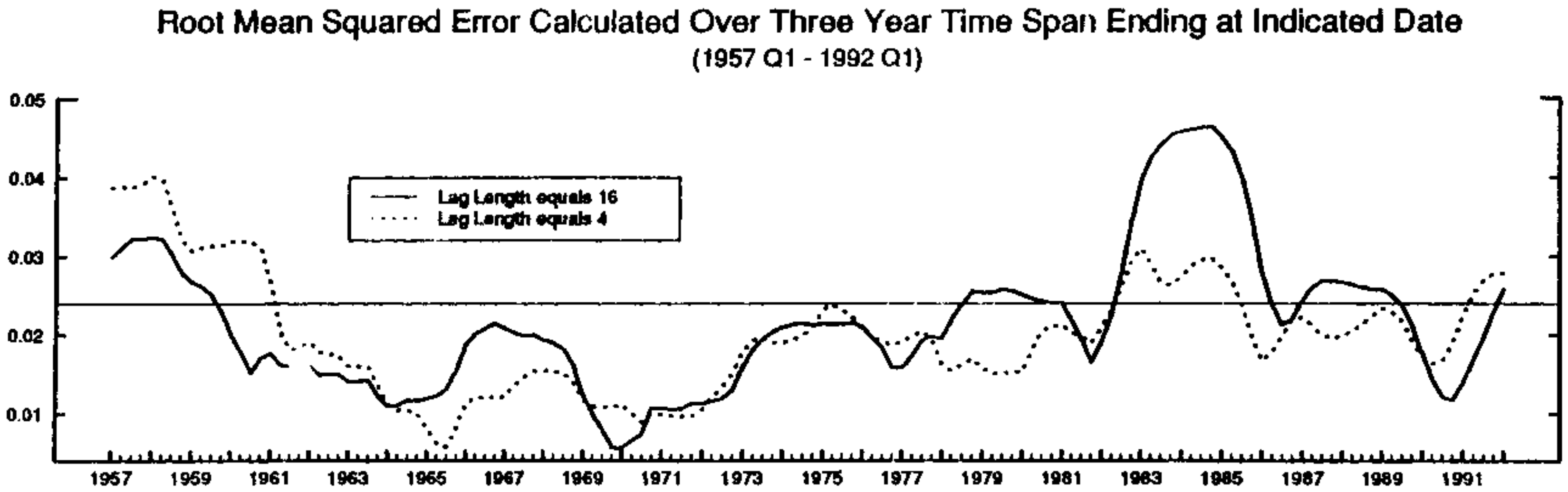
Chart 7

ADAS Model

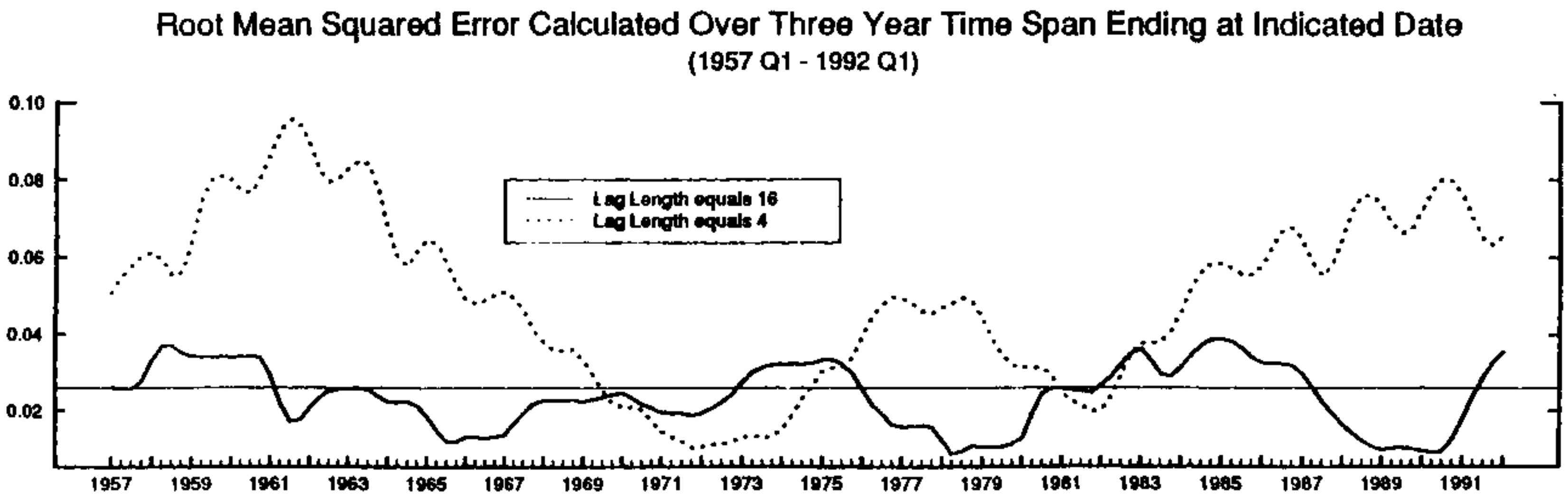


* Sin... n Results Based on a 15 Year Rolling-Horizon Estimates

Chart 8

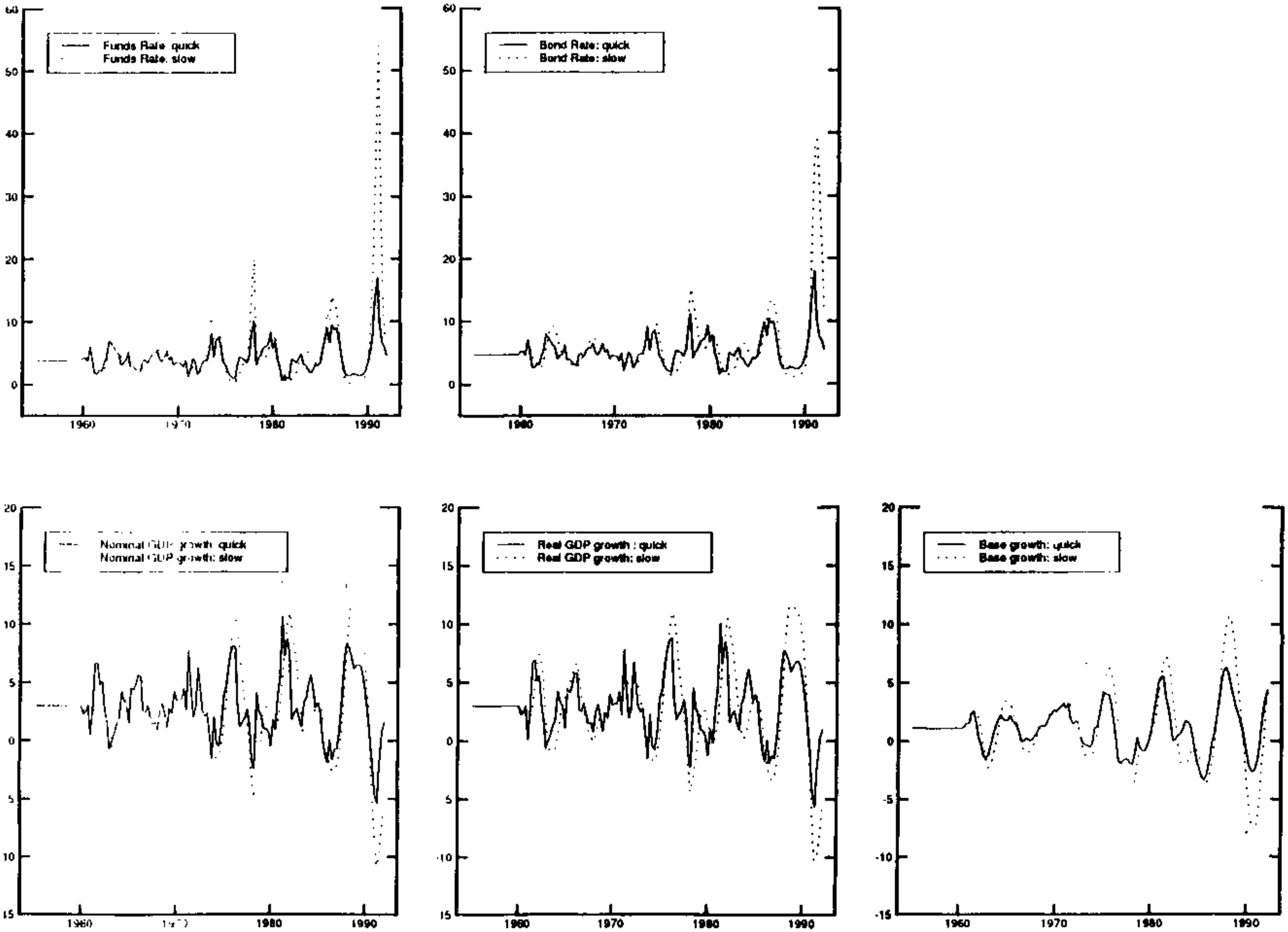


Nominal Aggregate Demand Model



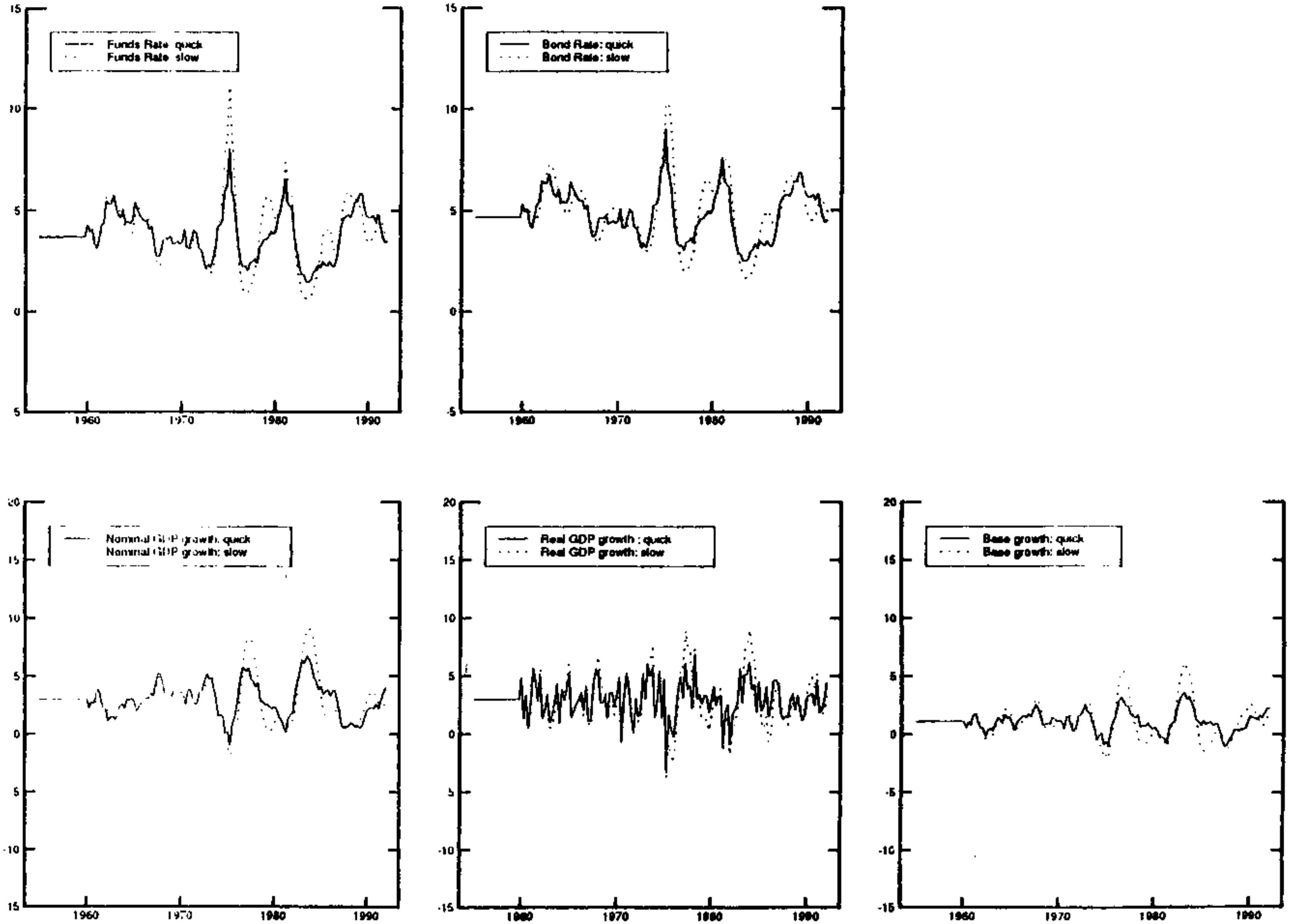
ADAS Model

Chart 9-A
Base Demand Shocks



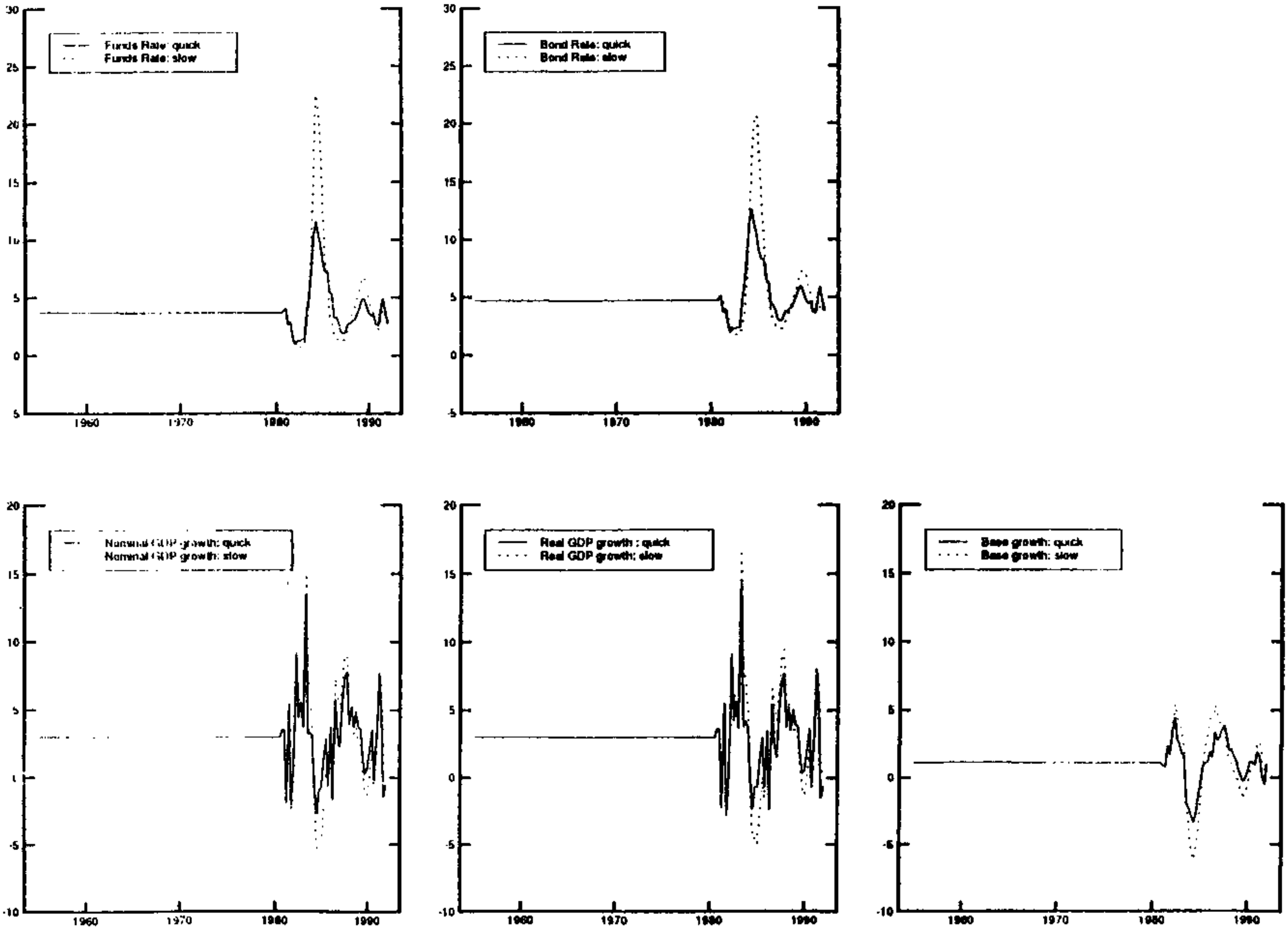
Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 9-B
Price and Wage Equation Shocks



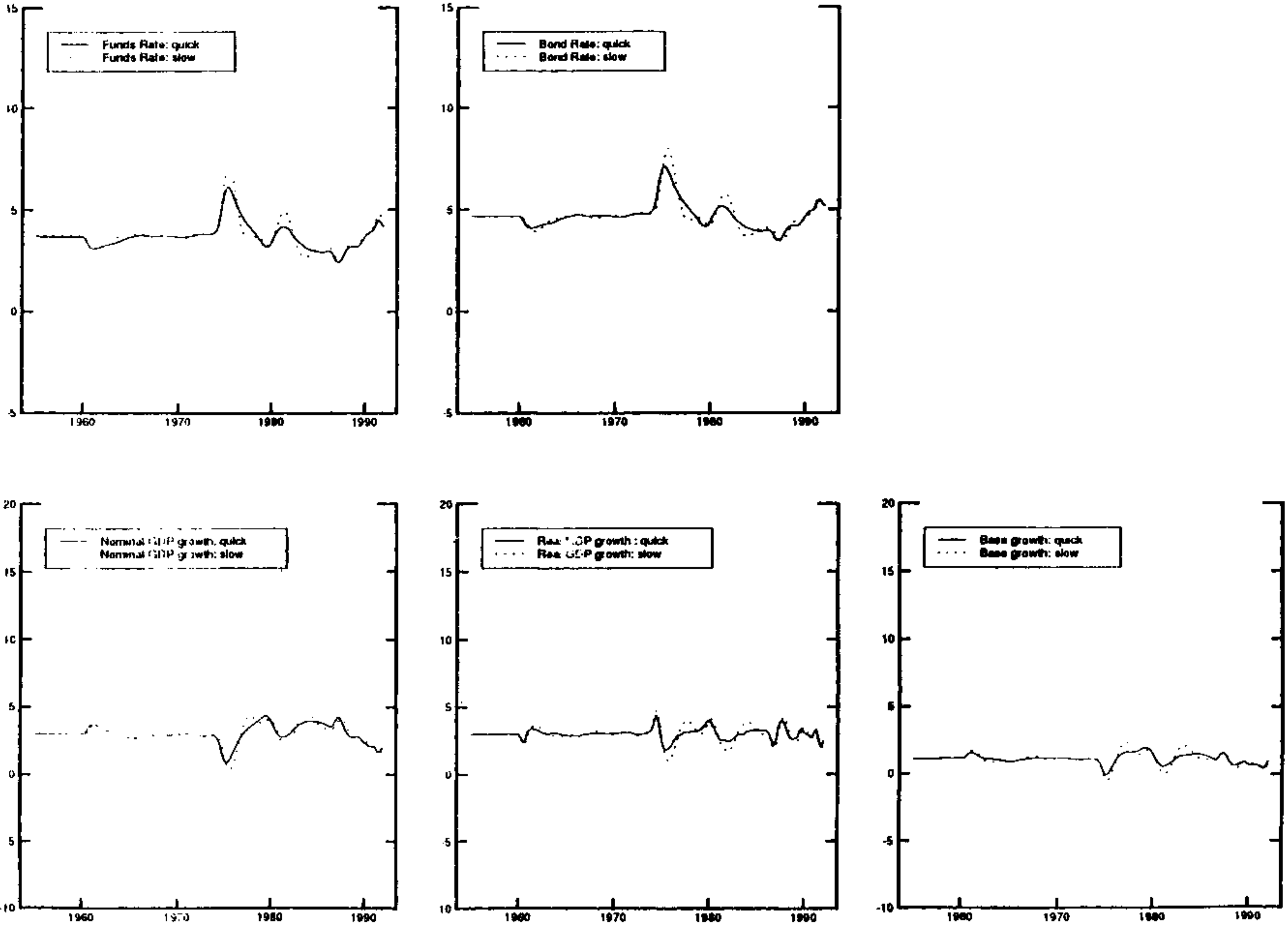
Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 9-C
IS Curve Shocks



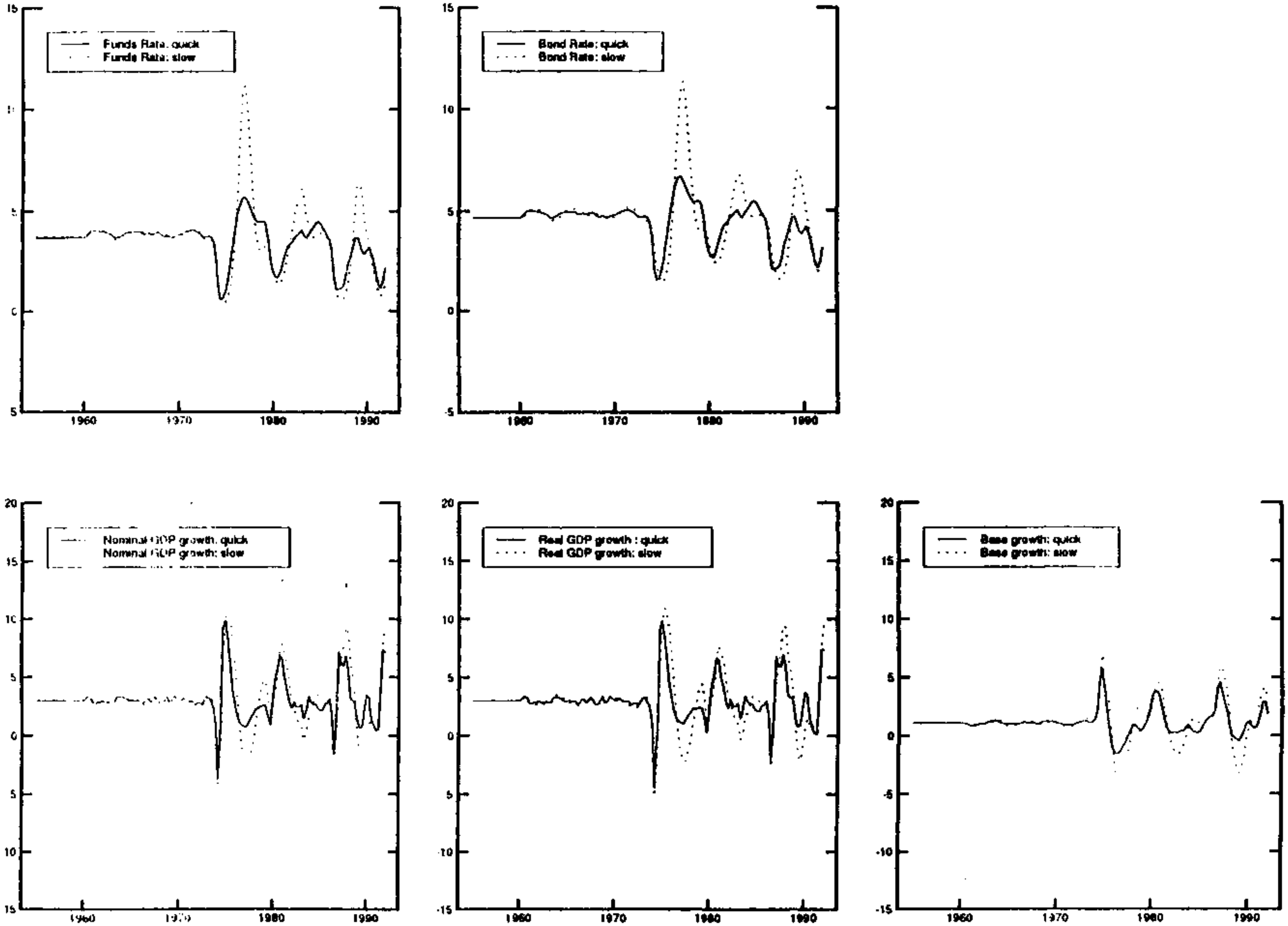
Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 9-D
Relative Price of Oil Shock (in supply side)



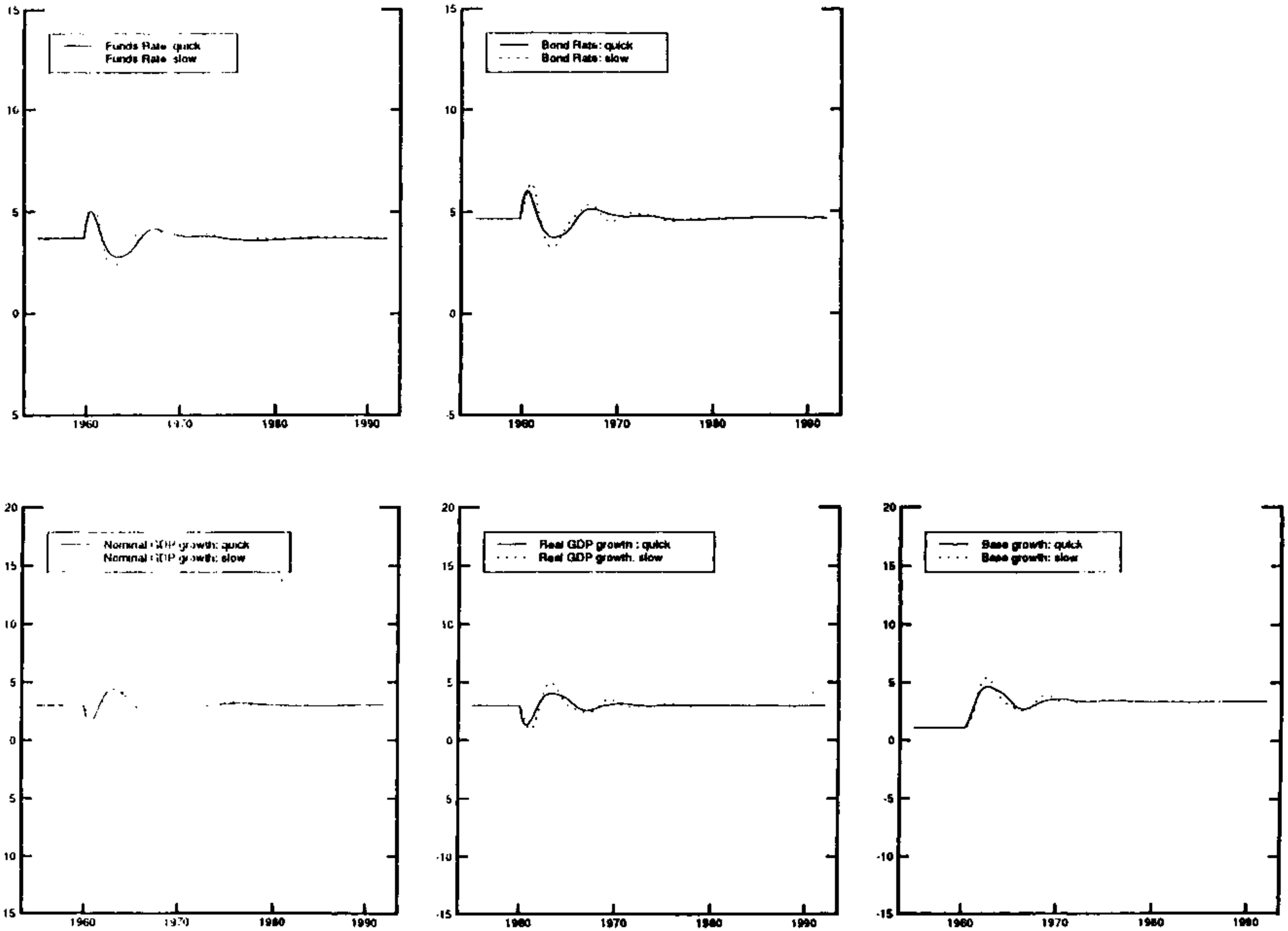
Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 9-E
Oil Shock (in IS curve)



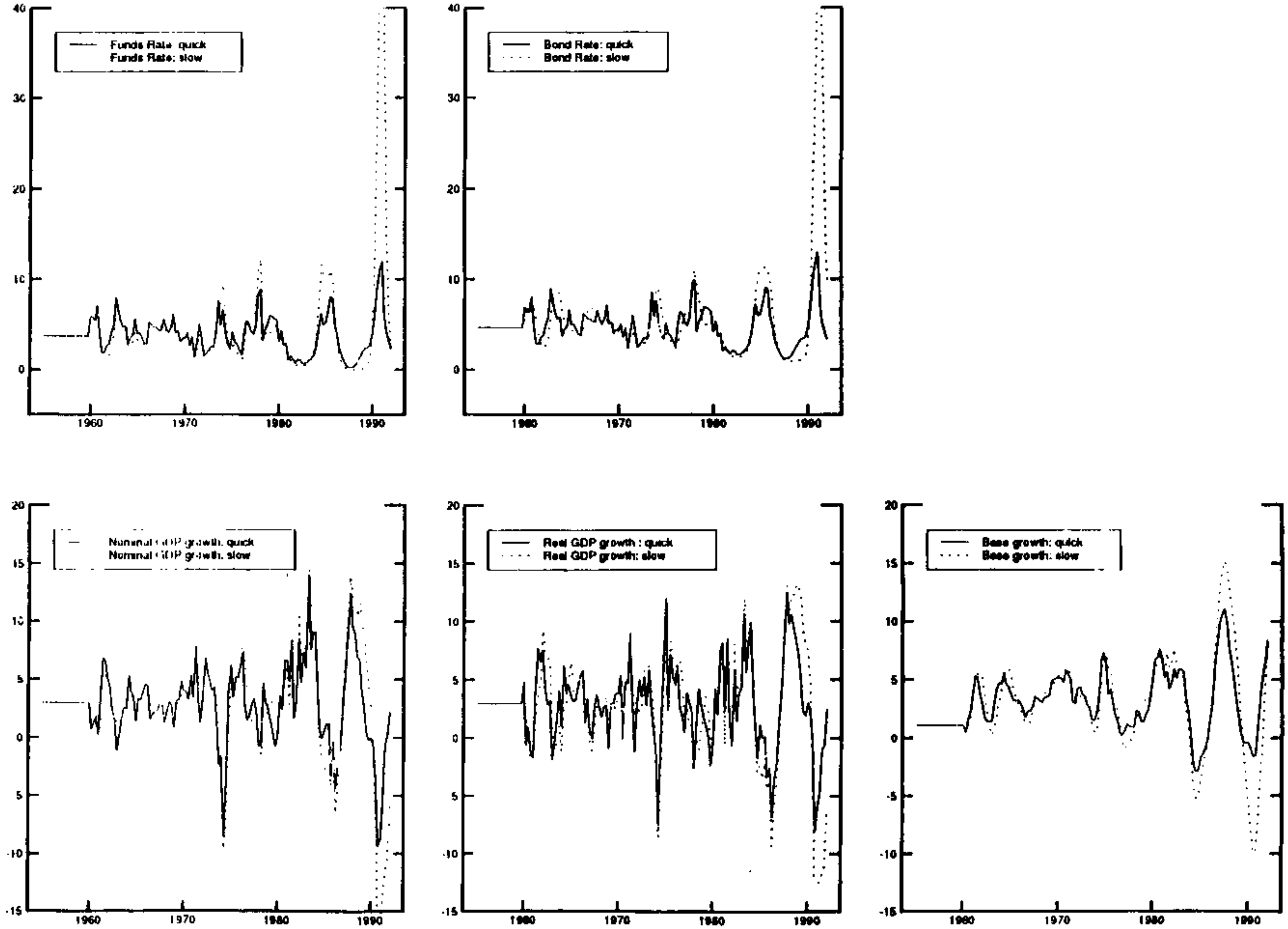
Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 9-F
Base Trend Shocks



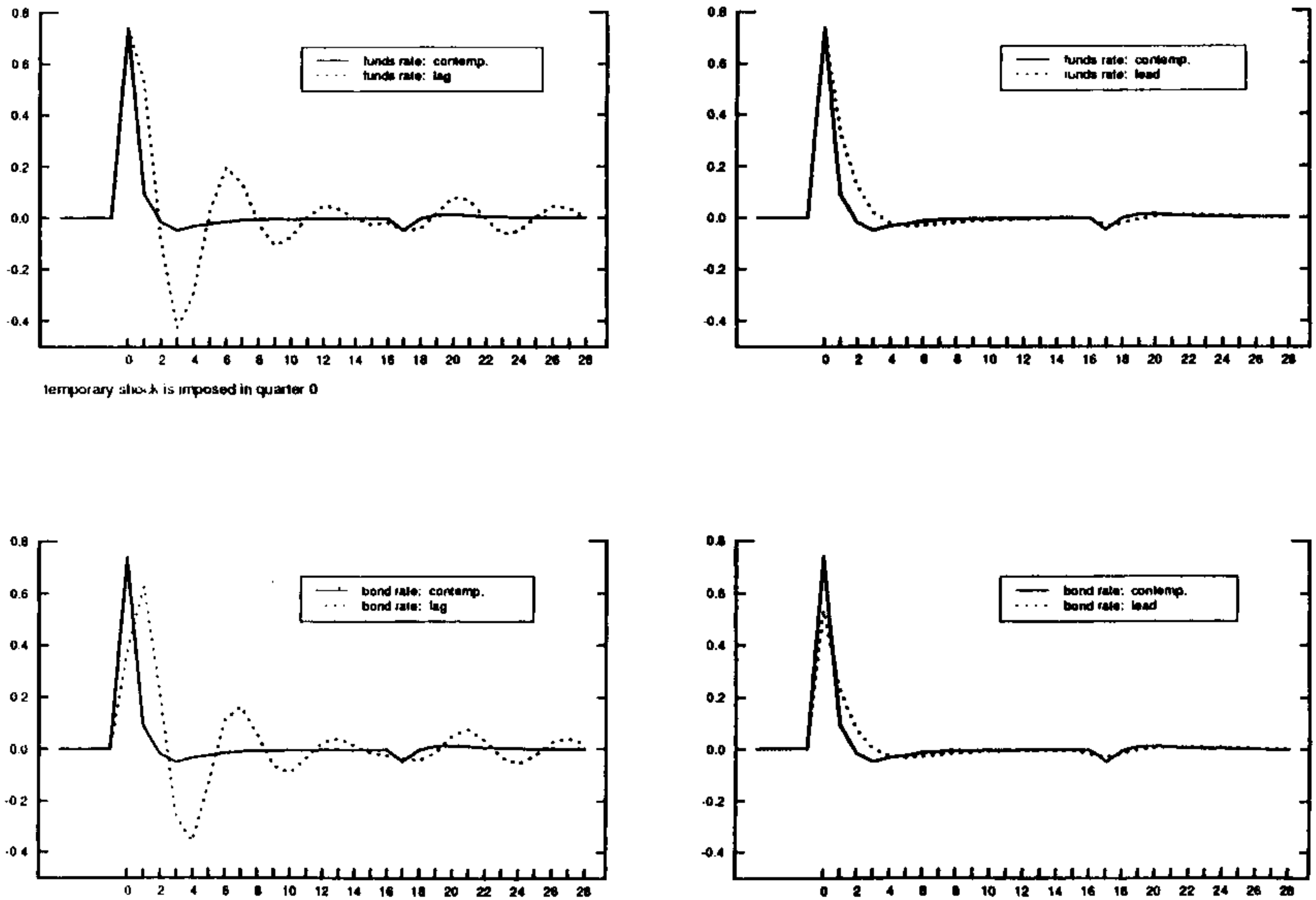
Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 9-G
All Shocks
IS curve shocks start in 1980:Q4



Quick and Slow refer to the speed of adjustment of the bond rate to the federal funds rate

Chart 10-A
Effects on Interest Rates of IS Curve Shock
(With Alternative Long-Rate Assumptions)

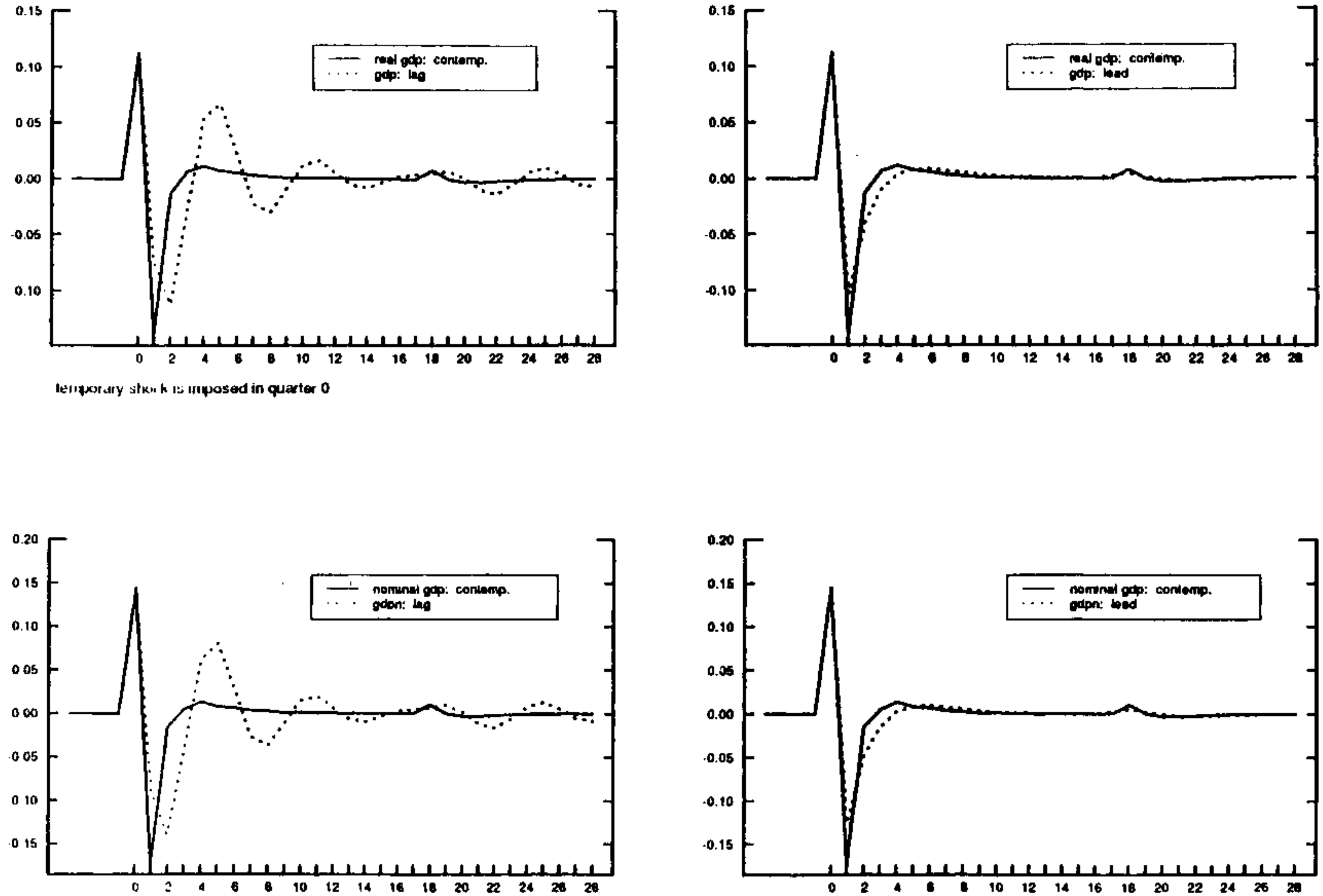


contemp = contemporaneous response only of long to short rate

lag = one period lag and contemporaneous responses of long to short rate (with equal weights)

lead = one period lead and contemporaneus responses of long to short rate (with equal weights)

Chart 10-B
Effects on GDP Growth of IS Curve Shock
(With Alternative Long-Rate Assumptions)

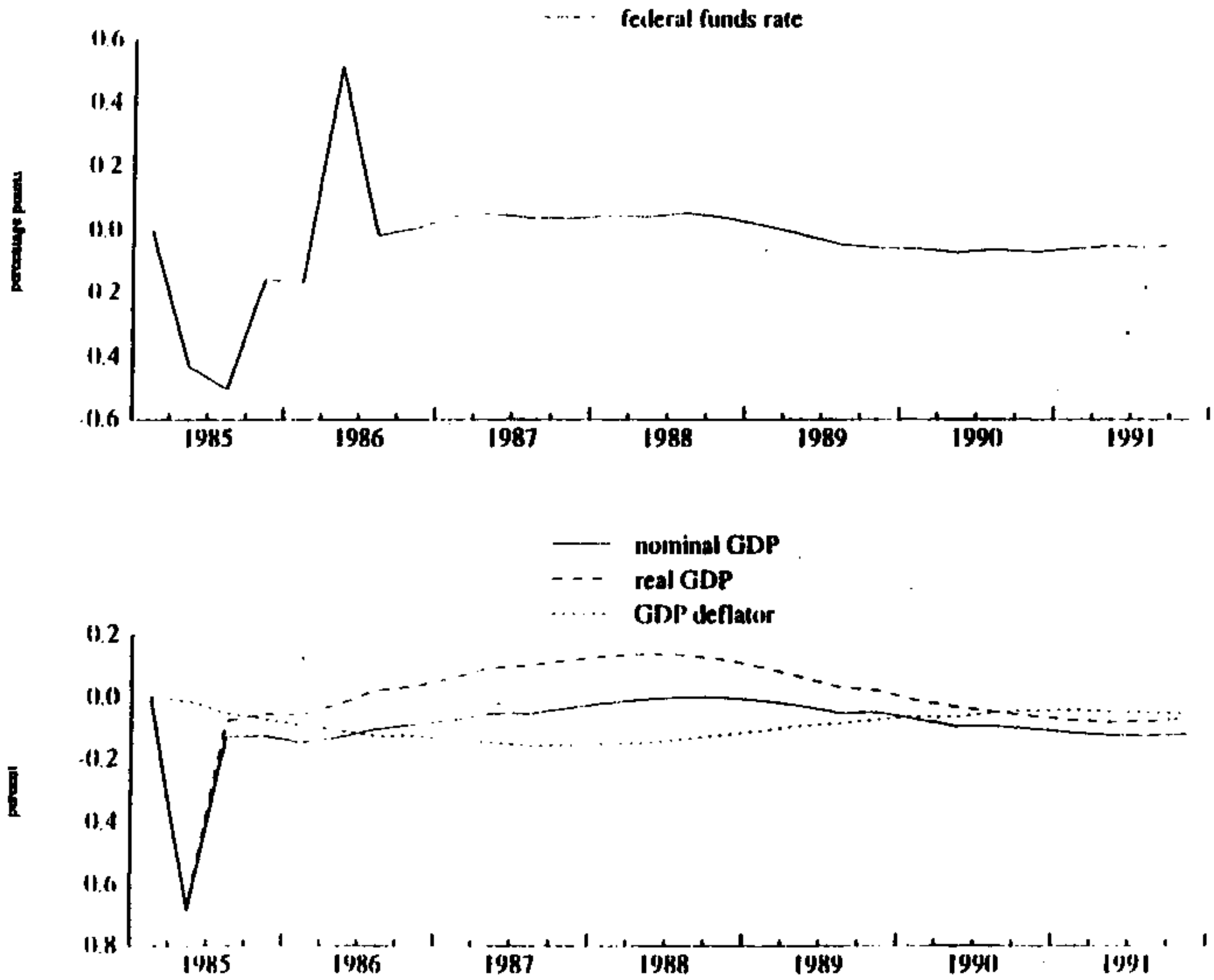


contemp = contemporaneous response only of long to short rate

lag = one period lag and contemporaneous responses of long to short rate (with equal weights)

lead = one period lead and contemporaneus responses of long to short rate (with equal weights)

Chart 11
POLICY RULE: FUNDS RATE INSTRUMENT; NOMINAL GDP TARGET
One-time negative government spending shock
(deviations from baseline)



APPENDIX: I

In the IS curve in the small macro model with interest rates, the demand for real GDP adjusts to the lagged value of the gap between GDP and its long-run equilibrium value. The latter is composed of two terms: the first is potential output (QPOT), constructed on the basis of trends in output between periods of apparent full utilization of resources.[47] A second component is the dependence of long-run output on the real rate of interest. The real rate is measured as the difference between the 10-year Treasury bond rate and the expected 10-year-ahead inflation rate as measured by the Hoey survey. Since the survey data are available only since 1980:Q3, the estimation is started in 1980:Q4 due to the one-period lag with which the real rate enters the IS curve. Finally, an oil shock variable captures uncertainty in relative prices due to oil price changes. This term--OILSHK--depends on the absolute value of changes in the relative price of oil and depresses demand whether relative oil prices rise or fall.[48] (Mnemonics are at the end of the appendix)

$$
\begin{aligned}
\text{(A-1)}\ \Delta\log(GDP) = {} & \underset{(4.49)}{.024} - \underset{(1.65)}{.071}\,[(\log(GDP) - \log(QPOT)]_{-1} \\
& - \underset{(4.18)}{.015}\,\log[RTB10Y - HOEY]_{-1} - \underset{(2.61)}{.023}\,OILSHK_{-1} \\
& - \underset{(2.03)}{.020}\,OILSHK_{-2} - \Delta\log(QPOT)_{-1}
\end{aligned}
$$

R^2 = .37
D-W = 1.41
Std. Error = .0675
Estimation period = 1980:4 - 1992:1

On the supply side we use a model based on equations (4) and (5) in the text but add supply shocks in terms of the relative price of oil. So while the price equation is unchanged, the wage equation is:

47. The methodology for estimating potential output was developed by Steven Braun, "Estimates of Current Quarterly Gross National Product by Pooling Preliminary Labor Market Data" Journal of Business and Economic Statistics, vol. 8, (July, 1990), pp.293-304.

48. The lagged change in the log of potential output--with the unitary coefficient--assures that output grows as the rate of potential output in steady-state equilibrium.

$$\text{(A-2)}\ \Delta\log(WAGE) = \underset{(3.60)}{.0014} + \underset{(4.98)}{.25}(\log(GDP) - \log(QPOT))$$

$$- \underset{(3.53)}{.18}[\log(GDP - \log(QPOT)]_{-1} \quad -INFLAG$$

$$+ \underset{(1.40)}{.0039}\ \Delta\log(RPOIL)_{-1} + \underset{(2.3)}{.01}\ \Delta\log(RPOIL)_{-2}$$

$$+ \underset{(3.49)}{.008}\ \Delta\log(RPOIL)_{-3}$$

$R^2 = .62$
D-W = 1.64
Std. Error = .0046
Estimation period: 1960:1 - 1992:1

Mnemonics

GDP = real GDP

HOEY = Hoey survey expected inflation

INFLAG = Eight-quarter moving average of inflation as measured by the implicit GDP delator.

OILSHK = Oil shock variable absolute value of $\Delta\log(PUVFL/P)$ where

PUVFL = average dollar price per imported barrel of oil.

P = Implicit GDP deflator

QPOT = potential real GDP

RPOIL = Relative price of oil: PUVFL/P

RTB10Y = 10-year Treasury bond rate

WAGE = Average hourly earnings in manufacturing

APPENDIX II: BASE DEMAND SHOCKS

In the model with a disaggregated aggregate semand side of the economy, we specified the following base demand function (heteroskedasticity robust t-statistics in parentheses):

$$(1).\quad b_t = \underset{(455.83)}{-2.18} + 1.0\, x_t - \underset{(-6.33)}{.022}\, r_t - \underset{(-48.40)}{.005}\, T + \underset{(21.30)}{.006}\, D82T$$

$$\text{Adj-}R^2 = .986 \qquad \text{D-W} = .31 \qquad \text{Std. Error} = .0171$$

$$\text{Estimation period} = 1960{:}1 - 1992{:}1$$

where:

b_t ≡ log of the St. Louis monetary base
x_t ≡ log of nominal GDP
r_t ≡ Box-Cox transformation of the federal funds rate
T ≡ Linear time trend
D82T ≡ Linear time trend beginning in 1982:1

Since the estimated base demand shocks can contribute substantially to the fluctuations in simulated interest rates, the residuals from this model are compared with those from a base demand specification advocated by Robert Rasche.[49] Rasche considers two specifications for the demand for the monetary base--one unrestricted and one restricted. In the former, the growth rate of the monetary base is regressed on a constant, contemporaneous and lagged growth rates of real GNP and the contemporaneous and lagged growth rates of a short term interest rate. The estimated unrestricted version is :

$$\Delta b_t - \Delta x_t = \underset{(-3.25)}{-.002} - \underset{(-1.89)}{.008}\, \Delta R_t - \underset{(-3.15)}{.015}\, \Delta R_{t-1} - \underset{(-3.08)}{.010}\, \Delta R_{t-2} + \underset{(6.88)}{.007}\, D82$$

$$-\underset{(-18.85)}{.848}\, \Delta y_t + \underset{(2.41)}{.134}\, \Delta y_{t-1} + \underset{(5.08)}{.245}\, \Delta y_{t-2} - \underset{(-5.70)}{.537}\, DINFU_t +$$

$$R^2 = .764 \qquad \text{D-W} = 1.10 \qquad \text{Std. Error} = .0055$$

49. See "M1 - Velocity and Money Demand Functions: Do Stable Relationships Exist?" in Carnegie-Rochester Conference Series on Public Policy, 27, 1987, p. 9-88.

Estimation period = 1953:2 - 1992:1[50]

where:

x_t ≡ log of nominal GNP
y_t ≡ log of real GNP
D82T ≡ Dummy variable equal to zero prior to 1982:1 and one thereafter.
DINFU ≡ A measure of unexpected inflation, constructed as the residuals from an ARIMA(0,1,1) model for the inflation rate.
R ≡ The log of the 3 month Treasury bill rate.
D82T ≡ Linear time trend beginning in 1982:1

The restricted specification imposes three constraints. First, all the interest rate coefficients are equal. Second, the coefficients on lagged real GNP are equal. And third, the sum of the coefficients on real GNP sum to zero. Rasche interprets this last restriction to mean that the velocity of the monetary base responds only to transitory changes in real income. Together these restrictions decrease the number of estimated coefficients from to 9 to 5.

$$\Delta b_t - \Delta x_t = \underset{(-9.86)}{-.006} \quad \underset{(-10.33)}{-.018} \sum_{j=0}^{2} \Delta R_{t-j} \quad \underset{(-14.84)}{-.719} \{\Delta y_t - .5 \sum_{j=1}^{2} \Delta y_{t-j}\}$$

$$\underset{(-4.94)}{-.574} \; DINFU_t + \underset{(6.13)}{.007} \; DUM82_t$$

R^2 = .712 D-W = 1.13 Std. Error =.0061
Estimation period = 1953:2 - 1992:1[51]

The F-statistic for the test of the null hypothesis that the restrictions hold is 9.22. The restrictions can be rejected at the 5 percent level of statistical significance. Using these variables,

50. Excluding 1980:1 to 1980:3 due to the imposition of credit controls.

51. Excluding 1980:1 to 1980:3 due to the imposition of credit controls.

Rasche also found that for this specification the restrictions were rejected for the 1953:2-1985:4 and 1953:1-1981:4 estimation periods.

Chart A-1 plots the residuals from Rasche's restricted and unrestricted specifications, and the change in the residuals from the base demand function used in the simulations (equation 6). In Table A-1 we provide some descriptive statistics for these three estimates of historical shocks to base demand, both for the full overlap of the samples, 1960:1 to 1992:1 (excluding 1980:1-1980:3), and for the sub-sample 1982:1 to 1992:1.

The table and chart show that the errors from equation (6) have a significantly larger variance than those from either of Rasche's models. But starting in the early 1980's and continuing through the present, the errors from all three models track each other closely. During the 1990's there appears to be some association of these errors with estimates of changes in U.S. currency held abroad--see Chart A-2. The note by Richard Porter attached at the end of this paper briefly describes the construction of this series.

Table A-1

1960:1 - 1992:1

Resdidual	Rasche (unrestricted)	Rasche (restricted)	Simulation (changes)	Variance
	Correlations			
Rasche (unrestricted)	1.0	.89	.52	2.8•e-3
Rasche (restricted)	.89	1.0	.57	3.8•e-3
Simulation (changes)	.52	.57	1.0	8.8•e-3

1982:1 - 1992:1

Resdidual	Rasche (unrestricted)	Rasche (restricted)	Simulation (changes)	Variance
	Correlations			
Rasche (unrestricted)	1.0	.92	.76	3.5•e-3
Rasche (restricted)	.92	1.0	.85	4.4•e-3
Simulation (changes)	.76	.85	1.0	7.5•e-3

Chart A - 1

Residuals from Estimated Demand Functions for the Monetary Base
(1953 Q2 - 1992 Q1)

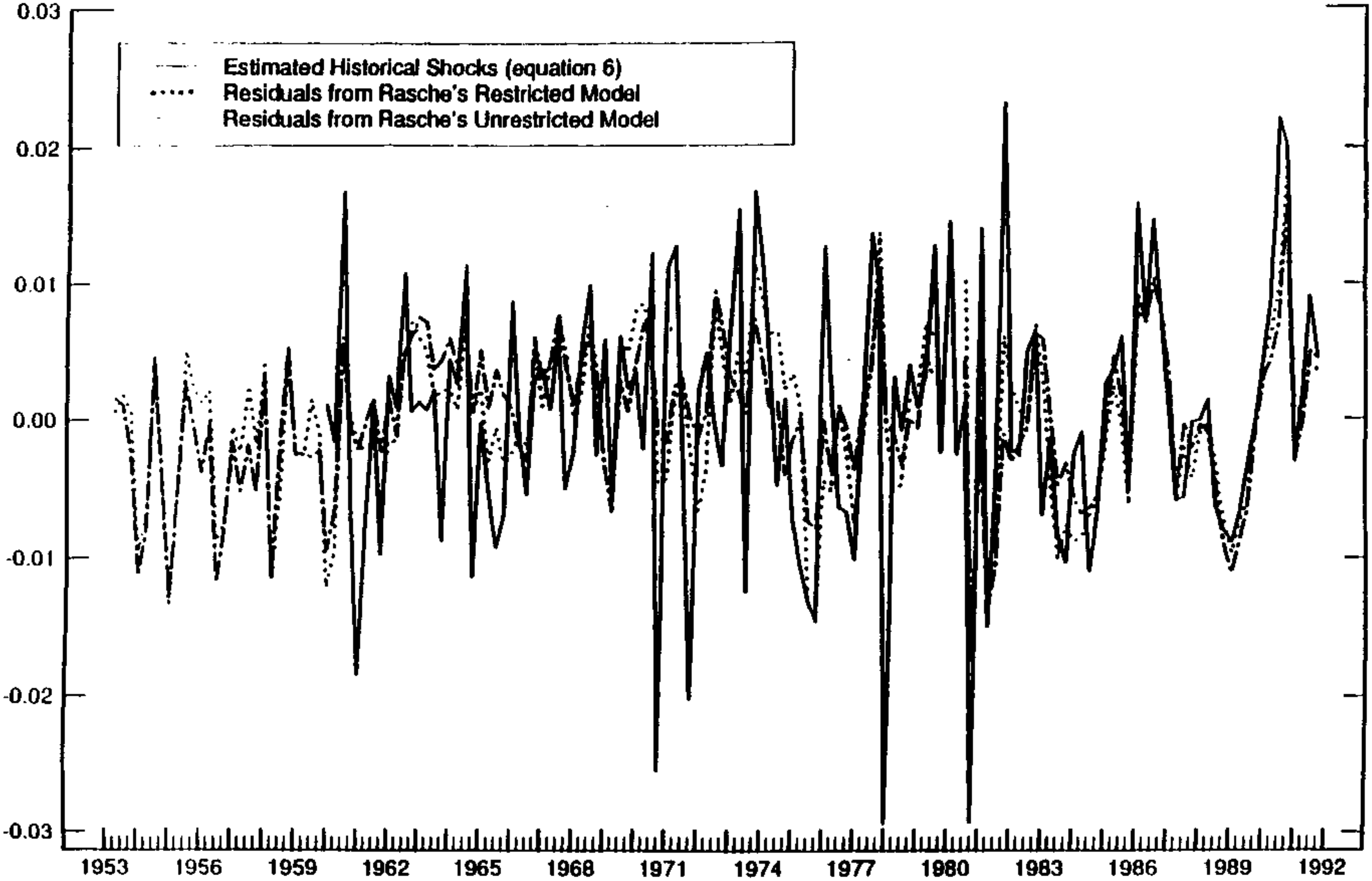
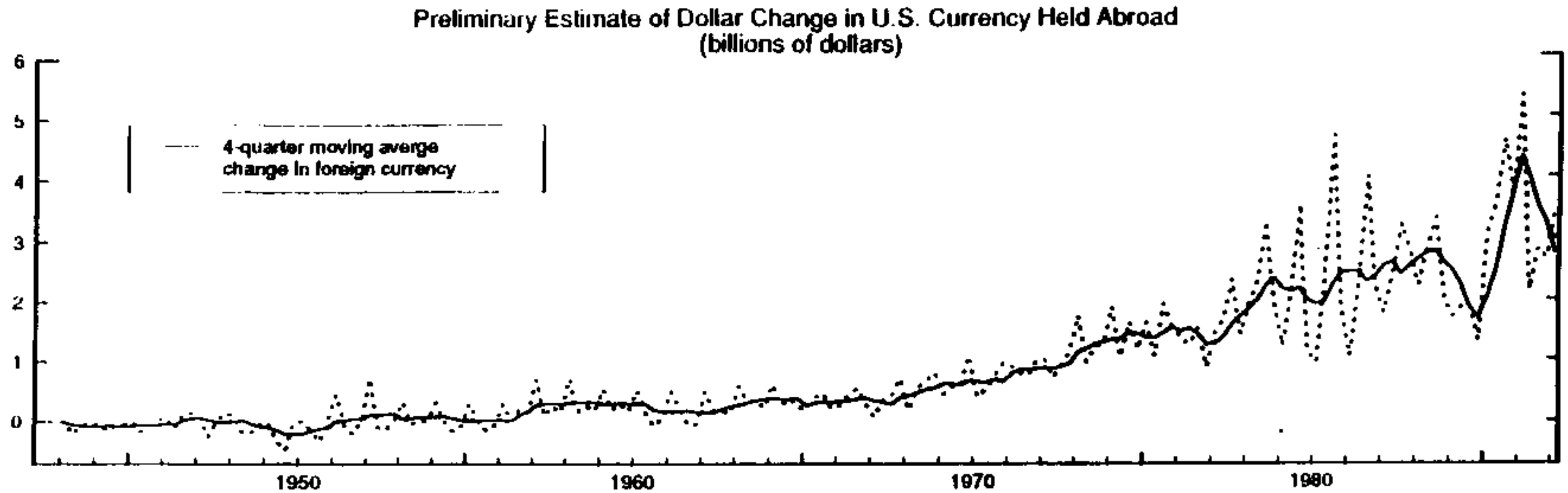
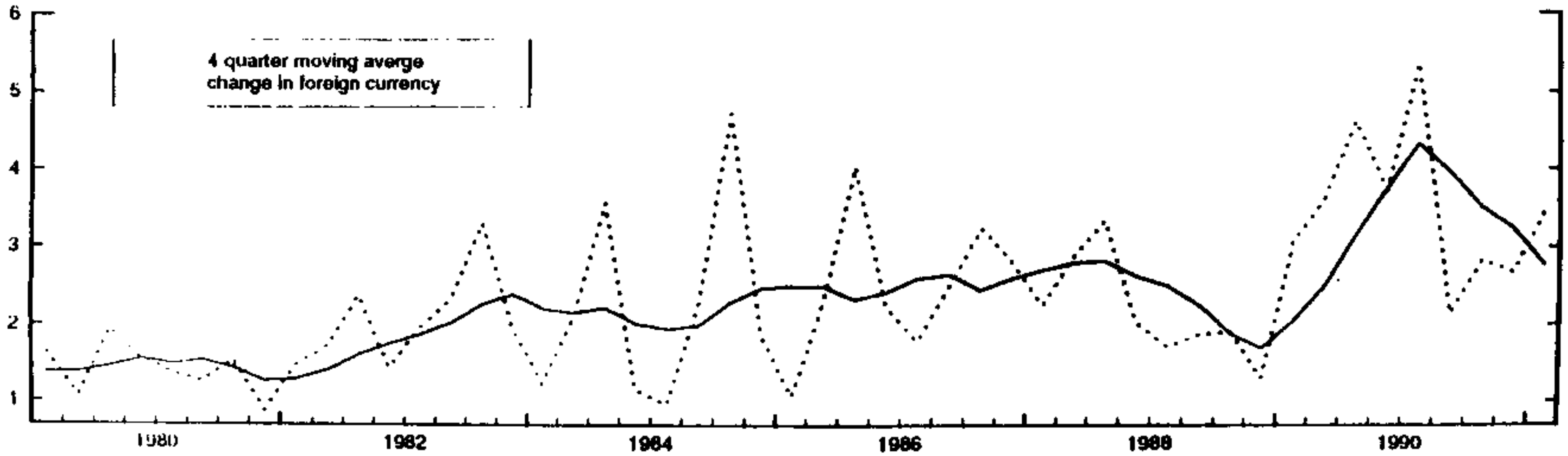


Chart A-2



Preliminary Estimate of Dollar Change in U.S. Currency Held Abroad
(billions of dollars)
4-quarter moving averge
change in foreign currency
6
5
4
3
2
1
0
1950
1960
1970
1980



4 quarter moving averge
change in foreign currency
6
5
4
3
2
1
1980
1982
1984
1986
1988
1990

APPENDIX: Estimates of Foreign Holdings of U.S. Currency -- An Approach based on Relative Cross-Country Seasonal Variations

by Richard D. Porter [1]

INTRODUCTION

This appendix provides a brief description of some staff research being undertaken to estimate the amount of U.S. paper currency (predominantly Federal Reserve notes) held outside the country. One reason for being interested in this question is that it may help us to understand why per capita currency holdings (at about $1,088 in March of 1992) are so large. A number of observers have suggested that such outsized per capita magnitudes probably reflect a large and growing stock of U.S. currency held outside the boundaries of the United States.

In research that I have been undertaking jointly with Jeff Hallman and Prof. Edgar Feige of the University of Wisconsin, four approaches have been investigated to estimate the quantity of currency held outside the U.S. Three of these approaches use aggregate data -- (1) a "direct" method that

1. Assistant Director, Division of Monetary Affairs, Board of Governors of the Federal Reserve System. I wish to thank Ron Goettler, who is now a graduate student at Yale, for expert research assistance. I also wish to thank Prof. Ed Feige of the University of Wisconsin for many useful discussions on this topic and my colleague Greg Hess for helpful comments that prompted me to devise the specific estimation method chosen for estimating the fraction of currency held abroad.

combines selected survey information on currency holdings of U.S. residents with limited data on net shipments of currency abroad,(2) a seasonal method, and (3) a velocity method. The fourth method uses a demographic model of the age of U.S. currency circulating inside and outside the U.S. based on FR 160 data (on currency flows within the System at the branches of the Federal Reserve) and two samples of notes in circulation that were taken early and late in 1989 of domestic and overseas notes. The appendix only discusses the seasonal method developed by the author.

ASSUMPTIONS

By looking carefully at not seasonally adjusted currency data for two countries, Canada and the United States, we explore one possibility for estimating currency abroad. Our working hypothesis is that if the United States did not have as large an overseas currency component, the relative magnitude of seasonal variations in currency would be larger. That is, we assume that the predominant use of the dollar abroad is not to conduct transactions that have a seasonal component, or at least a seasonal component that is recognizable from the U.S. viewpoint. If the dollar is primarily being held as a store of value, this requirement is obviously satisfied. If Argentina, Poland, or other countries hold sizeable amounts of dollars and augment their holdings, we assume that they are adding to the trend-cycle component of the series, not the seasonal component. That is, one could imagine that such currency held abroad stayed overseas for considerable periods and therefore was implicitly embedded in the trend-cycle component, not the seasonal component of the series.

But, as stated, the requirement is too stringent. There can be a two-way flow of currency between the United States and any of these foreign countries with the reflow back to the United States occasionally being larger than the outward flow. But what we need to assume is that such reflows do not follow a regular seasonal pattern.

Specifically, if net shipments of currency overseas had no apparent seasonal pattern, it would be safe to assume that overseas holdings of U.S currency had no seasonal.[2] Of course, there are no reliable statistics on the amount of currency held abroad. Most large legal shipments and receipts of United States paper currency to and from the rest of the world are handled by a small number of banks that, from time to time, have provided information to the Federal Reserve Bank of New York on the amounts and location of such shipments and receipts. [3] During the period between the two World wars such data were routinely collected for a sample of

---

2. Net shipments in some period are the difference between currency shipped out of the U.S. less currency returned to the U.S. in that period.

3. The New York Federal Reserve bank has traditionally supplied much of the currency that is exported by commercial banks to the rest of the world.

large New York City Banks and are reported in the Board's volume on *Banking and Monetary Statistics: 1914-1941.* Annual data were published for over a dozen countries: Austria, Belgium, Danzig, England, France, Germany, Greece, Italy, Latvia, Lithuania, Netherlands, Poland, Russia, Switzerland, and an "other" category. From an examination of autocorrelation and partial autocorrelation functions (the ACF and PACF) for such data, it is readily apparent that there is not a significant lag 12 term (seasonal component) in either the ACF or PACF of the interwar data set (1923-41) or in more recent data collected by the Federal Reserve Bank of New York from 1988-91 for 61 countries, see Table A.1.[4] Indeed, in terms of net shipments to individual countries, only one of the 61 countries examined in the latest four-year period had any noticeable seasonal pattern in net shipments. While noticeable in visual terms, it turned out to be statistically insignificant.[5]

4. From a formal statistical viewpoint, two out of the 61 countries had 12th-order autocorrelation coefficients that were marginally significant.

5. Two countries that had no apparent seasonal pattern in the net shipments data, turned out to have significant 12th order autocorrelation coefficients, though the significance level was only marginal.

A.1: Test of seasonality of net currency shipments[a]

	Autocorrelations		Partial Autocorrelations	
	Sample Period			
lag	1923-41	1988-91	1923-41	1988-41
12	.072	.174	.038	-.048
24	.030	-.214	-.011	.018

a. A value of.133 or greater would represent a significant autocorrelation coefficient during the interwar period; for the recent period, an entry in the table would need to exceed.289 to be statistically significant.

The economic reason for the absence of a seasonal in net shipments may well be one of cost. [6] It may well be too costly for an Argentinian bank to ship currency back to the U.S. during a seasonal low in the demand for dollars within its country. Thus, preceding with the assumption that there is no seasonal variation in the international component appears to be consistent with the available data on shipments of currency by banks.

6. Currently, there would be a charge of about $13,000 for a $50,000,000 shipment of currency plus transportation. Typically, there could be a $1 million dollar deductible insurance policy. Presumably, the opportunity cost of holding currency during a "seasonal" lull would involve not just the usual interest-rate opportunity cost but also the need to factor in the probability that one would fall short of U.S. currency during the lull and be forced to "make do" with the circulating media of the realm.

To benchmark what the U.S. seasonal would be in the absence of a foreign component, we turn to Canada. By all accounts Canada does not have a sizable international currency presence but it does have a similar set of denominations as the United States and, even an exchange rate level via a vis the U.S. that makes the individual denominations in the two currencies, roughly comparable.

A TENTATIVE SPECIFICATION

The simplest way of estimating the foreign currency component would be to assume seasonal variations in the two countries would be the same in relative terms in the absence of foreign components. More specifically, using a multiplicative model of seasonal adjustment the overall currency holding would be the product of the trend-cycle (and irregular) component, we call T, and the seasonal component, say S, which would be decomposed into the domestic and foreign components as follows:

(EQ A.1) $$T_t S_t = T_t^i S_t^i + T_t^o S_t^o$$

where the superscript i is associated with the multiplicative currency components held inside the country, the symbol o with those outside held inside the country, and the subscript t denotes time. If we let β_t be the fraction of the overall trend (T_t) held at home, $\beta_t \equiv \frac{T_t^i}{T_t}$, and $1-\beta_t$ the fraction held in foreign countries, $1-\beta_t \equiv \frac{T_t^o}{T_t}$, then (EQ A.1) can be rewritten as

(EQ A.2) $$T_tS_t = \beta_tT_t + (1-\beta_t)T_tS_t^o$$

Cancelling T_t from both sides of (EQ A.2) gives:

(EQ A.3) $$S_t = \beta_tS_t^i + (1-\beta_t)S_t^o$$

Then since the foreign seasonal component does not vary over the seasons by assumption, that is, $S_t^o \equiv 1\ \forall t$, so (EQ A.3) simplifies to:

(EQ A.4) $$S_t = \beta_tS_t^i + (1-\beta_t)$$

or solving for β_t,

(EQ A.5) $$\beta_t = \frac{S_t-1}{S_t^i-1}$$

Given a seasonal adjustment procedure, we can use the estimate of the overall seasonal component for the currency component of M1 in the U.S. to estimate S_t. And we can use the analogous figure for Canada to estimate S_t^i and thereby obtain the fraction held abroad as $1-\beta_t$.

REVISED SPECIFICATION

However, equations (EQ A.1) to (EQ A.5), assume that, absent a foreign component, the U.S. and Canada would have the same relative seasonal patterns in each an every month. But, in fact, to estimate currency held abroad, we do not need to assume that the seasonal patterns in the two countries are the same up to a scale factor.

Indeed, without some modification, the estimate of β represented by (EQ A.5) will not produce sensible estimates if, as occasionally happens, the estimate of the seasonal factor for Canada happens to equal to unity. Clearly, the estimate of β becomes infinite in that case. If $S^i \neq 1$, (EQ A.5) can produce misleading estimates. The problems occurs when that the Canadian factors do not uniformly lie above (or below) the U.S factors. Such events occur during the months in the year when the factors are moving above (or below) the threshold of unity. That is, while broadly speaking, the seasonal factors for Canada and the United States exhibit what one would expect -- with Canadian movements in the summer and around Christmas being larger than those for the United States, and falling off more sharply subsequently -- the seasonal factors for Canada do not simply follow the same intra yearly pattern as those for the United States.

We can reinterpret (EQ A.5) and avoid these problems by focusing on the relative amplitude of the seasonal variations in the U.S.versus Canada. For example, in recent years the seasonal high in both the U.S. and Canada is reached in December while the seasonal low is reached in February. Thus, we could take the difference between these two magnitudes as the estimate of the amplitude and derive our estimate of β from that.

In fact, we can generalize this a bit to obtain an estimate for individual months within a year. Our proposed estimate is

(EQ A.6)

$$\beta = \frac{max_{t \in T} S_t - min_{t \in T} S_t}{max_{t \in T} S_t^i - min_{t \in T} S_t^i} = \frac{\hat{S}_t}{\hat{S}_t^i},$$

where $t \in T$ denotes the months within the "T" 12-month span and the hat over the seasonal factors denotes the range, maximum seasonal factor minus minimum seasonal factor, for any 12-month span. That is, we generate monthly estimates by taking the maximum and minimum for any 12 month span and then use the r.h.s of (EQ A.6) to estimate the domestic share of currency. [7]

Thus, the basic assumption is that relative to underlying trend-components, the domestic swings in currency demand in the Canadian and United States are the same over a moving year. Presumably, this holds because the extremes in the domestic demand for currency over a year in the two countries are influenced by the same set of factors, common patterns in weather, holidays, culture and the like. Such an assumption might, of course, be more acceptable if one were to concentrate on similar regions, such as the states in the upper mid west in the United States with the provinces

7. Since there are an even number of months in the year, we are not able in any month to look forward and backward the same number of months to obtain a moving estimate of the amplitude associated with that month. To get around this problem, we have arbitrarily looked back 5 months and ahead 6 months in computing these estimates. Doing it the reverse way -- looking back 6 months and ahead 5 months -- does not change the results materially.

directly to the north in Canada. But we leave such an effort for further work.

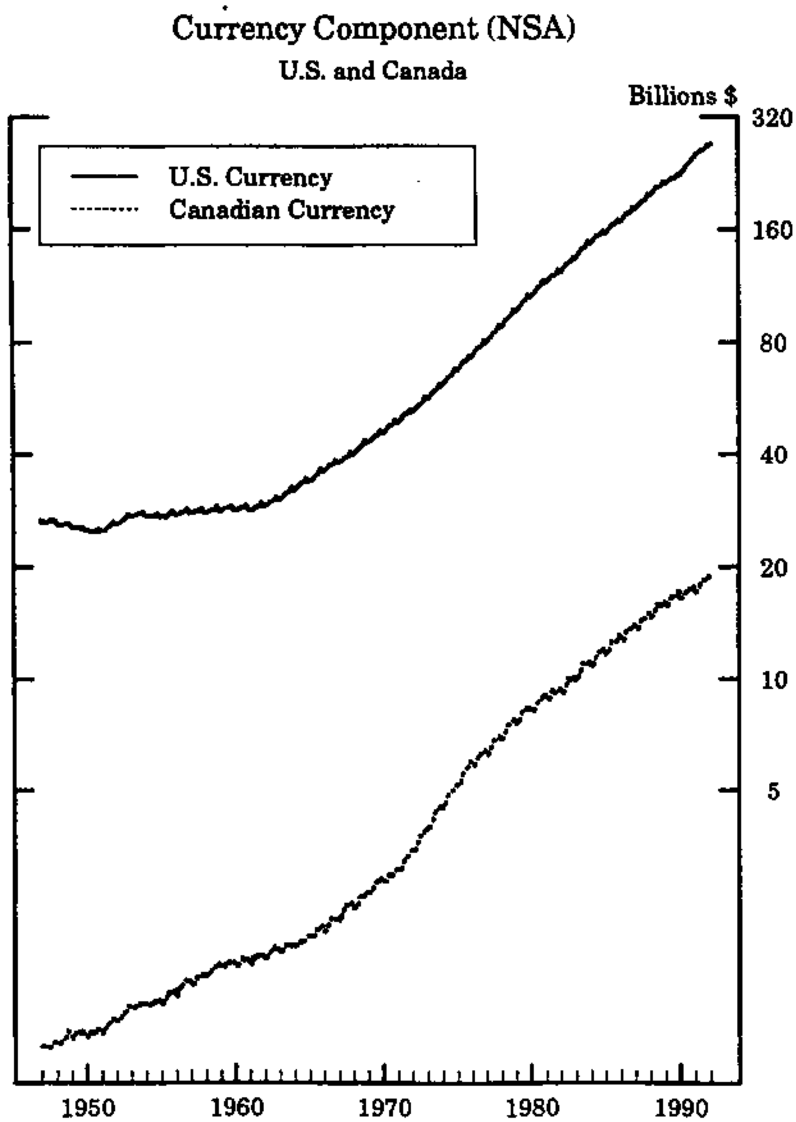
EMPIRICAL IMPLEMENTATION

A.1 shows monthly seasonally unadjusted currency components for the United States and Canada for the period from 1947 to date. Visually, the strength of the seasonal pattern in the U.S. data diminishes over time, particularly in recent years. The top panels in A.2 present estimates of the seasonal factors for the currency component of M1 for the U.S.and for Canada. The figure depicts the factors on the same scale so as to be able to judge relative magnitudes; and to treat the data in a parallel fashion, we used the same seasonal adjustment technique STL with identical adjustment options. [8] In the late 1940s, the estimated amplitude derived with STL of the Canadian seasonal factors is larger but not too much larger than the comparable U.S. figures. However, by the end of the period, the Canadian figures have tended to widen considerably while those for the U.S. have narrowed. It is evident that for the overall series that the Canadian seasonal variations are each gradually increasing somewhat over time while the U.S. seasonal components are declining. The way to reconcile these results is to assume that the for-

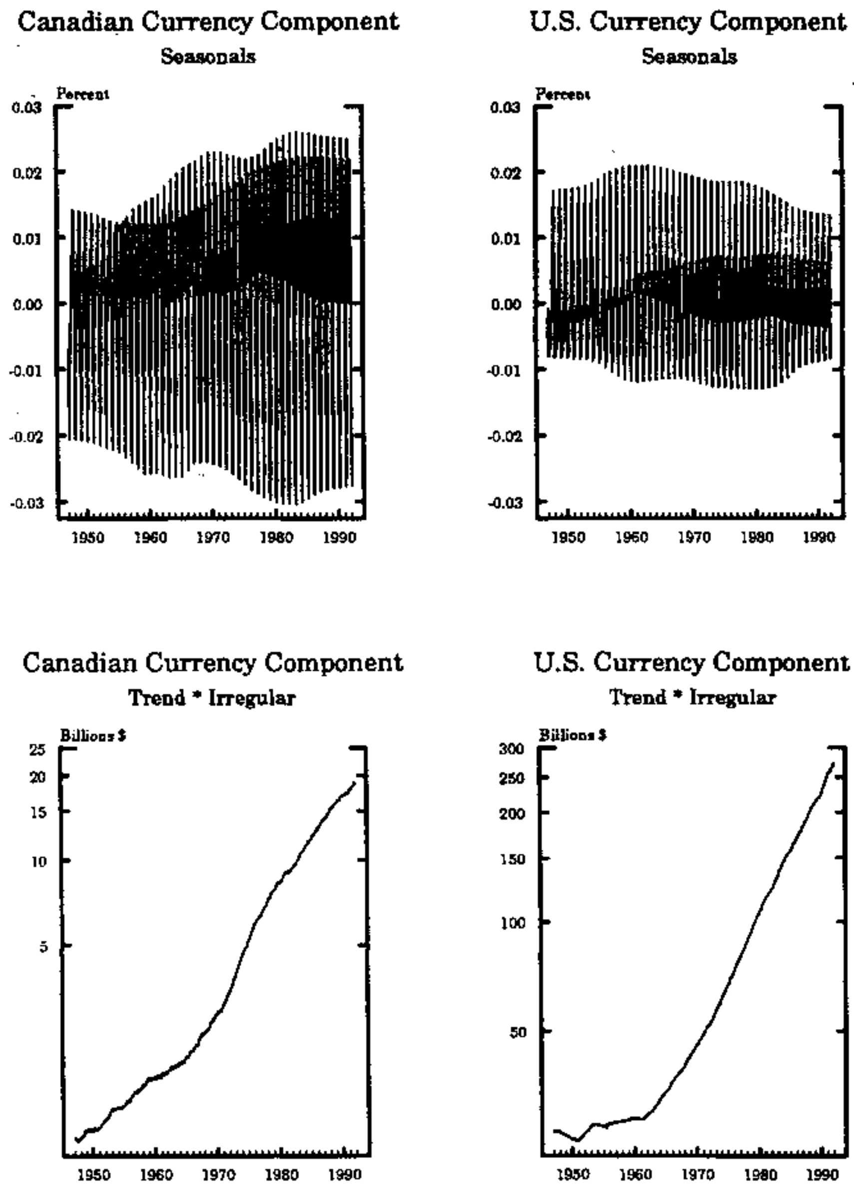
8. R.B. Cleveland, W.S. Cleveland, J.E. McRae, and I. Terpening,"STL: A Seasonal-Trend Decomposition Procedure Based on Loess." *Journal of Official Statistics*, 1990, vol. 6, pp. 3-73.

eign component of U.S. currency holdings is increasing over time.

A.1 Seasonally Unadjusted Currency Components



A.2: Seasonal Estimates for the U.S. and Canadian Currency Components of M1



This procedure naturally results in a stair-step estimate of the fraction of currency held abroad since the maximum and minimum points do not always change as additional months of data are added to these estimates --- see the dotted line in A.3.

To smooth through these stair-step estimates we have also used the Lowess smooth with a relatively small fraction of the data being used at each point, $f = \frac{1}{6}$. [9] The resulting smoothed estimate, shown by the solid line in A.3, starts in 1947 with overseas currency being about 27 percent of total currency. (See column (1) of Table A.2 for the annual numbers underlying this chart.) The overseas fraction then falls to 18.4 percent in 1955 and then begins rising, reaching 59 percent or just under $160 billion in the first quarter of 1992.Such an estimate implies that total currency holdings held inside the United States are about $444 per capita in the first quarter. While introspection suggest that such a number is still quite large, it is not fundamentally inconsistent with other information.

9. The lowess command in S-PLUS gives a robust local smooth of scatterplot data. See William S. Cleveland, "Robust locally weighted regression and smoothing scatterplots," *Journal of the American Statistical Association*, vol. 74, pp. 829-836.

A.1

	Estimated currency held abroad	
	Using (EQ A.6) based on currency components	Using (EQ A.6) based on a weighted average of denominations
	(percent held abroad, annual average of monthly figures)	
	(1)	(2)
1947	27.2	NA
1948	26.8	NA
1949	26.1	NA
1950	25.5	NA
1951	24.9	NA
1952	24.0	NA
1953	22.8	NA
1954	20.5	NA
1955	18.4	NA
1956	18.5	NA
1957	20.0	NA
1958	20.7	NA
1959	21.2	NA
1960	21.3	NA
1961	22.3	34.7
1962	25.4	34.8

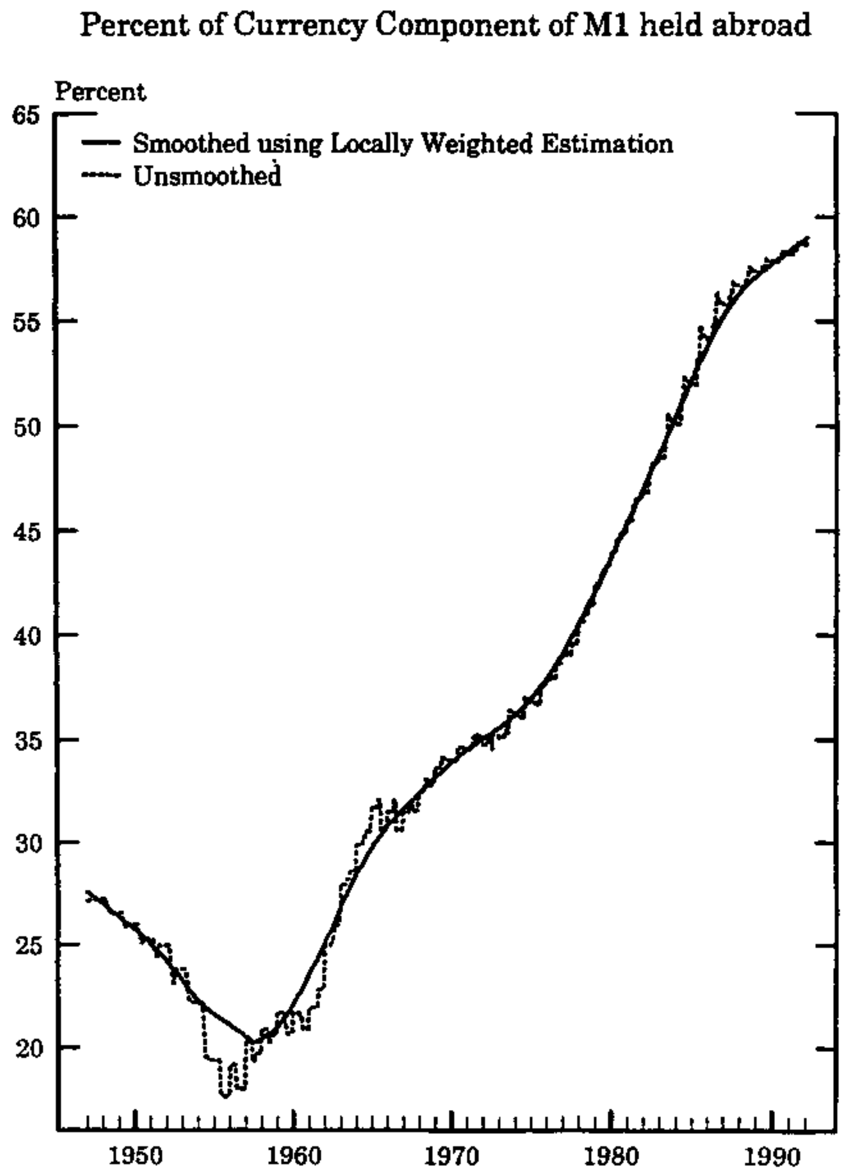
A.1

	Estimated currency held abroad	
	Using (EQ A.6) based on currency components	Using (EQ A.6) based on a weighted average of denominations
	(percent held abroad, annual average of monthly figures)	
	(1)	(2)
1963	28.3	34.6
1964	30.2	34.6
1965	31.3	34.7
1966	31.2	34.9
1967	31.6	35.2
1968	32.7	36.0
1969	33.9	36.9
1970	34.4	38.1
1971	34.9	39.4
1972	35.0	41.0
1973	35.6	42.6
1974	36.4	44.3
1975	37.0	46.0
1976	38.2	47.8
1977	39.2	49.6
1978	41.0	51.3
1979	42.9	53.1

A.1

	Estimated currency held abroad	
	Using (EQ A.6) based on currency components	Using (EQ A.6) based on a weighted average of denominations
	(percent held abroad, annual average of monthly figures)	
	(1)	(2)
1980	44.4	54.7
1981	46.0	56.2
1982	47.5	57.6
1983	49.4	58.9
1984	51.2	60.1
1985	53.2	61.1
1986	55.0	61.9
1987	56.2	62.3
1988	57.0	62.7
1989	57.6	62.9
1990	58.1	63.3
1991	58.5	63.8

A.3 Seasonal-based estimate of the fraction of U.S. Currency Held Abroad.



ARE THESE ESTIMATES CONSISTENT WITH OTHER "FACTS"?

Specifically, an estimate of 59 percent is in some ways in agreement with other information, possibly survey information. Based on information from the Federal Reserve 1986 Survey of Currency and Transaction Account Usage (SCATU), the currency holdings of adults living in households account for only about 11 to 12 percent of the stock outstanding. [10] This figure includes an estimate of households' currency "hoards." Moreover, this percentage appears to be stable, as indicated by the results of the 1984 SCATU and a 1945 pilot survey conducted for the Board by the U.S. Department of Agriculture as a precursor of the early Surveys of Consumer Finances. [11] Apart from the relatively small amount of currency that is estimated to be lost or destroyed (about four percent), the remainder of the currency stock must be held by businesses, by small numbers of domestic residents who are unlikely to be respondents to a consumer survey including people engaged in illegal transactions, or by foreigners. [12]

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10. See Robert B. Avery, Gregory E. Elliehausen, Arthur B. Kennickell, and Paul A. Spindt, "Changes in the Use of Transaction Accounts and Cash from 1984 to 1986," *Federal Reserve Bulletin*, March 1987, pp. 179-196.

11. Ibid. p. 191.

12. See Robert Laurent, "Currency in Circulation and the Real Value of Notes," *Journal of Money, Credit and Banking*, May 1974, pp. 213-226. Laurent estimates that currency that has been lost or destroyed amounted to between 2-1/2 and 4-1/2 percent of the total quantity of currency outstanding.

Although no information is available on the currency holdings of businesses, it is difficult to believe that businesses hold much more currency than households. Most retail operations only need seed cash at the beginning of each business day to operate. As a consequence, the only firms and farms that would be likely to hold much cash are those that are located at a significant distance from depository institutions or firms that did not feel safe in routinely depositing sizeable amounts of currency with their depositories. In addition, in the business category includes "vault cash" of nondespositories, for example, firms engaged in check-cashing or trading in foreign exchange. Clearly, such an estimate could be much too large.

Using estimates from the IRS on the level of illegal transactions and assuming that all such transactions are made in cash and that this cash turns over at the same rate as the currency holdings of households, it is possible to account for another five percent of the stock. [13] Holdings of currency by other persons not observed in the survey would have to be extraordinarily skewed to account for the remaining currency; best guesses are that this group might account for a few percentage points. [14] Combining these rough estimates, one might estimate that at about thirty eight percent

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13. For the details on this calculation, see Robert Avery and others, "Changes in Transaction Accounts," op. cit.,p. 191.

14. Ibid., p. 191.

of the currency stock was accounted for as being held domestically, with the remaining 62 percent held somewhere else, say outside of the country, see Table A.2. The total

A.2 A possible allocation of currency holdings

Category	Percent of Currency in various categories
Households[a]	11-12
Businesses excluding depositories[b]	12
Lost or destroyed[c]	2-1/2-4-1/2
Held by wealthy individuals[d]	3
Used in illegal transactions[e]	5
Total	32-1/2-35-1/2

a. Based on SCATU survey.

b. Rough guess, probably more of an upper bound.

c. Based on Laurent's work.

d. Another rough guess.

e. Based on IRS sources and SCATU, see text.

accounted for is not that dissimilar from what we have estimated using the seasonal method, lending some degree of independent support for the seasonal approach being taken.

ESTIMATES OF CURRENCY HELD ABROAD BY DENOMINATION

Up until now we have exclusively used the currency component of M1 for both Canada and the United States because the currency component represents currency in the hands of the public, that is, outside of depositories. We do know that the currency held by depositories as vault cash remains inside the country so it makes sense to exclude such currency from our calculations. But it may also be of interest to apply the same methodology to a dataset on individual denominations -- ones, fives, and so on up to hundreds. In that case, we are forced to include vault cash in the calculation since there are no available estimates of vault cash by denomination.[15] A.4 displays estimates for six denominations from ones to hundreds in the top three panels, with the lower left panel repeating A.3 and the lower right panel representing the weighted average of the denominations with the weights equal to the relative shares in the denominations. Table A.4 displays the annual figures associated with the denomination data in this chart. (Column 2 of Table A.2 gives the weighted average denomination results.) On balance, the denomination data are in line with the results using the currency components, as can be seen by comparing the lower pan-

15. There is one technical advantage in using the denominational data compared with the currency component measures. For denominations, the U.S. and Canadian data are both end-of-month data. For the currency component, we are using monthly average data for the U.S. and interpolated monthly-average data for Canada the latter being obtained as an average of successive end-of-month figures.

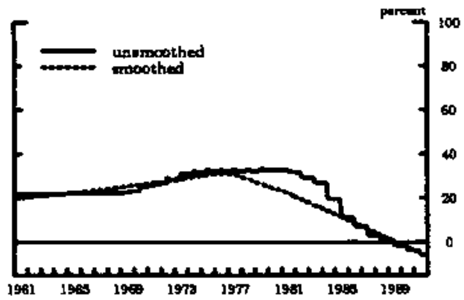
els. [16] The denomination data also accord with casual evidence that suggests that a large part of the foreign currency holdings are in large-denomination notes, particularly hundred-dollar notes, column 6 in Table A.4.

Finally, there is one aspect of the chart and Table A.4 that might appear anomalous. The estimates for one-dollar bills turn negative in 1989 because of a structural break in Canadian one-dollar bills, see column 1 of Table A.4. The Canadian one-dollar bill declined sharply beginning in 1987 as a result of the successful introduction of a one-dollar *coin*. Clearly since our approach does not account for the switch in Canada to one dollar coins, it could and does breakdown shortly after the coins were introduced. We have not tried to adjust for this innovation because its impact on the weighted average denomination, column 2 in Table A.2, is marginal and only appears near the end of our estimation period.

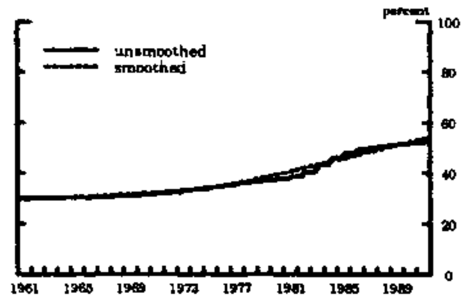
16. These calculations ignore the $25 bill in Canada and denominations over $100 in both countries. At first glance, it does not appear that these omissions bias the results up.

A.4: Seasonal-based estimate of foreign currency holdings by denomination

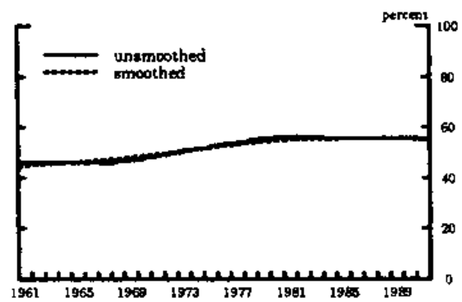
Ones



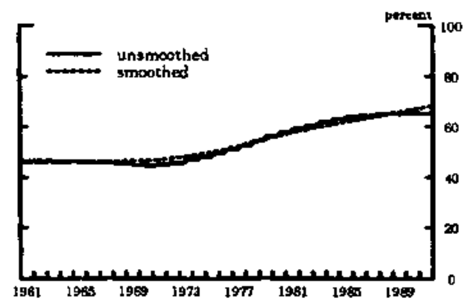
Fives



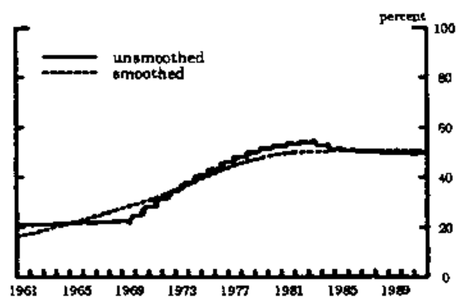
Tens



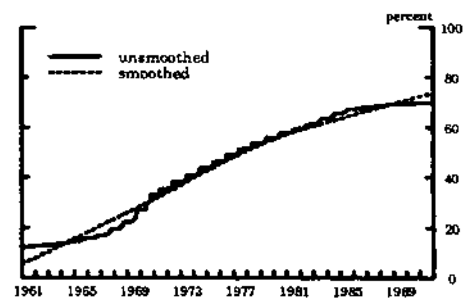
Twenties



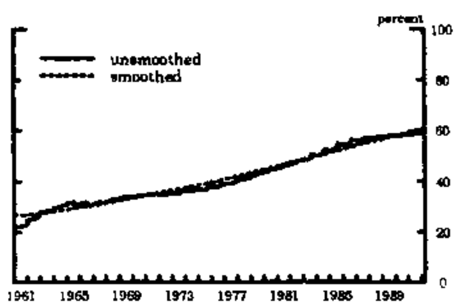
Fifties



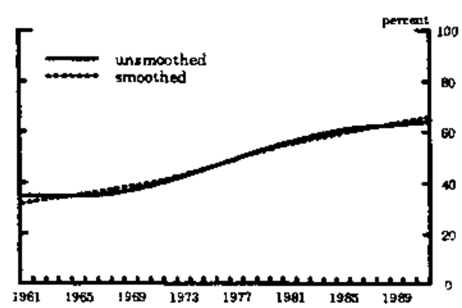
Hundreds



Total Using Currency Components



Total using weighted average of denominations



	Denominations of U.S. Currency Held abroad according to the seasonal method (EQ A.6)					
Year	$1	$5	$10	$20	$50	$100
	(percent held abroad, average of monthly estimates)					
	(1)	(2)	(3)	(4)	(5)	(6)
1961	21.8	30.2	46.1	46.4	20.9	12.4
1962	21.9	30.2	46.1	46.3	21.0	12.9
1963	21.9	30.2	46.0	46.3	21.1	13.5
1964	21.9	30.2	46.0	46.2	21.4	14.2
1965	21.9	30.2	46.0	46.0	21.6	15.1
1966	22.0	30.3	46.0	45.9	21.8	16.3
1967	22.2	30.4	45.9	45.6	22.0	17.9
1968	22.4	30.7	46.2	45.3	22.2	20.5
1969	22.5	30.9	46.8	44.8	23.0	24.0
1970	24.1	31.3	47.6	44.5	26.0	29.7
1971	26.1	31.9	48.5	44.8	29.4	34.2
1972	27.8	32.2	49.4	45.2	32.7	36.8
1973	29.8	32.8	50.4	46.1	36.0	39.6
1974	31.2	33.4	51.3	47.3	39.2	42.6
1975	32.1	34.0	52.1	48.4	42.0	45.3
1976	32.3	34.8	53.1	50.0	44.6	48.0
1977	32.3	35.5	53.9	51.6	47.1	50.4
1978	32.3	36.2	54.7	53.4	49.1	52.7
1979	32.5	36.7	55.4	55.2	50.9	54.9
1980	32.6	37.3	55.8	56.9	52.2	56.8
1981	32.1	38.0	56.0	58.4	53.1	58.6

	Denominations of U.S. Currency Held abroad according to the seasonal method (EQ A.6)					
Year	$1	$5	$10	$20	$50	$100
(percent held abroad, average of monthly estimates)						
	(1)	(2)	(3)	(4)	(5)	(6)
1982	30.2	39.4	56.0	59.8	53.8	60.6
1983	27.7	41.6	55.8	61.2	53.5	62.6
1984	22.6	44.5	55.6	62.4	52.2	64.8
1985	14.7	47.1	55.5	63.5	51.1	66.7
1986	8.9	48.8	55.5	64.1	50.6	67.9
1987	4.6	49.9	55.5	64.5	50.2	68.5
1988	1.5	50.6	55.5	64.8	50.0	68.9
1989	-0.8	51.1	55.4	65.0	49.8	69.2
1990	-2.9	51.6	55.4	65.2	49.6	69.5
1991	-4.9	51.9	55.3	65.4	49.5	69.7

COMMENTS ON PAPER BY HESS, SMALL, AND BRAYTON

Bennett T. McCallum[1]

I am pleased that Hess, Small, and Brayton (HSB) have undertaken a serious study of the properties and robustness of the operational rule for monetary policy that I have been promoting for the past few years.[2] In this note I want to take issue with some of the conclusions put forth (somewhat implicitly) by the authors so I should state at the outset that I view their paper as a valuable piece of work. It gives evidence not only that they have been careful in their econometric work but also that they have given considerable thought to my rationale for the policy rule in question and my reasons for studying it in a particular way. It is a thoughtful study.

The first of HSB's reasons for criticizing my proposed rule is that the relationship between the monetary base and nominal GNP has apparently broken down since the mid 1980s, leading to a deterioration in the rule's simulated performance. Even with this breakdown, the performance is actually not bad according to their results using my most rudimentary, single-equation model--see HSB's Chart 2 and column (ii) of Table 1. In the latter, the RMSE (root mean square error) for x_t (log of nominal GNP) relative to a steady three-percent growth path is only 0.024 for their extended

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1. H.J. Heinz Professor of Economics, Carnegie Mellon University, and Research Associate, National Bureau of Economic Research.

2. The main references are McCallum (1987, 1988, 1990). Useful extensions or applications have been provided by Hall (1990), Judd and Motley (1991), and Hafer, Haslag, and Hein (1991).

1954.1-1992.1 sample period, as compared to 0.020 for 1954.1-1985.4. But switching to their version of my three-equation ASAD model yields performance results that are substantially worse--as is shown by the RMSE values in columns (i)-(iv) of their Table 2. One reason for the difference is that the estimated coefficient on the contemporaneous value of base growth falls almost to zero when the longer sample period is used. But for some reason an even greater deterioration takes place when HSB impose steady-state neutrality restrictions on the estimated wage and price adjustment relations. In this regard, I would tend to share their opinion that these restrictions are reasonable. But it is unclear to me how the small reported changes in coefficient values (resulting from the restrictions) could bring about such a major deterioration in performance--especially since there is none when the shorter sample period is used.[3]

Accordingly, I have--since the conference was held--conducted some analogous calculations of my own. These differ in several respects from those of HSB, but all the differences are quite small--for example, I have used GNP data over 1954.1-1991.4 rather than GDP data over 1954.1-1992.1.[4] First, I re-estimated my ASAD model over 1954.1-1991.4 and performed the simulation as in McCallum (1988, 1989) with $\lambda = 0.25$.[5] The deterioration was much less severe

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3. See columns (i) and (iii) in Table 2 of HSB (1992).

4. I could not find some of the values for 1991.4, so mine were generated by assuming that their percentage changes relative to 1991.3 were the same as for the comparable variables in the revised GDP accounts.

5. My new estimates are reported in the appendix.

than that found by HSB, the RMSE rising from 0.0191 to 0.0246. Then imposing constraints on the wage-adjustment and price-adjustment equations of this model, I again simulated over the 1954.1-1991.4 period and found very little additional deterioration--the RMSE value was 0.0277. Why HSB obtained the huge increase to 0.050 in this latter case is unclear to me; one would not expect the differences between their specification and mine to be substantial.[6] Until this mystery has been resolved, then, I am inclined to remain optimistic that the recent deterioration in performance is not as bad as the HSB study makes it appear.

Related troublesome results are those reported in the top panels of HSB's charts 6 and 7, which are RMSE values for the single-equation and ASAD models based on 15-year rolling sample periods. It should be emphasized, however, that the RMSE values (as well as the model estimates) pertain only to these 15 year periods. Thus the deterioration shown for recent years stems from recent macroeconomic instability as well as a reduction in the estimated effects of the base on aggregate demand. Even if the models had held up, that is, there would have been some deterioration shown. In this regard it is worth mentioning that a few years ago Flood and Isard (1988) conducted a study of my rule using 10-year rolling periods for model re-estimation, but summarizing the RMSE results over the entire sample period. And they found that even though the

6. Besides using GNP data and one fewer observation, my equations differed in the following ways. (i) As in my previous work, I used a fitted trend for "capacity" real GNP in calculating the ygap variable, with the fit pertaining to the sample period under study. (ii) As in my previous work, I used only one lagged inflation rate in the price adjustment equation.

crucial estimated coefficient on base growth (in the single-equation model) moved around a lot, the overall RMSE performance was actually <u>better</u> than with my procedure!

So, while I am disappointed to see that the last few years have been somewhat damaging to the case for my rule, I am not ready to conclude that it lacks promise. These last few years have been truly exceptional in many relevant ways, so a few more years of data may bring the overall results back on track. And also I would like to argue that it is wrong to place so much emphasis on the magnitude of the RMSE measures.[7] If it were to be found that the simple, automatic rule under discussion would actually deliver non-inflationary demand growth with fluctuations of about the same severity as in the postwar experience, then the rule's design should probably be judged as a rather remarkable success.

Let me go on now to the second main line of criticism by HSB, which concerns the rule's performance in models in which monetary policy actions are transmitted to aggregate demand entirely way of interest rates. In the authors' setup (pp. 13-19) aggregate demand is modeled by three relations: an IS function in which the relevant interest rate is a 10-year real rate; an equation connecting the nominal 10-year rate to the federal funds rate; and a base demand function in which the funds rate appears. In their studies, HSB use two versions of the equation relating long to short rates, one that specifies quick adjustment of the long rate and one that posits slower adjustments. With the quick-adjustment version, the policy

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7. I am no doubt at fault for starting this tendency myself, but portions of McCallum (1990) give considerable emphasis to the avoidance of instrument instability over a wide range of conditions.

rule seems to perform satisfactorily in terms of nominal GNP stabilizations, but in the other case the performance is much poorer. The RMSE is about four percent (instead of 2.5 percent) and, as HSB emphasize, the simulations feature very high variability of the funds rate.

With regard to these findings I have two comments. First, while I entirely agree that it is important to check robustness to model specification--indeed, that is a feature of my approach to studying the merits of a proposed rule--I am not certain that the HSB model is entirely appropriate. What we want to do is to consider estimated versions of alternative specifications that have some theoretical support. But the HSB model contains a relation--the long rate to short rate connection--that is not estimated but specified a priori. One or both versions may be inconsistent with the data. Second, something that they do not mention is that in my work I have used (among other specifications) a small VAR system that includes both the monetary base and a short term interest rate as variables. With such a system, the estimated parameters are free to take on values representative of models in which policy transmission is either via interest rates or "direct," in their terminology. And in this system, my experiments show GNP stabilization to be quite satisfactory with my rule, and indeed distinctly superior to that achieved when the interest rate is used as the instrument.[8] Admittedly, the simulations involve large fluctuations in the interest rate (with either instrument) but it is generally agreed that accurate achievement of nominal GNP targets

8. See pp. 61-66 in McCallum (1990).

would entail more funds rate variability than we have at present.

Finally, there is the finding that my rule leads to instrument instability when simulated in the MPS model. I would tend to agree with the HSB conjecture that this result is due to the time pattern of base demand responses to current and lagged interest rates, i.e., the pattern that is present in the MPS model. Whenever the magnitude of the current-period response is small, in relation to lagged responses, there will be a strong tendency toward instrument instability if the base is used as the instrument.[9] The question, then, is whether such a specification is reasonable. My argument that it is not is spelled out in McCallum (1985, pp. 583-585), where it is noted that theory suggests that previous-period interest rates should not appear in asset demand functions because such rates are irrelevant bygones. They seem to show up empirically, but my 1985 suggestion is that this is because of adjustment costs that imply a proper specification in which an asset demand quantity depends upon its own lagged value, the current opportunity-cost rate variable, and expectations of future values of the latter. In such a setup, one will tend to find lagged values of interest rates in distributed-lag regressions even though none are actually present. And, to come to the point, there is no tendency toward instrument instability in such a system--even though there is in one that erroneously includes lagged values rather than future expected values of the opportunity cost variable. On the basis of this argument, I would suggest that the MPS model's indication of

9. See McCallum (1985, p. 583) for one very simple example and references to more complex analyses.

instability with a base instrument may well be misleading.

In sum, although the HSB study has been thoughtfully designed and carefully executed, I would argue that it overstates the evidence suggestive of non-robustness of the policy rule performance results given in my 1988 and 1990 papers.

APPENDIX: EQUATION ESTIMATES

Here I report estimates for 1954.1-1991.4 of the equations of the ASAD model used in the simulations described in the paper's third paragraph. Notation is as in McCallum (1988) and (1990). The aggregate demand relation is:

$$\Delta y_t = \underset{(.001)}{0.0039} + \underset{(.077)}{0.2946}\,\Delta y_{t-1} + \underset{(.112)}{0.1549}\,(\Delta b_t - \Delta p_t)$$

$$+ \underset{(.114)}{0.1819}\,(\Delta b_{t-1} - \Delta p_{t-1}) + \underset{(.053)}{0.1127}\,\Delta g_t - \underset{(.054)}{0.0991}\,\Delta g_{t-1} + e_{1t}$$

$R^2 = 0.200 \qquad SE = 0.00906 \qquad DW = 2.08$

For the wage adjustment equation the unconstrained estimates are

$$\Delta w_t = \underset{(.001)}{0.0040} + \underset{(.039)}{0.1827}\,(y_t - \bar{y}_t) - \underset{(.040)}{0.1310}(y_{t-1} - \bar{y}_{t-1}) + \underset{(.070)}{0.7676}\Delta p_t^e + e_{2t}$$

$R^2 = 0.557 \qquad SE = 0.00468 \qquad DW = 1.67$

where $\bar{y}_t = 7.05816 + 0.00744t$, and with the constraint become

$$\Delta w_t = \underset{(.0004)}{0.0015} + \underset{(.040)}{0.2096}\,(y_t - \bar{y}_t) - \underset{(.040)}{0.1665}\,(y_{t-1} - \bar{y}_{t-1}) + 1.0\Delta p_t^e + e_{3t}$$

$R^2 = 0.524 \qquad SE = 0.00483 \qquad DW = 1.56$

The unconstrained price adjustment relation is

$$\Delta p_t = \underset{(.001)}{0.0009} + \underset{(.058)}{0.4610}\,\Delta w_t + \underset{(.060)}{0.4111}\,\Delta p_{t-1} + e_{4t}$$

$$R^2 = 0.675 \qquad SE = 0.00378 \qquad DW = 2.33$$

and with the constraint becomes

$$\Delta p_t = \underset{(0.516)}{-0.0006} + \underset{(.054)}{0.5180}\Delta w_t + 0.4820\Delta p_{t-1} + e_{5t}$$

$$R^2 = 0.660 \qquad SE = 0.00385 \qquad DW = 2.49$$

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NEW DIRECTIONS IN MONETARY POLICY RESEARCH: COMMENTS ON THE FEDERAL RESERVE SYSTEM'S SPECIAL MEETING ON OPERATING PROCEDURES[1]

John B. Taylor[2]

Summarizing this conference is a difficult job. The research is impressive in its volume, variety and quality. Many different economic views and methodologies were reported. A large number of substantially different models were brought forth, including Keynesian models, rational expectations models with sticky prices, real business cycle models, overlapping generations models, large-scale econometric models, multicountry models, time-series models and indicator models. There were 28 authors and 15 discussants. Without commenting on each contribution individually, I would like to discuss several general themes where I think significant progress was made as a result of the research presented at the conference.

OPERATING STRATEGIES AND MONETARY POLICY

The analytical division between operating strategies and monetary policy has become too fuzzy to be of much practical use, according to many of the research papers. Not too long ago the two-step analytical framework for formulating policy developed by Peter Tinsley and others in the early 1980s was typically used. According to this approach, one analytical step determined the level of bank reserves or interest rates to achieve a given level of money supply, while a separate analysis looked at how different levels of money growth would affect inflation

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[1] A written version of a summary of a meeting at the Federal Reserve System Committee on Financial Analysis at the Federal Reserve Bank of St. Louis, June 18-19, 1992.

[2] John B. Taylor is a Professor of Economics at Stanford University.

and real output. Few of the research papers at the conference followed that two-step approach.

Anne Marie Meulendyke's paper raised questions about why we need to worry so much about the reserve-money connection when interest rates are being targeted. In his comments Robert Hetzel even suggested that we skip over the reserve multiplier mechanism in teaching monetary economics. And Marvin Goodfriend's characterization of monetary policy in the 1980s examined how interest rates respond directly to inflation skipping over the money supply. Most model simulations didn't use a two-step analysis. The paper by Jeff Fuhrer and George Moore, for example, bypassed the two-step distinction between operating strategy and monetary policy itself. In the Fuhrer-Moore paper the Fed sets the short-term interest rate according to what happens to inflation and real growth. They then look at the impact on price stability and output stability.

In presenting his paper, Joe Gagnon mentioned that his model was quarterly and therefore not related to operating procedures which are monthly or weekly. But I think that is a technical distinction, reflecting the fact that quarterly models are easier to use than weekly models. If his model were monthly or weekly, he would still be studying the reaction of interest rates to inflation and output measures.

INTEREST RATE TARGETING

Almost every paper assumed that the interest rate rather than reserves was the immediate target variable for monetary policy. This reflects recent experience in the United States and many other countries, as documented by John Morton, Paul Wood and Bruce Kasman. Moreover, the researchers who looked at policy normatively--Joe Gagnon, Jeff Fuhrer, George Moore, John Judd and Brian Motley all focused on interest rate targeting policy. Gregory Hess, David Small and Flint Brayton concluded that interest rate targeting was superior to monetary base targeting.

To be sure, several participants raised reservations about interest rate targeting and made some useful points. In discussing Marvin Goodfriend's paper, Alton Gilbert emphasized the importance of continuing to pay attention to money growth targeting. The paper by Charles Evans and Steven Strongin found real M2 to be the most significant indicator of the group they analyzed suggesting a continued focus on money growth. And John Judd and Brian Motley showed that instabilities can arise under interest rate targeting in certain cases using simulation methods of the type originally used by A. W. Phillips in the 1950s.

Three other issues relating to interest rate targeting came up at the conference. First, should we think about interest rate targeting in real terms or nominal terms? Marvin Goodfriend focused his paper entirely on real interest rate targeting. I have modelled interest rate rules in real terms as well in my international policy analysis. However, real interest rate targeting is viewed suspiciously by some, perhaps because it is hard to think about the Fed targeting real interest rates in practice or perhaps because the expected rate of inflation is viewed as moving directly with the nominal interest rate. The main conceptual advantage to a real interest rate formulation is that the policy automatically adjusts for changes in expected inflation. If real interest rates respond to price deviations--that is the FOMC sets higher real rates when the price level is above target--there is no reason why a stable price level cannot be achieved.

Second, there is a problem about the sluggishness of the interest rate targeting regime. There is a very significant lesson from monetarism. When the economy starts to decline in a recession, targeting interest rates can prevent the automatic cut in interest rates that occurs with money targeting. In the 1970s when inflation was increasing, there were concerns about targeting interest rates because they were not adjusted up fast enough. Some automaticity is lost when interest rates are targeted, at least in comparison with targeting quantities. I think some restoration of that automaticity would be very beneficial.

Finally, I have concern that a complete focus on interest rate targeting could take policy discussions away from the importance of a nominal anchor. Keeping money in the discussion is important because it gives a basis for a long-run price target. In my view this is the purpose of P^* which is essentially a transformation of M2.

INTERNATIONAL ISSUES AND THE ROLE OF EXCHANGE RATES

The paper by Linda Cole and Robert Kahn emphasized the importance of the international transmission mechanism, but of the papers at the conference, only Joseph Gagnon considered the international implications of alternative operating strategies. The results of a recent Brookings Institution study organized by Ralph Bryant on policy rules in international models is therefore useful to consider. There seems to be a consensus among the international models that exchange rate targeting, or even bringing exchange rates into consideration as a key variable in the operating procedures, has undesirable consequences on price and output stability compared with nominal GDP targeting.

There may be some evidence of this in the period of history which Marvin Goodfriend covered in his paper. When we look at the last four or five years of monetary policy, there appears to have been a delay in tightening in Germany and Japan in the late 1980s. The tightening began about 12 to 18 months after the United States. The delay probably related to international exchange rate issues and, in particular, concerns about appreciation of the yen or mark. To the extent that this delay was not optimal in Japan and Germany, it raises some questions about those exchange rate issues.

POLICY RULES

The most important new direction at this conference, in my view, was the general focus on policy rules. There were no papers where the effects of a one-time change in the policy instrument were considered. Only two papers used a deterministic model simulation. One was the Fuhrer-Moore paper where the transition to a lower inflation rate was considered in one section. The other was in the Judd-Motley paper where deterministic simulations were used to see whether, in an A. W. Phillips style analysis, there were some instabilities. All evaluation of policy at the conference was conducted in the modern rational expectations sense of the analysis different policy rules.

In my view this is a welcome development and will have important monetary policy payoffs. It probably has already. Of course, a policy rule isn't necessarily the same thing as a constant money growth rate rule or constant anything rule. Moreover, a rule need not be mechanical. It can be operated through the Federal Open Market Committee (FOMC) where staff members are involved in making judgements. But it has to have some regularity or systematic features to it. The academic literature defines policy rule rigorously, through the Kydland-Prescott terminology of time consistency. Control-theory researchers know what a rule means. That it is not discretion is the most important thing.

However, there is a need to find a way to make the concept of a rule more operational. For this purpose I have found it helpful to divide policy issues into *design* questions, *transition* questions and *operation* questions.

Design questions are what most papers considered in this conference. For the most part they were looking to see how different operating rules work, either through different historical periods or through stochastic simulations.

There is also the question of transition. If one decides that one rule is better than another rule, how fast should it be implemented? If one decides that a rule with two percent inflation is better than a rule with five percent inflation, for example, how fast should one disinflate? Recently we have had a two-installment disinflation--the disinflation from 1979 to 1983 and another one from 1988 to 1992. Those are examples of transitions which are distinct from designing a policy rule. Transition issues arise in fiscal policy too--how fast do we get to a balanced budget?

Operation of a policy rule is perhaps the most difficult issue. It concerns how one translates abstract academic work with stochastic simulations into everyday practice at the FOMC.

One way to think about this problem is to imagine that Jeff Fuhrer, George Moore and Joe Gagnon are right--that the rule they say the Fed has been using over the last eight to 10 years is nearly the optimum rule. Of course, there should be more research on the issue and it should reflect the view that the level of inflation which was not satisfactory during the period. But imagine that the rule was correct. Then what needs to be done? Basically, we need to find a way to make that process work in the future, to describe in practical operational ways how those simple little algebraic formulas work.

One practical suggestion to achieve this goal was Brian Motley's that some rules be put in to the FOMC Bluebook on an experimental basis.

I don't know how that would work but it is an idea worth considering.

Another suggestion has more general applicability and was tried in the 1990 Economic Report of the President. In that Report an attempt was made to show how a policy rule could be used in practice and also to show that, to some extent, the FOMC policy had some features of a policy rule over the last 10 years. There are three aspects to this type of endeavor.

The first aspect is simply to stop using the word rule. It distracts people and makes them think of the constant money growth rate rule. An alternative is "systematic" policy. Words makes a difference in a policy environment.

The second aspect is to put features of a policy rule into two categories: (1) the features of a policy rule about which one is unsure, perhaps because the models are inaccurate and (2) the features of a rule which are more fundamental and on which there is much agreement. For example, two fundamental features of monetary policy rules are: interest rates need to rise when inflation rises to stabilize prices and interest rates need to fall when GDP declines to stabilize the economy and also to stabilize prices. The exact size of the response coefficients needs to be determined and falls into the first category. Agreement about the relevant indicator variables and the signs of the response coefficients would go a long way to making a "systematic" policy operational.

Third, and this is the continuing job of academics and policy staff, is to demonstrate to the policymakers the advantages of rules. Many of the papers at this productive meeting have provided such a demonstration.

CONCLUDING OBSERVATIONS

Bennett T. McCallum[1]

Let me begin by saying that I found this conference to be enjoyable and unusually informative. I definitely feel that I learned more than at a typical macro/monetary conference, whether academic or sponsored by some central bank. I am not so certain that I learned more on a per-paper basis, however; this conference may have set an all-time record for most total papers in less than two days.

Having so many papers has left me with serious problems as to how to proceed in these remarks, since they are supposed to be some form of summing up. A few days ago I decided that it would be infeasible to describe each of the 16 papers, even briefly, in the allotted time. Accordingly it seemed that such a summarization must not be the assignment; that it must be to express some integrating ideas that came from the presentations and discussions. This could be valuable, if well done, and might give the person doing it an opportunity to claim that his or her integrating ideas are ones that all the participants agreed upon--which would of course would be an exaggeration at best. But the assignment under this interpretation also seemed very difficult so, after some unfruitful attempts, I decided to try another approach, inspired by a previous experience. Specifically, I once heard James Tobin manage a conference summing-up by the process of giving awards to different papers: one

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for the most scientific effort, one for the most policy-relevant, one for the most preposterous assumptions, and so on. Attempting that approach, I was in fact able to come up with one award that seemed appropriate, the designation being for the paper whose subject matter departs the farthest from the announced topic of the conference (in this case, operating procedures). that prize, it seemed clear, should go to the paper by Fuhrer and Moore as it is a study of the wage-price or aggregate supply sector of the economy--which would seem to be about as far removed from "operating procedures" as is possible while remaining in the area of monetary macroeconomics.

But this award caused me some confusion, because I was extremely glad that the Fuhrer-Moore paper was included on the program, since its topic is one of the most important in all of macroeconomics and is also one that has been badly neglected by researchers over the past 10 years. Indeed, this is perhaps the most interesting paper one that topic that I've seen over the past decade, so the conference organizers should be applauded for its inclusion (and the authors for writing it).

In any event, this one award was the only one that I could come up with so Tobin's approach did not work for me, and I was again left with a puzzlement as to how to proceed. Accordingly, I have in fact been forced to fall back on some remarks concerning nominal income targets, policy rules, and so on that did not get expressed in the relevant session.

A notable feature of that session was the extent of agreement (partly implicit) that some form of nominal income targeting would be desirable for a central bank (such as the Fed) of a large economy. Since there was apparently a considerable amount of support for that idea, I would like to push it a bit farther by making the following points. To start, I would argue that nominal income is a more appropriate target variable than a broad monetary aggregate such as M2 or M3 for two reasons. First, with a nominal income target it is much easier to know approximately what growth rate magnitude would (if adopted) imply a non-inflationary path. One cannot know what growth rate of M2 would yield zero inflation--or two percent if that is the preferred rate--over the next 20 years, but we can be fairly confident that three or five percent annual nominal GDP growth would not be far wrong. Second, the fact that observations on monetary aggregates are available more promptly and more frequently is not, I would argue, a strong reason for preferring one of these aggregates over nominal income as a target variable. Instead, one could use M2 (for example) as an information variable, with its behavior leading to adjustments in instrument settings designed to induce GDP to approximate its target path. Furthermore, it is not necessarily the case that nominal GDP or GNP would be the preferred measure of nominal spending. It might be possible to find another broad measure of nominal spending that is available more promptly and frequently.

Next, I would like to address the contention that nominal GDP (for example) cannot be adopted as a target because the Fed cannot, for political reasons, claim to be managing the economy to as great an extent as would be suggested. In my judgment that contention is not conclusive because the policy rule adopted by the Fed does not have to be announced officially. The Fed could use a specific rule in its internal policy process while announcing publicly only the two goals that such a rule are intended to achieve--very low inflation on average with moderated cyclical fluctuations in real economic activity. Here I say "moderated" rather than "minimized" because it is not desirable to eliminate real fluctuations entirely--the portion brought about by technology shocks is not entirely undesirable.

It will be noted that I have slipped into the practice of talking about policy rules. I am aware that that word is objectionable to many individuals in the Federal Reserve System, so I should probably look for another word--because I suspect that many of these individuals do not actually object to the concept that I have in mind. What I mean by policymaking in conformance with a rule, as opposed to discretion, is a regular systematic procedure for selecting instrument settings as a function of the state of the economy, with the function selected in a way that does not attempt to exploit any temporary Phillips-type tradeoff. We know from the Kydland-Prescott and Barro-Gordon literature that a procedure that attempts to exploit a tradeoff based on current expectations will fail to do so on average but will impart an inflationary bias to the outcomes. What I mean by a rule is a systematic procedure that abstains from these attempts to exploit currently-held expectations.

The adoption of such a procedure need not be publically announced. If one were followed consistently, the Fed's resulting reputation as a central bank that avoids inflation would be established by experience rather than announcement. (There might be some benefit from consistent announced reminders of the policy's goals--low inflation and moderated cycles.) Then with such a reputation in place, the Fed would be able to respond aggressively to current conditions when, for example, a recession shows signs of developing.

The foregoing line of argument is complementary with Goodfriend's support for a congressional mandate for price stability. Such a piece of legislation would actually, despite appearance, constitute a constraint more on the behavior of Congress than on the behavior of the Fed--it would make it much more awkward for the Congress (or the Administration) to criticize the Fed when it finds it necessary to tighten monetary conditions.

There is one more point pertaining to nominal income targeting that needs to be mentioned. This point involves consideration of the suggestion that, because real shocks are highly persistent, it may be undesirable to try to drive nominal GNP values quickly back to a preset growth path after shocks have occurred. Instead, it might be preferable to treat past shocks as bygones by targeting growth rates rather than growing levels of nominal income. Such a policy would, if successful, result in a nominal income path that is non-trend-stationary but if the drift magnitude were equal to average output growth then expected inflation over any finite horizon would be zero. Furthermore, price level variability would not be severe if targeting errors are small.

Consequently, in my own work on nominal income targeting I have begun to experiment with a revised target scheme that utilizes growth rate targets. In a preliminary study I have found that in my collection of small models the simulated targeting errors are much smaller with this modified rule than with the rule pertaining to levels.[2] Furthermore, the variability of the instrument variable is reduced and it is possible to apply the instrument more aggressively without inducing instability. Consequently, although more work is needed, I am at the moment inclined to favor this modified (growth rate) version of a nominal GNP rule--or perhaps one that uses a weighted average of the growth-rate and growing-level target values.

In conclusion, I would like to add an apology for not having more to say about the many excellent papers in this conference. I feel that I have learned a good bit about history, day-to-day operations,

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2. See the conference paper by Hess, Small, and Brayton for a description and references.

procedures in other countries, term-structure anomalies, and several other topics--and I hope to learn more with additional study of these papers.