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Channels of Monetary Policy

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REVIEW

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President's Message

The view that, in the long run, monetary policy can affect only nominal variables is now widely held, both within the Federal Reserve and among economists generally. Moreover, there is a growing consensus that to achieve maximum achievable sustainable economic growth, the main objective of monetary policy should be price stability. On the other hand, there has never been agreement about how monetary policy actions are transmitted through the economy to prices. Certainly, if we could reach a consensus about this process, we might better agree on how best to achieve our long-run goal.

Many believe that monetary policy works through interest rates. By influencing short-term real interest rates, they contend, policy actions have an effect on long-term real rates and, in turn, spending, output and, eventually, prices. The extent to which interest rates respond to policy actions, however, is unclear, as is the degree to which interest rate changes affect spending. I confess that I am skeptical about our ability to consistently and predictably influence longer-term real interest rates. For this and other reasons, I am uneasy about trying to achieve price stability by adjusting nominal short-term rates.

Some researchers have argued that monetary policy actions affect the real economy by influencing the availability of credit. Indeed, some contend that the sharp decline in bank lending at the beginning of this decade—the so-called credit crunch—was evidence that monetary policy was too restrictive. All firms do not have equal access to credit markets. Thus, monetary policy actions may affect some more than others. What this tells us about the formulation and implementation of monetary policy is unclear to me, however. Nevertheless, I believe readers of this issue of *Review* will be intrigued about the discussion on the credit channel and its implications for the conduct of monetary policy.

Of course, the money channel is not without its problems. In the past, setting monetary target ranges and reducing them over time "operationalized" the Fed's resolve to contain inflationary pressures and move toward price stability. The apparent breakdown in the short-run relationship between nominal spending and the monetary aggregates—first M1 and, more recently, M2—has made the aggregates less useful in guiding policy, at least for now. What's more, a reduced emphasis on the aggregates may undermine the credibility of the Federal Open Market Committee's commitment to price stability.

Perhaps it is time to follow the lead of other central banks and quantify our long-term objective through an explicit inflation target. That, however, is a topic for another time, except that in debating channels of monetary policy, we cannot lose sight of what a central bank ultimately influences: prices. Nor can we lose sight of what a central bank does, which is influence reserve availability. What we need to learn more about is how these actions are transmitted through the economy to prices. A clearer understanding of this transmission mechanism can enhance policy credibility as well.

Thomas C. Melzer
President and Chief Executive Officer
Federal Reserve Bank of St. Louis

Editors' Introduction

The conventional wisdom once held that *money doesn't matter*. Now there is wide agreement that monetary policy can significantly affect real economic activity in the short run, though only the price level in the long run. Considerable debate remains, however, about how monetary policy affects the real economy and prices. The Nineteenth Annual Economic Policy Conference was devoted to assessing and deepening our understanding of how monetary policy works. This volume of the *Review* contains the proceedings of that conference. We believe that the careful and wide-ranging analyses presented here will focus the debate and perhaps further the profession's understanding of the monetary transmission mechanism.

The conference focused on what many consider to be the two principal channels of monetary policy: 1) its effect on interest rates; and 2) its effect on the availability of credit. These channels are sometimes referred to as the *money* (or *interest rate*) channel and the *credit* channel, although the conference made clear the difficulties associated with these labels. For example, some participants noted that monetary policy could affect the real economy even if it had little or no effect on real interest rates. Consequently, they objected to equating the money channel with the interest rate channel. Furthermore, one form of what is generically referred to as the credit channel requires that monetary policy actions significantly affect the real interest rate. This form of the credit channel differs from the interest rate channel in the way that changes in the real interest rate affect output. Consequently, calling one the interest rate channel and the other the credit channel is potentially misleading.

THE LIQUIDITY EFFECT

The first article, by Lee Ohanian and Alan Stockman, defines the liquidity effect as "the purported statistical relation between expansion of bank reserves or a monetary aggregate and short-run reductions in short-term interest rates." Ohanian and Stockman then explore the liquidity effect in general-equilibrium, representative-agent models.

Ohanian and Stockman's analysis shows that in a general-equilibrium environment, exogenous changes in money can, in principle, affect real output, prices or the interest rate. If money is neutral and prices adjust instantaneously, monetary policy changes the price level, but not output or the real interest rate. If prices do not adjust instantaneously, a liquidity effect occurs—the real interest rate declines in response to a monetary expansion. The failure of the price level to adjust immediately to its new long-run equilibrium, however, also produces expectations of inflation. From the Fisher relation, the nominal interest rate may either rise or fall, depending on the relative size of the liquidity and price expectations effects. If the liquidity effect is dominant, both the nominal and real rates fall. If the price expectations effect is dominant, the nominal rate rises.

Ohanian and Stockman show that within this class of models, variants differ in both the mechanisms that produce sluggish price adjustments and in how monetary policy actions influence the real economy. Their review considers a wide variety of equilibrium models: one- and two-sector sticky-price models, two-country models, limited-participation models (with and without representative agents), and even models where the only role for money is to reduce intermediation costs. In the last case, the liquidity effect is perverse: An increase in the money supply causes the real interest rate to rise because a monetary innovation represents a technological change. Many of these models include a cash-in-advance constraint and all require a mechanism that causes prices to adjust slowly to their equilibrium level.

In his discussion of Ohanian and Stockman's paper, Kevin Hoover re-interprets many of these models within a standard IS-LM aggregate-supply/aggregate-demand framework. Hoover questions whether the research agenda on which Ohanian and Stockman report, namely the modeling of monetary policy within a representative agent, cash-in-advance constraint framework, is useful for understanding the liquidity effect. Specifically, he questions whether the liquidity effect in such models truly reflects what most of the profession thinks of as the liquidity effect. First, he notes that in general-equilibrium models all of the endogenous variables are determined simultaneously and, hence, the interest rate cannot be "causally efficacious," as in most discussions of the liquidity effect. Second, Hoover argues that the liquidity effect is a feature of financial markets and that the financial sectors of these models are simply not sufficiently rich to capture the liquidity effect adequately. In models of the type presented by Ohanian and Stockman, the interest rate is solely determined by the shadow prices associated with consumption, leisure and saving choices. In the end, Hoover concludes "that we still are a long way from understanding the liquidity effect."

THE EMPIRICAL EVIDENCE

While the theoretical foundations for the liquidity effect remain controversial, the article by Adrian Pagan and John Robertson, and commentary by Lawrence Christiano, narrow the disagreement about the empirical relevance of the liquidity effect. Pagan and Robertson thoroughly review the empirical literature on the liquidity effect, differentiating between single-equation and systems-modeling approaches. Arguing for a systems approach, they focus their attention on the estimation of vector autoregressions (VARs), which is the most promising tool for identifying a statistically significant and empirically relevant liquidity effect.

Pagan and Robertson start with an interesting discussion of some basic differences between Sim's VAR approach and the older Cowles Commission methodology, which involves estimation of a simultaneous-equation structural model. The authors point out that the assumptions used to identify the structural parameters in VARs, that is, that the covariance matrix is diagonal and that the structure is recursive are, a priori, no more or less credible than the identifying restrictions adopted by the Cowles Commission approach. Since the Cowles Commission approach frequently results in over-identified systems, and the Wold casual ordering exactly identifies the structural parameters of the system, Pagan and Robertson state that "One might...categorize the difference as simply amounting to whether one wants to work with an exactly identified system or not."

Pagan and Robertson also point out the similarity in the approaches to selecting among what are essentially observationally equivalent structures. VAR practitioners frequently select from alternative Wold causal orderings by choosing the one whose impulse response functions are most consistent with their prior beliefs. Researchers in the Cowles Commission tradition generally perform dynamic simulations of alternative models, choosing the one whose dynamic responses most closely correspond to their prior beliefs.

Pagan and Robertson go on to confirm what previous empirical work suggests, namely, that finding a statistically significant liquidity effect depends critically on the definition of money used. A statistically significant liquidity effect is generally found only with nonborrowed reserves or the ratio of nonborrowed to total reserves. No statistically significant liquidity effect is found using total reserves, the monetary base or M1.

The authors investigate the robustness of the estimated liquidity effect to alternative specifications of the system by including first commodity prices, and then exchange rates and foreign interest rates. While these variables affect the magnitude and persistence of the liquidity effect, the overall conclusion remains; that is, a statistically significant liquidity effect is obtained only when nonborrowed reserves is used.

Pagan and Robertson also find that the magnitude of the estimated liquidity effect depends on the sample period. Specifically, the liquidity effect essentially vanishes when the VAR is estimated over the period 1982:12 to 1993:12. Christiano investigates whether this marked change is due to the small sample size or to a fundamental change in the variance-covariance matrix and concludes: "The primary reason for the shift in the impulse response function appears to lie in a shift in the variance-covariance matrix of the VAR disturbances." He notes, however, that the presence of autoregressive conditional heteroskedasticity (ARCH) in the covariance structure during this period means that this result could be a statistical artifact, rather than a true shift in the structure. Nevertheless, noting that the Fed's operating procedure changed in late 1982, Christiano speculates whether the observed change in the liquidity effect might be due to a change in policy regime.

Even ignoring the apparent disappearance of the liquidity effect recently, Pagan and Robertson find the liquidity effect to have been a relatively unimportant determinant of the behavior of the federal funds rate in the past. They find that a 1 percentage point increase in the level of nonborrowed reserves reduces the funds rate by about 13 basis points. Since the average absolute monthly change in nonborrowed reserves is about 0.9 percentage point, the immediate effect of policy actions on the funds rate seems modest. Moreover, even when they allow the effect to accumulate until the impulse response function turns positive, they find it was rare for the sum to be smaller than -60 basis points. Hence, they conclude that "most of the factors historically driving the federal funds rate do not seem to be due to the Fed... ."

THE CREDIT CHANNEL FOR MONETARY POLICY

Articles by Stephen Cecchetti and R. Glenn Hubbard survey the credit channel for monetary policy. Although these papers discuss much of the same literature and evidence, the confluence of their approaches provides a richer understanding of the issues than either article alone. Both make clear that there are *two* possible credit channels for monetary policy, and that both require asymmetry in the access of "small" and "large" firms to credit. The *bank credit channel* operates directly on the ability of depository institutions to make loans through the effect of monetary policy actions (open market operations) on bank reserves. For example, restrictive monetary policy actions reduce reserves and, thereby, loans. Unable to obtain bank or other external finance, bank dependent firms curtail planned spending.

The second credit channel, which goes by various names (such as the financial accelerator, excess sensitivity or the broad lending view), works through the effect of a policy-induced change in interest rates on the balance sheets of borrowers. For example, by reducing their real net worth, a policy-induced increase in the real interest rate makes it difficult for some, typically smaller, firms to attract capital. Unable to attract funds, these firms curtail planned spending. This view differs from the traditional analysis, whereby a policy-induced increase in interest rates makes marginal investment opportunities unprofitable.

Both Cecchetti and Hubbard evaluate the state of the macroeconomic and cross-sectional evidence on the credit channel. Cecchetti focuses on the aggregate evidence and frames his analysis in an interesting discussion of the difficulties associated with identifying changes in monetary policy, an analysis of several commonly used indicators of policy, and a discussion of how to differentiate alternative views using both aggregate time-series and cross-sectional data.

Hubbard, on the other hand, focuses on cross-sectional evidence. He concludes that there is considerable evidence that "the spending decisions of a significant group of borrowers are influenced by their balance sheet condition in the ways described by financial accelerator models."

The discussions of these papers by Mark Gertler and Bruce Smith follow very different lines. Agreeing with essentially all of what Cecchetti said, Gertler emphasizes the complementarity between the credit and traditional views of the effect of policy-induced changes in interest rates on spending. He illustrates how what he calls the financial propagation mechanism can magnify the traditional effect of policy-induced changes in interest rates. Gertler's emphasis on the propagation mechanism makes clear that this effect comes into play whatever the source of the impulse to interest rates. Hence, this propagation mechanism may have important implications for output and interest rates even if Pagan and Robertson are correct that the influence of monetary policy on interest rates is small.

Smith's analysis, on the other hand, undercuts the significance of the empirical research that Hubbard finds most supportive of the broad credit view. Smith shows that a general-equilibrium, modified-neoclassical growth model capturing several key features of models associated with the broad credit view of monetary policy, has considerably different implications. In contrast with most models generating a credit channel, Smith's model has multiple equilibria, with both a low capital stock, low-income equilibrium, and a high capital stock, high-income equilibrium. In the latter, a low marginal efficiency of capital and high income provide firms with significant amounts of internal finance. In this equilibrium, an expansionary monetary policy reduces output, the capital stock and credit. Hence, in one equilibrium, credit market imperfections magnify the effect of monetary policy in a way consistent with the broad credit view. In the other, the outcome is inconsistent with the credit view. Moreover, even when monetary policy produces results consistent with the credit view, it is not for the reason given by proponents of the credit view.

MICRO-FOUNDATIONS, ENDOGENOUS PRICE STICKINESS AND MONETARY POLICY

The last paper of the conference, by Allan Meltzer, revisits a theme of the first, namely, that sluggish price adjustment is necessary for monetary policy to have real effects. Meltzer's purpose is to provide microeconomic foundations for price setting and the gradual adjustment of prices to new information.

Meltzer argues that differences in information and costs associated with acquiring information explain three facts about price setting behavior: 1) that many prices are set; 2) that price setters choose to set nominal rather than real prices; and 3) that many prices change slowly over time. While not rejecting a role for menu prices, imperfect competition, relative and absolute price confusion and aggregation in explaining sticky-price behavior, Meltzer argues that these alternative explanations are not consistent with one or more features of price data. Instead, he argues that the cost of acquiring information and the inability of individuals to fully distinguish permanent from transitory shocks provide better micro-foundations for the sluggish adjustment of nominal prices observed in the data.

Meltzer argues that the now widely adopted approach to providing micro-foundation to macroeconomics, which features representative agents and complete Arrow-Debreu markets, have not, and will not, prove useful. He contends that this framework provides no role for monetary disturbances. Hence, he concludes that "it is not the appropriate micro-foundation for macroeconomics. No amount of squeezing, cutting and pasting will make it so."

In his discussion, Randall Wright focuses on Meltzer's remarks about the state of macroeconomics. Wright defends the use of general-equilibrium modeling in macroeconomics, arguing that this methodology has produced great strides in the professions' understanding of business cycles, labor markets and economic growth. Moreover, he argues that the use of overlapping-generations models has produced significant contributions to our understanding of the properties of monetary economies and the monetary policy debate, as well as about economics generally. While conceding that overlapping-generations models have not captured the medium of exchange function of money, he points out that there are other general-equilibrium models that explicitly capture this function of money and the private information problem. Finally, Wright concedes that these models "sometimes take the pricing aspect of the Arrow-Debreu paradigm too seriously." He notes, however, that the effect of sticky prices has been addressed by such models and states that Meltzer's article has not convinced him of the value of explaining endogenously sticky prices.

PANEL DISCUSSION

A panel discussion provided a capstone to the conference. The panelists, Ben Bernanke, Thomas Cooley and Manfred Neumann, each took a different approach to summarizing the profession's understanding of the effects of monetary policy. Bernanke argues that the semi-structural VAR approach is a fruitful method for investigating how monetary policy actions are transmitted through the economy. He also finds limited-participation models to be a realistic approach but, sounding a theme reminiscent of Hoover's comments, argues that the cash-in-advance constraint is implausible. He suggests that a more promising avenue would be to combine the limited-participation and sticky-price assumptions.

Bernanke acknowledges recent criticisms of the bank lending channel of monetary policy, and points to the need to differentiate between the bank lending channel and the balance sheet channel. He argues that continued work on the credit channel is desirable because of quantitative problems with the other leading models of the transmission mechanism, and because ongoing institutional changes will likely affect both the potency of policy and the interpretation of monetary policy indicators.

Cooley argues that the papers presented at the conference seem to take as given that monetary policy can affect the real economy at cyclical frequencies. He argues that the theoretical evidence that the Fed can moderate cyclical fluctuations in economic activity is weak and that the empirical evidence for this proposition is "extremely fragile." He argues that the evidence based on VARs or structural VARs is sensitive to the set of conditioning variables, the sample period and the identifying restrictions. Moreover, he asserts that models that treat money as exogenous are simply "meaningless."

Cooley argues that a more interesting and fruitful approach is to investigate the growth and welfare consequences of monetary policy shifts by modeling artificial economies and examining them using calibration methods. He argues that this approach permits explicit modeling of essential features of the hypothesized transmission mechanism and broadens the scope of inquiry from output effects at business cycle frequencies to growth and welfare.

Neumann examines the structure of what he terms the new money-credit view of monetary policy. Comparing this view with the monetarist view of the transmission mechanism of monetary policy, he concludes that the monetarist approach is the "more comprehensive." He points out that the monetarist approach assumes that all assets, financial and real, are imperfect substitutes. A change in base money sets in motion a broad process of portfolio substitution over a full array of real and financial assets, and over a broad array of financial institutions and firms. With this as background, Neumann points out how the monetarist approach of Brunner and Meltzer encompasses the traditional IS/LM analysis and the new money-credit view.

Neumann points out that the timing of the effect of monetary policy actions on bank holdings of government securities and loans, documented recently by Bernanke and Blinder (1992), is a direct implication of the monetarist theory of relative prices that Brunner (1970) had pointed out some time earlier. He also questions the need to find evidence in support of the broad credit channel because differences in financial assets and the existence of information cost are unassailable.

Finally, Neumann points out that the fact that monetary policy has distributional effects, impacting more on smaller, financially weaker firms, is not surprising. This has no implications for the conduct of monetary policy, he argues, except to reinforce the monetarist advice to avoid large swings in the creation of reserves or the monetary base.

The conference opened new areas of discussion and revisited others. It appears that the profession is progressing slowly toward a consensus view of the monetary transmission mechanism.

The theoretical foundation for the commonly accepted liquidity effect is disputed. Moreover, the empirical evidence indicates that the liquidity effect is relatively weak and short-lived. If monetary policy exerts relatively modest influence over the federal funds rate and if this influence has weakened significantly recently, for whatever reason, the effect of monetary policy through the interest rate channel or broad credit channel is dubious. The support for the narrowly focused bank lending channel is also weak, being open to considerable criticism and lacking empirical support. Although the profession has yet to agree on how monetary policy impulses are ultimately transmitted to the price level, we hope that the empirical and theoretical scrutiny of alternative monetary transmission mechanisms reported in these proceedings will stimulate new research into the channels of monetary policy.

Finally, a nod to the analysts in the Research Department of the Federal Reserve Bank of St. Louis who helped to review the text and data for each of the articles: Jerram Betts, Kelly Morris, Tom Pollmann, Steve Stohs, Rich Taylor and Chris Williams.

Daniel L. Thornton and David C. Wheelock
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May 15, 1995

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Theoretical Issues of Liquidity Effects

Lee E. Ohanian and Alan C. Stockman

One of the most pervasive real effects long-claimed for monetary policy is its ability to affect interest rates in the short run through channels other than the standard-expected inflation effect. The alleged short-term inverse relationship between interest rates and monetary policy is often called the "liquidity effect" of monetary policy. We use the term liquidity effect to refer to the purported statistical relation between expansion of bank reserves or monetary aggregates (or perhaps only surprise expansions of these aggregates) and short-run reductions in short-term interest rates. The liquidity effect can also refer to the common interpretation of this purported statistical relation: that the same central bank action that changes bank reserves or monetary aggregates *also* changes short-term interest rates. This definition corresponds to early use of the term, for example, by Friedman in 1968.[1]

We distinguish between a *nominal liquidity effect* (the aforementioned relation with a nominal interest rate) and a *real liquidity effect* (the aforementioned relation with a real interest rate). Either may occur without the other. For many purposes, real liquidity effects are more interesting because they indicate real effects of monetary policy. On the other hand, central banks around the world claim that their operating procedures directly target or control nominal interest rates—that they reduce reserves of the banking system (perhaps through open market sales) to raise the nominal interest rate or raise reserves of the banking system (perhaps through open market purchases) to reduce the nominal interest rate. It is difficult to interpret these claims without a coherent model of nominal liquidity effects.

The monetary policies that the Federal Reserve *claims* that it follows require the existence of liquidity effects. Many central bank operating procedures that involve use of the federal funds rate (or any other interest rate) as a target, instrument, or operating variable of monetary policy require a liquidity effect. The current operating procedure of the Federal Reserve is predicated on the existence of a liquidity effect in the sense that the Fed uses the federal funds rate as its proximate instrument of policy and contracts quantities of reserves and monetary aggregates by raising the funds rate (and vice versa). When the Fed raises the federal funds rate, it reduces reserves by the amount sufficient to achieve the desired increase. The smaller the required reduction in reserves, the larger the implied nominal liquidity effect. Of course, a central bank operating procedure that attempts only to tie down the nominal interest rate (which ties down the real interest rate plus the expected rate of change of the price level) may lack a nominal anchor to tie down the level of prices. If, however, the operating procedure also includes a provision to revert to control over the level of monetary aggregates if inflation exceeds some critical level, then the price level may be anchored at least within a certain range.

Attempts to isolate liquidity effects empirically are often subject to a unique problem: If the central bank operating procedure involves direct targeting of a short-term interest rate, statistical work and economic models that treat a monetary aggregate as exogenous and the nominal interest rate as endogenous may be misleading. This has led many economists to question the existence of liquidity effects. Although we do not attempt to resolve that issue in this article, we note that other kinds of evidence (that do not involve regressions of interest rates on allegedly exogenous monetary aggregates) suggest important liquidity effects in the

[1] Some economists use the term differently, viz. to refer to a particular class of theoretical models attempting to explain the purported relation.

data. Cook and Hahn (1989), for example, interpret their results as showing that changes in Fed targets for the federal funds rate have large, immediate effects on three-month, six-month and 12-month Treasury bill rates, without any apparent reverse effects of Treasury bill rates on the funds rate.

This article assumes the existence of real and nominal liquidity effects in the data and discusses the main explanations for liquidity effects that have been advanced in the literature. The theoretical issues associated with liquidity effects are important because different models imply different welfare effects of monetary policies and different effects on interest rates and other variables. Also, different models of liquidity effects have different implications for optimal monetary policies. They also provide different interpretations of the data. Finally, differing implications of various models suggest potential tests of those models.

LIQUIDITY EFFECTS IN STICKY-PRICE MODELS

Traditional Sticky-Price Models

The liquidity effect is a characteristic of traditional sticky-price (Keynesian) models. Consider a model with a conventional money-demand function, and a price level that is perfectly sticky,

$$\text{(1)} \qquad \log\left(\frac{m_d}{\bar{p}}\right) = \alpha_0 + \alpha_1 \log(y) - \alpha_2 \log(1+i) + \varepsilon_m,$$

where m_d is nominal money demand, $\bar{p}$ is the pre-determined price level, y is real income, i is the nominal interest rate, and ε_m is a mean-zero disturbance to money demand so that $E(\varepsilon_m) = 0$. Given the double-log specification, the parameters α_1 and α_2 are income and interest elasticities, respectively.

Suppose that the money supply, m, increases permanently by 10 percent. Because the price level is perfectly sticky, and money demand equals money supply in equilibrium, the real money supply also rises by 10 percent. Assume that $0 < \alpha_1 \leq 1$ (a relatively flat LM curve), which is consistent with empirical estimates of income elasticities, and assume that real income rises by less than 10 percent in response to the exogenous 10 percent increase in nominal money. In this case, the nominal interest rate would fall to equilibrate money supply and money demand, thus generating the liquidity effect. In most neoclassical flexible-price models, however, the price level would rise sufficiently in response to a permanent increase in the money supply so that the real money supply, real income and nominal interest rates would be unchanged.[2]

A One-Sector, Sticky-Price Rational-Expectations Model

Though it is not difficult to generate a liquidity effect in an IS-LM model with sticky prices, further research has shown that this is not a generic feature of sticky-price models. To see why, we consider a simple neoclassical-growth model with money and exogenous price stickiness, as in recent work by Cho and Cooley (1990) and King (1991). A representative household maximizes discounted expected utility, with preferences defined over consumption of a single physical good, c_t, and leisure, l_t:

$$\text{(2)} \qquad Max\ E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t).$$

The household faces a period budget constraint:

$$\text{(3)} \qquad w_t n_t + \left(r_t + (1-\delta)\right)k_t + \frac{m_t + \tau_t}{p_t} \geq c_t + k_{t+1} + \frac{m_{t+1}}{p_t}.$$

The household's wealth (measured in units of the consumption good) consists of wage income, $w_t\, n_t$, capital income and undepreciated capital stock, $(r_t + (1-\delta))k_t$, and the real value of money, including lump-sum monetary transfers from the government, $(m_t + \tau_t)/p_t$. (In this economy, the price level is simply the dollar price of the single good). The household uses its wealth to purchase consumption, and acquire new capital and new money. We assume that consumption purchases are subject to a cash-

[2] Of course, there can be non-superneutralities of money in flexible-price equilibrium models, such as in cash-in-advance models, in which the inflation tax reduces inputs of labor or capital.

in-advance constraint; consumption can only be acquired with existing cash:

$$(4)\qquad m_t + \tau_t \geq p_t c_t.$$

A competitive firm produces the single good using a stochastic constant-returns-to-scale production technology, $z_t f(K_t, N_t)$, that takes labor (N) and capital (K) as inputs. The term z is an exogenous productivity disturbance with the following autoregressive law of motion:

$$(5)\qquad z_t = (1-\phi) + \phi z_{t-1} + \varepsilon_{zt}.$$

The firm maximizes profits, treating factor prices parametrically:

$$(6)\qquad Max\; z_t f(K_t, N_t) - w_t N_t - r_t K_t.$$

Because the technology is constant returns to scale, maximum profits are zero. Profit maximizing input choices by the firms yield the following functions for factor prices (where subscripts indicate partial derivatives):

$$(7)\qquad w_t = z_t f_N(K_t, N_t)$$

$$(8)\qquad r_t = z_t f_K(K_t, N_t).$$

The resource constraint in this economy is:

$$(9)\qquad z_t f(K_t, N_t) + (1-\delta)K_t \geq C_t + K_{t+1}.$$

Remaining equilibrium conditions are given by household first-order conditions and market-clearing conditions. Efficient household choices for consumption, labor input, capital accumulation and money, with subscripts indicating partial derivatives, and λ_t denoting the date-t marginal value of wealth, are:

$$(10)\qquad \lambda_t = \beta E_t[\lambda_{t+1}(r_{t+1} + (1-\delta))]$$

$$(11)\qquad u_{ly} = \lambda_t w_t$$

$$(12)\qquad \frac{\lambda_t}{p_t} = \beta E_t\left(\frac{u_{ct+1}}{p_{t+1}}\right).$$

We assume that money growth is exogenous, and is given by the autoregressive process:

$$(13)\qquad \ln M_t = \ln M_{t-1} + \mu\left(\ln\left(M_{t-1}\right) - \ln\left(M_{t-2}\right)\right) + \varepsilon_{mt}.$$

Now, consider the one-period interest rate on a (nominally) risk-free bond between today and tomorrow. Although this asset will not be traded in this representative-agent economy, it is straightforward to compute the equilibrium asset price. The equilibrium interest rate implies that the representative household has, at the margin, no incentive to trade this security. The interest rate on this one-period bond is given by the relation:

$$(14)\qquad \left(1 + i_{t+1}\right) = \frac{1}{\beta E_t\left[\frac{u_{ct+1}}{p_{t+1}}\right]}\frac{u_{ct}}{p_t}.$$

Equilibrium with Pre-Determined Prices

Suppose prices are set one period in advance at the expected market-clearing price. (The commodity for which the pre-determined price is an equilibrium is expected consumption conditional on information at date $t-1$.) Given that the price is pre-determined, it is necessary to specify a rule for allocations: We first assume that output in this economy is purely *demand-determined*. That is, the representative firm sells as much output to households as demanded at the pre-determined price. This assumption is consistent with recent sticky-price literature, as in Blanchard and Kiyotaki (1987), in which monopolistically competitive firms willingly supply extra demand, as long as price exceeds marginal cost.

Unlike the IS-LM type model discussed at the beginning of this section, it is ambiguous whether the nominal interest rate falls in response to an unexpected increase in the money stock in this sticky-price economy. Assuming that the cash-in-advance constraint binds, consumption is relatively high today, which implies that the marginal rate of substitution between consumption today and tomorrow (the expected real interest rate) is low, which tends to reduce the nominal interest rate. If money growth is positively serially correlated, then expected inflation is high, which tends to increase the nominal interest rate. It is easy to see this result if we assume that households have perfect foresight, and that momentary utility is additively separable:

$$(15)\qquad u=\frac{c^{1-\rho}}{1-\rho}+\upsilon(l).$$

Taking natural logs of the asset-pricing relation under perfect foresight, we obtain the Fisher decomposition of the nominal interest rate into a real component and a nominal component reflecting future inflation:

$$(16)\qquad i_{t+1}\approx-\ln(\beta)+\rho\left(\ln(c_{t+1})-\ln(c_t)\right)+\ln(p_{t+1})-\ln(p_t).$$

Thus, the nominal interest rate falls only if the utility curvature parameter, ρ, is sufficiently large that the decline in the real interest rate reflecting negative-consumption growth more than offsets the increase in inflation. This typically implies that the curvature parameter ρ must exceed 1. (That is, risk aversion of the representative household exceeds that of log utility).

Note that the effect of an unexpected increase in the money stock on the nominal interest rate in this cash-in-advance economy depends on the allocation (rationing) rule. Suppose instead that output is determined by the *minimum of quantity demanded and quantity supplied*, as in Barro and Grossman (1971), rather than being determined by the quantity-demanded allocation rule. That is, households will be rationed in response to a positive money shock, and firms will be rationed in response to a negative money shock. In this "short-side" case, the cash-in-advance constraint no longer binds if there is a positive money shock, and the nominal interest rate must fall to zero. (This extreme response of the nominal interest rate is an artifact of the cash-in-advance framework of this model. It would likely disappear in a similar model in which the interest elasticity of the demand for money were non-zero.)

Solving and Simulating the One-Sector Sticky-Price Model

To gain some insight into this issue with a more general form of preferences, we have conducted a simulation of the demand-determined version of this model. Because the model does not possess a closed form, we computed an approximate equilibrium using a version of Marcet's (1990) procedure. We choose functional forms and parameters that have been commonly used in the business cycle literature. We assume that the momentary utility function is isoelastic, which is consistent with steady-state growth:

$$(17)\qquad u(c,l)=\frac{\left(c^{\psi}l^{1-\psi}\right)^{1-\rho}}{1-\rho}-1.$$

Production possibilities are assumed to be Cobb-Douglas:

$$(18)\qquad zf(K,N)=zK^{\theta}N^{1-\theta}.$$

The discount factor, β, equals 0.99, which implies a steady-state real interest rate of about 4 percent. The preference parameter, ψ, determines the share of discretionary time spent in producing market goods. We set $\psi = 0.37$, which implies that households work about one-third of their discretionary time. The curvature parameter ρ is set to 2. The production parameter, θ, is equal to capital's share of income and has averaged about 0.36 in the United States. The depreciation rate, δ, is set to 0.025, which implies an annual depreciation rate of 10 percent. The persistence parameter for the technology shock, ϕ, is 0.95, which is comparable to numbers used by Hansen (1985) and Prescott (1986). The innovation variance is set to 0.007, which is the estimate used by Prescott (1986) and others. The serial correlation parameter for money growth, μ, is 0.5, and the innovation variance is set to 0.009.

The experiment consists of holding the technology shock fixed at the unconditional mean, and letting the money supply increase by 1 percent at date t. The increase in the money stock is completely unanticipated. Unexpectedly high money growth raises real output in this model. Assuming that the cash-in-advance constraint binds, the percentage increase in consumption equals the percentage increase in the money stock. Figures 1-3 present the impulse response functions of capital, consumption and labor input to a 1 percent, unanticipated, permanent increase in the money stock. The capital stock increases only slightly; its increase is not sufficient to generate persistent changes in consumption or labor input. The response of the nominal interest rate to the money shock appears in Figure 4. The immediate effect of the money shock is to increase the nominal interest rate slightly: A Fisher decomposition shows that the real interest rate declines, but that the increase in expected inflation more than offsets this fall.

While we do not pursue a comprehensive analysis of this one-sector model, this example indicates that it is not necessarily easy to generate nominal liquidity effects in sticky-price models with explicit intertemporal optimization. Robert King reaches the same conclusion in a related monetary model which does not have unitary income elasticity of money demand, and which includes multi-period price setting.

Liquidity Effects in Models with Some Sticky Prices

The model discussed in the preceding section had the property that the *price level* was sticky in response to a monetary shock. This section analyzes the liquidity effect in an economy in which some, but not all, prices are sticky. The analysis in this section is drawn from Ohanian and Stockman (1994). The motivation behind this model is that while there is considerable evidence suggesting that some nominal prices change infrequently (see Carlton, 1989), there is also abundant evidence that many goods have prices that change frequently, such as food, automobiles, computers and gasoline. We consider a model with two physical consumption goods, *X* and *Y*, money introduced through a cash-in-advance constraint, and complete asset markets, with the exception of the friction induced by the cash-in-advance constraint. We first analyze a very simple economy without capital. The equilibrium in this simple economy can be calculated very quickly, and as a result it is possible to evaluate the properties of this economy for a wide variety of parameter values.

Figure 1

Impulse Response of Capital Stock to Money Shock

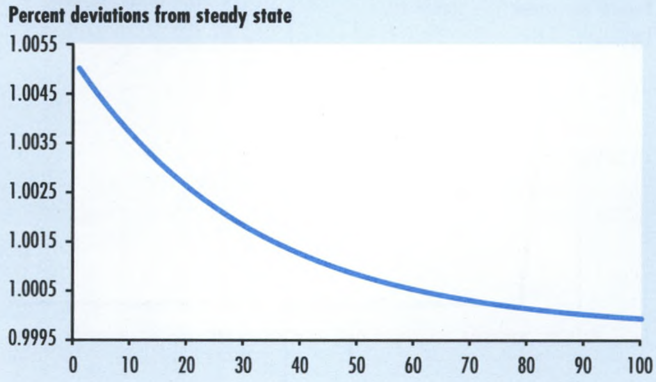


Figure 2

Impulse Response of Consumption to Money Shock

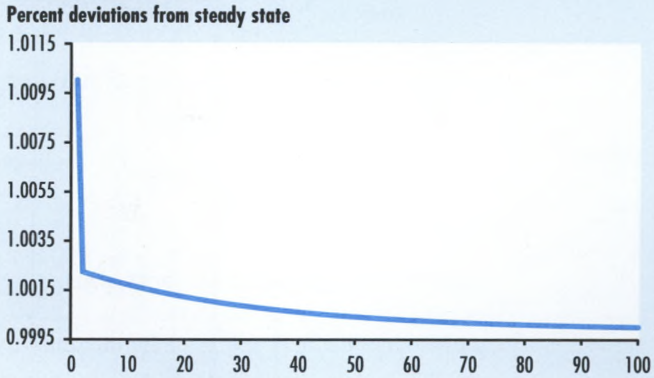


Figure 3

Impulse Response of Labor Input to Money Shock

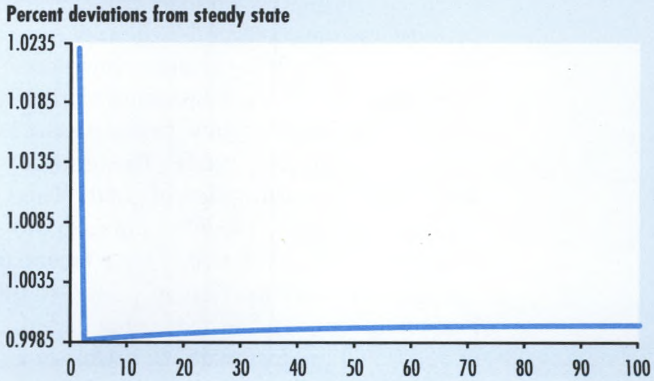
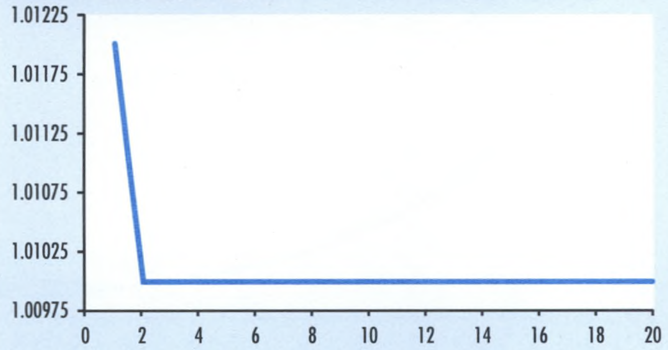


Figure 4

Impulse Response of Interest Rate to Money Shock

Percent deviations from steady state



A representative household maximizes discounted expected utility:

$$(19)\quad \max E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{(1-\rho)} \left(\alpha x_t^{(\sigma-1)/\sigma} + (1-\alpha) y_t^{(\sigma-1)/\sigma} \right)^{(\sigma/(\sigma-1))(1-\rho)} - \upsilon \cdot (L_{Xt} + L_{Yt}) \right]$$

subject to the sequence of constraints

$$(20)\quad n_{t-1} + \tau_t + P_{X,t-1} L^{\theta}_{X,t-1} + P_{Y,t-1} L^{\theta}_{Y,t-1} - M_t + v_t (q_t + d_t) - v_{t+1 q_t} = 0$$

and

$$(21)\quad M_t - P_{Xt} X_t - P_{Yt} Y_t \geq 0,$$

where equation 20 is a budget constraint for period-t asset markets and inequality (equation 21) is the cash-in-advance constraint which applies to period-t product markets (which immediately follow period-t asset markets, as in Lucas, 1982). The terms x and y refer to consumption of goods X and Y, L_X and L_Y refer to the labor hours to produce goods X and Y, $0 \leq \theta < 1$ is a parameter of the production function, n_{t-1} refers to the household's money holdings at the end of period $(t-1)$ product markets, τ refers to a lump-sum transfer of money to the household from the government, P_X and P_Y are nominal prices, M_t is the nominal money the household chooses as it leaves period-t asset markets and enters period-t product markets, υ_t is a vector of other assets the household owns at the beginning of period t, with dividend vector d and ex-dividend price-vector q. We assume that households have constant elasticity of substitution preferences across the two physical goods, where σ is the elasticity of substitution between x and y and ρ is a measure of overall curvature of the utility function. And υ is a leisure-preference parameter. ($1/\rho$ is the elasticity of intertemporal substitution.)

Assume that the cash-in-advance constraint (equation 21) binds as an equality every period and that $\tau \equiv 0$. It is easy to see that the flexible-price perfect foresight equilibrium for this simple production economy satisfies

$$(22)\quad M_t^S = P_{Xt} L^{\theta}_{Xt} + P_{Yt} L^{\theta}_{Yt},$$

$$(23)\quad P_{Xt} \lambda_t = \left(\alpha x_t^{(\sigma-1)/\sigma} + (1-\alpha) y_t^{(\sigma-1)/\sigma} \right)^{(1-\rho\sigma)/(\sigma-1)} \alpha L_{Xt}^{-\theta/\sigma},$$

$$(24)\quad P_{Yt} \lambda_t = \left(\alpha x_t^{(\sigma-1)/\sigma} + (1-\alpha) y_t^{(\sigma-1)/\sigma} \right)^{(1-\rho\sigma)/(\sigma-1)} (1-\alpha) L_{Yt}^{-\theta/\sigma},$$

$$(25)\quad \upsilon = \beta \cdot P_{Xt} \cdot \theta \cdot L_{Xt}^{\theta-1} \cdot \lambda_{t+1},$$

$$(26)\quad \upsilon = \beta \cdot P_{Yt} \cdot \theta \cdot L_{Yt}^{\theta-1} \cdot \lambda_{t+1},$$

where M_t^s is the (exogenous and constant, because $\tau = 0$) money supply at the end of period-t asset markets and λ is the current-value Lagrange multiplier on the constraint of equation 20. (Note that $\lambda = \gamma$, where γ is the current-value multiplier on the cash-in-advance constraint, because of the first-order condition for the choice of M_t.) Moreover, we can solve for the nominal interest rate on a one-period nominal asset using the pricing condition:

$$(27)\quad 1 + i = \frac{\lambda_t}{\beta \lambda_{t+1}}.$$

Equilibrium When Some Prices Are Sticky

We now suppose that nominal prices in the X industry are pre-determined: Sellers choose the nominal price $P_{X,t}$ at the end of period $t-1$. The nominal price of Y, on the other hand, adjusts to clear markets each period. We can vary the amount of price stickiness in the economy by varying the relative sizes of the X and Y industries. The nominal price of X is set to equate expected quantities supplied and demanded. As in the case of the one-sector model, we assume that output in the X industry is determined by the quantity demanded. An interesting feature of this setup is that it encompasses the standard Keynesian model and the flexible-price neoclassical model as special cases.

We begin with the economy in a nonstochastic, steady-state equilibrium with a constant money supply, and consider an unanticipated, permanent change in the nominal money supply at the beginning of period t. Real variables dated at $t+1$ and later are unaffected by this change in the money supply, but real variables at date t change because $P_{X,t}$ is pre-determined. Suppose the money supply falls permanently by 1 percent at date t, with $P_{X,t}$ fixed for one period. Because the quantity of X produced is determined by the quantity demanded, equation 25 (describing the supply of X) does not hold in the short run. Instead, we have equations 22-24 and 26 in the four variables $L_{X,t}$, $L_{Y,t}$, $P_{Y,t}$ and λ_t, (with λ_{t+1} taking its new steady-state value). Because a change in the money supply has no steady-state effect on x, y or L_X, equation 23 implies that it has no steady-state effect on $P_{X,t+1}\lambda_{t+1}$. Therefore, since the fall in the money supply lowers $P_{X,t+1}$ by 1 percent, it necessarily raises λ_{t+1} by 1 percent.

Tables 1-4 present the quantitative effects of a permanent 1 percent rise in the money supply (from 10.0 to 10.1) when $\sigma = 0.5$, $\theta = 0.64$, $\upsilon = 1$, $\beta = 0.99$ and $\rho = 2$. We choose the elasticity of substitution between x and y ($\sigma = 0.5$) to be less than the Cobb-Douglas case ($\sigma = 1$) since it seems reasonable to assume that the short-run substitutability between the two categories of goods may be relatively low. The value chosen for the production parameter, ($\theta = 0.64$), is often used in the equilibrium business cycle literature, and is identical to the value used in the one-sector model. We select overall curvature of the utility function ($\rho = 2$) that is consistent with empirical estimates, and is also identical to the value used in the one-sector model. Also, υ is a leisure preference parameter and does not play an important role for the experiments we conduct.[3]

The first column shows the variables of interest: the nominal one-period interest rate (in percent); the nominal prices of X and Y; labor input in each industry; output in each industry; real GNP evaluated at the equilibrium prices and production shares; and the total labor input. The second column displays the old steady-state (Old SS) levels of these variables, before the change in money. The SR

Table 1

Benchmark Case

	Old SS	SR	New SS	Ratio
i	4.167	3.701	4.167	−0.47
px	7.925	7.925	8.004	−0.99
py	7.925	8.012	8.004	0.10
Labor in *X*	0.4869	0.4924	0.4869	0.13
Labor in *Y*	0.4869	0.4882	0.4869	0.27
Output of *X*	0.6309	0.6355	0.6309	0.72
Output of *Y*	0.6309	0.6320	0.6309	0.17
GNP	1.262	1.267	1.262	0.45
Total labor	0.9738	0.9807	0.9738	0.70

Table 2

Very Small Sticky-Price Sector

	Old SS	SR	New SS	Ratio
i	4.167	4.057	4.167	−0.11
px	5.346	5.346	5.4	−0.99
py	10.74	10.85	10.85	0.02
Labor in *X*	0.1044	0.1053	0.1044	0.86
Labor in *Y*	0.7248	0.7252	0.7248	0.06
Output of *X*	0.2355	0.2368	0.2355	0.55
Output of *Y*	0.8138	0.8141	0.8138	0.04
GNP	0.9939	0.9943	0.9939	0.04
Total labor	0.8291	0.8305	0.8291	0.16

[3] We have analyzed specifications with different preferences over leisure, and the results are qualitatively similar to those reported below. For example, if preferences are logarithmic in leisure, the effect of a money shock on interest rates is about 70 percent as large as in the case of linear preferences over leisure.

Table 3

Intermediate Case

	Old SS	SR	New SS	Ratio
i	4.167	3.861	4.167	−0.31
px	7.032	7.032	7.103	−0.99
py	8.95	9.045	9.04	0.06
Labor in X	0.3191	0.3223	0.3191	1.01
Labor in Y	0.6235	0.6246	0.6235	0.18
Output of X	0.4814	0.4845	0.4814	0.65
Output of Y	0.7391	0.7399	0.7391	0.11
GNP	1.205	1.208	1.205	0.24
Total labor	0.9426	0.9469	0.9426	0.46

Table 4

Smaller Elasticity of Intertemporal Substitution

	Old SS	SR	New SS	Ratio
i	4.167	3.6	4.167	−0.57
px	6.137	6.137	6.199	−1.00
py	8.103	8.139	8.184	0.06
Labor in X	0.3546	0.3582	0.3546	1.00
Labor in Y	0.7672	0.7685	0.7672	0.17
Output of X	0.5151	0.6183	0.5151	0.64
Output of Y	0.844	0.8449	0.844	0.11
GNP	1.337	1.339	1.337	0.21
Total labor	1.122	1.127	1.122	0.43

column shows the short-run effects of the 1 percent rise in money (while the nominal price of X is fixed at its previous level). The fourth column (New SS) shows the new steady state, and the column labeled ratio displays the percentage by which a variable falls short of, or exceeds, its new steady-state level. For the interest rate, this column shows the difference between the short-run and steady-state interest rates.

Table 1 shows the results when $\alpha = 0.5$, so that the sticky-price sector represents half of the economy's output and half of all labor is employed in the sticky-price sector. A permanent 1 percent rise in the money supply is neutral in the long run, with a 1 percent rise in nominal prices and no effects on real variables. But in the short run, with p_X pre-determined, real GNP rises about 0.45 percent. There are significant differences across sectors: Output in the sticky-price sector rises 0.72 percent, while output in the flexible-price sector rises 0.17 percent. The rise in money raises the nominal price of Y, which reduces the relative price of X. This raises the quantity of X demanded and creates excess demand in the X industry. Since output of X is determined by the quantity demanded, output of X rises. Output of Y rises less because consumers substitute into purchases of X. (If the elasticity of substitution were greater than 1, this substitution would be larger and the output of Y would fall.) Notice that the nominal price of Y rises by about as much as if the price of X were flexible. It overshoots its long-run equilibrium by one-tenth of 1 percent (it would undershoot if the elasticity of substitution between X and Y were greater than 1).

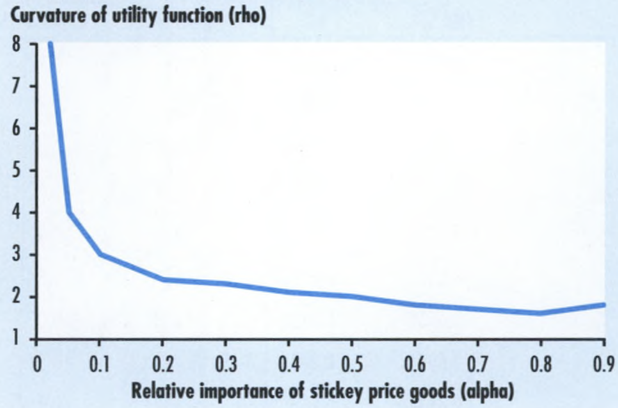
The rise in the money supply has a short-run "liquidity effect" on the nominal interest rate. In Table 1, the nominal interest rate falls 47 basis points, from 4.17 percent to 3.70 percent, in the short run. Because expected inflation is positive (the CPI is expected to rise another 0.50 percent), this represents a fall in the real interest rate (measured in terms of the output bundle) of about 1 percentage point. Notice that the liquidity effect occurs despite the introduction of money through a cash-in-advance constraint, which (when binding, as in these examples) builds in a zero interest-elasticity of the demand for money.

Table 2 shows that a change in the money supply can have a substantial liquidity effect on nominal and real interest rates in the short run even if only a small fraction of the economy has sluggish prices. This table presents results with the same parameter values as in Table 1, but with $\alpha = 0.04$, so that the sticky-price sector accounts for only about 12 percent of employment. A permanent 1 percent rise in money reduces the nominal interest rate by about 12 basis points. Table 3 shows that with $\rho = 2$, the liquidity effect is somewhat smaller if one-third of labor is employed in the sticky-price sector. If, however, the elasticity of intertemporal substitution is one-third ($\rho = 3$) rather than one-half, the interest rate falls 57 basis points when one-third of labor is employed in the sticky-price sector (see Table 4). With $\rho = 3$, the nominal interest rate falls 27 basis points even if the sticky-price sector accounts for only *15 percent* of employment, and raising ρ from 3 to 4 further doubles the size of the interest rate response, holding fixed the share of the economy with sluggish prices.

These examples demonstrate that a significant liquidity effect is consistent with a relatively small sticky-price sector. A further analysis of the relationship between the size of the sticky-price sector and the response of interest rates to a money shock is presented in Figure 5. This plot displays the (ρ, α) combinations that generate the midpoint estimate of the liquidity effect reported by Christiano and Eichenbaum (1992b), and shows that reasonable values of ρ combined with a small sticky-price sector are consistent with their estimates for U.S. data. While the size of the liquidity effect depends on the parameter ρ, in all other respects the responses of the economy to an increase in the money supply are virtually unaffected by changes in the elasticity of intertemporal substitution.[4]

Figure 5

Rho/Alpha Pairs Yielding Estimated (Midpoint) Liquidity Effects



A Two-Country Model

In previous work, such as Stockman and Ohanian (1994), we examined the effects of money supply changes in a two-country world in which some sectors of the economy have nominal prices that are sticky in the short run and other sectors have flexible prices. We showed that money supply changes have liquidity effects (a fall in the money supply raises the real and nominal interest rate) both within and across countries, and creates a cross-country, real interest rate differential.

We discussed a two-country model in which each country produces and consumes two internationally tradable goods, X and Y, using only labor as an input. There are two monies introduced through cash-in-advance constraints with the usual convention in which sellers' currencies are the medium of exchange for all transactions. Because the two countries are identical ex ante, we describe only the domestic country. A representative household in the home country maximizes

$$(28)\qquad E_0\sum_{t=0}^{\infty}\beta^t\left[\frac{1}{(1-\rho)}\left(\alpha x_t^{(\sigma-1)/\sigma} + (1-\alpha)y_t^{(\sigma-1)/\sigma}\right)^{(\sigma/(\sigma-1))(1-\rho)} - \upsilon\left(L_{Xt}+L_{Yt}\right)\right],$$

subject to the sequence of budget constraints

$$(29)\qquad P_{X,t-1}k_{X,t-1}L^{\delta}_{X,t-1} + P_{Y,t-1}k_{Y,t-1}L^{\delta}_{Y,t-1} + v_t\left(q_t + d_t\right) + \tau_t - v_{t+1}q_t - M_t - e_tN_t = 0$$

and sequences of the two cash-in-advance constraints,

$$(30)\qquad M_t - \min\left\{\bar{x}_t, x_t\right\}P_{Xt} - \min\left\{\bar{y}_t, y_t\right\}P_{Yt} = 0,$$

and

$$(31)\qquad N_t - \max\left\{x_t - \bar{x}_t, 0\right\}P^*_{Xt} - \max\left\{y_t - \bar{y}_t, 0\right\}P^*_{Yt} = 0,$$

where equation 29 is a budget constraint for period-t asset markets and equations 30 and 31 are the cash-in-advance constraints that apply to period-t product markets. The terms x_t and y_t refer to total home consump-

[4] In future work, we plan to analyze liquidity effects in a version of this hybrid model with capital accumulation and a mixture of monetary and technology shocks.

Table 5

Home Money Falls from 10 to 9.8

	Old SS	SR	New SS	Percentage Excess of SR to New SS
i	1.01	1.537	1.01	0.52
if	1.01	1.48	1.01	0.46
e	1.00	0.9794	0.98	−0.05
py	7.333	7.183	7.187	−0.05
pyf	7.333	7.334	7.334	0.002
lx	0.6534	0.6427	0.6534	−1.64
lxf	0.6534	0.6532	0.6534	−0.03
ly	0.6534	0.6499	0.6534	−0.54
lyf	0.6534	0.6535	0.6534	0.017

tion of goods X and Y, regardless of where the goods were purchased, $\bar{x}_t$ and $\bar{y}_t$ refer to home production of the two goods, M_t is the home household's stock of home money at the beginning of the product market, N_t is its stock of foreign money, used for purchasing imports (*if* imports are positive), and e is the exchange rate (in units of home money per unit of foreign money).

We assume that assets cannot be traded conditional on monetary transfers or taxes (positive or negative τ), so any decrease in the home money supply is financed by lump-sum taxes (negative τ) on households in the home country only, and any decrease in the foreign money supply directly affects only foreign households. Assuming $\tau \equiv \tau^* \equiv 0$, where τ^* is the transfer or tax in the foreign country, and $k_{X,t} = k_{X^*,t} = k_{Y,t} = k_{Y^*,t} = 1$ for all t, we showed that one flexible-price equilibrium is the same as in a closed economy, with no international trade or foreign money holding.

We assume that P_X and P_X^* (the foreign-currency nominal price of X produced and sold in that country) are pre-determined, chosen one period in advance. The nominal prices P_Y and P_Y^*, on the other hand, are flexible. Assuming flexible exchange rates and holding constant the foreign money supply N^S, we consider a small, unanticipated, permanent fall in M_t^S (the home money supply) starting from a nonstochastic steady-state equilibrium with constant money. In situations of excess supply, buyers purchase from sellers in the country with the lowest price (adjusted for the exchange rate). When prices are equal in both countries, buyers purchase first from sellers in their own country. We assume that in situations of excess demand for a good in some country, buyers residing in that country are first in line and buyers from the other country are last in line to buy that good.[5]

[5] Our previous paper discusses the various cases involving alternative corner solutions to the rationing problems that can arise in this model.

Necessary conditions for home-currency and foreign-currency bonds yield expressions for one-period nominal interest rates like 2.10 that, along with the law of one price for good Y, $P_Y = eP_Y^*$, and interest parity imply:

$$e_t = e_{t+1} \frac{\lambda_t^*}{\lambda_{t+1}^*} \frac{\lambda_{t+1}}{\lambda_t}, \quad (32)$$

where λ^* is the multiplier on the foreign representative household's current-period budget constraint. Equation 15 follows directly from the usual expression of interest parity ($e'/e = (1+i)/(1+i^*)$) and the standard asset-pricing equations for riskless nominal one-period bonds in each currency. In addition, we need the separate budget constraints for home and foreign households. The home household can buy (or sell) one-period nominal bonds B at the price $1/(1+i)$.

Table 5 shows the effects of a permanent, unexpected, 2 percent fall in the home country's money supply (from 10.0 to 9.8), starting from a steady-state equilibrium with a constant money supply and price level. We hold fixed the foreign money supply in this initial exercise and assume $\alpha = 0.5$, $\sigma = 0.5$, $\delta = 0.9$, $\upsilon = 1$, $\beta = 0.99$ and $\rho = 2$. This implies that half of GDP in each country consists of output of good Y, the relative price of Y in terms of X is initially unity, the exchange rate is initially 1, and the real (and nominal) interest rate is $1/\beta - 1$. Since $\sigma < 1$, the two goods are relatively poor substitutes. We also assume there is no initial international indebtedness, so initially the countries are identical and there is no international trade. (After a change in the money supply in one country—or in both—B can become non-zero and can remain non-zero in the new steady state.)

The first column of Table 5 shows the endogenous variables: the nominal price of Y

in the home and foreign countries (*py* and *pyf*); the nominal interest rate (in percent) in the home and foreign countries (*i* and *if*); the exchange rate (*e*); labor inputs in the *x* industry in the home and foreign countries (*lx* and *lxf*); and labor inputs in the *y* industries in the home and foreign countries (*ly* and *lyf*). The second column, Old SS, shows the old steady-state levels of the variables (before the change in money) from which the analysis begins. The SR column shows the short-run effects of the fall in money (while the nominal price of *X* is fixed at its previous level for one period). The New SS column shows the new steady state, and the column labeled percent shows the percentage by which a variable falls short of or exceeds its new steady-state level. For the interest rate, this column presents the difference between interest rates in the short run and in the new steady state.

The 2 percent fall in money leads, in the long run (New SS column), to a 2 percent fall in the nominal prices of goods *X* and *Y*, from 7.333 to 7.187. (The new steady-state relative price of *Y* in terms of *X* is 1, so the new price of *X* is also 7.187.) The interest rate is unaffected in the long run by the one-time change in the level of money, and the exchange rate falls 2 percent, from 1.00 to 0.98, in the long run. Long-run levels of employment in each industry in the home country (*lx* and *ly*) are unaffected, as are foreign employment levels in each industry (*lxf* and *lyf*) and long-run levels of output in each industry and in each country.

While the unexpected change in money is almost neutral in the long run ("almost" because it redistributes wealth and so has permanent effects), it is not neutral in the short run. The impact effect of the unexpected fall in home money is to raise the home-country nominal interest rate by 53 basis points. If one interprets this as a quarterly model (since the discount parameter is 0.99 per period), with one-quarter nominal price stickiness in the *X* industry, then the steady-state interest rate is 1.01 percent per quarter, or 4.04 percent per year. Then the 2 percent fall in home money raises the annualized home nominal interest rate by 211 basis points, to 6.15 percent per year. The *foreign* nominal interest rate also rises, by 47 basis points, on a per-period basis, which is 188 basis points on an annualized basis with this interpretation. The home nominal interest rate is then 20 basis points above the foreign rate on an annualized basis. This is reflected also in a slight *overshooting* of the exchange rate in the short run (it falls 0.05 percent below 0.98) followed by a small, expected (and actual) appreciation of home currency. Employment in the home country falls in both industries, particularly in the *X* industry with sticky prices. Overall output is unchanged in the foreign country, though there is a small sectoral reallocation of production from the *X* industry to the *Y* industry.

Table 6

Home and Foreign Money Fall from 10 to 9.8

	New SS	Percentage Excess of SR to New SS
i	2.012	
if	2.012	
e	1.	0
py	7.183	−0.05
lx	0.6426	−1.66
lxf	0.6426	−1.66
ly	0.65	−0.52
lyf	0.65	−0.52

The short-run appreciation of home currency, combined with the stickiness of both the home-money price of *X* sold at home and the foreign-money price of *X* sold abroad, implies that *X* is cheaper in the foreign country than in the home country, creating excess demand for *X* in the foreign country and excess supply in the home country. Foreigners are unconstrained in buying good *X* in their own country and home residents, who are last in line there, import *X* and buy the rest from sellers in their own country.

Table 6 shows the case in which both countries reduce their money supplies by the same percentage. The result is the same in each country as in a closed economy, and there is no international trade in either the short run or in the new steady state. The table shows the effects of an unexpected, permanent, 2 percent fall in money in both countries. This has identical effects in the two countries,

Table 7

Foreign Money Falls to 9.7, then to 9.80098; Home Money Falls to 9.8

	New SS	Percentage Excess of SR to New SS
i	3.041	
if	3.041	
e	1.	0
py	7.18	−0.10
lx	0.6463	−1.08
lxf	0.6317	−3.31
ly	0.6466	−1.04
lyf	0.6466	−1.03

Table 8

Foreign Money Falls to 9.85, then to 9.79952; Home Money Falls to 9.8

	New SS	Percentage Excess of SR to New SS
i	1.503	
if	1.503	
e	1.	0
py	7.185	−0.03
lx	0.6407	−1.94
lxf	0.648	−0.83
ly	0.6518	−0.26
lyf	0.6517	−0.26

so we can discuss only the home country. The fall in money reduces aggregate *nominal* spending, which reduces the nominal price of good Y. Because P_X is fixed in the short run, this increases the relative price of X, so consumers substitute good Y for good X, which further reduces output of X and works against the fall in spending on Y. If the elasticity of substitution in consumption, σ, were 1, output in the Y sector would remain unchanged and the nominal price of Y would fall by 2 percent. With $\sigma < 1$, output of Y falls along with output of X and P_Y overshoots its long-run fall. (If $\sigma > 1$, output of Y rises and its nominal price undershoots its long-run fall.)

One way for the foreign country to peg its exchange rate (in the absence of any other shocks) is to change its money supply in proportion to the change in the home money supply; in this model, there are other paths of monetary policy that also result in a pegged exchange rate. But these policies have vastly different effects on real and nominal interest rates.

Suppose the home country's money supply falls by 2 percent as before, and suppose the foreign country pegs its exchange rate at unity. Suppose also that the foreign government can *credibly commit* to a future path for the money supply. Because nominal prices are set one period in advance, for only one period, anticipated future changes in money can be fully incorporated into price-setting behavior. Table 7 shows the results of a foreign monetary policy that reduces the foreign money supply by 3 percent from $M^{S*} = 10$ to $M^{S*} = 9.7$ in the short run (while the home money supply falls from 10 to 9.8), and then changes M^{S*} to 9.80098 in the long run, assuming that $\alpha = 0.5$, $\sigma = 0.5$, $\delta = 0.9$, $\upsilon = 1$, $\beta = 0.99$ and $\rho = 2$, as in Table 5. The exchange rate remains at exactly 1, but the rise in world interest rates of 203 basis points exceeds the 100 basis point rise that occurs along the baseline path.

Table 8 shows the results when the foreign money supply falls *less* than the baseline case: It falls from 10 to 9.85 for one period and then permanently goes to 9.79952 (while home money falls to 9.8). We continue to assume $\alpha = 0.5$, $\sigma = 0.5$, $\delta = 0.9$, $\upsilon = 1$, $\beta = 0.99$ and $\rho = 2$. If the fall to 9.85 were permanent, foreign currency would depreciate and X would be cheaper in the foreign country. This would add to excess supply for X in the home country and reduce excess supply of X in the foreign country. This occurs up to the point at which the relative price is unity, that is, at an unchanged exchange rate. In this case, the rise in world interest rates is smaller (49 basis points) than in the baseline case, and similar to the rise in Table 5, even though the size of the change in the money supply is different. Finally, Table 9 shows the results when the foreign money supply falls even less in the short run—from 10 to 9.9 before permanently going to 9.79904. In this case, there is *no nominal liquidity effect* (though the real interest rate falls). If the home money

Table 9

Foreign Money Falls to 9.90, then to 9.79904; Home Money Falls to 9.8

	New SS	Percentage Excess of SR to New SS
i	0.9979	
if	0.9979	
e	1.	0
py	7.186	0.0006
lx	0.6389	−2.23
lxf	0.6534	−0.002
ly	0.6535	0.006
lyf	0.6534	−0.004

supply falls by only 0.5 percent in the short run, but the exchange rate is pegged by a commitment to future policy, then the nominal interest rate actually *falls* in each country (though, again, the real rate rises).

These tables illustrate that real and nominal interest rates do not depend solely on domestic monetary policy. Foreign policy and expected future domestic and foreign policies can create significant changes in the responses of both real and nominal interest rates. In particular, even the *sign of the interest rate response* to domestic monetary policy depends on foreign monetary policy. In addition, the response of nominal interest rates to changes in the money supply is highly nonlinear. That nonlinearity, illustrated by these tables, suggests that linear statistical analysis may miss key features of the relations between money and interest rates.

Liquidity Effects, Increasing Returns and Multiple Equilibria

A very different model with sticky prices has been analyzed by Beaudry and Devereux (forthcoming). An infinitely lived representative household maximizes discounted expected utility:

$$(33) \qquad Max\ E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln(c_t) - \eta n_t \right).$$

Beaudry and Devereux make use of the Rogerson-Hansen construct, which implies that the utility function for the representative household is linear in leisure.

Final goods, Y, are produced from an isoelastic technology using intermediate inputs,

$$(34) \qquad Y = \left[\int_0^{\omega} m(i,t)^{\phi}\, di \right]^{\frac{1}{\phi}},$$

where $m(i)$ is the amount of intermediate input used in the production of final goods; ω represents the measure of intermediate goods-producing firms and is fixed exogenously. Intermediate-goods firms produce output from an increasing returns-to-scale technology that uses capital and labor,

$$(35) \qquad m(i,t) = z_t F(K_{it}, N_{it})^{\gamma},$$

where the degree of increasing returns is indexed by γ; z_t is an exogenous technology shock and the log of z is assumed to follow a random walk. Money plays a very different role in this economy relative to the other models discussed in this article. Households have no demand for money in this economy; instead, cash is held by banks because it reduces intermediation costs. Banks accept deposits from households and lend to intermediate-goods producers, who must finance capital inputs before selling their product to final-goods producers. The representative bank's intermediation cost function is assumed to be isoelastic in real balances and deposits:

$$(36) \qquad B\left(\frac{M}{P}\right)^{(1-\tau)} D^{\tau}.$$

It is assumed that $\tau > 1$, so that costs are reduced by acquiring real balances. Banks are owned by households and maximize the present discounted value of cash flows,

$$(37) \qquad Max \sum_{t=0}^{\infty} \Omega_t(S_t) CF(S_t) dS,$$

where Ω is a state-contingent pricing function and CF is the bank's cash flow.

Final-goods producers are price takers, but intermediate-goods producers are monopolistic competitors. The increasing returns parameter γ plays a fundamental role. In models with substantial increasing returns, there is a continuum of stationary equilibria. This occurs because, with large enough increasing returns, the eigenvalues governing the policy functions are both outside the unit circle and the model no longer has the standard saddlepath property. Since there are multiple equilibria, the authors choose the equilibrium in which nominal prices do not respond to current innovations to money or technology. Sticky prices in this economy have a much different implication than in standard sticky-price setups. In conventional sticky-price models, nominal prices would change in response to monetary or technology innovations if that were possible. In the Beaudry and Devereux economy, however, there is no ex post regret in that no producer has an incentive to change his price after shocks are revealed. Monetary and technology shocks generate substantial changes in economic activity in this model. In particular, there are large and persistent increases in output, consumption and investment in response to either type of shock. Moreover, an unanticipated increase in money leads to a significant and prolonged reduction in the nominal interest rate. With strong increasing returns, this is one of the few models that has internal propagation mechanisms capable of generating persistent liquidity effects. However, the model generates only a nominal liquidity effect and not a *real* liquidity effect. In fact, monetary expansion *raises* the real interest rate in this model. (Because preferences are separable over consumption and leisure, marginal utility of consumption depends only on date *t* consumption, so a rising real rate is implied by the consumption-Euler equation.) So the fall in the nominal rate is due entirely to substantial, persistent deflation induced by the monetary shock.

The channel through which money affects real quantities in this model differs significantly from the monetary transmission mechanisms in the other models discussed in this article. In fact, an increase in the money stock in this economy is isomorphic to a favorable technology shock that affects financial intermediaries. An increase in the stock of money, combined with sticky prices, results in higher real balances and raises the productivity of the banking sector. Lower intermediation costs, with strong increasing returns, lead to the substantial increase in output that occurs in this model.

The striking feature of this model is that small monetary shocks lead to significant and persistent liquidity effects, as well as large, persistent increases in real quantities. Of course, the very strong internal propagation mechanisms in the model that make these phenomena occur have not been established. Large increasing returns are required in this economy, which raises a number of questions. If actual production technologies exhibit economies of scale in this range, we would expect to see greater temporal concentration of production (periods of very high production, followed by periods of no production). The volatility of output, consumption, investment and labor input in this increasing-returns model is almost surely much greater than the corresponding volatility in the data. In addition, this model suggests large profits (or high per-period fixed costs) for business enterprises that are not obviously evident in the data. Finally, with even a small interest elasticity of money demand, the model would imply a large effect on capital accumulation, output and other variables of a change in secular inflation, because a rise in inflation would operate like a tax on financial intermediation (analogous to a negative monetary shock in their model).

The nominal liquidity effect and *inverse* real liquidity effect implied by this model reflect the fact that an increase in the money stock leads immediately to a sharp deflation. Of course, the standard interpretation of liquidity effects is that monetary increases are associated with lower nominal *and* real interest rates, and it is perhaps not surprising that a model in which an increase in the nominal money stock leads to a future increase in the nominal value of money reduces nominal interest rates. Though some vector autoregressions suggest that nominal prices do not immediately increase in response to a monetary shock, it is not yet an established empirical fact that higher money leads to a falling price level over horizons corresponding to business cycle frequencies, as is the case in the Beaudry and Devereux model.

INTEREST RATES AS PREDICTORS OF FUTURE ACTIVITY

It is reasonably well established that short-term interest rates rise prior to recessions. These correlations have been interpreted as important evidence for the existence of significant liquidity effects, and for monetary business cycle models. In this section, we consider a very simple equilibrium model in which increases in nominal interest rates precede economic downturns, but the correlations between nominal interest rates and future changes in output are due to an exogenous shock. This model is used to illustrate in a simple way that there are alternative interpretations of these correlations that are consistent with neoclassical economic theory and observations.

This section is drawn from Cooley and Ohanian (1990). Consider a representative household with preferences given by:

$$(38)\qquad Max\, E\sum_{t=0}^{\infty}\beta^{t}\frac{c_t^{1-\sigma}-1}{1-\sigma}.$$

Consumers maximize the expected present value of utility subject to the budget constraint:

$$(39)\qquad m_t+\tau_t+R_tb_t+z_t(q_t+p_td_t) \geq p_tc_t+m_{t+1}+b_{t+1}+z_{t+1}q_t$$

and the cash-in-advance (asset market) constraint:

$$(40)\qquad R_tb_t+m_t+\tau_t\geq p_tc_t+b_{t+1}.$$

The budget constraint states that consumer wealth, which consists of nominal money holdings (m_t), a lump-sum monetary transfer (τ_t), interest and principal on one-period bonds (R_tb_t), and the value of equity, $z_t(q_t+p_td_t)$, must be sufficient to finance consumption (c_t) new money (m_{t+1}), new one-period debt (b_{t+1}) and new equity ($z_{t+1}\,q_t$). The price level for the economy is given by p_t. The equilibrium for this model is straightforward: Consumption of the representative agent must be equal to the endowment (d), the equilibrium prices of equity and bonds insure that the agent is willing to hold equity, and there is no incentive for an agent to issue debt.

For current purposes, we assume initially that money grows deterministically:

$$(41)\qquad m_{t+1}=G_tM_t,\quad G_t\geq 1.$$

The endowment process is stochastic, and is the only source of uncertainty in this model. One-period debt is specified as sure nominal debt: One dollar today yields R dollars tomorrow, $R\geq 1$. Since this is a representative-agent economy, this security will be in zero-net supply, but the asset can be priced by using the household's marginal condition:

$$(42)\qquad 1=\beta E_t\left[\left(\frac{c_t}{c_{t+1}}\right)^{\sigma}\frac{P_t}{P_{t+1}}R_{t+1}\right].$$

For analytical convenience, we assume that the endowment is generated by a log-normal distribution. This implies that the one-period interest rate is given by:

$$(43)\qquad \ln(R_t)=-\ln(\beta)-\frac{(1-\sigma)^2}{2}\mathrm{var}(\Delta\ln(c_{t+1})) +\ln(G_{t+1})+(\sigma-1)E[\Delta\ln(c_{t+1})],$$

where $\Delta\ln(c_{t+1})$ is defined as the growth rate of consumption between today and tomorrow.

Suppose that the log of the endowment follows an integrated process:

$$(44)\qquad \ln(c_{t+1})=\alpha+\ln(c_t)+b(L)\varepsilon_t,$$

where $b(L)$ is a polynomial in the lag operator L and is square summable, and ε_t is an i.i.d. random variable with $E(\varepsilon)=0$, $E(\varepsilon^2)=\upsilon^2$.

Defining $d_k=\sum_{i=0}^{k}b_i$, it can be shown that the one-period nominal interest rate in this economy is given by:

$$(45)\qquad \ln(R_t)=-\ln(\beta)-\frac{(1-\sigma)^2}{2}\upsilon^2+(\sigma-1)\alpha +(\sigma-1)\left[\sum_{k=0}^{\infty}(d_{k+1}-d_k)\varepsilon_{t-k}\right] +\ln(G_{t+1}).$$

Note that in this economy, the nominal interest rate necessarily rises prior to a recession if the risk-aversion coefficient (σ) is less than 1. This is because if the economy is at a cyclical peak, then the term

$$\left[\sum_{k=0}^{\infty}\left(d_{k+1}-d_{k}\right)\varepsilon_{t-k}\right]<0.$$

Moreover, if one compares the spread between short- and long-term debt, then it is also the case that the yield curve necessarily inverts prior to a recession, and this is a strong feature of the data. The explanation for this is due to expected inflation. If households anticipate the endowment to fall next period, there are two forces at work on the interest rate. First, given the constant growth rate rule for money, higher expected inflation tends to push up the nominal rate. A falling endowment, however, implies that the real rate will fall. If risk aversion is less than unity, then inflation risk is more important than endowment risk, and the interest rate rises prior to a downturn.

Of course, the price level in this model is countercyclical; high price levels (and inflation rates) are associated with low endowment states. But as Kydland and Prescott (1990) and Cooley and Ohanian (1990) have pointed out, the price level in the United States is strongly countercyclical over the postwar period. The predictions of this simple model are also in line with observations reported by Fama (1981) regarding a negative association between stock returns and inflation.

As an extension, this model could be used to interpret an even richer set of correlations that has been reported (for example, Christiano and Eichenbaum, 1992a) in which open market sales (Federal Reserve tightening), high interest rates and subsequent downturns occur. This would simply require price level smoothing on the part of the Fed. For example, suppose that individuals expect a fall in the endowment, and a corresponding rise in the inflation rate (in the absence of any change in monetary policy). If the Fed is interested in pursuing price level smoothing, then the Fed would conduct open market sales of securities to reduce the amount of cash in the economy, and lower the future price level. As long as the Fed did not (or was unable to) completely smooth price-level fluctuations, we would observe Fed tightening, higher nominal interest rates, and future output declines. The behavior of the money supply, however, would be entirely endogenous.

This model illustrates how observations that are often interpreted as results of the liquidity effect can have very different explanations consistent with neoclassical models. While it is unlikely that real shocks account entirely for the observed correlations between nominal interest rates, the money stock and output, given the strong countercyclical behavior of the price level, it is not at all unreasonable to expect that this mechanism is responsible for at least some of these associations.

LIMITED-PARTICIPATION MODELS

Limited-participation (LP) models refer to a class of models, originally proposed independently by Rotemberg (1984) and Grossman and Weiss (1983), and later developed further by Lucas (1990).[6] These models provide an alternative interpretation of liquidity effects. While the sticky-price models discussed above all imply that assets can be priced by using consumption-Euler equations, so that the effects of a monetary disturbance on the time path of consumption determines whether there is a real liquidity effect (as well as how large it is and how long it lasts), limited-participation models provide a means of breaking the link between consumption-Euler equations and real interest rates.

The basic economics of the limited-participation theory can be illustrated with a modified version of the Grossman and Weiss model with logarithmic utility. Households are staggered in their visits to financial markets. "Evens" visit financial markets in even-numbered periods and "Odds" visit in odd-numbered periods. It takes time for people to exhaust their money balances, so most people do not participate in financial markets continuously. At any point in time, some are in financial markets and some are out of financial markets. As in cash-in-advance models, households must use cash to buy goods, but in this model households spend

[6] Jovanovic (1982) presents a related model.

their money over two periods rather than one. Also as in cash-in-advance models, each period consists of an asset market (AM) followed by a product market (PM).

A nonstochastic steady-state equilibrium in the Grossman and Weiss model can be described as follows. At period-one asset markets, Odds obtain money for spending during product markets in periods one and two. Then, at period-one product markets, Odds spend a fraction ϕ of their money on goods, where $\phi = 1/(1+\beta)$ and β is the discount rate, and save the remaining fraction $(1-\phi)$ of their money to spend during the second period. At the same time, in period-one product markets, Evens spend all the money they have left, which is a fraction ϕ of the money they had acquired last period (in period-zero asset markets). This will be utility-maximizing behavior for households with separable logarithmic utility and a constant discount rate facing constant nominal prices and opportunities to hold only money and riskless one-period nominal bonds as assets.

Consider a steady state in which Odds and Evens are equally wealthy and have the same consumption profiles (except that they are out of phase by a period). In a steady state with a fixed nominal money supply, M^S, and with constant endowments of goods, $y = 1$, equilibrium nominal prices are constant and total nominal spending on goods each period is $(1/(2-\phi))M^S$, while $((1-\phi)/(2-\phi))M^S$ money is *not* spent (because it is carried over to the next period by the households that will not be in asset markets next period).

Starting from this steady state, an unanticipated open market purchase has real effects in the short run: The increase in money must initially be acquired by those households that are in asset markets when it occurs. Suppose the open market operation occurs in an odd period, so odd households initially acquire it all (by selling bonds for money). Because all households spend cash slowly (over two periods), not all the new money is spent at first. The price level rises less-than-proportionally to the money supply. Because Even households (who did not attend financial markets this period) planned already to spend all their money on goods, the increase in the price level reduces their consumption. With constant endowments, equilibrium requires that Odd households consume more this period. However, this increase in consumption by Odd households is temporary, so the anticipated growth rate of the Odd household's consumption falls. The consumption-Euler equation for Odd households then implies that the real interest rate over two periods (from now until the Odd household again enters assets markets) falls. Notice, however, that the model breaks the link between real interest rates and the consumption-Euler equation of Even households, so it breaks the link between real interest rates and the path of *aggregate* consumption.

More precisely, there are equal numbers of Odd and Even households. Odd households choose consumptions, c_t, and withdrawals of money from financial markets (every other period), M_t, to maximize

$$\sum_{t=1}^{\infty} \beta^{t-1} \ln\left(c_t^o\right), \tag{46}$$

subject to a sequence of constraints

$$P_t c_t^o + P_{t+1} c_{t+1}^o = M_t^o \qquad \text{for } t \text{ odd} \tag{47}$$

and

$$B_t^o + P_{t-1} = M_t^o + \frac{B_{t+2}}{\left(1+i_{t,t+2}\right)} + \tau_t \quad \text{for } t \text{ odd}, \tag{48}$$

and initial conditions on B_0^o, the initial level of "bonds" held by the representative Odd household, and P_0, the period-zero price level; τ_t is a lump-sum tax payment that the household must pay (to balance the government budget). Odd household own claims on the endowment streams of firms: They are entitled to the dividends paid by the firm during asset markets at odd-numbered periods (from sales in the product market at the previous even-numbered periods). Firms pay their entire revenue as dividends. The term M_1^o shows the money that the Odd household acquires during asset markets at date 1 for use in product markets at dates 1 and 2. This money comes from dividends paid by firms from their sales of goods at date-zero product markets. Notice that utility maximization implies that $P_t c_t^o = \phi M_t^o$ and

$P_{t+1}\, c^o_{t+1} = (1-\phi)M^o_t$. Even households solve an analogous maximization problem.

The government collects lump-sum taxes and uses the proceeds as interest on its debt; the representative household has a tax liability equal to the present value of the total government debt. The government may also engage in open market operations. The government's budget constraint is

$$(49) \qquad M^S_t - M^S_{t-1} + \frac{B^g}{1+i_{t,t+1}} + \tau_t = B^g_t,$$

which says that the government finances it debt obligations by printing money, or by borrowing from or imposing lump-sum taxes on households currently in asset markets. In the steady state, this budget constraint becomes simply $\tau = (i/(1+i))B^g$. The initial level of government bonds is given exogenously.

Equilibrium requires a sequence of prices and interest rates so that households maximize utility, and product and asset markets clear:

$$(50) \qquad c^o_t + c^e_t = 1$$

and

$$(51) \quad M^e_t = P_{t-1} + M^S_t - M^S_{t-1} \qquad \text{for } t \text{ even},$$

$$(52) \quad M^o_t = P_{t-1} + M^S_t - M^S_{t-1} \qquad \text{for } t \text{ odd}.$$

The latter conditions require that households in financial markets acquire all the money paid by firms as dividends that period plus any new money printed by the government.

Consider the following sequence of events in a steady-state equilibrium with fixed money supply M. In each *odd* period t, the representative Odd household acquires money $(1/(2-\phi))M$ at asset markets and then spends $(\phi/(2-\phi))M$ in product markets, saving $((1-\phi)/(2-\phi))M$ to spend next period. The representative Even household spends all its remaining money, $((1-\phi)/(2-\phi))M$, on goods. Total nominal spending on goods is $(1/(2-\phi))M$. In each *even* period, the representative Even household acquires money $(1/(2-\phi))M$ at asset markets and then spends $(\phi/(2-\phi))$M in product markets, saving $((1-\phi)/(2-\phi))M$ to spend next period. The representative Odd household spends all its remaining money, $((1-\phi)/(2-\phi))M$. Again, total nominal spending on goods is $(1/(2-\phi))M$. This sequence repeats in the steady state. Because output is unity, the steady-state nominal price level is $(1/(2-\phi))M$.

Now consider a parametric change in the money supply at date 1, starting from this nonstochastic steady state. The government buys a one-period bond (from the Odd household) with newly printed money. The Odd household now has $(1/(2-\phi))M+\Delta M$ dollars and spends $\phi((1/(2-\phi))M+\Delta M)$ on goods. The Even household still has $((1-\phi)/(2-\phi))$M dollars to spend. Total nominal spending and the price level are then

$$(53) \qquad \phi\left(\frac{1}{2-\phi}M+\Delta M\right)+\frac{1-\phi}{2-\phi}M$$
$$= \frac{1}{2-\phi}M+\phi\Delta M.$$

With $\phi \le 1$, the price level rises but falls short of its new steady-state value of $(1/(2-\phi))(M+\Delta M)$. This rise in the price level reduces the real consumption of Even households from $1-\phi$ to $((1-\phi)/(2-\phi))M/((1/(2-\phi))M+\Delta M)$. Equilibrium real consumption of Odd households rises by the amount that Even household consumption falls.

The following period ($t = 2$), Even households acquire all the money that was spent at $t = 1$ and spend a fraction ϕ of it, so they spend $\phi[(1/(2-\phi))M+\phi\Delta M]$. Odd households spend their remaining $(1-\phi)((1/(2-\phi))M+\Delta M)$ on goods, so total nominal spending (and the price level) is $(1/(2-\phi))M+(\phi^2+1-\phi)\Delta M$. With $1/2 \le \phi \le 1$, the price level rises at $t = 2$ and overshoots its new steady-state level. The price level then falls below its steady-state level at $t = 3$ and shows damped oscillations as it approaches its new steady state. (The subsequent adjustment of the price level can be described by the difference equation, $P_t = \phi P_{t-1} + (1-\phi)P_{t-2}$.)

Equilibrium real interest rates can be computed in this model from consumption-Euler equations. Consumption by Odd households rises at $t = 1$ (when the open market purchase occurs), then falls at $t = 2$ (as Even households go to asset markets and acquire the portion of the new money that Odd households spent at $t = 1$). The two-period change in consumption for Odd households is also negative, as the economy approaches (with two-period oscillations) its new steady state. So the two-period market real interest rate falls at $t = 1$, and the implicit one-period real interest rate from the consumption-Euler equations of Odd households also falls. This is the liquidity effect of monetary expansion in the basic limited-participation model. Notice that because consumption of Even households falls at $t = 1$, the implicit one-period real interest rate from their consumption-Euler equations *rises* at $t = 1$, but this is not reflected in any market interest rates because these households are not currently participating in asset markets. At $t = 2$, the two-period market real interest rate rises above its steady-state level because the two-period change in consumption of Even households is positive. So the liquidity effect in the limited-participation model is necessarily of limited duration: It vanishes (and in fact reverses itself) when the identity of the participants changes.

The liquidity effect from the limited-participation model results from the temporary change in consumption of the households who have use of a disproportionate share of newly printed money. In the simple model discussed above, these households cannot use this money to finance a permanent increase in consumption. More generally, the increase in money may raise liquidity (in the model above, relax the two-period, cash-in-advance constraint) by more than it raises wealth, so households that obtain the additional money may choose an increase in consumption that is (at least partly) temporary. Although in equilibrium *other* households must then experience a temporary fall in consumption, the limited-participation nature of the model breaks the link between interest rates and the consumption-Euler equations of those households.

Representative Household Limited-Participation (RHLP) Models

Limited-participation models are complicated because they involve heterogeneity. Lucas (1990) and Fuerst (1992) developed variations on the limited-participation model that simplify it by using a representative household, thereby eliminating wealth-redistribution effects. Their models go further than the heterogenous-agent LP model discussed above by eliminating the connection between real interest rates and *any* consumption-Euler equation. The models split the representative household into individuals with unique tasks who later pool wealth and consumption. One person in the household purchases goods with money while another participates in financial markets and receives new money transfers. The new money, in the hands of the latter person, cannot immediately reach the former person and is therefore not available for immediate spending in the goods market. As a result, nominal goods prices do not immediately reflect the new money. (With a binding cash-in-advance constraint in the goods market, nominal prices do not depend at all on the size of the current monetary transfer.) In this way, the model generates short-run price stickiness in response to unanticipated increases in the money supply. The new money introduced into the economy enters the loans market as firms must use money to pay inputs. Households work for money they can use to buy goods next period. Because they know that nominal prices will rise next period, the nominal reservation wage rises in proportion to that increase in prices. This raises the nominal amount of money the firm must borrow to pay wages. However, because a disproportionate share of new money is used in this factor market (rather than being spread throughout all markets that require money), the real interest rate falls.

Although the model is simpler than the LP model in that there is a representative household, its timing and household splits add new complications. We describe here only the setup of a basic RHLP model (readers are referred to the papers by Lucas and Fuerst for discussions of the model's solution and implications). The basic model has several steps. First, households start each period with all the economy's money, while firms will hold all the economy's money at the end of each period. Initially, households divide money between buying goods and lending to financial firms: They lend D_t dollars to financial firms and keep $M_t - D_t$ dollars to spend on goods. Second, financial firms receive a lump-sum transfer, τ_t, from the government. Third, financial firms lend their money, $D_t + \tau_t$, to goods-producing firms. Fourth, goods-producing firms use some or all of this cash to pay $w_t L_t$ for labor services (in a perfectly competitive labor market) because labor services are subject to a cash-in-advance constraint. Fifth, goods-producing firms produce $f(k_t, z_t L_t)$ goods using this labor and (previously installed) capital; they decide how many goods to install as capital for next period, I_t, and how many to sell to households in a perfectly competitive environment. Sixth, goods-producing firms sell $f(k_t, z_t L_t) - I_t$ goods to households for $M_t - D_t$ dollars. Seventh, goods-producing firms repay (with interest) their loans from financial firms: They pay $(D_t + \tau_t)(1 + i_t)$ to financial firms. Eighth, goods-producing firms pay dividends, Π_t, to households with all their remaining money:

$$(54) \quad \Pi_t = M_t - D_t - (D_t + \tau_t)(1 + i_t) + D_t + \tau_t - w_t L_t.$$

Finally, financial firms pay interest of $(1 + i_t)D_t$ to households on their loans, and dividends to households with all their remaining money, $(D_t + \tau_t)(1 + i_t) - (1 + i_t)D_t$. So the total amount of money that financial firms pay to households at this point is $(1 + i_t)D_t + (D_t + \tau_t)(1 + i_t)$. After this payment, households have money balances of $M_t + \tau_t$, which come from four sources: interest on loans to financial firms; wage income; dividends from goods-producing firms; and dividends from financial firms.

The representative household chooses consumption, labor supply and deposits to maximize expected utility,

$$(55) \quad E_t \sum_{t=0}^{\infty} \beta^{t+1} \left[U(c_t, 1 - L_t) \middle| Info_t \right],$$

subject to a sequence of budget constraints:

$$(56) \quad M_{t+1} = M_t + \Pi_t + \upsilon_t + i_t D_t + w_t L_t - P_t c_t,$$

where Π_t and υ_t are the nominal dividends paid at the end of period t by goods-producing firms and financial firms, M_t is beginning-of-period money balances, $i_t D_t$ is the interest the household earns on its deposits at financial firms, $w_t L_t$ is labor income, and $P_t c_t$ is nominal spending on consumption goods. This budget constraint can be rewritten as

$$(57) \quad M_{t+1} = M_t + \tau_t + P_t\left[f(k_t, z_t L_t) - k_{t+1} - c_t \right],$$

where τ_t is the nominal lump-sum transfer of new money to the representative financial firm and $f(k_t, z_t L_t) - k_{t+1}$ is output of goods minus investment spending by the representative goods-producing firm. (This formulation assumes 100 percent depreciation of capital each period.) The household is also subject to a sequence of cash-in-advance constraints:

$$(58) \quad P_t c_t \le M_t - D_t.$$

Households must choose labor supply and deposits for date t prior to the realization of uncertainty at date t, but can choose consumption after the resolution of uncertainty at that date.

The representative competitive goods-producing firm maximizes

$$(59) \quad E_t \sum_{t=0}^{\infty} \beta^{t+1} \left[\frac{U_{c,t+1}}{P_{t+1}} \pi_t \middle| Info_t \right],$$

where $U_{c,t+1}$ is the representative household's marginal utility of consumption at date t, P_{t+1} is the price level at date $t+1$, and $Info_t$ is the firm's information set at date t. The fir-m's production function depends on capital, labor and a productivity shock, z_t, so production is $f(k_t, L_t, z_t)$. Nominal profit equals nominal income from sales, $P_t f(k_t, L_t, z_t)$, minus expenditure for investment, $P_t k_{t+1}$, minus expenditure for labor, $w_t L_t$:

$$(60) \quad \pi_t = P_t f(k_t, L_t, z_t) - P_t k_{t+1} - w_t L_t.$$

The representative financial firm acquires loans (deposits) D_t from households by paying interest i_t, receives a lump-sum transfer τ_t from the government, and lends B_t to goods-producing firms at the interest rate i_t. It chooses loans and deposits to maximize

$$(61) \qquad E_t \sum_{t=0}^{\infty} \beta^{t+1} \left[\frac{U_{c,t+1}}{P_{t+1}} \upsilon_t \middle| Info_t \right],$$

where its nominal dividends υ_t are given by

$$(62) \qquad \upsilon_t = \tau_t + i_t B_t - i_t D_t.$$

Note that the total amount a financial firm pays to households at the end of a period equals dividends plus interest payments, or $\tau_t + i_t B_t$.

The basic idea of the model above is similar to the limited-participation models of Rotemberg (1984) and Grossman and Weiss (1983). In this model, all households fully participate in financial markets, but monetary transfers enter through credit markets (in the sense that they go to financial firms, which then lend the money) and households cannot use this new money to buy consumption goods. This breaks the link between consumption growth and the real interest rate. Although the separation of product and financial markets creates a sluggish response of the nominal price level to a monetary shock, it is the dispersion of markets rather than price stickiness *per se* that creates the effect of money on real and nominal interest rates in the model.

Limited-participation models suggest that econometricians can disregard aggregate consumption data when examining the connection between consumption and interest rates implied by the consumption-Euler equation. The models instead impose a different necessary condition relating real interest rates to different intertemporal marginal rates of substitution. The Grossman and Weiss model related it to the consumption of a subset of consumers, that is, those who are "in financial markets." The RHLP model relates it instead to an intertemporal margin faced by firms.

Several other researchers have extended these kinds of models to deal with other asset-pricing issues. In a recent article, for example, Lynch (1994) develops a non-monetary model in which aggregate consumption data are not connected with asset prices in the usual way because individual consumption decisions are made at finite intervals that are longer than the measurement interval for asset prices (aggregate consumption is related to asset prices indirectly and in a different way, however). (This is reminiscent of the Grossman-Laroque model of purchases of durable goods, which are made infrequently due to transactions costs). Lynch also assumes individual heterogeneity in that decisions of different individuals are staggered. This assumption ensures that there is no decision interval for which the model can be rewritten in terms of a representative agent; hence, aggregate consumption is not relevant for asset prices. The staggering of decisions makes the model similar to limited-participation models: With two groups of agents, say, Odds and Evens as in the earlier discussion, Evens finance consumption in odd-number periods out of previously held assets by selling riskless, zero-transaction-cost assets. Finite intervals for consumption decisions, with staggered decision periods across households, smooth the aggregate intertemporal marginal rates of substitution and reduce their correlation with asset prices. Lynch studied the implications of this model for the equity-premium/riskless-rate puzzle (with mixed success). (The infrequent decisionmaking might be thought to be due to the costs of making decisions; Lynch calculates that the total utility loss relative to every-period decisionmaking is about 1 percent of wealth.) In Lynch's model, consumption plans are followed through with certainty between decision intervals.

Though limited-participation models of this sort appear to have met with at least some success in asset-pricing issues more generally, heterogeneous-agent limited-participation models have not been applied quantitatively to liquidity effects. Like the representative-household limited-participation models, they break the simple link between consumption and interest rates implied by the usual consumption-Euler equation. In contrast to the RHLP model, they do not replace that connection with a similar relation involving firms. Instead, they place restrictions on movements in interest rates and consumption by a subset of the population. This suggests those models would be easier to test (using panel data) than models in which money demand by firms for purchases of inputs plays a major role. It also suggests a possible common model for explaining liquidity effects and resolving other asset-pricing puzzles. We believe additional research along these lines may be useful.

CONCLUSIONS

Most economists believe that liquidity effects appear in the data for the U.S. economy, though the size of the effects (if it even exists) is a subject of controversy, due largely to identification problems in statistical work. The theoretical explanation for nominal or real liquidity effects also remains controversial. While many economists interpret liquidity effects as results of sluggish nominal price adjustments, others interpret them as reflecting costs of complete and continuous participation in markets that allow monetary changes to cause redistributions or to channel spending into certain areas (such as increased spending by firms on factors of production). Others suggest that liquidity effects reflect part of the economy's coordination on a particular equilibrium when multiple solutions are possible. Other alternative explanations may appear in future research. Goodfriend (1995) has recently suggested a model in which imperfectly competitive firms face kinked demand curves and price sluggishness emerges endogenously, creating real effects of monetary policy in which liquidity effects play a role. More generally, the problem of explaining liquidity effects theoretically is part of the broader problem of explaining the effects of monetary policies on a wide range of economic variables. Current explanations may be suggestive, but no definitive model has yet emerged.

REFERENCES

Barro, Robert, and Herschel Grossman. "A General Disequilibrium Model of Income and Employment," *The American Economic Review* (March 1971), pp. 82-93.

Beaudry, Paul, and Michael Devereux. "Monetary Policy and the Real Exchange Rate in a Price-Setting Model of Monopolistic Competition," *Carnegie-Rochester Conference Series* (forthcoming).

Blanchard, Olivier, and Nobuhiro Kiyotaki. "Monopolistic Competition and the Effects of Aggregate Demand," *The American Economic Review* (September 1987), pp. 647-66.

Carlton, Dennis. "The Theory and the Facts of How Markets Clear: Is Understanding Industrial Organization Valuable for Understanding Macroeconomics?" in R. Schmalensee and R.D. Willig, eds., *Handbook of Industrial Organization*. North-Holland, 1989, pp. 909-46.

Cho, Jang-Ok, and Thomas Cooley. "The Business Cycle with Nominal Contracts," working paper (1990), University of Rochester.

Christiano, Lawrence J., and Martin Eichenbaum. "Liquidity Effects and the Monetary Transmission Mechanism," *The American Economic Review* (May 1992a), pp. 346-53.

_______ and _______. "Liquidity Effects, Monetary Policy, and the Business Cycle," National Bureau of Economic Research *Working Paper No. 4129* (August 1992b).

Cook, Timothy, and Thomas Hahn. "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s," *Journal of Monetary Economics* (November 1989), pp. 331-51.

Cooley, Thomas, and Lee E. Ohanian. "Term Structure Inversion and Real Activity," working paper (1990), University of Rochester.

Fama, Eugene F. "Stock Returns, Real Activity, Inflation and Money," *The American Economic Review* (September 1981), pp. 545-65.

Friedman, Milton. "Factors Affecting the Level of Interest Rates," *Savings and Residential Financing, 1968 Conference Proceedings*, U.S. Savings and Loan League, 1968, p. 7.

Fuerst, Timothy. "Liquidity, Loanable Funds, and Real Activity," *Journal of Monetary Economics* (February 1992), pp. 3-24.

Goodfriend, Marvin. "Moderately Inflationary Monetary Policy," working paper (1995), Federal Reserve Bank of Richmond.

Grossman, Sanford, and Laurence Weiss. "A Transactions-Based Model of the Monetary Transmission Mechanism," *The American Economic Review* (December 1983), pp. 871-80.

Hansen, Gary. "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics* (November 1985), pp. 309-27.

Jovanovic, Boyan. "Inflation and Welfare in the Steady State," *Journal of Political Economy* (February 1982), pp. 561-77.

King, Robert G. "Money and Business Cycles," working paper (1991), University of Rochester.

Kydland, Finn, and Edward Prescott. "Business Cycles: Real Facts and a Monetary Myth," Federal Reserve Bank of Minneapolis *Quarterly Review* (spring 1990), pp. 3-18.

Lucas, Jr., Robert E. "Liquidity and Interest Rates," Journal of Economic Theory (April 1990), pp. 237-64.

_______. "Interest Rates and Currency Rates in a Two-Country Model," *Journal of Monetary Economics* (November 1982), pp. 335-59.

Lynch, Anthony W. "Staggered Decision-Making by Individuals: Pricing Implications and Empirical Evidence," working paper (1994), University of Chicago.

Marcet, Albert. "Solving Nonlinear Models by Parameterizing Expectations," working paper (1990), Federal Reserve Bank of Minneapolis.

Ohanian, Lee E., and Alan C. Stockman. "How Much Price Stickiness is Necessary for Reasonable Liquidity Effects?" working paper (1994).

Prescott, Edward. "Theory Ahead of Business Cycle Measurement," *Carnegie-Rochester Conference Series on Public Policy* (spring 1986), pp. 11-44.

Rotemberg, Julio. "A Monetary Equilibrium Model with Transactions Costs," *Journal of Political Economy* (February 1984), pp. 40-58.

Stockman, Alan C., and Lee E. Ohanian. "The Short-Run Independence of Monetary Policy under Pegged Exchange Rates," working paper (1994), University of Rochester.

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Commentary

Kevin D. Hoover

Lee Ohanian and Alan Stockman's paper presents a careful, lucid survey of a series of technically difficult models of the liquidity effect. I would like first to clarify for the reader (exactly as I had to do for myself) what seem to me to be the key issues and conclusions of their survey and then to offer an assessment (not of their admirable paper, but) of the research program on which it reports.

In years, I am somewhat younger than Alan Stockman and slightly older than Lee Ohanian. In training, however, I am completely antediluvian. I will therefore attempt to clarify the issues using, for the most part, the venerable (and much maligned) IS-LM model. Ohanian and Stockman begin their analysis of the liquidity effect with an IS-LM model. But they treat it as if it were just another model on par with the sequence of micro-foundational models that they explore through the rest of the paper. Actually, the IS-LM model operates on a different plane from the other models. It displays the relationships among aggregates with only the most implicit commitment to particular micro-foundations. Therefore, each of Ohanian and Stockman's models can be seen as attempts to fill in the details that lie behind the IS-LM-AS (aggregate supply) analysis, rather than as substitutes for that analysis. Thus, consider, for example, their first model: the sticky-price model. Cast as a dynamic optimization model for a representative agent, it can be seen as particularizing the IS-LM model: It treats the consumption function as a life-cycle or permanent-income type; the investment function as the most rudimentary neoclassical type; money demand as governed by the quantity theory; and labor supply as derived from utility maximization; and, most important of all, it insists that these functions and the decisions that lie behind them are joint and not independent. But if we keep these restrictions in mind, we can still use the IS-LM model to understand what some of the issues are.

THE LIQUIDITY AND INFLATION EFFECTS

Consider the canonical (classical) IS-LM-AS in Figure 1. The aggregate supply curve is vertical, indicating market clearing in labor and product markets. If the money supply increases by ΔM, the LM curve shifts to the right, and equivalently the AD (aggregate demand) curve shifts upward. At the original price level, p, aggregate demand exceeds aggregate supply. If such a situation is technically infeasible, then prices must rise from p to p', which shifts the LM curve back to its original position, since the location of the LM curve depends on the real money supply, M/p. Interest rates remain unchanged. This is the flexible price case.

Now, if, in the short-run aggregate supply can exceed its long-run level at AS (which might be, as Ohanian and Stockman observe, a result of the assumption of monopolistic competition) and if prices are sticky, say at p, then output rises and interest rates fall from i to i'. This is the liquidity effect: An expansion of money results in a fall in interest rates. It is a fall in the nominal interest rate and, because prices are sticky, in the real interest rate as well.

If increases in the money supply are not simply lump-sum, but are this period's realization of higher growth rates of money associated with increasing rates of inflation, then there is another effect to consider. Investment is a function of ex ante (or anticipated) real rates, not of nominal rates of interest. As anticipated rates of inflation increase, a constant ex ante real interest rate must be represented by higher nominal rates of interest. Thus, as the rate of inflation increases in Figure 2 by $\Delta\hat{p}$, the IS curve must shift vertically by $\Delta\hat{p}$ in order for each level of GNP to correspond to the correct real interest rate.[1]

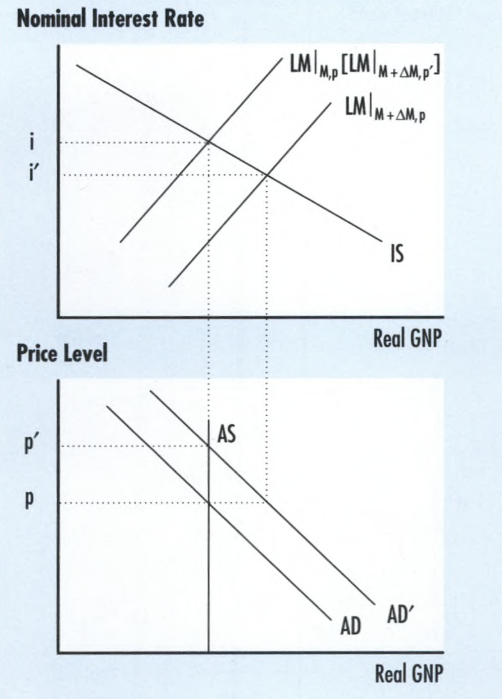
[1] That it is only the IS curve that is shifted by a change in anticipated inflation results from nominal interest rates being plotted on the vertical axis. Were the vertical axis to measure real interest rates instead, then the LM curve would shift and the IS curve would not be directly affected. See Mundell (1971, pp. 18-19).

If prices are sticky at *p*, then the nominal interest rate rises by less than the increase in inflation to *i′*: Anticipated inflation stimulates output, investment and (short-run) growth.[2] Real rates therefore fall. This is the Mundell-Tobin effect.[3] If, however, prices are flexible, prices rise until aggregate demand equals aggregate supply (from *p* to *p′*), shifting the LM curve back and increasing interest rates from *i* to *i″*. Here, the nominal interest rate fully reflects the increased rate of inflation. This is the Fisher effect: An increase in inflation corresponds to a one-for-one increase in nominal interest rates.[4]

There can also be a Mundell-Tobin effect with flexible prices. If consumption depends not only on GNP but also on the real value of nominally denominated wealth (bonds or money), then, as in Figure 3, there are two effects: First, the upward shift of the IS curve by the full amount of the anticipated inflation and, second, a partly offsetting downward shift of the IS curve owing to rising prices that reduce real wealth in the consumption function.[5] The LM curve has to shift less far back to restore equality between aggregate demand and supply, so that interest rates rise from *i* to *i′*, which is less than the increase in inflation. Real rates of interest therefore fall. Because of the full employment assumption, current output is unchanged, but investment rises (and consumption falls) as a result of lower real rates of interest, which increases the rate of GNP growth.

Therefore, we have three effects: a liquidity effect; a Fisher effect; and a Mundell-Tobin effect. These constitute a powerful taxonomy, and—I think—one that is clearer than that used by Ohanian and Stockman. Ohanian and Stockman define a liquidity effect to be the systemic change in an interest rate as the result of a monetary expansion. They distinguish between a real and a nominal liquidity effect. I think that it would better to reserve the term liquidity effect only for those changes in the real rate of interest induced directly by money expansion. The only interesting liquidity effects are real because, without a change in the real rate of interest, there can be no accompanying effect on any other real variables that interest us: GNP; investment; consumption; and employment. What we should recognize is that liquidity effects are often (and depending upon the model, often necessarily) accompanied by the other two effects. The systemic effect is the sum of several partial effects.

Figure 1



THE MODELS

Ohanian and Stockman consider a series of models. How do these effects play out in each of them?

One-Sector, Sticky-Price, Rational-Expectations Model

Some of the key features of this model were already described above. One additional feature is that money is modeled using the cash-in-advance constraint. In the IS-LM model, this means that the LM is vertical at a level of GNP determined by the real supply of money (Figure 4). The increase in money (the shift of LM to the right) has the usual liquidity effect, ceteris paribus, reducing the interest rate. In this model, we can understand that effect as arising from an increase in current consumption because of the relax-

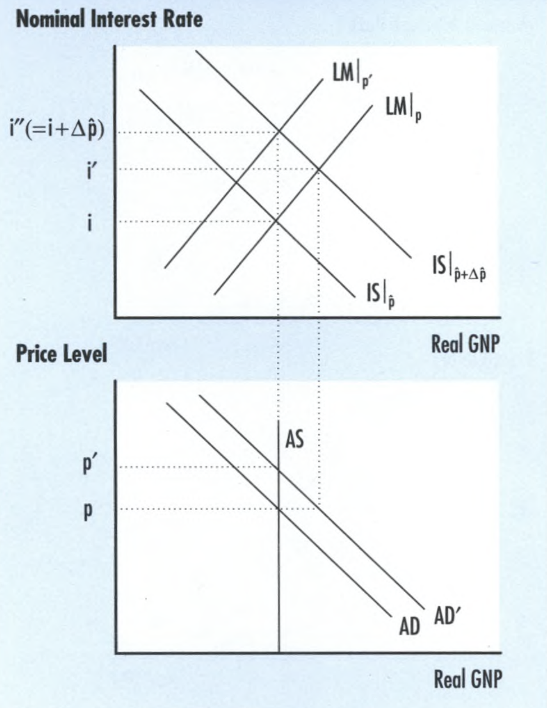
[2] The steady-state rate of growth is not affected.

[3] Tobin (1965) concentrates on the increase in the steady-state capital stock that results from the depression of real interest rates due to anticipated inflation, and the Mundell-Tobin effect is often thought of as a proposition about capital deepening and the accompanying increase in steady-state consumption. The presentation here, however, closely follows Mundell (1971, chapter 2). Mundell focuses on the failure of the Fisher hypothesis through exactly the same mechanism. Mundell's treatment suits the issues raised in the current discussion of the liquidity effect. For an excellent historical discussion of the relationship of the Fisher hypothesis to the Mundell-Tobin effect, see Cottrell (1993).

[4] See Fisher (1930).

[5] The initial shift of the IS curve from $IS|\dot{p},p$ to $IS|\dot{p}+\Delta\dot{p},p$ would, ceteris paribus, result in a shift in aggregate demand from AD to AD′. Since aggregate demand falls with rising prices because of the wealth effect, the final aggregate demand curve is flatter than AD″.

Figure 2



ation of the cash-in-advance constraint. Optimally, agents want to consume more in future periods as well (an implication of the life-cycle/permanent-income hypothesis) and so increase capital accumulation today, lowering the rate of return on capital and the real rate of interest. (Notice that the liquidity effect here has nothing whatsoever to do with the interest elasticity of the demand for money; it works the same whether the LM curve is vertical or simply upward sloping.)[6]

Prices are pre-determined in the current period in this model. They can, however, adjust in the future. Thus, an unexpected increase in money this period is associated with perfectly anticipated inflation. Consequently, the IS curve shifts up at the same time that the LM curve shifts out. There are two cases. In Figure 4a, the liquidity effect outweighs the inflation effect, and both real and nominal interest rates fall. In Figure 4b, the inflation effect outweighs the liquidity effect, and nominal interests rates rise, although since i' is less than i'', real interest rates fall. As Ohanian and Stockman observe, which case one obtains depends on the degree of relative risk aversion (or equivalently on the degree of intertemporal substitution between consumption today and tomorrow). Yet, either way the real rate falls, which is the important point about the liquidity effect. Christiano (1991) usefully distinguishes between a *dominant* liquidity effect (Figure 4a) and a non-dominant liquidity effect (or dominant inflation effecting, as shown in Figure 4b).

[6] This point deserves emphasis since Ohanian and Stockman note it in a way that suggests mild surprise or novelty and because many economists talk as if an interest-elastic money demand implied a liquidity effect. Although the interest elasticity of money demand affects the *size* of the liquidity effect, it is neither necessary nor sufficient for its existence. It is not necessary because there is a liquidity effect in Figure 4, where the LM curve is vertical. It is not sufficient because there is no liquidity effect in Figure 1, where the LM curve is not vertical, unless we make the additional assumption that prices are sticky.

Models with Some Sticky Prices

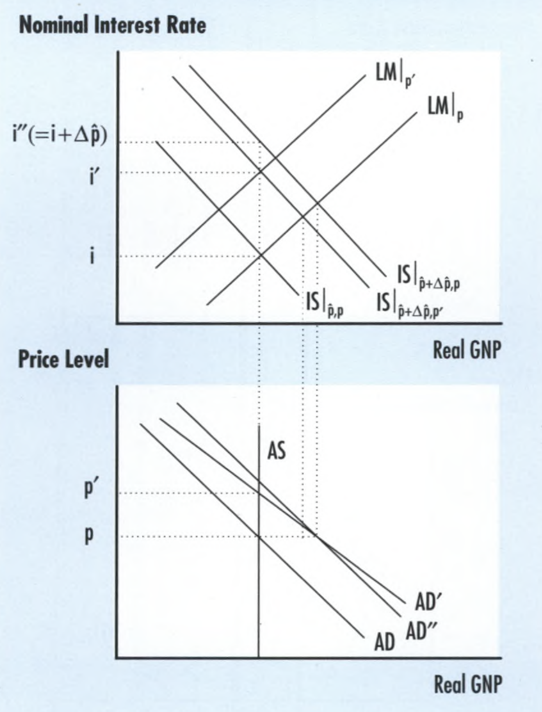
In the model with perfectly flexible prices, there is no anticipated inflation effect, because the price level jumps immediately to bring aggregate supply and demand back into equality. If some prices are flexible this period, fewer prices will have to adjust in future periods. Therefore, while there will be an anticipated inflation effect, it will be smaller than in the model with all prices sticky. It is therefore in this case less likely that the inflation effect will dominate as in Figure 4b, and more likely that both nominal and real interest rates will fall. Ohanian and Stockman's contribution with respect to this model is to show that for reasonable parameterizations only small degrees of price stickiness are enough to produce dominant liquidity effects.

Capital Accumulation and Technology Shocks

The possibility of Hicks-neutral technology shocks and capital accumulation introduces two new effects into the analysis. A technology shock can be represented as in Figure 5 as shifting the AS curve to the right. If prices were perfectly flexible, they would fall immediately (without anticipated inflation) from p to p', shifting the LM curve right and lowering the interest rate to i''. This is the pure *technology-shock effect*. If prices are not perfectly flexible, however, there will be anticipated deflation, and the IS curve will also shift down, so that the final equilibrium interest rate is i''. This fall in the nominal rate is greater than the pure Fisher effect $(i-i''')$ so that the real rate falls.

Unlike a neutral technology shock, capital accumulation, ceteris paribus, not only shifts the AS curve to the right, it also reduces the marginal product of capital, which can be represented by a downward shift of the IS curve. This would simply magnify the drop in interest rates (real and nominal) in Figure 5. The interesting question, which can be answered in Ohanian and Stockman's parameterized model, but not in this qualitative model, is what the typical time-series behavior of interest rates would be given repetitive shocks to both money and technology in the face of capital accumulation.

Figure 3



The Increasing-Returns Model

The increasing-returns model is much more difficult to cast in an IS-LM-AS framework, although it could no doubt be done with some ingenuity. The model, which I know only from Ohanian and Stockman's sketch, does not appear to have very attractive properties with respect to the empirical observations that motivate Ohanian and Stockman's survey. I therefore omit further consideration of it.

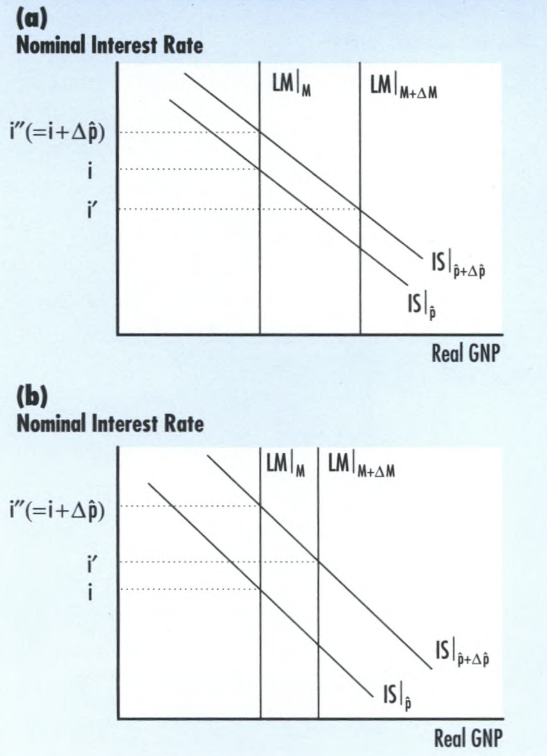
Limited-Participation Models

Ohanian and Stockman consider two models in which asset markets and goods markets are separated so that household decisions with respect to holdings of money and consumption must be made sequentially. The simpler of the two for our purposes is the one associated with Grossman and Weiss, and Rotemberg. This model is less easily rendered in an IS-LM version. Nevertheless, it is not difficult to understand its essence.

I think that it is helpful to consider an even simpler model than Ohanian and Stockman's simplification of Grossman and Weiss' model. I like to think of the Grossman and Weiss model as a kind of Hindu overlapping-generations model. The young in the overlapping-generations model corresponds to Grossman and Weiss' odd agents, and the old to their even agents. Instead of the old dying as they do in a standard overlapping-generations model, they are reincarnated again as young, while the young become old. Unlike Ohanian and Stockman, or Grossman and Weiss, let us first consider the model without a cash-in-advance constraint. That an increase in the money supply that is disproportionately received by one of the generations in an overlapping-generations model results in a less-than-proportional increase in prices is a standard result.[7] The intuition is simple. If the young receive an increase, they appear to have higher wealth at current prices and wish to consume more, now and in the future. If total resources are fixed, then prices rise. This has two effects: It reduces the real value of the increased money available to the young, and it reduces the real value of the money held by the old, reducing their consumption and freeing up resources available to the young. Because extra resources are available to the young, the price level need not rise as far to reduce the real value of the young's holdings of money to a sustainable level. The trick only works because the resources available to the young can be extracted from the old through an inflation tax. As the money becomes more dispersed—as it must when the young spend some of it—both young and old come to hold the new money balances. But since inflation can transfer resources but not create them, even-

[7] See Hoover (1988, chapter 6, section 3).

Figure 4



tually prices must rise in direct proportion to the increased money supply. Thus, even though prices rise less than proportionally this period, further inflation can be anticipated.

Since money is the only asset in my simplified version of this model, the real rate of interest is just the inverse of the rate of inflation, and the nominal rate of interest is zero. The liquidity effect in this model is the fall in the real rate due to increased inflation. Ohanian and Stockman's version of Grossman and Weiss' model is able to retain a non-zero nominal interest rate by imposing a cash-in-advance constraint that applies to two periods instead of just one for those in the asset market, and to one period for those out of the asset market. This means that even if nominal interest rates rise above zero, money will of necessity still be held.

The Lucas model goes one step further in collapsing the two types of agents into a single household with common budgets and consumption, but with sequencing of financial and consumption decisions or differentiated roles for household members. The fundamental idea remains similar.

THE PROSPECTS FOR LIQUIDITY MODELS

The critical question to ask about all of these models is whether they really capture the liquidity effect that we think we see in the world or, for that matter, whether they capture our intuitive understanding of the liquidity effect. I think there is reason to doubt that they do. I see two related problems.

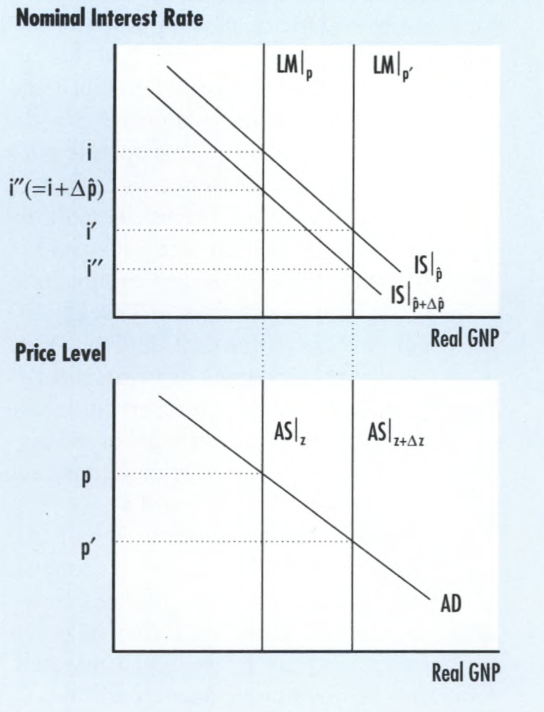
First, in all of these models—including even the basic IS-LM model with a vertical LM curve—the liquidity effect seems to operate through the wrong mechanism. The modus operandi of the liquidity effect in the models surveyed by Ohanian and Stockman is to affect the marginal rates of substitution between consumption in different periods or between consumption and leisure. In most of the models, although an interest rate is determined, interest rates do not matter in the sense that they are not causally important, but rather are priced as redundant assets. Thus, for example, the sticky-price model sets the interest rate according to the following logic: If there were a bond, it would have to yield a real rate of interest equal to the marginal rate of substitution between consumption today and consumption tomorrow, or it would be dominated in rate of return by real capital. In the model, that logic is perfectly correct; it picks out the correct shadow price. My concern, however, is precisely that this is a *shadow* price of a *shadow* asset. Bonds do not do anything important in the model; they are dispensable—a fifth wheel for the economic car. Yet, normally, we think the liquidity effect is important because monetary policy affects interest rates and interest rates are *causally* effective in altering consumption and, more particularly, investment decisions.

These models miss this feature for two reasons. First, because they are general-equilibrium models in which all the endogenous variables are determined simultaneously, they cannot adequately model the causal efficacy of interest rates. Causes operate in particular directions, and directionality requires recursive rather than simultaneous structure. The second reason that these models miss the causal efficacy of interest rates is that there is no mechanism for interest rates to be determined other than through the shadow prices associated with consumption, leisure and saving choices. The financial sectors in these models are simply not rich enough. Partly this is a result of the models assuming representative agents. Robinson Crusoe does not need a financial system. The point is not that there is something wrong in principle with general-equilibrium models. Rather, it is that a model of the liquidity effect should have important financial markets. Models in which the same equilibria are supported whether or not bonds are present appear to miss the crucial point.[8]

Actually, Grossman and Weiss' model is not technically a representative-agent model if that is taken to mean a single-agent model, but it is close enough to make no difference for my point. Similarly, it is true of all the limited-participation models that bonds have a non-redundant function. Their function, however, is an artifact of the cash-in-advance constraint, about which I shall have more to say presently.

It might be useful to compare the understanding of interest rate determination in this model with that of John Maynard Keynes in *The General Theory*.[9] Keynes assumed that the economy was populated by heterogeneous people with a diversity of opinions about what normal interest rates were. At current rates, those who feared capital losses would hold money (which for Keynes included Treasury bills and other short-term, interest-bearing assets) and those who hoped for capital gains would hold bonds. The market interest rate was determined as the point at which those hopes and fears were balanced. An injection of money lowered interest rates because a lower rate increased the proportion of the population who feared capital loss and therefore increased their willingness to hold the new money. Investors in real capital then looked to the market rate as part of their process of evaluating the desirability of a new investment. I am not arguing that Keynes' analysis is necessarily correct, but it does seem better than the representative-agent models at capturing the spirit of the liquidity effect: The financial market matters fundamentally and interest rates are causally efficacious. Two further points: Keynes highlights the importance of the term structure, because he distinguishes between short (or money) rates of interest and long-term rates of interest and, at the same time, he raises the question of what to count as money.

Figure 5



What to count as money raises the second major problem with all of the models in Ohanian and Stockman's survey: They rely on the cash-in-advance constraint. Money, therefore, is whatever asset is a direct constraint on current expenditure. The cash-in-advance constraint is, however, a lousy way to model money, mainly because it is not clear that any asset serves uniquely to limit current expenditure. For very few purchases is cash literally necessary in advance of purchase: Coins in vending machines are one of the few obvious examples. For any number of other purchases, cash may be preferred, for example, because of lower transactions costs or anonymity. Reflection on the trends in transactions technology, however, suggests that cash is becoming less and less essential; credit cards do for almost everything. And,

[8] McCallum (1983) makes a related point about money. In an acceptable monetary model, the existence of money should alter the set of possible real outcomes for the economy.

[9] See Keynes (1936, chapter 13).

although credit card accounts must be settled, ultimately through the transfer of central bank reserves between banks, the settlement is not *in advance* but *in arrears*. And this is not just the trend of the future; it is for large parts of the economy the established practice from ancient times. Businesses operate on trade credit. My grandparents, who ran a rural grocery in Georgia, extended credit to the inhabitants of Chattanooga Valley and were paid when their customers became more liquid. The amusing chapter in Thackery's *Vanity Fair* on "How to Live on Nothing a Year" is premised on the practice of 19th-century English merchants of extending credit payable on "quarter days." A good model of money is elusive, but the cash-in-advance constraint is a weak reed on which to build it.

So where does that leave us? Ohanian and Stockman's efforts mean that we know a good deal more about a particular research program, but I am afraid what they have convinced me is that the particular research program—representative-agent, cash-in-advance models—is a dead end and that we still are a long way from understanding the liquidity effect.

REFERENCES

Christiano, Lawrence J. "Modeling the Liquidity Effect of a Money Shock," Federal Reserve Bank of Minneapolis *Quarterly Review* (winter 1991), pp. 3-34.

Cottrell, Allin. "Keynes and the Keynesians on the Fisher Effect," working paper (October 1993), Wake Forest University.

Fisher, Irving. *The Theory of Interest.* Macmillan, 1930.

Hoover, Kevin D. *The New Classical Macroeconomics: A Sceptical Inquiry.* Blackwell, 1988.

Keynes, John Maynard. *The General Theory of Employment Interest and Money.* Macmillan, 1936.

McCallum, Bennett T. "The Role of Overlapping-Generations Models in Monetary Economics," in Karl Brunner and Allan H. Meltzer, eds., *The New Monetary Economics, Fiscal Issues and Unemployment.* Carnegie-Rochester Conference Series on Public Policy, vol. 23. North Holland, 1983, pp. 13-46.

Mundell, Robert A. *Monetary Theory: Inflation and Growth in the World Economy.* Goodyear, 1971.

Tobin, James. "Money and Economic Growth," *Econometrica* (October 1965), pp. 671-84.

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Resolving the Liquidity Effect

Adrian R. Pagan and John C. Robertson

"Resolving: To separate into constituent or elementary parts"
(The Macquarie Dictionary)

The effect on interest rates of a change in monetary policy has long been an important topic in monetary economics, and there is now a large body of literature that has studied the existence and magnitude of any such effect. Strong conclusions have emerged, and yet, little is available by way of work that attempts to account for the diversity of conclusions. This article aims to fill some of this gap. As the title suggests, it does this by separating out the basic elements of the arguments that lead to the recorded conclusions. In later sections, these are enumerated and discussed. The first section of the article sets out the framework underlying existing studies, followed by an examination of whether the proper object of investigation is a single relationship or a complete system. We come down in favor of the systems viewpoint. Even then, there are many other factors that can account for a diversity of outcomes, and section three is devoted to a consideration of these, ranging from issues of measurement to the sample of data selected for the empirical work. The fourth section explores the interrelationship of monetary policy and the term structure, while the final section presents some conclusions.

THE BASIC MODEL

Although there has been some dissent over the years, mainly from those believing that excess money balances have a powerful direct influence on expenditures, conventional wisdom on the transmission mechanism of monetary policy has been that the effects are felt via interest rates. A very stylized view of this mechanism is available from the money demand and supply relations, which are either explicit or implicit in most models:

$$(1) \qquad m_t^d = \alpha_1 + \alpha_2 r_t + \varepsilon_t^d$$

$$(2) \qquad m_t^s = \beta_1 + \beta_2 r_t + \varepsilon_t^s$$

$$m_t^d = m_t^s,$$

where d indicates demand, s supply, m_t is the log of nominal money, r_t is the nominal interest rate, while ε_t^d and ε_t^s are mutually uncorrelated demand and supply shocks. In the textbook treatment of this model, r_t, responds to shifts in the money supply, engineered by varying β_1, and the relation $dr_t/d\beta_1 = (\alpha_2 - \beta_2)^{-1}$ means that the interest rate decreases when money supply increases, provided $\alpha_2 < 0$ and $\beta_2 \leq -\alpha_2$. This negative reaction of the interest rate to a rise in money supply is termed the liquidity effect.

When there is a random variable attached to money supply, a change in β_1 can be thought of as a movement in the expected value of $\beta_1 + \varepsilon_t^s$, and the money supply shock might simply be re-labeled $\varepsilon_t^{s\prime}$, with the conceptual experiment performed by changing the expected value of $\varepsilon_t^{s\prime}$ from β_1 to a new value. Since, mathematically, there is no difference between the response to a change in ε_t^s or a change in the expected value of $\varepsilon_t^{s\prime}$, we will henceforth concentrate upon describing the effects of a change in ε_t^s. Such an orientation is now standard in the literature and will be adopted here, so that the liquidity effect will focus upon the simulated response of interest rates to a money supply shock, setting all other shocks to zero.

The above model is static and implies that all adjustments are instantaneous. To make it dynamic, one might augment each relation in equations 1 and 2 with lagged values in m_t and r_t to produce

$$(3)\quad m_t = \alpha_1 + \alpha_2 r_t + \overline{B}_{dm}(L)m_t + \overline{B}_{dr}(L)r_t + \varepsilon_t^d$$
$$m_t = \beta_1 + \beta_2 r_t + \overline{B}_{sm}(L)m_t + \overline{B}_{sr}(L)r_t + \varepsilon_t^s$$

with $\overline{B}_{ij}(L)$ being polynomials in the lag operator of the form $\overline{b}_{1ij}L + \overline{b}_{2ij}L^2 + ...$. There is now a distinction to be made between impact effects and the responses over time. In general, one can solve these equations to produce a moving-average representation for interest rates:

$$(4)\quad r_t = C_d(L)\varepsilon_t^d + C_s(L)\varepsilon_t^s$$

where $C_j(L) = (c_{0j} + c_{1j}L + ...)$, and the impact effect will be $c_{0s} = (\alpha_2 - \beta_2)^{-1}$ while the effects over time are measured from the impulse responses c_{ks}.

In the framework just described, strong restrictions have been placed upon both the demand and supply functions of money, as the demand for money would also be expected to depend, inter alia, on the level of income (or wealth) and the price level, while the supply of money depends upon the "reaction function" of the authorities. In the scenario described by equation 2, the reaction function depends solely upon the current level of the interest rate, whereas one might expect that current developments in the price level, exchange rates, output and so on would also play a role. Thus, ignoring dynamics for the moment, equations 1 and 2 might become

$$(5)\quad m_t = \alpha_1 + \alpha_2 r_t + \alpha_3 p_t + \alpha_4 y_t + \varepsilon_t^d$$
$$m_t = \beta_1 + \beta_2 r_t + \beta_3 p_t + \beta_4 y_t + \varepsilon_t^s,$$

where p_t and y_t are logs of the price level and output, respectively. If one inverts the money demand function to produce

$$(6)\quad r_t = \gamma_1 + \gamma_2 m_t + \gamma_3 p_t + \gamma_4 y_t + \varepsilon_t^r$$

the immediate liquidity effect will be

$$(7)\quad \partial r_t / \partial\varepsilon_t^s = \gamma_2 \partial m_t / \partial\varepsilon_t^s + \gamma_3 \partial p_t / \partial\varepsilon_t^s + \gamma_4 \partial y_t / \partial\varepsilon_t^s$$

and this depends upon more parameters than just α_2 and β_2 as r_t could change either directly, or indirectly through variations in p_t and y_t. To evaluate the full effect, therefore, requires us to consider the complete system formed from m_t, r_t, p_t, y_t (and whatever other variables are important to money demand and supply). It is now no longer sufficient to focus just upon the interest elasticity of the demand and supply of money.

In practice, the relations in equation 5 will also exhibit dynamics, possibly with lagged values of all the variables appearing on the right-hand side of each function. If we collect the variables that are regarded as being part of the system in an n x 1 vector z_t, we could write the supply and demand functions as

$$(8)\quad m_t = \alpha_1 + \alpha_2 r_t + \alpha_3 p_t + \alpha_4 y_t + \overline{B}_{sz}(L)z_t + \varepsilon_t^s$$

$$(9)\quad r_t = \gamma_1 + \gamma_2 m_t + \gamma_3 p_t + \gamma_4 y_t + \overline{B}_{dz}(L)z_t + \varepsilon_t^d$$

More generally, the whole system might be written as

$$(10)\quad B_0 z_{t-1} = B_1 z_{t-1} + \ldots B_p z_{t-p} + \varepsilon_t^z.$$

Pre-multiplying equation 10 by B_0^{-1} yields the "reduced-form" vector autoregression (VAR) representation for z_t,

$$(11)\quad z_t = B_0^{-1}B_1 z_{t-1} + \ldots + B_0^{-1}B_p z_{t-p} + B_0^{-1}\varepsilon_t^z$$
$$= A(L)z_{t-1} + e_t^z$$

and solving for r_t, gives us a moving-average representation of the interest rate of the form

$$(12)\quad r_t = D_z(L)e_t^z$$
$$= D_z(L)B_0^{-1}\varepsilon_t^z$$
$$= C_m(L)\varepsilon_t^m + C_{\bar{z}}(L)\varepsilon_t^{\bar{z}},$$

where $\overline{z}_t$ are the elements in z_t excluding m_t, and $\varepsilon_t^m = \varepsilon_t^s$ is the money supply shock.[1] Note that there are two decompositions presented here; one involving the "reduced form" shocks e_t^z from the VAR in equation 11, and one involving the "structural" shocks ε_t^z from equation 10.

Questions over the existence and magnitude of the liquidity effect are seen to hinge critically upon the measurement of the parameters in the "structural relations." In particular, to isolate the money supply shock, it is necessary that one be able to estimate both the contemporaneous effects, α_j, γ_j, and the

[1] From now on we will identify structural equation errors according to the variable taken to appear on the left-hand side of the equation. This has the advantage of freeing up the choice of whether it is the interest rate or money that should be the dependent variable in a demand or supply equation. Hence, ε_t^m is the error in the structural equation that has m_t on the left-hand side, and this might be either demand or supply, depending upon the context. For example, Gordon and Leeper (1994) choose to normalize the demand equation with money and the supply equation with the interest rate.

nature of the dynamic relationships. For example, if the terms $\bar{B}_{sr}(L)r_t$ were omitted from equation 3, the identified supply shock would actually be $\bar{B}_{sr}(L)r_t+\varepsilon_t^s$, and so the computed impulse responses would be incorrect. It is no wonder then that much of the controversy about the presence and nature of the liquidity effect really comes down to estimation issues.

ESTIMATION METHODS

Single-Equation Estimation Methods

In a single-equation method, an attempt is made to directly estimate the terms of $C_m(L)$ in equation 12. Early studies, summarized in Thornton (1988), absorbed $C_{\bar{z}}(L)\varepsilon_t^{\bar{z}}$ into the error term, and then proceeded to measure ε_t^m by regressing m_t against lagged values of m_t, y_t and p_t, and so on. However, such a regression does not produce an estimate of ε_t^m in general, but rather the reduced-form error e_t^m. The two will coincide only if there are no contemporaneous effects of any variables upon money. Hence, the methodology involves strong assumptions. A further problem is that the error term in the regression of r_t on $\hat{\varepsilon}_{t-j}^m (j \geq 0)$, cannot be uncorrelated with $\varepsilon_t^{\bar{z}}$ unless all the shocks are uncorrelated. This assumption seems most problematic if the system has been under-specified, either in terms of lag length or the number of variables taken to constitute it. Failure to account for these effects will lead to biases in the estimated coefficients. A different complication is the fact that residuals replace ε_t^m in the estimated relation. Because one is estimating the coefficients of lagged values of ε_t^m, the situation is that analyzed in Pagan (1984), where it is shown that the estimated standard errors are understated.

A related single-equation approach which focuses on estimating the impact response c_{0s} is that of Mishkin (1981, 1982). He inverted the money-demand equation as in equation 6 and took expectations with respect to some assumed information set η_{t-1} to produce

$$(13) \quad E(r_t|\eta_{t-1}) = \gamma_1 + \gamma_2 E(m_t|\eta_{t-1}) + \gamma_3 E(p_t|\eta_{t-1}) + \gamma_4 E(y_t|\eta_{t-1}).$$

Subtracting equation 13 from equation 6 then yields a relation among the reduced-form errors:

$$(14) \quad e_t^r = \gamma_2 e_t^m + \gamma_3 e_t^p + \gamma_4 e_t^y + \varepsilon_t^r.$$

Effectively, one is attempting to estimate the parameters of a money-demand function. However, one might query whether this is a satisfactory method for doing so. First, e_t^m only measures the money supply shock if there are no contemporaneous effects of p_t or r_t on money supply (a restriction explicitly recognized by Mishkin). Second, e_t^p, e_t^y and so on are correlated with ε_t^r in general, since, from equation 11, $e_t^z = B_0^{-1}\varepsilon_t^z$ will be a function of ε_t^r. Finally, it is necessary that precise estimates of ε_t^m be extracted, and this necessitates making the set of conditioning variables large enough to completely describe the money supply relation.

The two methods just described will be referred to as single-equation procedures and designated as SING1 and SING2, respectively.

Systems Methods

Simultaneous-equation estimation methods address the issue of how to estimate the parameters of a system such as those in equation 10. However, some assumptions have to be made about the nature of the system if consistent estimates are to be obtained, and a number of approaches have emerged in this regard. Each approach is in evidence in the literature on the liquidity effect and involves some constraint upon the covariance matrix of the errors ε_t^z and/or the parameters in the matrices B_0, B_1,... . Table 1 summarizes the four main approaches in this context.

In the Cowles Commission methodology, $cov(\varepsilon_t^z)$ was left unrestricted, but the $B_j (j \geq 0)$ was restricted.[2] For models of monetary phenomena, this often meant that enough lagged values of r_t, m_t and so on, were omitted from the system to identify the coefficients attached to the endogenous variables remaining in the demand and supply equations. Sims (1980) condemned such exclusion on restrictions as "incredible," a stance that has been taken up by the academic community to such an extent that one now rarely sees the Cowles Commission approach mentioned

[2] Of course, the Cowles Commission methodology recognized other possibilities, which effectively corresponded to the other approaches documented in Table 1, but these were rarely implemented. See, for example, Koopmans, Rubin and Leipnik (1950).

Table 1

Restrictions on Equation 10 Used in Different Systems Methods

	B_0	$Bj\,(j \geq 1)$	$cov(\varepsilon_t^z)$
Cowles Commission SEM	x	x	
VAR (SYS1)	x		x
VAR (SYS2)	x		x
VAR (SYS2+SYS3).	x	x	x

in macroeconometric work. Having decided that no elements in B_j $(j \geq 1)$ could be restricted, that is, all lagged values appear in every equation, Sims was forced to adopt two other assumptions to estimate B_0.

First, he proposed that the structural errors ε_t^z have a diagonal covariance matrix, that is, they were uncorrelated, so that a money-supply shock could be regarded as independent of a money-demand shock. Second, he chose to make B_0 lower triangular. Together, these assumptions produced a Wold causal ordering, and that terminology is one frequently used in the literature. Thus, the ordering $\{m, p, y, r\}$ means that m_t is determined; m_t depends only on lagged values of m_t, p_t, y_t and r_t. The next variable in the ordering depends on contemporaneous values of the previous variables in the ordering and lagged values of itself and the remaining variables; for example, p_t depends on m_t and lagged values of p_t, y_t and r_t. An alternative way of expressing the implications of these assumptions is that the simultaneous system in equation 10 has been transformed to one that is *recursive*, making OLS the appropriate estimator of the unknown parameters in B_0.[3] It is rather unclear why this set of assumptions is viewed as any more credible than those proposed by the Cowles Commission. Indeed, if Sims' assumptions are invalid, inconsistent estimates of the contemporaneous impact of the variables will result, just as they would be obtained if the exclusion restrictions adopted by the Cowles Commission were incorrect.

One important difference to the Cowles Commission framework is that the latter generally works with over-identified systems, that is, more restrictions were placed upon the B_j's than were needed to exactly identify the parameters. The assumption of a recursive model exactly identifies the parameters of the system and, hence, imposes no testable restrictions on the VAR. One might therefore categorize the differences as simply amounting to whether one wants to work with an exactly identified system or not.

The Wold ordering technique seems to be very popular in the literature on the liquidity effect, being used by Leeper and Gordon (1992), Eichenbaum (1992), Christiano and Eichenbaum (1992), Sims (1992) and Eichenbaum and Evans (1992), inter alios. This method will be denoted as SYS1 in what follows. For a given set of variables, authors utilizing the SYS1 approach often experiment with many different orderings, and seem to select between these observationally equivalent structures according to some prior belief about the signs and persistence of selected impulse responses computed from the system. For example, Eichenbaum criticizes the ordering adopted by Sims (1992), in which the interest rate is taken as pre-determined, on the grounds that a monetary expansion, brought about by a decrease in ε_t^r, produces persistent negative effects upon prices. Actually, this modus operandi is quite similar to the approach taken by researchers within the Cowles Commission tradition, in the sense that the validity of their estimates was often analyzed by the simulation properties of the models, that is, the dynamic responses of endogenous variables to selected exogenous variables.

Of course, there are intermediate positions. The order condition for identification requires that the number of unknown parameters in B_0 must not exceed $n(n+1)/2-n$, and these might be distributed throughout B_0 rather than being placed so as to make it triangular. This method is often referred to as a structural VAR (SVAR) approach, in the sense that while no restrictions are imposed upon the dynamics via B_j $(j \geq 1)$, non-triangular restrictions are imposed on B_0. We will designate this as the SYS2 method. In the liquidity literature, the main representative of an SYS2 structure is Gordon and Leeper (1994), who work with a system of seven variables $[m, r, u, y, p, r_{10}, cp]$, where u is the unemployment rate, r_{10} is the 10-year bond

[3] Sims actually found $cov(\varepsilon_t^z)$ and B_0 such that $\hat{B}_0^{-1}\,\hat{cov}(\varepsilon_t^z)(\hat{B}_0')^{-1} = \hat{cov}(e_t^z)$, where the right- hand side is the estimated covariance matrix of reduced-form (VAR) errors. Numerically, this decomposition can be effected by applying a Choleski decomposition to the right-hand side. We feel that this description of the estimator obscures the fact that a simultaneous equation system has been assumed recursive, a point emphasized by Cooley and LeRoy (1985) in their critique of Sims' work.

rate, and cp is the log of the commodity price index. The system is taken to be recursive except for money demand and supply which have the form

$$(15)\quad \begin{aligned} m_t &= \alpha_1 + \alpha_2 r_t + \alpha_3 p_t \\ &\quad + \alpha_4 y_t + B_{mz}(L) z_t + \varepsilon_t^m \\ r_t &= \gamma_1 + \gamma_2 m_t + \gamma_3 r_{10t} \\ &\quad + \gamma_4 cp_t + B_{rz}(L) z_t + \varepsilon_t^r, \end{aligned}$$

respectively.

An alternative way for reducing the number of unknown parameters in a SVAR is to impose restrictions between the elements of B_0 and B_j $(j \geqslant 1)$, a strategy we will refer to as SYS3. These constraints arise from the belief that certain multipliers in the system have known long-run values. Shapiro and Watson (1988) provide a general treatment of re-parameterizations for studying models that have the SYS3 nature, and they show that such strategies free up some of the elements in $z_{t-j}(j \geqslant 1)$ to be used as instruments. To illustrate this, consider the simple bivariate system

$$(16)\quad z_{1t} = b_{12} z_{2t} + \bar{b}_{11} z_{1t-1} + \bar{b}_{12} z_{2t-1} + \varepsilon_{1t}$$

$$(17)\quad z_{2t} = b_{21} z_{1t} + \bar{b}_{21} z_{1t-1} + \bar{b}_{22} z_{2t-1} + \varepsilon_{2t}$$

If this was a traditional system, b_{12} and b_{21} are not identifiable. However, if one imposes the restriction that $E(\varepsilon_{1t}\varepsilon_{2t}) = 0$, one of them is estimable. Now, let us consider the long-run response of z_{1t} to ε_{2t}, which is $(b_{12}+\bar{b}_{12})/\{(1-\bar{b}_{11})(1-\bar{b}_{22})-(b_{12}+\bar{b}_{12})(b_{21}+\bar{b}_{21})\}$. If this response is set to zero, then $b_{12} = -\bar{b}_{12}$ and equation 16 becomes

$$(18)\quad z_{1t} = b_{12}(z_{2t} - z_{2t-1}) + \bar{b}_{11} z_{1t-1} + \varepsilon_{1t},$$

and so b_{12} can be estimated consistently by using z_{2t-1} as an instrument for Δz_{2t}. Hence, this procedure in SVAR work is identical to the long-recognized possibility of estimating B_0 by imposing restrictions (other than exclusion ones) upon the parameters of a simultaneous equations system.

The argument generalizes to a system of the form

$$(19)\quad B_0 z_t = B_1 z_{t-1} + \ldots + B_p z_{t-p} + \varepsilon_t$$

in the following way. Let the long-run multipliers of a change in z_t to ε_t be $(B_0 - B_1 - \ldots - B_p)^{-1} = adj(B_0 - B_1 - \ldots - B_p)/det(B_0 - B_1 - \ldots - Bp)$. Suppose that one of the long-run multipliers is zero, say the (i, j)'th. Then $[adj(B_0 - B_1 - \ldots - Bp)]_{ij} = 0$ and this imposes some restrictions between the parameters in B_0 and those in $B_1, \ldots, B_p$. To illustrate the impact of this, consider estimating the first equations

$$(20)\quad z_{1t} = \sum_{k=2}^{n} b_{1k} z_{kt} + \sum_{l=1}^{p} \sum_{k=1}^{n} \bar{b}_{1k}^{1} z_{kt-1} + \varepsilon_{1t},$$

simplified by setting $n = 2$, $p = 2$ to get

$$(21)\quad \begin{aligned} z_{1t} &= b_{12} z_{2t} + \bar{b}_{11}^{1} z_{1t-1} + \bar{b}_{11}^{2} z_{1t-2} \\ &\quad + \bar{b}_{12}^{1} z_{2t-1} + \bar{b}_{12}^{2} z_{2t-2} + \varepsilon_{1t}. \end{aligned}$$

Now, the long-run multiplier being zero will generate a restriction that $\varphi(b_{12}, \bar{b}_{11}{}^1, \bar{b}_{11}{}^2, \bar{b}_{12}{}^1, \bar{b}_{12}{}^2) = 0$, and we should be able to write $\bar{b}_{11}{}^1 = \phi(b_{12}, \bar{b}_{11}{}^2, \bar{b}_{12}{}^1, \bar{b}_{12}{}^2)$ so that the equation reduces to[4]

$$(22)\quad \begin{aligned} z_{1t} &= b_{12} z_{2t} + \phi z_{1t-1} + \bar{b}_{11}^{2} z_{1t-2} \\ &\quad + \bar{b}_{12}^{1} z_{2t-1} + \bar{b}_{12}^{2} z_{2t-2} + \varepsilon_{1t}. \end{aligned}$$

This restriction frees up an instrument for z_{2t} among z_{1t-1}, z_{1t-2}, z_{2t-1} and z_{2t-2} since ϕ is known once the other parameters are given. Consequently, provided the long-run restriction actually involves the parameters of interest (which may not happen as it is $[adj(B_0 - B_1 - \ldots - B_p)]_{ij}$ which equals zero), one can estimate b_{12} using as instruments $z_{1t-1}, \ldots, z_{2t-2}$. In the liquidity literature, the SYS3 approach has been applied by Lastrapes and Selgin (1994), while Gali (1992) uses ideas from both the SYS2 and SYS3 approaches.

As is evident from the proceeding discussion, there have been many proposals about how to estimate the parameters of the simultaneous system. In all instances, certain moment conditions are used, and so the estimators can be given instrumental variable (IV) interpretations, in which pre-determined variables in the system are used as instruments. In the Cowles approach, it is necessary that the pre-determined variables excluded from an equation be uncorrelated with the equation's error term while, in the recursive systems approach, the structural equation errors need to be uncorrelated with one another as well as any right-hand side endogenous variables.

[4] Parameters from the equation for z_{2t} will also appear in the restriction.

When the number of unknown parameters equals the number of moment conditions, as in a recursive VAR, it is impossible to test the validity of such restrictions, and it becomes simply an act of faith that they are valid. If the assumption is wrong, then it would be expected that there will be biases in the estimates of the parameters. For example, observe that a liquidity effect may require that the demand-interest elasticity be negative. In the event that a liquidity effect is not found, one might ask: What is problematic about the implicit demand function being estimated? Given that we are concerned with a simultaneous-equation system, the most likely explanation would be bias due to the simultaneity. For example, if the system is ordered recursively as $\{m, p, y, r\}$, but m_t is not predetermined for r_t, then the OLS estimator of the contemporaneous liquidity effect will be biased away from a true negative value and might even produce a positive value. Hence, it is hard to know whether any lack of evidence for a liquidity effect is due to the actual state of the world or estimation/identification difficulties.[5] Accordingly, it seems that there is always going to be an element of indeterminacy in a study of the existence of the liquidity effect.

Another estimation issue concerns the usefulness of the available instruments. In particular, it is important that the instruments are correlated with their respective endogenous variables. When instruments X_1 are in a structural equation already, it is the correlation of the complete set of instruments X with the endogenous variable, after partialling out X_1, that is important. It may be that the raw correlation is high while the partial correlation is very low. Studies by Staiger and Stock (1993), Pagan and Jung (1993), Kocherlakota (1990) and Nelson and Startz (1990) have all concluded that there can be large biases in the estimators of the parameters attached to the endogenous variables if the partial instrument correlation is weak, for example, <0.2. Thus, it is important that this quantity be examined. In the simple SYS3 example constructed above, the correlation between the instrument and regressor is determined by the magnitude of the autocorrelation in z_{2t}. As the autoregressive root tends to unity, one would get worse estimates of b_{12}. This problem has been studied by Sarte (1994) and, in the context of the liquidity effect, Pagan and Robertson (1995).

EXAMINING THE STUDIES

Table 2 presents a summary of some of the evidence on the liquidity effect for studies using monthly or quarterly data. Perhaps the most striking characteristic is the fact that early failure to detect a liquidity effect (largely based on single-equation methods) has been replaced by a conclusion that there generally is a liquidity effect when inferences are based on systems methods. Although this is a comforting outcome, the transition needs to be analyzed carefully, to ensure that the observed relation is in fact robust to any assumptions made in order to identify it. Four concerns can be distinguished, involving how sensitive the conclusion is to:

1. different definitions of the monetary stance;
2. different models;
3. different estimation procedures and restrictions; and
4. different data samples.

In what follows, we examine these issues using monthly data. Descriptions of the data are contained in the appendix. The money, price and output series are measured in logs and are seasonally adjusted. Three sample periods have been chosen. The longest, from 1959:1-1993:12, was fitted with a 14th-order VAR, while the shortest runs from 1982:12-1993:12 and has a sixth-order VAR. An intermediate period of 1974:1-1993:12 with an eighth-order VAR was selected to roughly coincide with the period of flexible exchange rates. These choices also reflect those adopted in the literature. Equation-by-equation and system diagnostic tests (not reported) indicated the absence of residual autocorrelation, but found autoregressive conditional heteroskedasticity (ARCH) and some non-normality, particularly in the money and interest rate equation residuals estimated over longer sample periods. The ARCH effect was less evident in models using post-1982 data.

[5] Some have attempted to control for simultaneity by choosing data periods and intervals in which m_t can be reasonably regarded as predetermined, for example, by using weekly data in the lagged reserve accounting regime—see for example, Cochrane (1989).

Table 2

Summary of Selected Studies on the Liquidity Effect

Author	Sample	Freq	Money Variables	Interest Rate	Main Other Variables	Model Type	Max Lags	Finding
Mishkin (1982)	1959:1-1976:4	Q	ΔM2, ΔM1	R6–R3	ΔP, ΔY	SING1	4	no
Reichenstein (1987)	1965:01-1983:03	M	ΔM1	ΔR3	ΔP, ΔY, U	SING1	4	no
Thornton (1988)	1958:08-1987:06	M	ΔM1, ΔM0, ΔNBR	ΔR3	ΔP, ΔY	SING1	6	no/yes
Leeper & Gordon (1992)	1954:07-1990:12	M	ΔM2, ΔM1, ΔM0	FF	P, Y	SING1/2, SYS1	36/18	no
Sims (1992)	1958:04-1991:02	M	M1	FF	P, Y, ER, CP	SYS1	14	yes
Eichenbaum (1992)	1965:01-1990:01	M	M1, M0, NBR	FF	P, Y	SYS1	14	no/yes
Christiano & Eichenbaum (1992)	1959:01-1990:03	M/Q	M1, M0, NBR	FF	P, Y	SYS1	14/5	no/yes
Eichenbaum & Evans (1992)	1974:01-1990:05	M	NBRX	FF	Y, P, RF, RER	SYS1	6	yes
Christiano, Eichenbaum & Evans (1994)	1960:1-1992:3	Q	NBR	FF	P, Y, CP, TR	SYS1	4	yes
Gali (1992)	1955:1-1987:3	Q	ΔM1	R3	ΔP, Y	SYS2/SYS3	4	yes
Lastrapes & Selgin (1994)	1959:01-1993:12	M	M0, M1, M2	R3	Y, M – P	SYS3	14	yes
Gordon & Leeper (1994)	1982:12-1992:04	M	M2, TR	R1, FF	R10, P, Y, U, CP	SYS2	6	yes

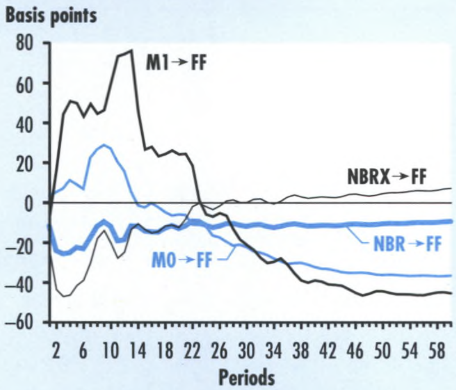
Different Money Variables

A crucial question is whether changing the definition of money has been important. Here, it would seem as if the answer is yes. The consensus from Table 2 is that for single-equation and recursive models, defining money as M0 or M1 does not result in a liquidity effect, while finer measures such as nonborrowed reserves, NBR, or the ratio of nonborrowed to total reserves, NBRX, do. Nevertheless, one should dig a little deeper into the issue of measuring monetary action. Remember from equations 1 and 2 that we are concerned with the response of interest rates to a shift in the intercept of the money supply equation, and this was measured by computing the impulse response of interest rates to the money supply structural errors. Hence, if one could identify a series corresponding to shifts in the intercept over time, that would constitute the basis for an appropriate way to measure the monetary stance. Such series have been constructed by Romer and Romer (1989) and Boschen and Mills (1993). Eichenbaum and Evans (1992) have shown that there is a strong liquidity effect when the first of these measures is used.

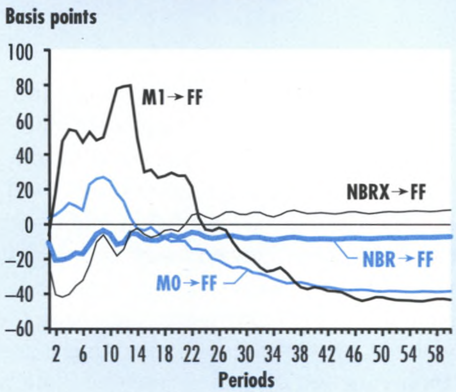
For recursive models, a money-supply or M-rule interpretation implies that shocks to the money-supply equation are identified with monetary policy. For example, one might assume an ordering such that money is predetermined for the interest rate (and possibly other variables as well) and use the error from the money equation and the estimated dynamics to derive the impulse responses of the interest rate. Ignoring the dynamics, this amounts to assuming that the supply function of money is perfectly inelastic with respect to the interest rate. A different strategy, employed by Sims (1992), and Bernanke and Blinder (1992), is to order the VAR such that the interest rate is predetermined for money and to treat shocks to the interest rate equation as the monetary policy indicator. This yields an interest rate or R-rule interpretation, since, ignoring the dynamics, this is equivalent to assuming that the supply function is perfectly elastic with respect to interest rates. Empirically, defining money as M0 or M1 does not result in a liquidity effect in a recursive VAR under M-rule interpretations, while using NBR or NBRX does yield a liquidity effect for either M-rule or R-rule identification schemes. For example, Figure 1 presents the implied interest rate responses to a one-unit monetary expansion under an M-rule (an increase in ε_t^m) for various measures of money, and two alternative

Figure 1a, b

M→FF, {M,Y,P,FF} Model, 1959:01-1993:12



M→FF, {Y,P,M,FF} Model, 1959:01-1993:12



orderings of a four-variable VAR of m, *r*, *y* and *p*, where *r* is measured by the federal funds rate, *FF*, *p* is measured by the log of the consumer price index, *P*, and *y* is measured by the log of the industrial production index, *Y*. The VAR is fit to the sample 1959:01-1993:12, and the recursive models parallel some of those reported in Christiano and Eichenbaum (1992).

It is not sufficient, however, to simply concentrate upon the impulse response functions relating to interest rates and money, as it is possible that a model producing a plausible liquidity effect also creates implausible effects of monetary policy upon other variables in the system. This was Eichenbaum's (1992) objection to Sims' work. Sims pointed out that there was a "price puzzle" generated from a simple four-variable model based on M1, since an expansionary monetary action (in his case, an R-rule contraction in ε_t^r) led to a persistent fall in the price level). Eichenbaum's proposed solution to this was to replace M1 or M0 with NBR, and to place *P* and *Y* prior to money and interest rates in the ordering, so that the Federal Reserve's M-rule responds contemporaneously to price and output variables, but not interest rates. Eichenbaum reports a small positive response to expansionary monetary policy in this case. Earlier, Thornton (1988), in a single-equation analysis, observed that NBR was the only measure of money which displayed evidence of a liquidity effect. Thornton's conclusion has been reiterated by Christiano and Eichenbaum (1992) in a systems context (see Figure 1). Subsequently, Strongin (1992) has suggested that the ratio of NBR to total reserves, TR, denoted NBRX, is the best monetary measure, and Eichenbaum and Evans (1992) have adopted NBRX in their work on exchange rates.[6]

Figure 2 presents the impulse responses of *P*, *Y* and *FF* to monetary shocks in VARs ordered as {*Y*, *P*, *NBR*, *FF*, *TR*}, {*Y*, *P*, *NBRX*, *FF*} and {*Y*, *P*, *NBR*, *FF*}, respectively. In contrast to the finding in Eichenbaum (1992), it is apparent that the price puzzle is still present regardless of which monetary measure is adopted, although in all cases the estimated responses are relatively small.[7] The difference between these and the Eichenbaum results can be explained by noting that Eichenbaum used a slightly different sample period (1965:01-1990:01). Computing impulse responses from a VAR fit to this sub-sample does produce impulse responses very similar to those he reports. Hence, it seems as if the estimated price-impulse responses are unstable, at least if NBR or NBRX are used to measure monetary actions. We examine the issues of model stability and the precision of the point estimates in more detail further in this article.

Perhaps the most controversial issue with the use of nonborrowed reserves is whether it constitutes an effective way of measuring monetary policy. The variable NBRX is very highly negatively correlated with borrowed reserves BR (-0.82 over the period 1959:01-1993:12), raising the question about how the latter should be treated. Suppose that total

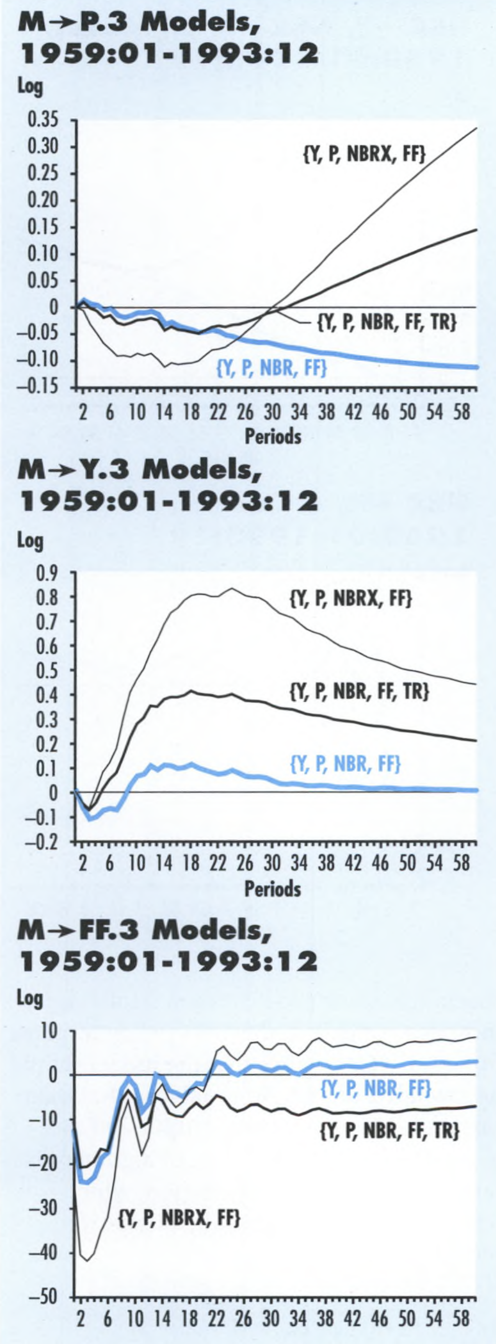
[6] Strongin (1992) actually used the ratio of NBR to TR_{-1}.

[7] These results are also quite robust to reversing the ordering of *Y* and *P* at the top of the recursion.

reserves, $TR = NBR + BR$, showed no variation. Then, if BR has a positive relation to FF, NBR must be negatively related to FF. A model of this sort was constructed by Gilles and others (1993). They effectively fix the total demand for reserves by making it depend upon real factors exogenous to the monetary sector, and then add a "discount window" function in which the supply of borrowed reserves is a positive function of FF. Hence, they concluded that the observed negative relation between NBR and FF simply reflects the way that the Federal Reserve has operated the discount window. The import of this model is not entirely clear because it makes the supply of BR a function of FF, whereas the data indicates that the relation is between BR and the spread between the Federal funds and the discount rate, RD—that is, $SPRD = FF - RD$ (see Mishkin, 1992), and therefore, BR is not a function of FF alone. Indeed, statistically, it would not make sense to relate BR solely to FF, as the latter is best described as an integrated process while the former is not. This is evidenced by augmented Dickey-Fuller (with 12 lags) tests of −1.88 (FF) and −3.47(BR), as compared to a 5 percent critical value of −2.86.

What is in dispute here is the degree of substitutability of NBR and BR. With zero substitutability, NBR would appear to summarize monetary policy quite well. But if there was perfect substitutability, total reserves would be a better measure, and, with the exception of the study by Gordon and Leeper (1994), this does not seem to result in a liquidity effect, all responses being quite similar to those from M0 or M1. An attempt to allow for non-zero substitutability might be to incorporate demand and supply functions for both NBR and BR into the analysis. A variant of this idea would be to include both NBR and total reserves (TR) in the VAR, and this has been done by Christiano and others (1994). Doing so produces more reasonable price and income responses than the {*Y*, *P*, *NBR*, *FF*} model, and broadly similar responses to those from the {*Y*, *P*, *NBRX*, *FF*} model (Figures 2a and 2b), although the price effect is still negative for a long period of time. There is also some increase in the magnitude of the liquidity effect, and it is less persistent than for the model {*Y*, *P*, *NBR*, *FF*} (Figure 2c).[8]

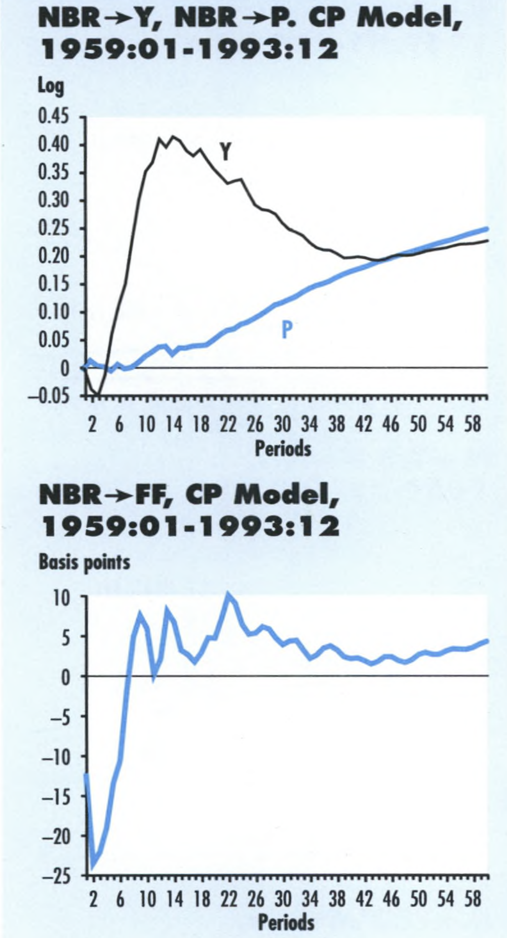
Figure 2a-c



The result that neither of the NBRX or NBR/TR formulations are capable of completely eliminating the price puzzle is consistent with the view of Sims (1992) that the main source of the price puzzle is the

[8] To avoid the potential problems associated with using NBRX in the recursive VAR formulations examined in later sections, we will henceforth adopt the strategy of including both NBR and TR in the recursive models.

Figure 3a, b



absence of some pre-determined inflation indicator variable in the Fed's policy response function. This implies that the model should be extended to include variables other than just money, interest rates, output and the general price level. This line of argument is taken up in the next sub-section, which deals with the issue of using alternative model formulations.

Model Variation

One explanation for the range of conclusions regarding the liquidity effect arises from the non-uniqueness of models. We have already alluded to this when discussing recursive versus non-recursive systems, and even within a given causal framework models can vary, as reflected in the ordering or set of variables taken as constituting the system. Too small a set of variables implies misspecified relations, which can affect estimates of both contemporaneous and dynamic responses. Because there is a cost to making the list of variables too large, it is imperative that theoretical ideas and past research are used to indicate what variables are likely to be of major importance. For example, Sims (1992) and Christiano and others (1994) extend the NBR/TR formulation to include a measure of commodity prices. In particular, they consider the M-rule ordering {*Y*, *P*, *CP*, *NBR*, *FF*, *TR*}, where CP is a commodity price index. Thus, output, the general price level and commodity prices are taken as predetermined in setting policy. Estimating their model using the monthly data, we find that the *Y* response is initially negative, but then persistently positive after a few months, while the *P* responses are now persistently positive (Figure 3a) and the liquidity effect lasts approximately seven months (Figure 3b). It seems that including additional variables in the policy setting rule goes some way to eliminating the anomalous price effects that were obtained using simpler models.

Another possible model variation is to allow for interaction with the foreign sector. Open economy models, for example, McKibbin and Sachs (1991), emphasize the determinants of the size of the liquidity effect in the following quotation:

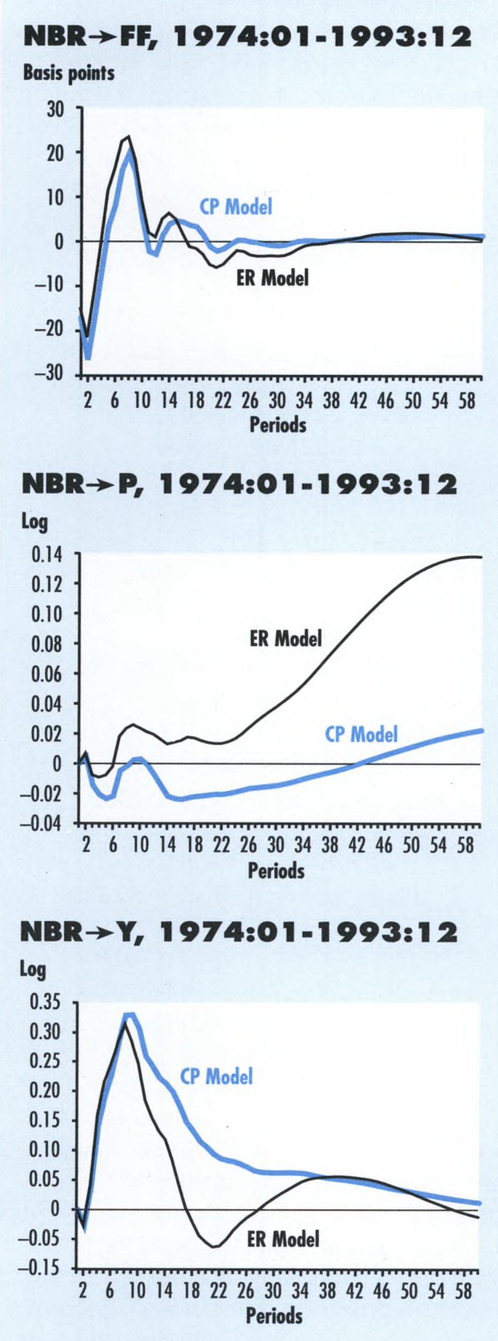
> "If the effect of the exchange rate on domestic demand is large (through the effect on the trade balance), and if the effect of domestic demand on money demand is large (through the income elasticity of demand), and if the home currency depreciation causes a rapid rise in domestic prices, then it can be shown that home nominal interest rates will tend to rise after the money expansion ... But if one or all of these three channels are weak, then domestic nominal interest rates will tend to fall after the money expansion... ."

Using the MSG model, their simulations show a strong liquidity effect for the United States but a weak one for Japan, even though the interest elasticity of demand in both countries is assumed to be the same.

It is clear from such studies that there is a need to allow for an exchange rate e_r offset. Introducing an exchange rate also demands the addition of a foreign interest rate r_f, to allow for the possibility of uncovered interest parity, that is, $e = r - r_f$. Within a recursive system, r_f would need to appear as the first variable and e will appear after r. Eichenbaum and Evans (1992) and Sims (1992) contain results which suggest that the conclusions reached with systems excluding e_r and r_f remain valid, although the magnitude of any effects differ. Using the trade-weighted exchange rate, *ER*, a weighted foreign interest rate series, *RF*, and an ordering {*RF, Y, P, CP, NBR, FF, ER, TR*}, later referred to as the exchange rate model (ER), we find that the liquidity effect is reduced slightly from that observed for the "commodity price" (CP) formulation {*Y, P, CP, NBR, FF, TR*} (Figure 4a). There are greater qualitative differences for the price responses. Figure 4b shows these for the CP and ER models. Unlike the situation for the full sample, there is a perverse price response with the CP model that is largely corrected by the ER model, pointing to the fact that the long-run responses can be very different as models change, even though the short-run responses are similar. In contrast, the estimated short- and long-run responses of *Y* are similar in both the CP and ER models, as shown in Figure 4c.

The question of how to choose between alternative models is a vexed one. As mentioned previously, most analyses seem to concentrate upon how closely multipliers correspond to prior conceptions. This seems to be a restrictive viewpoint. Structural relations have been estimated in getting the multipliers and it seems appropriate that one should examine how plausible the estimates of these parameters are. In particular, the nature of the liquidity effect directs us to the demand for money function, and we would expect that it should feature negative interest, positive income and (probably) positively signed price elasticities. A full set of structural coefficient estimates for the CP and ER models is presented below. The CP model results for the periods 1959:01-1993:12 and

Figure 4a-c



1974:1-1993:12 are presented in equations 23 and 24, respectively, and the ER model results for the sub-period (1982:12-1993:12) are in equation 25. Note that because money is ordered immediately prior to the interest rate in the CP and ER model, the initial impulse response of the interest rate to money shocks is simply given by the magnitude of the interest elasticity of demand for money. This follows directly from equation 7 as the stated recursive structure has $\partial p_t / \partial \varepsilon_t^s = \partial y_t / \partial \varepsilon_t^s = 0$. More generally, however, it is clear that it would be possible for the liquidity effect to "exist" and yet for all of the parameter estimates in the demand function to be incorrectly signed.

$$
\begin{aligned}
(23)\quad P &= .0186Y \\
CP &= .43P + .25Y \\
NBR &= -.007CP - .39P - .25Y \\
FF &= 8.08Y - 5.42P - 2.62CP \\
&\quad - 12.41NBR \\
TR &= -.02Y + .36Ç + .012CP \\
&\quad + .423NBR + .006FF
\end{aligned}
$$

$$
\begin{aligned}
(24)\quad P &= .038Y \\
CP &= -.42P + .40Y \\
NBR &= .04CP - .29P - .41Y \\
FF &= 11.73Y + 19.20P - 1.73CP \\
&\quad - 17.07NBR \\
TR &= .005Y + .6P - .009CP \\
&\quad + .41NBR + .006FF
\end{aligned}
$$

$$
\begin{aligned}
(25)\quad P &= .002RF + .055Y \\
CP &= -.012RF + .212Y - .130P \\
NBR &= -.008RF - .492Y \\
&\quad + .171P + .049CP \\
FF &= .401RF + 11.732Y + 7.332P \\
&\quad - 2.052CP - 14.952NBR \\
TR &= .005RF + .037Y + .4192P \\
&\quad - .006CP + .410NBR \\
&\quad + .005FF + .012ER
\end{aligned}
$$

With the possible exception of the *P* variable in the demand for money function (*FF*) of the CP model estimated over the period 1959:01-1993:12, the estimated structural relations are what would be expected, with prices responding in a procyclical way, monetary policy (in terms of *real* NBR movements) reacting negatively to expansions in prices and output, and a demand for money function that has positive income and negative interest rate effects. Interpretation of the equation for TR is harder, but it is interesting in that it shows that changes in NBR are only partially reflected in TR, which can be interpreted as indicating that there is substitutability between NBR and BR.

Perhaps the main use of the idea that one should think of the issue in structural terms is that it forces one to think carefully about the complete specification of the system, and such considerations suggest that there may be problems in modeling the data with particular choices of the set of variables. For example, suppose M2 is used as the measure of money. Then, for such a broad measure of money, one really needs to have another interest rate in the system to capture the fact that a large component of the assets making up M2 are interest-bearing. If the dependent variable in the (inverted) demand for money function is taken to be the three-month T-bill rate, *R3*, then we might take the federal funds rate as proxying the rate of return on M2 assets. For a VAR ordered as {*P*, *Y*, *M2*, *FF*, *R3*} we find that the estimated implied demand for money function appears relatively stable based on a CUSUM test, and a liquidity effect is observed. But the demand relation is quite unstable if FF and/or its lags are omitted from the VAR. Hence, a VAR only in the variables {*P*, *Y*, *M2*, *R3*} would appear to be a poor choice. More generally, given the large body of literature that has evolved pointing to the instability of U.S. money demand functions, the fact that estimated parameters of a demand for money function are fundamental to any conclusion regarding the liquidity effect has to be cause for concern. Even if the menu of variables seems complete, it still may be that the relationship between them is unstable, or the use of linear models inappropriate, for some measures of money and interest rates, and for some sample periods.

Different Estimation Methods and Restrictions

How much do systems methods contribute to the analysis of the liquidity effect? Potentially, a good deal. As previously mentioned in the discussion on single-equation estimation procedures, the estimates made of the monetary stance are ideally the structural rather than reduced-form errors, and so a regression of r_t upon a distributed lag of these values could produce quite different results. Only if the monetary policy variable

Table 3

Impulse Responses of *FF* to *NBR*

	{NBR, P, Y, FF}	{P, Y, NBR, FF}
c_{0s}	−15.39	−14.56
c_{1s}	−25.70	−23.03
c_{2s}	−25.79	−20.32
c_{3s}	−24.58	−18.48
c_{4s}	−23.56	−18.28
c_{5s}	−25.62	−19.92

is determined solely by past quantities will the two coincide. In terms of the recursive VAR, a single-equation approach corresponds to a case in which the monetary variable is ordered first, whereas the systems approach generally has money appearing later in the ordering. However, it turns out that the conclusions reached concerning the liquidity effect do not differ greatly because of this modification, as evidenced by the close correspondence of the distributed lag coefficients from the regression of FF against 36 lags of $\hat{\varepsilon}_t^m$ in Table 3, in which ε_t^m is alternatively measured as the structural errors from the two orderings {*NBR*, *P*, *Y*, *FF*} and {*P*, *Y*, *NBR*, *FF*}. Apparently, the conclusions reached by Thornton (1988) in his single-equation study are not changed by purging the monetary variable of any contemporaneous effects.[9]

In the discussion in the first section, it was suggested that the estimation issues relate to how to consistently estimate, inter alia, the parameters of both the demand and supply of money functions. Working with recursive systems, we assume the interest rate is not to enter into one of these curves, thereby sidestepping the simultaneity issue. If one wishes to estimate equations 8 and 9 with no zero restrictions on either α_2 or γ_2, it is necessary to proceed in some other way. Gordon and Leeper (1994) and Gali (1992) provide examples of how this might be done. For example, Gordon and Leeper estimate the money-supply disturbance from a structural model of seven variables, $z = [m, r, u, y, p, r_{10}, cp]'$, in which the money demand and supply block has the form

$$(26)\qquad \begin{aligned} m_t &= \alpha_1 + \alpha_2 r_t + \alpha_3 p_t \\ &\quad + \alpha_4 y_t + B_{mz}(L) z_t + \varepsilon_t^m \\ r_t &= \gamma_1 + \gamma_2 m_t + \gamma_3 r_{10t} \\ &\quad + \gamma_4 cp_t + B_{rz}(L) z_t + \varepsilon_t^r, \end{aligned}$$

respectively, with $E(\varepsilon_t^m \varepsilon_t^r) = 0$. The rest of the system is taken to be recursive, ordered as $\{u, y, p, r_{10}, cp\}$. Because these variables are predetermined for m_t and r_t, $X_t = \{1, u_t, y_t, p_t, r_{10t}, cp_t, z_{t-j}, j > 0\}$ provide a valid set of instrumental variables for r_t in the money-demand equation, and for m_t, in the money-supply equation. They estimate equation 26 subject to $E(\varepsilon_t^m \varepsilon_t^r) = 0$ via FIML, using a six-lag VAR, and monthly data from 1982:12 to 1992:04. Pagan and Robertson (1995) extend the sample period to 1993:12, giving $T = 127$ observations, and focus on the results for $m = TR$ and $r = FF$.

The existence of the liquidity effect hinges upon the signs and magnitudes of both the demand and the supply elasticity, and there are a number of issues in this regard. First, the precision of estimation of the demand elasticity stems in part from the use of the residual of the supply equation as an additional instrument, and the structural residuals are only valid instruments if $E(\varepsilon_t^m \varepsilon_t^r) = 0$. In this instance, the assumption may be checked as the system is overidentified—that is, there are more instruments among X_t than are needed to estimate the parameters. Using the parameter estimates from doing IV with X_t only, that is, excluding the supply-equation residuals, reveals that the correlation between the demand- and supply-equation residuals is −0.39, which is significantly different from zero (if money is measured by M2, the correlation becomes −0.79). Also, the excess instruments in X_t contribute little to the prediction of TR in the supply equation. The F-test of the hypothesis that they do not enter the first-stage TR regression yields a value of only 1.49, compared to a 10 percent critical value of 2.18. The presence of weak instruments means that the elasticity estimates may be severely biased. Finally, as Gordon and Leeper acknowledge, R10 is probably not a valid instrument for FF in the demand equation.

[9] Thornton actually uses differences rather than levels of the variables in his regression and adds in a lagged dependent variable. The latter is not a good idea. Equation 12 suggests that one should be able to omit variables other than the money shocks without producing biases, although any omitted variables will cause serial correlation that would be important for standard error computations. If one had a model in which the true relation is of the form $r_t = \gamma m_t + \varepsilon_t^r$ and $m_t = \rho m_{t-1} + \varepsilon_t^m$, then $r_t = \rho r_{t-1} + \varepsilon_t^m + \varepsilon_t^r - \rho\varepsilon_{t-1}^r$, and a regression of r_t on r_{t-1} and lagged values ε_t^m may well indicate that only the first response is non-zero. One actually sees this effect if lagged r_{t-1} is added to the regressions for Table 3.

Table 4

Estimates of Gordon and Leeper Demand and Supply Model

	FIML (1982:12-1992:04)		FIML (1982:12-1993:12)		IV (1982:12-1993:12)	
	Demand (*TR*)	Supply (*FF*)	Demand (*TR*)	Supply (*FF*)	Demand (*TR*)	Supply (*FF*)
FF	−.028 (.014)		−.026 (.013)		−.0099 (.010)	
TR		30.28 (10.95)		22.578 (9.987)		23.529 (13.629)
P	.958 (.752)		1.007 (.603)		.796 (.486)	
Y	.495 (.315)		.650 (.311)		.353 (.237)	
R10		.456 (.101)		.341 (.099)		.342 (.010)
CP		1.893 (1.326)		1.879 (1.410)		1.890 (1.418)
var($\hat{\varepsilon}_t$)	6.73e-5	5.04e-2	6.61e-5	4.98e-2	4.62e-5	5.31e-2
corr($\hat{\varepsilon}^s_t \hat{\varepsilon}^d_t$)	0		0		−.385	
over-id test p-value	.04		.09		.41	.06

Gordon and Leeper estimate the model using a six-lag VAR and data from 1982:12 to 1992:04 (T = 107). We use data from 1982:12 to 1993:12 (T = 127). Asymptotic standard errors are reported in parentheses below the point estimates. Note that the reported estimates are for the contemporaneous coefficients of the supply and demand functions. The dynamics are left unrestricted, and are partialled out by fitting the VAR.

Comparing the IV and FIML results reported in Table 4, we see there is a close correspondence between the IV and FIML estimates of the supply equation. In contrast, the IV demand elasticity estimate is much larger than the corresponding FIML estimate (−0.01 vs. −0.026) and is no longer significantly negative.[10] A negative correlation between the structural errors would be expected to produce a negative bias in the FIML estimator of the demand elasticity, and this leads to a smaller magnitude for the liquidity effect for a given supply elasticity estimate. The inconsistency will be proportional to the actual correlation between ε_t^m and ε_t^r when $E(X_t'\varepsilon_t^m) = 0$. Against this, the supply elasticity estimate itself may be biased due to weak instruments. The net outcome of these two effects is indeterminate but does cast some doubt on whether the liquidity effect uncovered by Gordon and Leeper is a real one.

Another approach to estimating equations 8 and 9 that eschews recursive assumptions is to impose some long-run restrictions upon the impact of monetary shocks. Lastrapes and Selgin (1994) and Gali (1992) impose a variety of these. Lastrapes and Selgin begin by postulating that a unit shock in the money supply causes prices to rise by a unit in the long run, that is, real money balances do not change, while there is a zero long-run impact on output and interest rates. As explained in the preceding section, when discussing the SYS3 procedure, such restrictions free up instruments that can be used to estimate the elements of B_0. Taking the system to be estimated as (where all lagged values are suppressed)

[10] Adding the IV supply-equation residual as an additional instrument for FF in the demand equation yields almost exactly the FIML estimate of the demand-equation parameters.

[11] To estimate the system, we follow LS and rewrite it to involve real money in place of p_t, as that enables us to impose zero restrictions upon the lag distributions on m_t in each equation. At the end, we convert back to the system involving p_t, m_t, r_t and y_t.

$$\begin{aligned}(27)\quad \Delta p_t &= -b_{12}^0\Delta y_t - b_{13}^0\Delta m_t - b_{14}^0\Delta r_t + \varepsilon_{1t}\\ \Delta y_t &= -b_{21}^0\Delta p_t - b_{23}^0\Delta m_t - b_{24}^0\Delta r_t + \varepsilon_{2t}\\ \Delta m_t &= -b_{31}^0\Delta p_t - b_{32}^0\Delta y_t - b_{34}^0\Delta r_t + \varepsilon_{3t}\\ \Delta r_t &= -b_{41}^0\Delta p_t - b_{42}^0\Delta y_t - b_{43}^0\Delta m_t + \varepsilon_{4t}\end{aligned}$$

imposition of the long-run restrictions on each of the equations for p_t, y_t and r_t enables the estimation of three of the b_{ij}^0.[11]

Before further analysis, one has to consider why the system above is measured in differences, whereas most of the systems described previously are in levels. Lastrapes and Selgin (1994) argue that the variables m_t, p_t, r_t and y_t are integrated but not cointegrated. If equation 27 was written in levels, the error terms must be Integrated of order one $I(1)$; otherwise, the equations would represent cointegrating relations among the variables. Hence, it is appropriate to transform all the variables by differencing. Suppose, instead, that one proceeded to impose the long-run restrictions upon the levels model. To make the analysis simple, focus on the equation for output and assume that the only right-hand side variables are mt and m_{t-1}. Then, as previously explained in the second section, one would be using m_{t-1} as an instrument for Δm_t when the equation is re-parameterized to have Δm_t and m_{t-1} as the two regressors (m_{t-1} is eliminated because its coefficient is the long-run response of zero, leaving the only regressor as Δm_t). This estimator is $\hat{b}_{23}^0 = b_{23}^0 - (T^{-1}\Sigma m_{t-1}\Delta m_t)^{-1}(T^{-1}\Sigma m_{t-1}\varepsilon_{2t})$. If m_t is $I(1)$, both the numerator and denominator are asymptotically random variables, and the instrumental variables estimator converges asymptotically to a random variable, failing to even be consistent. The use of differenced variables obviates this problem as the new re-parameterized equation features $\Delta^2 m_t$ as regressor and Δm_{t-1} as instrument, and $T^{-1}\Sigma\Delta m_{t-1}\Delta^2 m_t$ will converge to a constant.

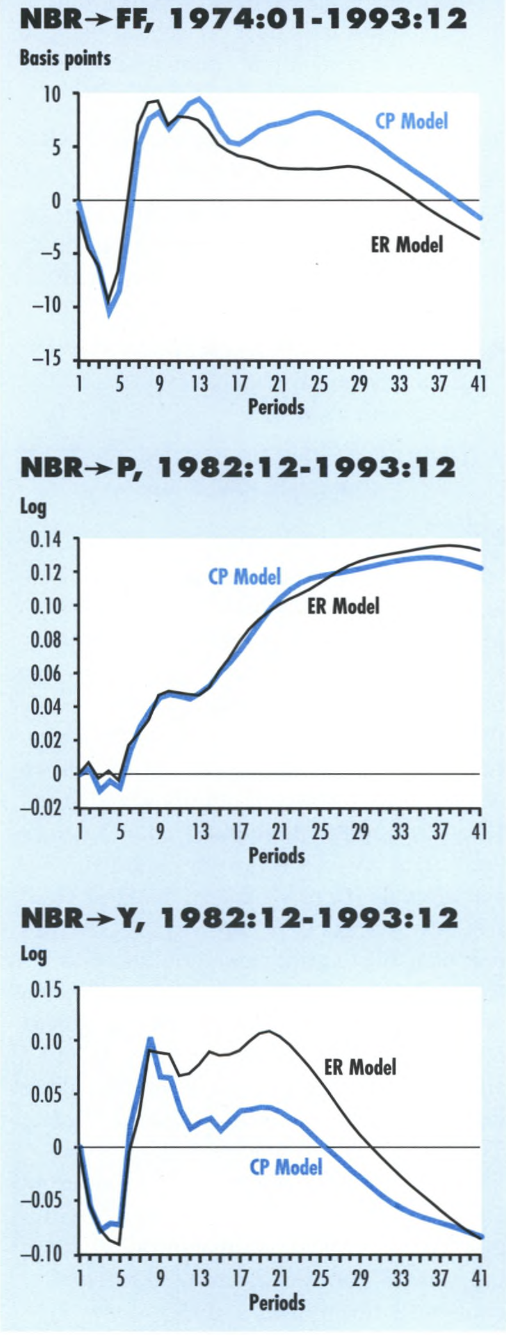
Now, let us consider the various estimates that might be made of the initial impulse response of r_t to shocks in m_t. To estimate this, we need to be able to form B_0^{-1}. Accordingly, six restrictions need to be placed upon the system to identify the elements in B_0. It is useful to draw these from one of the following five alternatives:

1. The matrix of long-run impulse responses, $C(1)$, is lower triangular. This implies that the three long-run restrictions on the impact of money supply shocks on prices, output and interest rates hold, as well as analogous ones involving money demand and aggregate demand shocks.
2. The three long-run money supply shock restrictions hold, along with $b_{12}^0 = b_{14}^0 = b_{24}^0 = 0$.
3. Long-run restrictions on the effect of money supply shocks on prices and output hold (but not on interest rates), along with $b_{12}^0 = b_{14}^0 = b_{24}^0 = b_{34}^0 = 0$.
4. Only the long-run restriction on the effect of money supply shocks on prices holds, along with $b_{12}^0 = b_{14}^0 = b_{24}^0 = b_{34}^0 = b_{23}^0 = 0$.
5. There are no long-run restrictions, and B_0 is lower triangular, that is, the system is recursive.

The first of these is what Lastrapes and Selgin actually use. Most of their paper specifically mentions only three long-run restrictions, but this fails to identify the magnitude of the responses, and the quantitative results they present require the extra long-run restrictions. As an experiment, we consider other ways of estimating B_0 that impose only the long-run restrictions emphasized by Lastrapes and Selgin, allied with various short-run assumptions. In particular, we build up to a recursive system $\{p, y, m, r\}$ by progressively removing the long-run assumptions. Given these choices, and with m being base money and r the three-month T-bill rate, the impact multipliers are, respectively, −63, −20, −8, 5 and 7, showing that the long-run restrictions do indeed help to identify a liquidity effect. The magnitude of the effect is large if six long-run restrictions are imposed, but if only the three restrictions Lastrapes and Selgin discuss are adopted, the magnitude is much the same as found with simple recursive systems featuring NBR and FF.

Clearly, there are a number of econometric estimation issues raised by the work with non-recursive models such as those of Gordon and Leeper, Lastrapes and Selgin, and Gali, and some of these are explored in detail in Pagan and Robertson (1995). For instance, it is shown there that the instruments implicitly used by all three studies are very weak, and this leads to biases in the estimated impulse

Figure 5a-c



response functions, raising the possibility that the observed magnitudes for the various responses are partly an artifact of the estimation procedures adopted.

Different Data Samples

Compounding the difficulties arising from the use of different sets of variables and structural models in the various studies, most of the empirical models are estimated using different sample periods. There are a number of ways of examining the robustness of results from changing the sample period, some of which are considered here. First, the estimates could be sensitive to estimation over a sub-period. Examining the impulse responses for the CP and ER models when estimated only with observations from the period 1982:12-1993:12, we find that each model produces small negative initial effects on interest rates and that the largest negative effects, after three of four periods, are around one-third of what was in evidence over the period 1974:01-1993:12. Compare Figures 4a and 5a. Moreover, while the price responses are similar for both models (see Figure 5b), the income responses are perverse (see Figure 5c).

To understand why the conclusions drawn from the models fitted over the 1982:12-1993:12 sub-sample are so different, we might start by examining the underlying structural relations. As mentioned earlier, in recursive systems like the ER and CP models, the initial effect of money shocks on interest rates requires that one only examine the interest elasticity of money demand drawing our attention to the estimated money demand curves in each period. The implicit contemporaneous components of the demand equations corresponding to those in equations 24 and 25 for the 1982:12-1993:12 period are

$$CP\text{:}\quad FF = -.14NBR + 12.42Y + 18.28P + 2.97CP$$

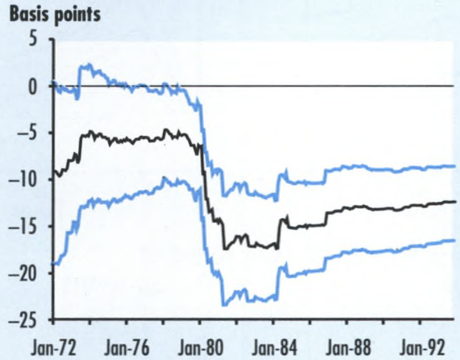
$$ER\text{:}\quad FF = .26NBR + 12.12Y + 11.14P + .19RF + 3.05CP.$$

Over the longer period, the interest rate coefficient was strongly negative so that the estimated liquidity effect was genuine. In this shorter sample, the situation is not as clear. A comparison of the two sets of estimates points to instability in the money-demand equation. On the basis of this evidence, one would have to be skeptical about the presence of a liquidity effect, although an alternative interpretation might be that the observations from the 1982-93 decade are just uninformative about the size of the interest rate coefficient, and that a longer series of data has managed to produce more precise estimates of that parameter.[12]

To shed further light on this issue, we estimated the money-demand equation from the CP model using varying-coefficient techniques. Figure 6a presents the recursive estimate of the NBR coefficient in the FF equation. What is striking in this graph is that the magnitude of the liquidity effect increased very sharply after the change of operating procedures of the Fed in October 1979. In light of the standard errors, the evidence for a liquidity effect in pre-1979 data does not seem very convincing, and there is a suggestion that the 1982-93 decade may be closer to the pre-1979 period in what it says about liquidity effects. To assess this latter proposition, we re-estimated the NBR coefficient, but now with a moving sample window of 120 months so that the last point estimate uses data from 1983:12-1993:12. Figure 6b presents this information. It is very clear from this graph that 1979-82 is a watershed period when it comes to empirical work on the liquidity effect. If it is omitted from the data, it would be very hard to believe that the initial impact on interest rates of money supply movements is not close to zero.[13]

Figure 6a, b

Recursive Estimates of Contemporaneous FF Response to NBR Shock +/- 2SE (CP Model)



10-Year Rolling Estimates of Contemporaneous FF Response to NBR Shock +/- 2SE (CP Model)

Given the sensitivity of results to the sample period, it is desirable to investigate the uncertainty about the estimates in more detail. Here we encounter some difficulties. The presence of (near) unit roots in the data means that standard asymptotic formulae for standard errors, based on the assumption that the random variables are stationary, will be incorrect and parametric simulation methods seem to be the best approach to producing standard errors. Even then, there are problems in implementing the simulations. One of these arises from the fact that, over any period incorporating 1979-82, there is extensive ARCH in the VAR equations for interest rates and money. The dependence introduced by the ARCH errors means that one cannot assume that the shocks are i.i.d, and, therefore, simple bootstrapping methods are not strictly appropriate in this context.[14] We have ignored the effects of ARCH and have determined percentile-based, 90 percent confidence intervals for the CP model by re-estimating the impulse responses from 1,000 samples of artificial data bootstrapped from the estimated CP model.[15] Figures 7a-c present the computed confidence intervals for the income responses over the three sample periods of 1959:01-1993:12, 1974:01-1993:12 and 1982:12-1993:12, respectively. We find that the income responses could easily be zero for the first few periods, and are then only positive in subsequent periods for models fit using the longer samples. The corresponding results for prices are presented in Figures 7d-f, and these show that negative price responses are easily realized from a model that has positive point estimates for price responses. Finally, as Figures 7g-i show, one gets a well-defined liquidity effect over the first two periods

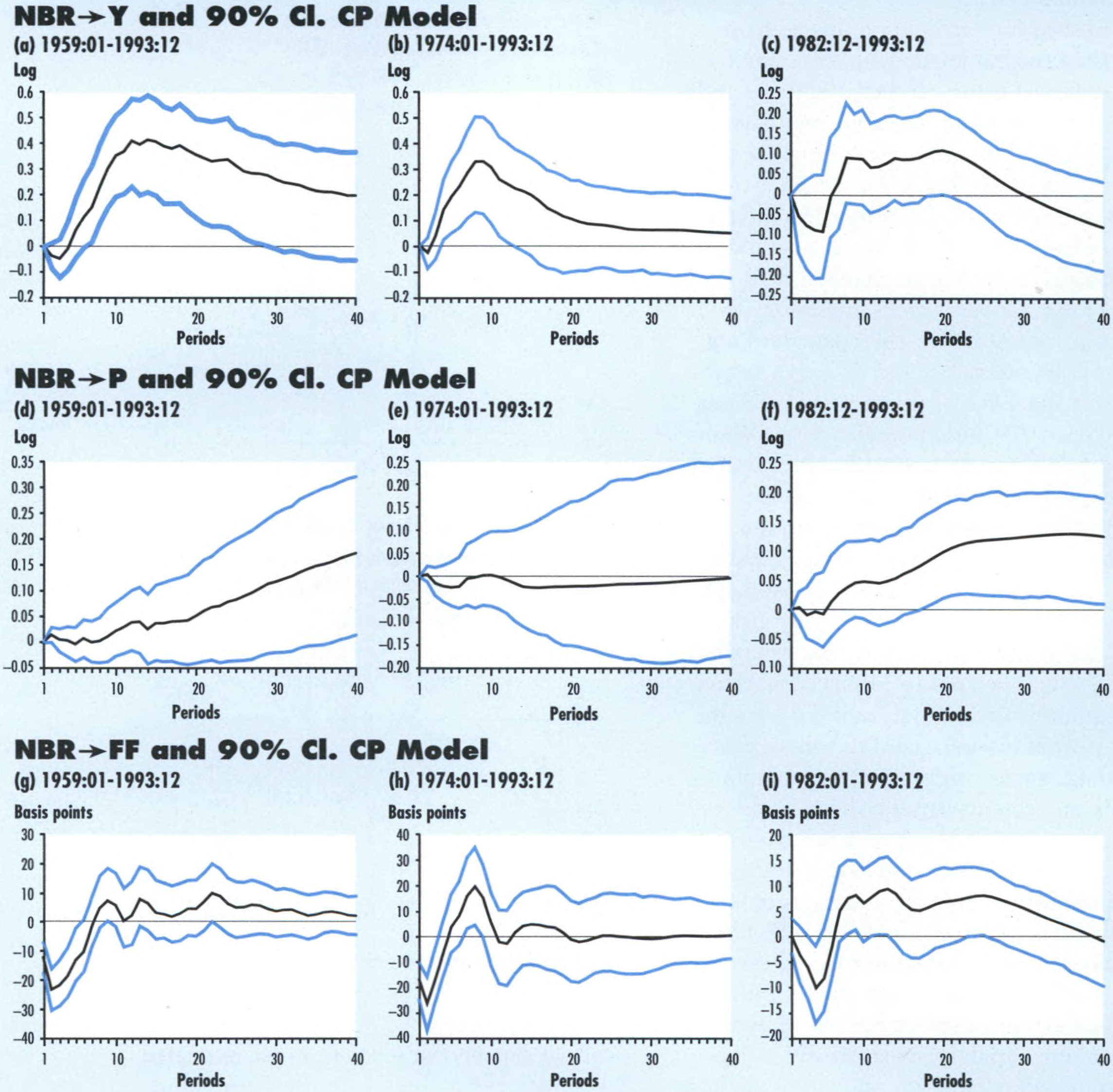
[12] The ordering is therefore {*P, Y, MO, R3*}, which reverses *P* and *Y* from the CP model. This has little effect. For example, for the recursive model, if one orders *Y* first, the response at impact is nine rather than seven. There seems no good reason to choose one ordering over the other.

[13] This is consistent with Cochrane (1989) and Gordon and Leeper (1992), who find a strong liquidity effect using single-equation, distributed-lag techniques on data for the period 1979 to 1982, whereas similar analyses using data prior to 1979 were unable to find evidence for the liquidity effect.

[14] There are many other problems that arise in computing confidence intervals which are not adequately dealt with in the literature. First, some studies use a Monte Carlo integration procedure in RATS, which assumes that VAR parameter estimators are normally distributed, and this will be incorrect in the presence of unit roots. Second, because the information presented is the whole impulse response function, the standard errors computed for any given response (say the k'th step) do not capture the range of uncertainty about the whole function. Finally, the impulse responses are functions of the VAR parameters. If there are more of the former than the latter, estimators of the former must have a singular distribution. Since one sometimes sees hundreds of impulses displayed on a page, it is very likely that the distributions are singular.

[15] Similar results to those reported here are obtained when the error is simulated from a $NID(0, \hat{\Sigma}_e)$ distribution instead.

Figure 7a-i



but not over the last. Notice also that, particularly for prices and output, the confidence intervals are asymmetric. This asymmetry may be due to the non-stationarity in the data. Some previous studies have assumed that the estimated coefficients can be drawn from a normal distribution, whereas it is known theoretically that they should be sampled from a skewed distribution if there are unit roots in the data. Sampling from a normal density will induce the confidence intervals to look symmetric. Lastrapes and Selgin (1994) are an exception, and they find asymmetry in their bootstrapped confidence intervals. In their case, however, we suspect the asymmetries are the result of biases in the point estimates arising from the use of first-differenced variables as instruments (see Pagan and Robertson, 1995, for details).

THE EFFECTS ON THE TERM STRUCTURE

Relatively little attention has been paid to the impact of monetary policy upon the complete term structure of interest rates, despite the fact that the results will be important to an understanding of the transmission mechanism. There is a voluminous literature on the term structure in both finance and economics which concentrates upon the slope of the term structure and the number of factors influencing it. Rarely are the factors decomposed into those that are monetary and those that are not. Cook and Hahn (1989) study the immediate changes seen in longer-term rates in response to an announced change in the federal funds rate, concluding that this effect becomes small for longer maturities. However, this does not address the question of the influence of a monetary policy change, since the federal funds rate is influenced by many factors, and we might expect them to have different influence at different points in the term structure.

One way to proceed would be to utilize the expectations theory of the term structure, which links long-term rates to the average of expected short-term rates.[16]

$$r_t^L = n^{-1}E_t[\sum_{i=0}^{n-1} r_{t+i}].$$

Using the expression for r_t in equation 12 and taking derivatives with respect to ε_t^m,

$$\partial r_t^L / \partial \varepsilon_t^m = n^{-1}\sum_{i=0}^{n-1} c_{im},$$

we can obtain the long-run responses by summing the short-term ones. For one-unit shocks to ε_t^m in the CP model over the full sample period, these are $-12.4(n = 1)$, $-19.3(n = 4)$ and $3.18(n = 120)$, which are of the same order of magnitude as for the federal funds rate but of opposite sign at longer maturities.

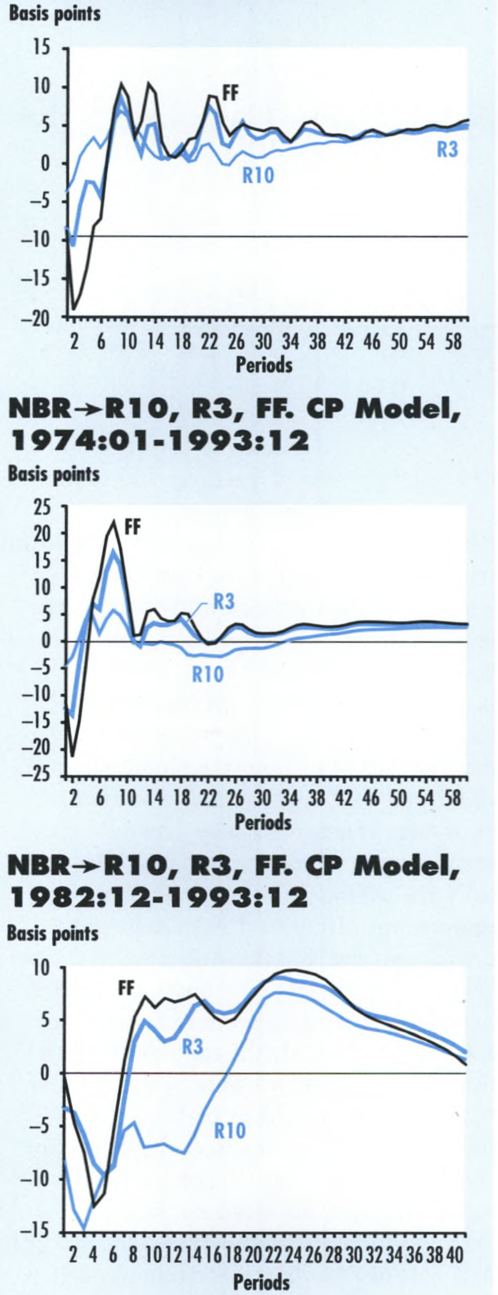
An alternative method, which does not depend upon the expectations theory holding, is to simply add longer-term rates to the VAR and to directly compute impulse responses for various interest rates. These are presented in Figure 8 for FF, R3 and R10 using an augmented CP model ordered as $\{Y, P, CP, NBR, FF, R3, R10, TR\}$, and estimated over the three sample periods used in the paper. For the two longer periods, the outcomes resemble those noted by Cook and Hahn (1989), but the period 1982:12-1993:12 shows the greatest effect of monetary variations to be on the long-term rate.

Figure 8a-c

NBR→R10, R3, FF. CP Model, 1959:01-1993:12

NBR→R10, R3, FF. CP Model, 1974:01-1993:12

NBR→R10, R3, FF. CP Model, 1982:12-1993:12



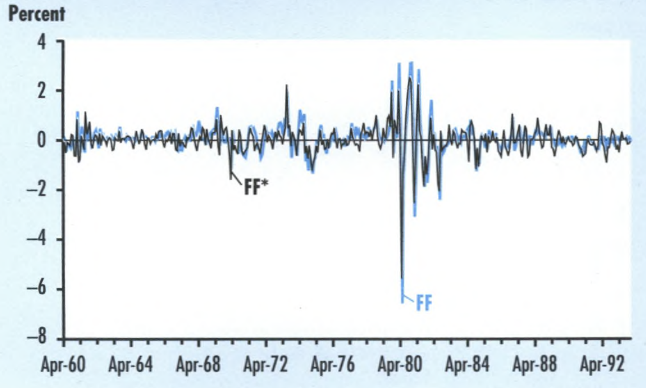
CONCLUSION

That the Fed can influence the federal funds rate on a daily basis is scarcely debatable. What is puzzling has been the failure of these actions to show up in data. Perhaps this simply reflects the fact that most empirical

[16] In fact, this is a linearization of the precise formula, and higher-order terms in the Taylor series expansion show that the long-term rate will depend upon higher-order moments of the conditional density.

Figure 9

Monthly Change in FF and FF*, CP Model



work does not use daily data, or it might be a consequence of reactions within the economy offsetting the initial impact over a longer time period. It is therefore reassuring that recent work seems to have isolated a liquidity effect with monthly data. How large is the effect? If one takes nonborrowed reserves as the relevant money variable, the immediate response of the federal funds rate in the CP model might be taken to be around −13 basis points as a consequence of a 1 percent point rise in the level of NBR. How large this is obviously depends on the feasible range of variation in NBR. Historically, the average absolute change in NBR innovations (1959:01-1993:12) is for a 0.9 percent rise, but it is only around 0.7 percent during the 1990s. Consequently, the measured effect does seem to be small. Even if we cumulate the multipliers until they turn positive, it would be rare for the sum to be smaller than −60 basis points, so that most of the factors historically driving the federal funds rate do not seem to be due to the Fed once one looks at it from a monthly viewpoint. Figure 9 illustrates this, plotting ΔFF and ΔFF^*, where FF^* is the (one-step) predicted value of FF using the CP model after setting the NBR innovation to zero, that is, assuming there is no policy action. Most of the variation in interest rates seems to be explained by factors other than those directly attributed by the model to monetary policy.[17]

Even if one accepts the "new" view regarding the presence of a liquidity effect, there are a number of caveats. Foremost among these are: The models do not seem to be very robust to data coming from the 1980s; The implied structural models can sometimes be implausible; The estimation procedures often rely on weak information and, for recursive models, the long-run multipliers can be contrary to a priori beliefs. How much damage these features do to the new view is an unsolved puzzle. If one encounters odd results, it is hard to know what their cause is without some underlying economic model. It may be that one can produce the observed responses within a plausible economic model as a consequence of choosing a particular calibration of it. Research in the past five years has to be credited with directing attention to the fact that analyses of the transmission mechanism require a systems perspective, but it is not clear that the recursive systems chosen for the investigation are as useful as they might be. Once unexpected results are found, the lack of a structure makes it very hard to account for them. In our view, the natural progression has to be toward non-recursive models with less profligate dynamics. The attempt to say nothing about dynamics has inevitably lead to a focus upon a set of variables that may be too narrow to capture the main interactions in an economy.

[17] Actually, we do not believe that these innovations represent policy. As we emphasized at the beginning of the article, ideally one wants to measure the effects of policy-related shifts in the money supply curve, and the dynamic effects of such changes could be identified with the impulse responses with respect to supply innovations. However, this does not justify treating innovations as policy. It is our belief that the innovations can be best thought of as a mixture of policy and "noise," the latter stemming from the fact that we are working with a model. Setting the innovations to zero therefore overcorrects for policy changes, although in this instance the implied policy component would still be small.

REFERENCES

Bernanke, Ben S., and Alan S. Blinder. "The Federal Funds Rate and the Channels of Monetary Transmission," The American Economic Review (September 1992), pp. 901-21.

Boschen, John F., and Leonard O. Mills. "The Narrative Approach to Evaluating Monetary Policy: Consistency of Interpretation and the Relation of Monetary Activity," working paper (1993), Federal Reserve Bank of Richmond.

Cochrane, John H. "The Return of the Liquidity Effect: A Study of the Short-Run Relation Between Money Growth and Interest Rates," Journal of Business and Economic Statistics, (January 1989), pp. 75-83.

Cooley, Thomas F., and Stephen F. LeRoy. "Atheoretical Macroeconomics: A Critique," Journal of Monetary Economics (November 1985), pp. 283-308.

Cook, Timothy, and Thomas Hahn. "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s," Journal of Monetary Economics (November 1989), pp. 331-51.

Christiano, Lawrence J., and Martin Eichenbaum. "Identification and the Liquidity Effect of a Monetary Policy Shock," in Alex Cuikerman, Zvi Hercowitz and Leonard Leiderman, eds., *Business Cycles, Growth and Political Economy.* MIT Press, 1992, pp. 335-70.

________, ________ and Charles Evans. "The Effects of Monetary Policy Shocks: Some Evidence from the Flow of Funds," National Bureau of Economic Research *Working Paper No. 4699* (April 1994).

Eichenbaum, Martin. "Comments" on "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy" by C. Sims, *European Economic Review* (June 1992), pp. 1001-11.

________ and Charles Evans. "Some Empirical Evidence on the Effects of Monetary Policy Shocks on Exchange Rates," National Bureau of Economic Research *Working Paper No. 4271* (February 1993).

Gali, Jordi. "How Well Does the IS-LM Model Fit Postwar U.S. Data?" *Quarterly Journal of Economics* (May 1992), pp. 709-38.

Gilles, Christian, John Coleman and Pamela Labadie. "Identifying Monetary Policy with a Model of the Federal Reserve," Board of Governors of the Federal Reserve System *Finance and Economics Discussion Series No. 93-24* (July 1993).

Gordon, David B., and Eric M. Leeper. "The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification," Federal Reserve Bank of Atlanta *Working Paper No. 93-5* (April 1993).

Kocherlakota, Narayana R. "On Tests of Representative Consumer Asset Pricing Models," *Journal of Monetary Economics* (October 1990), pp. 285-304.

Koopmans, Tjalling C., H. Rubin and R.B. Leipnik. "Measuring the Equation Systems of Dynamic Economics," in Tjalling C. Koopmans, ed., *Statistical Inference in Dynamic Economic Models*, Cowles Commission Monograph 10. John Wiley and Sons, 1950.

Lastrapes, W.D., and G. Selgin. "The Liquidity Effect: Identifying Short-Run Interest Rate Dynamics Using Long-Run Restrictions," working paper (1994), University of Georgia, Department of Economics.

Leeper, Eric M., and David B. Gordon. "In Search of the Liquidity Effect," *Journal of Monetary Economics* (June 1992), pp. 341-69.

McKibbin, Warwick J., and Jeffrey D. Sachs. *Global Linkages: Macroeconomic Interdependence and Cooperation in the World Economy.* Brookings Institution, 1991.

Mishkin, Frederic S. *The Economics of Money, Banking, and Financial Markets.* Harper Collins, 1992.

________. "Monetary Policy and Short-Term Interest Rates: An Efficient Markets-Rational Expectations Approach," *Journal of Finance* (March 1982), pp. 63-72.

________. "Monetary Policy and Long-Term Interest Rates: An Efficient Markets Approach," *Journal of Monetary Economics* (January 1981), pp. 29-55.

Nelson, Charles R., and Richard Startz. "The Distribution of the Instrumental Variables Estimator and its T-ratio When the Instrument is a Poor One," *Journal of Business* (Part 2, January 1990), pp. 125-40.

Pagan, Adrian R. "Econometric Issues in the Analysis of Regressions with Generated Regressors," *International Economic Review* (February 1984), pp. 221-47.

________ and John C. Robertson. "Structural Models of the Liquidity Effect," The Australian National University *Working Paper No. 283* (1994).

________ and Y. Jung. "Understanding the Failure of Some Instrumental Variable Estimators," working paper (1993), The Australian National University.

Reichenstein, William. "The Impact of Money on Short-Term Interest Rates," *Economic Inquiry* (January 1987), pp. 67-82.

Romer, Christina D., and David H. Romer. "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," in Oliver Jean Blanchard and Stanley Fischer, eds., National Bureau of Economic Research *Macroeconomics Annual.* MIT Press, 1989, pp. 121-70.

Sarte, P.G. "On the Identification of Structural VAR's," working paper (1994), University of Rochester.

Shapiro Matthew D., and M.W. Watson. "Sources of Business Cycle Fluctuations," in Stanley Fischer, ed., National Bureau of Economic Research *Macroeconomics Annual.* MIT Press, 1988, pp. 111-48.

Sims, Christopher A. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review* (June 1992), pp. 975-1000.

________. "Macroeconomics and Reality," *Econometrica* (January 1980), pp. 1-48.

Staiger, D., and J.H. Stock. "Instrumental Variables Regression with Weak Instruments," working paper (1993), Harvard University, Kennedy School of Government.

Strongin, Steven. "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle," Federal Reserve Bank of Chicago *Working Paper No. 92-27* (November 1992).

Thornton, Daniel L. "The Effect of Monetary Policy on Short-Term Interest Rates," this *Review* (May/June 1988), pp. 53-72.

Appendix

DATA AND DATA SOURCES

Except for the commodity price series the data are sourced from CITIBASE. The corresponding CITIBASE mnemonics are reported in parentheses. The data are monthly from 59:01 to 93:12. All series except interest rates and the exchange rate are seasonally adjusted.

Money (seasonally adjusted):
- *M2* (FM2) = log of M2.
- *M1* (FM1) = log of M1.
- *M0* (FMBASE) = log of money base (Federal Reserve Bank of St Louis definition).
- *TR* (FMRQA+F6CMRE) = log of total reserves.
- *NBR*(FMRNBC) = log of non-borrowed reserves plus extended credit.
- *BR* (FMRRA - FMRNBC) = log of borrowed reserves excluding extended credit.
- *NBRX* = ratio of non-borrowed to total reserves (proportion).

Interest Rates (percent, not seasonally adjusted):
- *R*10 (FYGT10) = 10-year Treasury Note yield.
- *R*3 (FYGM3) = three-month Treasury bill yield (secondary market).
- FF (FYFF) = federal funds rate.
- RD (FYGD) = discount rate.
- RF (FWAFIT) = weighted-average foreign interest rate.

Other Series:
- *Y* (IP) = log of industrial production index.
- *P* (PUNEW) = log of consumer price index, urban.
- *CP* (76AXD) = log of industrial country commodity price index. From the IMF International Financial Statistics data tape.
- *U* (LHUR) = unemployment rate, all workers 16 and over.
- *ER* (EXRUS) = log of weighted-average exchange rate.

Lawrence J. Christiano is a professor of economics at Northwestern University. The author is grateful to Manuel Balmaseda for excellent research assistance, and to V.V. Chari and Martin Eichenbaum for discussions.

Commentary

Lawrence J. Christiano

The Pagan and Robertson article presents a useful review of the evidence on the empirical status of the liquidity effect proposition—that an exogenous increase in the money supply drives the rate of interest down. It discusses how the consensus in the empirical literature has shifted from an initial one of skepticism to what Pagan and Robertson call "the new view": that the liquidity effect proposition has substantial empirical support. In my comment, I offer an alternative perspective on the evolution of the empirical literature, one which focuses on the dynamic correlations between three monetary aggregates and the federal funds rate.

A valuable contribution of the Pagan and Robertson article is to document evidence to suggest that the liquidity effect may have gotten smaller in the years since 1982. This is an important observation which deserves more attention to determine exactly what it means. It may simply be a statistical artifact, reflecting the relatively small amount of information in the post-1982 data. Assessing this is complicated by the fact, documented further below, that most of the evidence of a change reflects sub-sample variation in the estimated variance-covariance matrix of vector autoregression (VAR) residuals. As Pagan and Robertson note, these residuals appear to be characterized by autoregressive conditional heteroskedasticity (ARCH) effects and, under these circumstances, it may be difficult to identify a true change in an unconditional variance-covariance matrix. But, assuming that the change in the variance-covariance matrix of VAR residuals is in fact real, then this raises further interesting questions of interpretation: Has the liquidity effect in fact gotten smaller, or is the evidence of a reduction an artifact of an error in the specification of monetary policy? The calculations that produce evidence of a change in the liquidity effect assume there has been no change in monetary policy. Most commentators on Fed policy think that there was a shift in policy in late 1982.

WHAT IS THE "LIQUIDITY EFFECT" AND WHY CARE ABOUT IT?

I begin my discussion by defining what I mean by a liquidity effect, which I take to be a property of an economic model. An economic model possesses a liquidity effect if it has the following characteristic: An exogenous, persistent, upward shock in the growth rate of the monetary base, engineered by the central bank and not associated with any current or prospective adjustment in distortionary taxes, drives the nominal rate of interest down for a significant period of time.

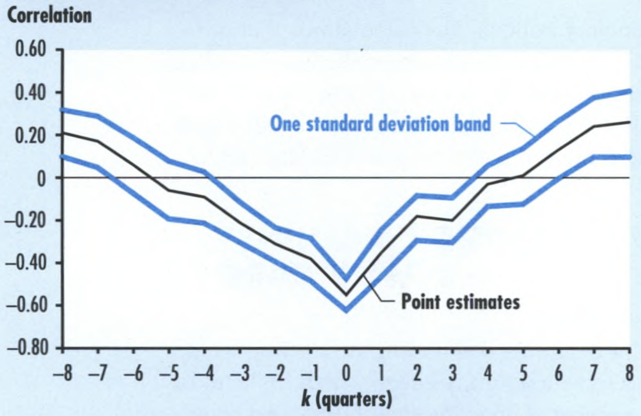
This definition of the liquidity effect can be distinguished from the traditional, partial-equilibrium liquidity effect in the literature. That refers to the fall in the interest rate that is required by a downward-sloped money demand schedule when the money supply increases and there is no change in the price level and level of income. Many existing general-equilibrium models that do not possess a liquidity effect in the sense that I define it do display a partial-equilibrium liquidity effect.

The basic question addressed in the Pagan and Robertson article, and in the empirical liquidity effect literature, is: What do the data say about the relative plausibility of the following two types of models: models with a liquidity effect and models with the implication that an exogenous increase in the monetary base drives the nominal rate of interest up?

The reason why this question is interesting is that the answer one selects has important implications for the construction of quantitative macroeconomic models with money. This is discussed further in Christiano (1991) and Christiano and Eichenbaum (1995).

Figure 1

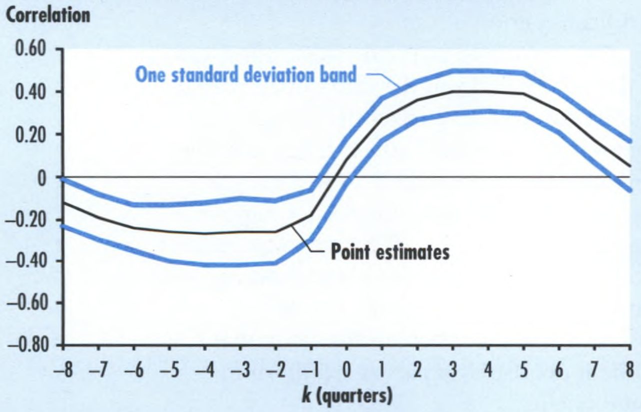
Correlation Between the Fed Funds Rate(*t*) and NBR(*t-k*)



Notes: Data are quarterly and cover the period 1959: 1-1991:4. Money data have been logged, and both series have been HP-filtered prior to doing the computations.

Figure 2

Correlation Between the Fed Funds Rate(*t*) and the Monetary Base(*t-k*)



Notes: See notes to Figure 1.

EVOLUTION OF VIEWS ON THE EMPIRICAL STATUS OF THE LIQUIDITY EFFECT

Historically, economists have taken the plausibility of the liquidity effect for granted. This is reflected in standard intermediate macroeconomics textbooks, which feature models exhibiting liquidity effects. However, when researchers initially attempted to quantify the liquidity effect using data, they came away quite skeptical as to its plausibility. (Examples include King, 1983; Melvin, 1983; and Mishkin, 1983). This had an impact on the development of monetary business cycle models. For example, Barro (1987, p. 521) and Robert King (1991) cite these findings as evidence in support of the first wave of monetized real business cycle models. These models have the implication that an exogenous increase in money growth, if persistent, leads to a *rise* in the nominal rate of interest. Now the consensus has returned to the traditional position in favor of liquidity effects. This in turn has sparked efforts to identify frictions which allow monetary models to display a liquidity effect.

A case can be made that this evolution in thinking reflects early analysts' tendency to focus exclusively on broader monetary aggregates and their tendency to ignore the sources of endogeneity in money. To gain insight into the role played by these considerations, consider the results reported in Figures 1-3, taken from Christiano and Eichenbaum (1992). They display the cross-correlation between different monetary aggregates and the federal funds rate (black line), together with plus-and-minus one standard-deviation confidence bands (blue line). The monetary aggregates examined include nonborrowed reserves (NBR), the monetary base (M0) and M1. Both the interest rate and the monetary aggregates have been logged and Hodrick-Prescott filtered prior to the computations.[1] The data display three key features: (1) The broad monetary aggregates covary *positively* with current and future values of the interest rate; (2) *negatively* with past values of the interest rate; and (3) NBR covaries *negatively* with current and future values of the interest rate.

In view of the first feature, it is perhaps not surprising that analysts who assumed the endogenous component of money is small and focused on broader monetary aggregates, arrived at the view that the evidence does not support an important liquidity effect. Early research which recognized the potential role of endogeneity took the view that the Fed conducts monetary policy by targeting the nominal interest rate. (See, for example, Bernanke and Blinder, 1992; and Sims, 1986.) Under this view, exogenous innovations in

[1] The nonborrowed reserves data were obtained from Steve Strongin. The other data were taken from CITIBASE. The federal funds rate, monetary base and M1 have mnemonics FFYF, FMBASE and FM1, respectively. The results reported in Figures 1-3 are robust to alternative detrending procedures and sample periods. See Christiano and Eichenbaum (1992) for details.

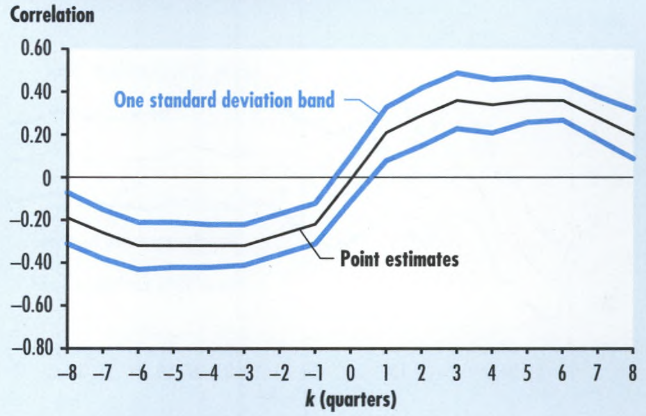
base growth engineered by the central bank are associated with innovations in the interest rate. Feature two of the data helps explain why these analysts favor the liquidity effect view that an upward revision in the Fed's interest rate target is implemented by engineering a *reduction* in the money supply. Finally, beginning with Thornton (1988), researchers have recently begun working with NBR. In light of feature three, it is perhaps not surprising that they have tended to conclude that the evidence favors the liquidity effect view.

While the correlations I just described go a long way toward explaining why different researchers reached different conclusions about the empirical status of liquidity effects, they do not tell the whole story. That is because the liquidity effect pertains to the sign of the correlation between the components of interest rates and money that reflect *exogenous* disturbances to monetary policy. Raw correlations, by contrast, reflect the joint movements of interest rates and money arising due to the effects of all shocks, not just exogenous monetary policy shocks. To see why this distinction probably matters, consider the correlation between logged and detrended gross domestic product and NBR in Figure 4.[2] The fact that the contemporaneous correlation is significantly negative may reflect a policy of "leaning against the wind" at the Fed. If so, then the raw correlation between interest rates and NBR reflects in part the response of both variables to whatever shocks are driving GDP. Such shocks could in principle produce a positive or negative correlation between money and interest rates, independent of whether the liquidity effect is operative.

Coleman, Gilles and Labadie (1995), CGL, present a couple of hypothetical examples that illustrate very nicely how this could happen. The examples underscore the importance of isolating the exogenous monetary policy component of a monetary indicator variable. They are also useful for illustrating the kind of steps researchers take in practice to build confidence that the shocks they have isolated are indeed monetary policy shocks and not something else. In one of CGL's examples, the economy is driven by a single shock, one that is non-monetary in origin. CGL assume that

Figure 3

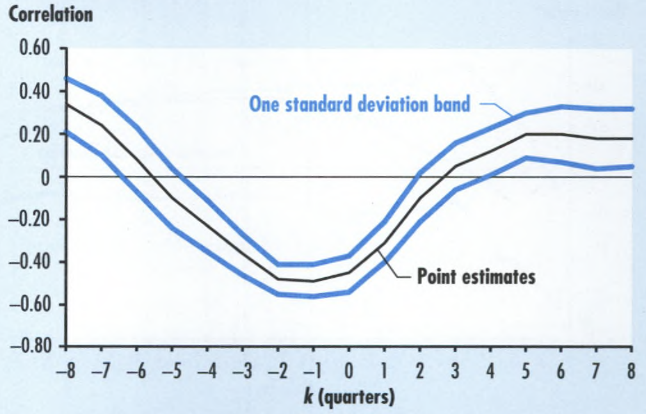
Correlation Between the Fed Funds Rate(*t*) and M1(*t-k*)



Notes: See notes to Figure 1.

Figure 4

Correlation Between GDP(*t*) and NBR(*t-k*)



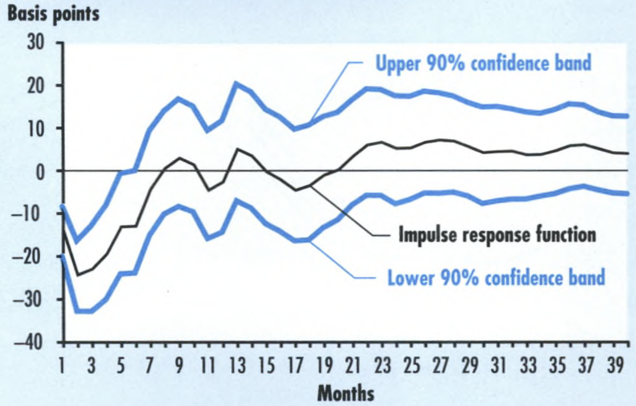
Notes: Data are quarterly and cover the period 1959: 1-1991:4. Both variables were logged and HP-filtered prior to the compuutations.

the shock drives up the equilibrium nominal rate of interest, and that this produces an accommodation at the Federal Reserve's discount window. The Federal Open Market Committee (FOMC) is assumed to partially offset the impact of this on total bank reserves by undertaking contractionary open market operations which have the effect of reducing nonborrowed reserves. In an economy like this, there would be a negative correlation between the rate of interest and NBR, even

[2] The gross domestic product data are taken from CITIBASE.

Figure 5

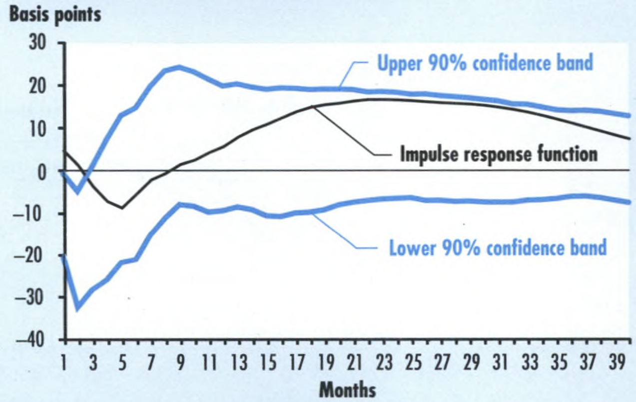
Interest Rate Response to Orthogonalized NBR Shock



Notes: Impulse response based on 14-lag, six-variable VAR estimated using monthly data, 1959:1-1991:10.

Figure 6

Interest Rate Response to Orthogonalized NBR Shock



Notes: Impulse response function based on six-lag, six-variable VAR estimated for period 1982:12-1991:10. Confidence interval is the one implied by the 14-lag, six-variable VAR fit to whole sample.

though there are no monetary policy shocks at all.

CGL's second example illustrates how an economy with monetary policy shocks, but only an anticipated inflation effect and *no* liquidity effect, could also generate a negative correlation between nonborrowed reserves and the interest rate. Suppose the Fed signals policy shifts in advance of actually implementing them, and that a signal of an imminent increase in the growth of total reserves produces an immediate rise in the interest rate. Suppose the rise in the interest rate results in an accommodation at the discount window, so that to insulate total reserves from this, the Fed must reduce nonborrowed reserves. In a world like this, one would expect a negative correlation between nonborrowed reserves and the interest rate, even though there is no liquidity effect.

It is in an effort to avoid the sort of pitfalls illustrated by the CGL examples that the recent literature has taken great pains to isolate the exogenous component of monetary policy in monetary indicator variables. The assumptions made to do this are called identifying assumptions, and they typically involve incorporating more variables into the analysis. Additional steps are taken to further reduce the likelihood of the kind of problems emphasized in the CGL examples. One strategy for doing so is pursued in Christiano, Eichenbaum and Evans (1994), CEE. To build confidence that their shocks correctly isolate the exogenous shock to policy, CEE analyze the impact of their monetary policy shock measures on many macroeconomic variables. Based on their findings, they conclude that their monetary policy shock measures probably do not suffer significantly from the sort of distortions illustrated in the two CGL examples. For example, it seems unlikely that the CEE policy shock really measures the private economy shock in CGL's first example. That's because CEE find that a negative shock to nonborrowed reserves leads to a rise in unemployment and inventories, and a fall in output, employment, profits, and the broad monetary aggregates. It seems hard to imagine a reasonable model in which a non-monetary shock would have these effects. Finally, CGL's second example seems implausible in light of the CEE finding that a negative shock to NBR leads to a fall in the broader monetary aggregates.

In sum, the basic outlines of the story describing the evolution of thinking about liquidity effects can be understood with reference to simple correlations between various monetary aggregates and the interest rate. The full story is more complicated and involves a broader set of variables. These are used first to isolate a measure of the exogenous component of monetary policy, and then to "test" that the resulting measure does not confound shocks that are non-monetary in origin. This part of the story involves many assumptions. Significantly, researchers using a wide variety of plausible assumptions have reached the conclusion that the data support the liquidity effect view.

A VANISHING LIQUIDITY EFFECT?

Pagan and Robertson report calculations that suggest the liquidity effect may be smaller in the 1980s than before. To see this, first consider Figure 5, which displays the response of the interest rate to an orthogonalized innovation in nonborrowed reserves. The response is based on what Pagan and Robertson call the CP model of Christiano, Eichenbaum and Evans (1994). The underlying six-variable, 14-lag VAR was estimated using the period 1959:01 to 1991:10. The blue lines are 90 percent confidence intervals computed by the bootstrap method outlined in the Pagan and Robertson article.[3] Note the statistically significant negative initial response of the interest rate. A 1 percent rise in nonborrowed reserves drives the funds rate down about 15 basis points (annual rate) in the current month, and 25 basis point in the next month. The Pagan and Robertson observation can be seen by comparing Figure 5 with Figure 6, which displays the interest rate response based on a six-lag, six-variable CP model estimated over the sample 1982:12 to 1991:01.[4] This impulse response function has the implication that a 1 percent rise in nonborrowed reserves leads to a contemporaneous rise of 1 basis point in the funds rate, followed by relatively small reductions of 3, 8 and 13 basis points in the first, second and third months, respectively, after a shock. After that, the point estimates in Figures 5 and 6 are quite similar. The other curves in Figure 6 enable one to test the null hypothesis that the data from the later sample are consistent with the model fit to the whole sample. They define a 90 percent bootstrap confidence interval, constructed using the 14-lag VAR model and its fitted residuals estimated for the entire sample. Note that the first two impulses lie outside this confidence interval, so that the null hypothesis is rejected.[5] This test suggests that the reduction in the liquidity effect in the 1980s is more than what one would expect given that the 1980s constitute a relatively small sample of data.

The primary reason for the shift in the impulse response function appears to lie in a shift in the variance-covariance matrix of the VAR disturbances. One way to see this is to note that the biggest change in going from the full sample to the short sample is in the estimated impact effect of an orthogonalized NBR shock. That object is a direct function of the variance-covariance matrix of the fitted disturbances. (In particular, it is the 5,4 element in the lower triangular Choleski decomposition of the variance-covariance matrix.)

Another way to see this is to consider Figure 7. That reproduces the impulse response functions reported in Figures 5 and 6 for convenience. In addition, Figure 7 reports an impulse response function obtained by combining the lagged coefficients from the 14-lag VAR fit to the period 1959:01-1991:10, with the variance-covariance of the sub-set of its fitted disturbances covering the period 1982:12-1991:10.[6]

Note that the resulting impulse response function resembles the one fit to the post-1982 data in that it implies a small liquidity effect. Thus, in essence the statistical test reported in the previous paragraph (and, presumably, in Pagan and Robertson too) is a rejection of the null hypothesis of constancy of a particular function of the VAR disturbance variance-covariance matrix.

The fact that the smaller liquidity effect in the 1980s reflects instability in the estimated variance-covariance of fitted disturbances raises two questions. First, Pagan and Robertson have emphasized that there is "extensive ARCH in the VAR equations for interest rates and money." But the procedure I used (following Pagan and Robertson) to deduce that there is statistically significant instability in the impulse response functions assumes the disturbances are *iid*. Under these circumstances, one presumes that extensive ARCH in the disturbances would greatly increase the probability of false rejections in tests of the null hypothesis of no change in a variance-covariance matrix. This is because

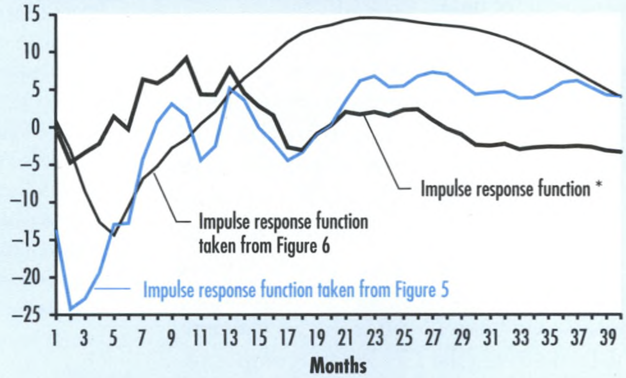
[3] That is, I used random samples of the fitted VAR disturbances, together with the estimated VAR and actual U.S. data for the required 14 initial conditions to generate 1,000 artificial data sets of 388 observations each, for all six variables in the VAR. In each artificial data set, I fit a 14-lag, six-variable VAR and computed an impulse-response function using the procedure underlying the computations for the point estimates in Figure 5. Let $\alpha_i(k)$ denote the i^{th} month's response of the interest rate to a policy shock, $i = 1,...,36$, on the k^{th} artificial data set, $k = 1, ...,1000$. Then, for each i, $\alpha_i(k)$ was ordered from largest to smallest. The 50th and 950th elements are reported as the top and bottom curves in Figure 5.

[4] The lags lengths of the two models correspond to the choices made by Pagan and Robertson. A six-lag model for the long sample period does not work well. The Ljung-Box Q-statistic at lag 24 computed on the residuals for the interest rate equation has a value of 43, with a significance level of 1 percent. This convinced me that six lags is too short for this sample. The Q-statistic computed for the six-lag VAR fit to the post-1982 sample did not show any evidence of serial correlation in the residuals.

[5] The bootstrap confidence intervals were computed as follows. Using U.S. data for the required 14 initial conditions, the empirically estimated 14-lag VAR was used to simulate 1,000 artificial data sets of 388 observations each. The residuals for each data set were obtained by random sampling from the fitted residuals. The last 107 observations in each sample were used as the estimation period for fitting a six-lag VAR and computing an impulse response function like the middle (*continued on following page*)

Figure 7

Interest Rate Response to Orthogonalized NBR Shock



* obtained by combining lagged VAR coefficients from VAR fit to whole sample with innovation variance-covariance matrix from post-1982 period.

under ARCH, a sample variance-covariance matrix can display substantial time variation, even though the underlying unconditional variance-covariance matrix is constant. Thus, it remains an open question whether the smaller estimated liquidity effect in the 1980s is simply a statistical artifact.

Second, the apparent instability in the variance-covariance matrix of VAR disturbances suggests it might be fruitful to explore the possibility of policy shifts using the "identified VAR" identification strategy pursued by Bernanke (1986) and Sims (1986). There are two reasons for this: (1) It is widely thought that policy did change across the 1979-82 and 1982-present periods; and (2) the Bernanke-Sims style approach would predict a change in the variance-covariance matrix of residuals under a change in policy. Whether it predicts precisely the instability observed is an open question.[7]

CONCLUSION

To summarize, the authors draw attention to a reduction in the estimated size of the liquidity effect in the 1980s. This certainly deserves attention. However, the right statistical techniques have not yet been applied to determine whether the apparent change is statistically significant, or just an artifact of the small number of observations. Assuming it is not a statistical artifact, it would be interesting to investigate exactly what it means. Does it reflect specification error due to a change in policy regime? Does it reflect that the liquidity effect actually was smaller in the 1980s, perhaps because agents became more sensitive to news about inflation?

To assess the results in this article, it is important to recall what is at stake here. Views about the presence or absence of a liquidity effect in the data determine what kind of monetary models macroeconomists use to conduct policy analysis. In early monetized real business cycle models, the interest rate money dynamics were dominated by strong anticipated inflation effects. The Pagan-Robertson article presents no evidence to support the notion that there is a strong *rise* in interest rates in response to an expansionary monetary policy shock, as these models require. Instead, all the point estimates indicate a fall in the interest rate in the wake of a positive monetary policy shock. In particular, the Pagan and Robertson article provides no evidence that macroeconomists should abandon models exhibiting liquidity effects and go back to simple monetized real business cycle models.

(*footnote 5 cont.*)
line in Figure 6. The confidence intervals were computed using the 1,000 impulse response functions with the same method as the one underlying Figure 5.

[6] That is, let $Y_t = A(L)Y_{t-1} + u_t$, where u_t are the fitted VAR disturbances and $A(L)$ denotes the fitted 14-lag matrix polynomial of VAR coefficients. Let V denote the variance-covariance matrix of u_t covering the period 1982:12-1991:10 only. Let $CC' = V$ be the lower triangular Choleski decomposition of V. Then, the numbers in Figure 7 are the coefficients in the 5,4 element of the matrix polynomial $[I-A(L)]^{-1}C$.

[7] Another interesting question is whether such an analysis could be reconciled with dynamic macroeconomic theory.

REFERENCES

Barro, Robert J. *Macroeconomics*, 2nd edition. John Wiley & Sons, 1987.

Bernanke, Ben S. "Alternative Explanations of the Money Income Correlation," in Karl Brunner and Allan Meltzer, eds., *Carnegie Rochester Conference Series on Public Policy* (autumn 1986), pp. 49-100.

Bernanke, Ben S., and Alan S. Blinder. "The Federal Funds Rate and the Channels of Monetary Transmission," *The American Economic Review* (September 1992), pp. 901-21.

Christiano, Lawrence J. "Modeling the Liquidity Effect of a Monetary Shock," Federal Reserve Bank of Minneapolis *Quarterly Review* (winter, 1991), pp 3-34.

_______ and Martin Eichenbaum. "Identification and the Liquidity Effect of a Monetary Policy Shock," in Alex Cukierman, Zvi Hercowitz and Leonard Liederman, eds., *Business Cycles, Growth and Political Economy.* MIT Press, 1992, pp. 335-70.

_______ and _______. "Liquidity Effects, Monetary Policy and the Business Cycle," National Bureau of Economic Research *Working Paper No. 4129* (August 1994).

_______, _______ and Charles Evans. "The Effects of Monetary Policy Shocks: Evidence From the Flow of Funds," *Review of Economics and Statistics* (forthcoming).

Gali, Jordi. "How Well Does the IS-LM Model Fit Post War U.S. Data," *Quarterly Journal of Economics* (May 1992), pp. 709-38.

King, Robert. "Money and Business Cycles," working paper (1991), University of Rochester.

King, Stephen R. "Real Interest Rates and the Interaction of Money, Output, and Prices," working paper (1983).

Melvin, Michael. "The Vanishing Liquidity Effect of Money on Interest: Analysis and Implications for Policy," *Economic Inquiry* (April 1983), pp. 188-202.

Mishkin, Frederic S. *A Rational Expectations Approach to Macroeconomics: Testing Policy Ineffectiveness and Efficient-Markets Models.* University of Chicago Press, 1983.

Thornton, Daniel L. "The Effect of Monetary Policy on Short-Term Interest Rates," this *Review* (May/June 1988), pp. 53-72.

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Is There a "Credit Channel" for Monetary Policy?

R. Glenn Hubbard

Understanding the channels through which monetary policy affects economic variables has long been a key research topic in macroeconomics and a central element of economic policy analysis. At an operational level, a "tightening" of monetary policy by the Federal Reserve implies a sale of bonds by the Fed and an accompanying reduction of bank reserves. One question for debate in academic and public policy circles in recent years is whether this exchange between the central bank and the banking system has consequences in addition to those for open market interest rates. At the risk of oversimplifying the debate, the question is often asked as whether the traditional interest rate or "money view" channel presented in most textbooks is augmented by a "credit view" channel.[1]

There has been a great deal of interest in this question in the past several years, motivated both by developments in economic models (in the marriage of models of informational imperfections in corporate finance with traditional macroeconomic models) and recent events (for example, the so-called credit crunch during the 1990-91 recession).[2] As I elaborate below, however, it is not always straightforward to define a meaningful credit view alternative to the conventional interest rate transmission mechanism. Similar difficulties arise in structuring empirical tests of credit view models.

This paper describes and analyzes a broad, though still well-specified, version of a credit view alternative to the conventional monetary transmission mechanism. In so doing, I sidestep the credit view language per se, and instead focus on isolating particular frictions in financial arrangements and on developing testable implications of those frictions. To anticipate that analysis a bit, I argue that realistic models of "financial constraints" on firms' decisions imply potentially significant effects of monetary policy beyond those working through conventional interest rate channels. Pinpointing the effects of a narrow "bank lending" channel of monetary policy is more difficult, though some recent models and empirical work are potentially promising in that regard.

I begin by reviewing the assumptions and implications of the money view of the monetary transmission mechanism and by describing the assumptions and implications of models of financial constraints on borrowers and models of bank-dependent borrowers. The balance of the article discusses the transition from alternative theoretical models of the transmission mechanism to empirical research, and examines implications for monetary policy.

HOW REASONABLE IS THE MONEY VIEW?

Before discussing predictions for the effects of alternative approaches on monetary policy, it is useful to review assumptions about intermediaries and borrowers in the traditional interest rate view of the monetary transmission mechanism. In this view, financial intermediaries (banks) offer no special services on the asset side of their balance sheet. On the liability side of their balance sheet, banks perform a special role: The banking system creates money by issuing demand deposits. Underlying assumptions about borrowers is the idea that capital structures do not influence real decisions of borrowers and lenders, the result of Modigliani and Miller (1958). Applying the intuition of the Modigliani and Miller theorem to banks, Fama (1980) reasoned that shifts in the public's portfolio preferences among bank deposits,

[1] For descriptions of the debate, see Bernanke and Blinder (1988) and Bernanke (1993).

[2] For an analysis of the "credit crunch" episode, see Kliesen and Tatom (1992) and the studies in the Federal Reserve Bank of New York (1994). The paper by Cantor and Rodrigues in the New York Fed studies considers the possibility of a credit crunch for nonbank intermediaries.

bonds or stocks should have no effect on real outcomes; that is, the financial system is merely a veil.[3]

To keep the story simple, suppose that there are two assets—money and bonds.[4] In a monetary contraction, the central bank reduces reserves, limiting the banking system's ability to sell deposits. Depositors (households) must then hold more bonds and less money in their portfolios. If prices do not instantaneously adjust to changes in the money supply, the fall in household money holdings represents a decline in real money balances. To restore equilibrium, the real interest rate on bonds increases, raising the user cost of capital for a range of planned investment activities, and interest-sensitive spending falls.[5]

While the money view is widely accepted as the benchmark or "textbook" model for analyzing effects of monetary policy on economic activity, it relies on four key assumptions: (1) The central bank must control the supply of "outside money," for which there are imperfect substitutes; (2) the central bank can affect real as well as nominal short-term interest rates (that is, prices do not adjust instantaneously); (3) policy-induced changes in real short-term interest rates affect longer-term interest rates that influence household and business spending decisions; and (4) plausible changes in interest-sensitive spending in response to a monetary policy innovation match reasonably well with observed output responses to such innovations.

In this stylized view, monetary policy is represented by a change in the nominal supply of outside money. Of course, the quantity of much of the monetary base is likely to be endogenous.[6] Nonetheless, legal restrictions (for example, reserve requirements) may compel agents to use the outside asset for some transactions. In practice, the central bank's influence over nominal short-term interest rates (for example, the federal funds rate in the United States) is uncontroversial. There is also evidence that the real federal funds rate responds to a shift in policy (see, for example, Bernanke and Blinder, 1992).

Turning to the other assumptions, that long-term rates used in many saving and investment decisions should increase or decrease predictably in response to a change in short-term rates is not obvious a priori based on conventional models of the term structure. Empirical studies, however, have documented a significant, positive relationship between changes in the (nominal) federal funds rate and the 10-year Treasury bond rate (see, for example, Cohen and Wenninger, 1993; and Estrella and Hardouvelis, 1990). Finally, although many components of aggregate demand are arguably interest-sensitive (such as consumer durables, housing, business fixed investment, and inventory investment), output responses to monetary innovations are large relative to the generally small estimated effects of user costs of capital on investment.[7]

I shall characterize the money view as focusing on *aggregate*, as opposed to *distributional*, consequences of policy actions. In this view, higher default-risk-free rates of interest following a monetary contraction depress desired investment by firms and households. While desired investment falls, the reduction in business and household capital falls on the least productive projects. Such a view offers no analysis of distributional, or cross-sectional, responses to policy actions, nor of aggregate implications of this heterogeneity. I review these points not to suggest that standard interest rate approaches to the monetary transmission mechanism are incorrect, but to suggest strongly that one ought to expect that they are incomplete.

HOW REASONABLE IS THE CREDIT VIEW?

The search for a transmission mechanism broader than that just described reflects two concerns, one "macro" and one "micro." The macro concern, mentioned earlier, is that cyclical movements in aggregate demand—particularly business fixed investment and inventory investment—appear too large to be explained by monetary policy actions that have not generally led to large changes in real interest rates. This has pushed some macroeconomists to identify financial factors in propagating relatively small shocks, factors that correspond to accelerator models that explain investment data relatively well.[8] Indeed, I use the term "financial accelerator" (put forth by Bernanke, Gertler and Gilchrist,

[3] Fama's insight amplifies the earlier contribution of Brainard and Tobin (1963) that monetary policy can be analyzed through its effects on investor portfolios.

[4] More generally, in a model with many assets, this description would assign to the money view of the transmission mechanism effects on spending arising from any changes in the relative prices of assets.
While this simple two-asset-model description of the money view is highly stylized, it is consistent with a number of alternative models beyond the textbook IS-LM model (see, for example, Hubbard, 1994), including dynamic-equilibrium cash-in-advance models (for example, Rotemberg, 1984; and Christiano and Eichenbaum, 1992).

[5] For an empirical description of this transmission mechanism in the context of the Federal Reserve's forecasting model, see Mauskopf (1990).

[6] See, for example, "limited participation" models as in Lucas (1990) and Christiano and Eichenbaum (1992).

[7] See, for example, analyses of inventory investment in Kashyap, Stein and Wilcox (1993) and Gertler and Gilchrist (1993). See also the review of empirical studies of business fixed investment in Chirinko (1993) and Cummins, Hassett and Hubbard (1994).

[8] This current fashion actually has a long pedigree in macroeconomics, with important contributions by Fisher (1933), Gurley and Shaw (1955, 1960), Minsky (1964, 1975) and Wojnilower (1980). Some econometric forecasting models have also focused on financial factors in propagation mechanisms (see, for example, the description for the DRI model in Eckstein and Sinai, 1986). Cagan (1972) provides an empirical analysis of money and bank lending views. An early contributor to the contemporary credit view literature is Bernanke (1983).

forthcoming) to refer to the magnification of initial shocks by financial market conditions.

The micro concern relates to the emergence of a growing literature studying informational imperfections in insurance and credit markets. In this line of inquiry, problems of asymmetric information between borrowers and lenders lead to a gap between the cost of external finance and internal finance. The notion of costly external finance stands in contrast to the more complete-markets approach underlying the conventional interest rate channels, which does not consider links between real and financial decisions.[9]

Although a review of this literature is beyond the scope of this article, I want to mention three common empirical implications that have emerged from models of the financial accelerator.[10] The first, which I just noted, is that uncollateralized external finance is more expensive than internal finance. Second, the spread between the cost of external and internal finance varies inversely with the borrower's net worth—internal funds and collateralizable resources—relative to the amount of funds required. Third, an adverse shock to a borrower's net worth increases the cost of external finance and decreases the ability of the borrower to implement investment, employment and production plans. This channel provides the financial accelerator, magnifying an initial shock to net worth. (See, for example: Fazzari, Hubbard and Petersen, 1988; Gertler and Hubbard, 1988; Cantor, 1990; Hoshi, Kashyap and Scharfstein, 1991; Calomiris and Hubbard, forthcoming; Hubbard and Kashyap, 1992; Oliner and Rudebusch, 1992; Fazzari and Petersen, 1993; Hubbard, Kashyap and Whited, forthcoming; Bond and Meghir, 1994; Cummins, Hassett and Hubbard, 1994; Carpenter, Fazzari and Petersen, 1994; and Sharpe, 1994.)[11] Links between internal net worth and broadly defined investment (holding investment opportunities constant) have been corroborated in a number of empirical studies.[12]

Let me now extend this argument to include a channel for monetary policy.[13] In the money view, policy actions affect the overall level of real interest rates and interest-sensitive spending. The crux of models of information-related financial frictions is a gap between the cost of external and internal finance for many borrowers. In this context, the credit view offers channels through which monetary policy (open market operations or regulatory actions) can affect this gap. That is, the credit view encompasses distributional consequences of policy actions, because the costs of finance respond differently for different types of borrowers. Two such channels have been discussed in earlier work: (1) financial constraints on borrowers and (2) the existence of bank-dependent borrowers.

Financial Constraints On Borrowers

Any story describing a credit channel for monetary policy must have as its foundation the idea that some borrowers face high costs of external finance. In addition, models of a financial accelerator argue that the spread between the cost of external and internal funds varies inversely with the borrowers' net worth. It is this role of net worth which offers a channel through which policy-induced changes in interest rates affect borrowers' net worth (see, for example, Gertler and Hubbard, 1988). Intuitively, increases in the real interest rate in response to a monetary contraction increase borrowers' debt-service burdens and reduce the present value of collateralizable net worth, thereby increasing the marginal cost of external finance and reducing firms' ability to carry out desired investment and employment programs. This approach offers a credit channel even if open market operations have no direct quantity effect on banks' ability to lend. Moreover, this approach implies that spending by low-net-worth firms is likely to fall significantly following a monetary contraction (to the extent that the contraction reduces borrowers' net worth).

The Existence of Bank-Dependent Borrowers

The second channel stresses that some borrowers depend upon banks for external funds, and that policy actions can have a direct impact on the supply of loans. When banks are subject to reserve requirements on liabilities, a monetary contraction drains reserves,

[9] Potential effects of adverse selection problems on market allocation have been addressed in important papers by Akerlof (1970) and Rothschild and Stiglitz (1976), and have been applied to loan markets by Jaffee and Russell (1976) and Stiglitz and Weiss (1981), and to equity markets by Myers and Majluf (1984). Research on principal-agent problems in finance has followed the contribution of Jensen and Meckling (1976). Gertler (1988), Bernanke (1993) and King and Levine (1993) provide reviews of related models of informational imperfections in capital markets.

[10] See also the review in Bernanke, Gertler and Gilchrist (forthcoming). These implications are consistent with a wide class of models, including those of Townsend (1979), Blinder and Stiglitz (1983), Farmer (1985), Williamson (1987), Bernanke and Gertler (1989, 1990), Calomiris and Hubbard (1990), Sharpe (1990), Hart and Moore (1991), Kiyotaki and Moore (1993), Gertler (1992), Greenwald and Stiglitz (1988, 1993) and Lamont (1993).

[11] For households, Mishkin (1977, 1978) and Zeldes (1989) provide evidence of effects of household balance sheet conditions on consumer expenditures.

[12] The appendix presents a simple model that illustrates these predictions.

[13] For broader descriptions of credit view arguments, see Bernanke (1993), Friedman and Kuttner (1993), Gertler (1993), Gertler and Gilchrist (1993) and Kashyap and Stein (1994). An early exposition of a role for credit availability appears in Roosa (1951).

possibly decreasing banks' ability to lend. As a result, credit allocated to bank-dependent borrowers may fall, causing these borrowers to curtail their spending. In the IS-LM framework of Bernanke and Blinder (1988), both the IS and LM curves shift to the left in response to a monetary contraction. Alternatively, an adverse shock to banks' capital could decrease both banks' lending and the spending by bank-dependent borrowers. Such bank lending channels magnify the decline in output as a result of the monetary contraction, and the effect of the contraction on the real interest rate is muted. This basic story raises three questions, relating to: (1) why certain borrowers may be bank-dependent (that is, unable to access open market credit or borrow from nonbank financial intermediaries or other sources), (2) whether exogenous changes in banks' ability to lend can be identified, and (3) (for the analysis of open market operations) whether banks have access to sources of funds not subject to reserve requirements.

The first question is addressed, though not necessarily resolved, by the theoretical literature on the development of financial intermediaries[14]. In much of this research (see especially Diamond, 1984; and Boyd and Prescott, 1986), intermediaries offer low-cost means of monitoring some classes of borrowers. Because of informational frictions, non-monitored finance entails deadweight spending resources on monitoring. A free-rider problem emerges, however, in public markets with a large number of creditors. The problem is mitigated by having a financial intermediary hold the loans and act as a delegated monitor. Potential agency problems at the intermediary level are reduced by having the intermediary hold a diversified loan portfolio financed principally by publicly issued debt.[15] This line of research argues rigorously that borrowers for whom monitoring costs are significant will be dependent upon intermediaries for external finance,[16] and that costs of switching lenders will be high.[17] It does not, however, necessarily argue for bank dependence (for example, finance companies are intermediaries financed by non-deposit debt).

Second, even if one accepts the premise that some borrowers are bank-dependent in the sense described earlier, one must identify exogenous changes in banks' ability to lend. Four such changes have been examined in previous research. The first focuses on the role played by banking panics, in which depositors' flight to quality—converting bank deposits to currency or government debt—reduces banks' ability to lend (for empirical evidence, see Bernanke, 1983, and Bernanke and James, 1991, for the 1930s and Calomiris and Hubbard, 1989, for the National Banking period).

A second argument emphasizes regulatory actions, such as that under binding Regulation Q ceilings in the United States (see, for example, Schreft, 1990; Kashyap and Stein, 1994; and Romer and Romer, 1993) and regulation of capital adequacy (see, for example, Bernanke and Lown, 1992; and Peek and Rosengren, 1992).[18] Empirical evidence for this channel is quite strong. Third, Bizer (1993) suggests that increased regulatory scrutiny decreased banks' willingness to lend in the early 1990s, all else equal.

The fourth argument stresses exogenous changes in bank reserves as a result of shifts in monetary policy. In principle, such a shift in monetary policy could be identified with a discrete change in the federal funds rate in the aftermath of a dynamic open market operation or with a change in reserve requirements. Because the effects on reserves of changes in reserve requirements are generally offset by open market operations, bank-lending-channel stories are generally cast in terms of open market operations.

An illustration of the gap between models and practice surfaces in addressing the third question of the ease with which banks can raise funds from non-deposit sources (for example, CDs), when the Fed decreases reserves. Romer and Romer (1990) have pointed out, for example, that if banks see deposits and CDs as perfect substitutes, the link between open market operations and the supply of credit to bank-dependent borrowers is broken. Banks are unlikely, however, to face a perfectly elastic supply schedule for CDs at the prevailing CD interest rate. Since large-denomination CDs are not insured at the margin by federal deposit insurance, prospective lenders must ascertain the quality of the issuing bank's portfolio. Given banks' private information about at

[14] Models of equilibrium credit rationing under adverse selection (for example, Stiglitz and Weiss, 1981) offer another mechanism through which an increase in the level of default-risk-free real interest rates reduces loan supply. Credit rationing is not required for the bank-dependent-borrower channel to be operative. Instead, what is required is that loans to these borrowers are an imperfect substitute for other assets and that the borrowers lack alternative sources of finance.

[15] Calomiris and Kahn (1991) offer a model of demandable debt to finance bank lending.

[16] A substantial body of empirical evidence supports the idea that banks offer special services in the lending process. For example, James (1987) and Lummer and McConnell (1989) find that the announcement of a bank loan, all else equal, raises the share price of the borrowing firm, likely reflecting the information content of the bank's assessment. In a similar spirit, Fama (1985) and James (1987) find that banks' borrowers, rather than banks' depositors, bear the incidence of reserve requirements (indicating that borrowers must not have easy access to other sources of funds). Petersen and Rajan (1994) show that small businesses tend to rely on local banks for external funds.

[17] See, for example, the discussion in Petersen and Rajan (1994).

[18] Owens and Schreft (1992) discuss the identification of "credit crunches." See also the description in Hubbard (1994).

least a portion of their loan portfolio, adverse selection problems will increase the marginal cost of external finance as more funds are raised (see, for example, Myers and Majluf, 1984; and Lucas and McDonald, 1991). In addition, as long as *some* banks face constraints on issuing CDs and those banks lead to bank-dependent borrowers, a bank lending channel will be operative.

While the foregoing discussion centers on open market operations, regulatory actions by the central bank—credit controls, for example—represent another way in which monetary policy can have real effects through influencing the spending decisions of bank-dependent borrowers. Here the effects are likely to be more pronounced than for the case of open market operations, since the question of the cost of non-deposit sources of funds is no longer central, and the effectiveness of such regulatory actions depends only on the existence of bank-dependent borrowers.

GOING FROM MODELS TO EMPIRICAL RESEARCH

Both the financial-constraints-on-borrowers and bank-lending-channel mechanisms imply significant cross-sectional differences in firms' shadow cost of finance and in the response of that cost to policy-induced changes in interest rates. Accordingly, empirical researchers have attempted to test these cross-sectional implications. As I examine this literature, I explore how Modigliani-Miller violations for nonfinancial borrowers, financial intermediaries or both offer channels for monetary policy beyond effects on interest rates. The appendix frames this discussion using a simple model; an intuitive presentation follows.

EMPIRICAL RESEARCH ON THE CREDIT VIEW

Studies Using Aggregate Data

The microeconomic underpinnings of both financial accelerator models and the credit view of monetary policy hinge on certain groups of borrowers (perhaps including banks or other financial intermediaries) facing incomplete financial markets. Examining links between the volume of credit and economic activity in aggregate data (with an eye toward studying the role played by bank-dependent borrowers) requires great care. Simply finding that credit measures lead output in aggregate time-series data is also consistent with a class of models in which credit is passive, responding to finance expected future output (as in King and Plosser, 1984). Consider the case of a monetary contraction, for example. The effect of the contraction on interest rates could depress desired consumption and investment spending, reducing the demand for loans.

In a clever paper that has stimulated a number of empirical studies, Kashyap, Stein and Wilcox (1993)—henceforth, KSW—examine relative fluctuations in the volume of bank loans and a close open market substitute, issuance of commercial paper. In the KSW experiment, upward or downward shifts in both bank lending and commercial paper issuance likely reflect changes in the *demand* for credit. However, a fall in bank lending while commercial paper issuance is rising might suggest that bank loan *supply* is contracting. To consider this potential co-movement, KSW focus on changes over time in the mix between bank loans and commercial paper (defined as bank loans divided by the sum of bank loans and commercial paper). They find that, in response to increases in the federal funds rate (or, less continuously, at the times of the contractionary policy shifts identified by Romer and Romer, 1989), the volume of commercial paper issues rises, while bank loans gradually decline. They also find that policy-induced changes in the mix have independent predictive power for inventory and fixed investment, holding constant other determinants.[19]

The aggregate story told by KSW masks significant firm-level heterogeneity, however. The burden of a decline in bank loans following a monetary contraction is borne by smaller firms (see Gertler and Gilchrist, 1994).[20] Moreover, the evidence in Oliner and Rudebusch (1993) indicates that once trade credit is incorporated in the definition of small firms' debt and once firm size is held

[19] Oliner and Rudebusch (1993) and Friedman and Kuttner (1993) have disputed the KSW interpretation of the mix as measuring a substitution between bank loans and commercial paper. They argue that, during a recession, shifts in the mix are explained by an increase in commercial paper issuance rather than by a decrease in bank loans.

[20] Morgan (1993) finds a similar result in an analysis of loan commitments. After an episode of monetary contraction, firms without loan commitments receive a smaller share of bank loans.

constant, monetary policy changes do not alter the mix.

It also does not appear that bank-dependent borrowers switch to the commercial paper market following a monetary contraction. Instead, the increase in commercial paper issuance reflects borrowing by large firms with easy access to the commercial paper market, possibly to smooth fluctuations in their flow of funds when earnings decline (Friedman and Kuttner, 1993) or to finance loans to smaller firms (Calomiris, Himmelberg and Wachtel, forthcoming).

Studies Focusing on Cross-Sectional Implications

More convincing empirical tests focus on the *cross-sectional* implication of the underlying theories—namely that credit-market imperfections affect investment, employment or production decisions of some borrowers more than others. At one level, existing cross-sectional empirical studies have been successful: There is a substantial body of empirical evidence documenting that proxies for borrowers' net worth affect investment more for low-net-worth borrowers than for high-net-worth borrowers (holding constant investment opportunities). This suggests that, to the extent that monetary policy can affect borrowers' net worth, pure interest rate effects of open market operations will be magnified.

The second body of empirical analysis of information-related imperfections focuses on the effects of monetary policy on borrowers' balance sheets. Gertler and Hubbard (1988) conclude that, all else equal, internal funds have a greater effect on investment by non-dividend-paying firms during recessions. The evidence of Gertler and Gilchrist (1994) is particularly compelling here. Analyzing the behavior of manufacturing firms summarized in the *Quarterly Financial Reports* data, Gertler and Gilchrist consider differences in small and large firms' responses to tight money (as measured by federal funds rate innovations or the dates identified by Romer and Romer, 1989). In particular, small firms' sales, inventories and short-term debt decline relative to those for large firms over a two-year period following a monetary tightening, results consistent with the financial accelerator approach. They also demonstrate that the effects of shifts in monetary policy on the small-firm variables are sharper in periods when the small-firm sector as a whole is growing more slowly, also consistent with the financial accelerator approach. Finally, they show that the ratio of cash flow to interest expense (a measure of debt-service capacity) is associated positively with inventory accumulation for small, but not for large, manufacturing firms.

The Gertler and Gilchrist results, which are very much in the spirit of the earlier cross-sectional tests of financial accelerator models, have been borne out for studies of fixed investment by Oliner and Rudebusch (1994) and for inventory investment by Kashyap, Lamont and Stein (1994).[21] In addition, Ramey (1993) shows that, for forecasting purposes, the ratio of the sales growth of small firms to that for large firms offers significant information about future GDP.

Finally, using the firm-level data underlying the aggregates summarized in the *Quarterly Financial Reports*, Bernanke, Gertler and Gilchrist (forthcoming) analyze the differences in sales and inventories between large and small manufacturing firms by two-digit industry. They find that fluctuations in the large firm-small firm differences are roughly the same size as fluctuations in the corresponding aggregate fluctuations for the manufacturing sector. Because small firms' sales (as they define small firms) comprise about one-third of the sales of the manufacturing sector, roughly one-third of cyclical fluctuations in manufacturing sales can be explained by large firm-small firm differences.

Assessing the Bank Lending Channel

While the principal empirical predictions of the financial accelerator approach have been corroborated in micro-data studies and low-net-worth firms appear to respond differentially to monetary contractions, the question of the role of *banks* remains. I consider this question below in three steps.

First, is there evidence of significant

[21] Toward this end, more direct comparisons of borrowing by bank-dependent and nonbank-dependent borrowers have been offered. Using firm-level data, Kashyap, Lamont and Stein (1994)—henceforth KLS—follow the Fazzari, Hubbard and Petersen (1988) approach of classifying groups of firms as a priori finance-constrained (in this case, bank-dependent) or not. In particular, they study inventory investment by publicly traded firms with and without bond ratings, as a proxy for bank dependence. Focusing on the 1982 recession (as an indirect means of identifying a period following a tight money episode), they find that inventory investment by non-rated firms was influenced, all else equal, by the firms' own cash holdings, an effect not present for the inventory investment by rated firms. In subsequent boom years (which KLS identify with an easy money episode), they find little effect of cash holdings on inventory investment for either non-rated or rated companies. These patterns lead KLS to conclude that a bank lending channel was operative in response to the monetary contraction. However, the KLS results are consistent with a more general model in which low-net-worth firms face more costly external finance in downturns.

departures from Modigliani and Miller's results for certain groups of banks in the sense that have been identified for firms? Second, is there evidence that small- or low-net-worth firms are more likely to be the loan customers of such banks? Finally, do low-net-worth firms have limited opportunities to substitute credit from unconstrained financial institutions when cut off by constrained financial institutions?

Applying the Modigliani and Miller Theorem for Banks

Kashyap and Stein (1994) apply the intuition of the models of effects of internal net worth on investment decisions by nonfinancial firms to study financing and lending decisions by banks. This is an important line of inquiry in the bank lending channel research agenda, because it addresses the ease with which banks can alter their financing mix in response to a change in bank reserves and the effect of changes in the financing mix on the volume of bank lending. Just as earlier studies focused on cross-sectional differences in financing and real decisions of nonfinancial firms of different size, Kashyap and Stein analyze cross-sectional differences in financing and lending decisions of banks of different size. To do this, they use data drawn from the quarterly "Call Reports" collected by the Federal Reserve.

Kashyap and Stein construct asset size groupings for large banks (those in the 99th percentile) and small banks (defined as those at or below the 75th, 90th, 95th or 98th percentiles). They first show that contractionary monetary policy (measured by an increase in the federal funds rate) leads to a similar reduction in the growth rate of nominal core deposits for all bank size classes. They find significant heterogeneity across bank size classes, however, in the response of the volume of lending to a change in monetary policy. In particular, a monetary contraction leads to an increase in lending in the short run by very large banks. This is in contrast to a decline in lending in the short run by smaller banks. These do not simply reflect differences in the type of loans made by large and small banks. A similar pattern emerges when loans are disaggregated to include just commercial and industrial loans.

One possible explanation for the Kashyap and Stein pattern is that a monetary contraction weakens the balance sheet positions of small firms relative to large firms. If small firms tend to be the customers of small banks and large firms tend to be the customers of large banks, a fall in loan demand (by small borrowers) for small banks could be consistent with the differential lending responses noted by Kashyap and Stein. To examine this possibility, Kashyap and Stein analyze whether small banks increase their holdings of securities relative to large banks during a monetary contraction. They actually find that small banks' securities holdings are less sensitive to monetary policy than large banks' securities holdings, though the difference in the responses is not statistically significant.

The use of bank size as a measure to generate cross-sectional differences does not correspond precisely to the underlying theoretical models, which stress the importance of net worth. In this context, bank capital may be a better proxy. Peek and Rosengren (forthcoming) analyze the lending behavior of New England banks over the 1990-91 recession. Their results indicate that the loans of well capitalized banks fell by less than the loans of poorly capitalized banks.[22] Hence, as with the Kashyap and Stein findings, their evidence suggests there are effects of informational imperfections in financial markets on the balance sheets of intermediaries as well as borrowers.

Matching Borrowers and Lenders

The last two questions relate to the matching of borrowers and lenders. The former asks whether the firms identified by empirical researchers as finance-constrained are the loan customers of the constrained (small) banks such as those identified by Kashyap and Stein. This line of inquiry requires an examination of data on individual loan transactions, with information on characteristics of the borrower, lender and lending terms.[23] One could establish whether constrained firms are the customers of constrained banks and whether such firms

[22] Using data on commercial banks nationwide over the 1979-92 period, Berger and Udell (1994) found little evidence that the introduction of risk-based capital requirements per se affected credit allocation. Hancock, Laing and Wilcox (1994) also use quarterly data on individual bank's portfolios to estimate the responsiveness of portfolio composition to changes in capital requirements. They find that "capital shortfall" institutions reduced their C&I loans response by larger total amounts, all else equal, than "capital surplus" institutions.

[23] Anil Kashyap, Darius Palia and I are currently engaged in such an analysis.

switch from constrained banks to unconstrained ones during episodes of monetary contractions. Theories emphasizing the importance of ongoing borrower-lender relationships imply that such switches are costly and unlikely. If true, part of the monetary transmission mechanism takes place through reductions in loan supply by constrained banks.

The latter of the two questions suggests the need to study a broader class of lenders than banks. If borrowers from constrained banks can switch at low cost to nonbank lenders following a monetary contraction, the narrow bank credit channel of monetary policy is frustrated. In this vein, Calomiris, Himmelberg and Wachtel (forthcoming) analyze firm-level data on commercial paper issuance and argue that large, high-quality, commercial paper-issuing firms increase paper borrowings during downturns to finance loans to smaller firms.[24] They note that accounts receivable rise for paper-issuing firms, supporting the notion that these firms may serve as trade credit intermediaries for smaller firms in some periods. From the standpoint of the bank lending channel, it is important to establish what happens to the costs and terms imposed by these intermediaries. If, on the one hand, such terms are no more costly than bank intermediary finance, then the switch of borrowers from being bank customers to being trade credit customers entails very limited macroeconomic effects. On the other hand, if large, paper-issuing firms accept their intermediary role reluctantly, very costly trade credit may exacerbate a downturn by raising the cost of funds for constrained firms. More empirical investigation of trade credit terms is needed to resolve this question.

Empirical Research on Conventional Interest Rate Channels

More empirical research is also needed to assess the validity of the basic money view. A central problem is that, while most empirical studies focus on monetary aggregates such as M2, the theoretical description offered in the first section suggests an emphasis on outside money and, importantly, on components of outside money over which the central bank can exercise exogenous control. First identifying exogenous changes in monetary policy is difficult.[25] Recent research by Bernanke and Blinder (1992) and Christiano, Eichenbaum and Evans (forthcoming) offers promising strategies for studying the effects of monetary policy shocks.

In addition, recent analyses of policy-reduced-form models document a significant, negative relationship in quarterly data between the percentage change in real GDP relative to potential GDP and the change in the federal funds rate.[26] Such studies must first confront the possibility that the measured interest sensitivity of output reflects links between interest rate and net worth changes for certain groups of borrowers/spenders. A second issue, noted by Morgan (1993) and Cohen and Wenninger (1993), is that quarterly residuals from estimated policy-reduced-form equations display large negative errors during recessions, suggesting the possibility of an asymmetric response of economic activity to increases or decreases in the federal funds rate.[27] Finally, more theoretical and empirical research is needed to examine links between changes in short-term real interest rates (which are significantly influenced by policy actions) and changes in long-term real interest rates (which affect firms' cost of capital).

CONCLUSION AND IMPLICATIONS FOR MONETARY POLICY

This survey argues that the terms money view and credit view are not always well-defined in theoretical and empirical debates over the transmission mechanism of monetary policy. Recent models of information and incentive problems in financial markets suggest the usefulness of decomposing the transmission mechanism into two parts: one related to effects of policy-induced changes on the overall level of real costs of funds; and one related to magnification (or financial accelerator effects) stemming from impacts of policy actions on the financial positions of borrowers and/or intermediaries.

Two observations emerge clearly from the literature. First, the spending decisions

[24] Another possibility is that the weakened balance sheet positions of many borrowers precipitates a "flight to quality" by lenders generally, increasing the demand for commercial paper issues of large firms.

[25] The dates of monetary policy contractions suggested by Romer and Romer (1989) have generated significant controversy. Shapiro (1994) argues, for example, that empirical evidence favors the hypothesis that several Romer dates are predictable using measures of unemployment and inflation as determinants of actions by the Federal Open Market Committee; see also the discussion in Cecchetti (1995). Hoover and Perez (1994) offer a number of criticisms of the Romers' approach.

[26] Such relationships are typically estimated as:

$$Y(t) = a + bY(t-i) - cH(t-i) - dF(t-i),$$

where Y is the percentage change in real GDP relative to potential GDP, H is the percentage change in the high-employment federal budget surplus, F is the change in the federal funds rate, t is the current time period, and i denotes lags. See, for example, Hirtle and Kelleher (1990), Perry and Schultze (1992) and Cohen and Wenninger (1993).

[27] Cover (1992) finds still stronger evidence of asymmetric effects when monetary aggregates are used as the policy indicator instead of the federal funds rate.

of a significant group of borrowers are influenced by their balance sheet condition in the ways described by financial accelerator models. Second, even in the presence of more sophisticated financial arrangements, there are still information costs of screening, evaluation and monitoring in the credit process, imparting a special role for intermediaries (be they banks or other lenders) with cost advantages in performing these tasks.[28]

The first observation suggests that financial factors are likely to continue to play a role in business fluctuations. The second suggests that regulatory policies affecting information-specializing intermediaries are likely to affect the cost of credit for at least some borrowers. In part because of interest in alternative views of the monetary transmission mechanism and in part because of concern over the effects of institutional change in the financial system, academics and policymakers are analyzing whether the scope for monetary policy to affect real outcomes is becoming narrower. Both observations noted above are consistent with a heightened role for monetary policy in affecting real decisions of firms with weak balance sheet positions. Developing ways to incorporate borrower heterogeneity in both economic models of money and credit and in forecasting is an important, practical task for economic modelers and policymakers.

Whether the simplest bank lending channel—that a fall in banks' reserves following contractionary open market operations decreases both banks' ability to lend and borrowers' ability to spend—is operative is not clear, however. More micro-evidence at the level of individual borrower-lender transactions is needed to resolve this question. At the same time, proponents of the simplest characterization of an interest rate channel must address both the cross-sectional heterogeneity in firms' response to monetary policy and the extent to which observed interest rate effects on output reflect differentially large effects of policy on certain classes of borrowers.

REFERENCES

Akerlof, George. "The Market for Lemons: Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics* (August 1970), pp. 488-500.

Berger, Allen N., and Gregory F. Udell. "Did Risk-Based Capital Allocate Bank Credit and Cause a 'Credit Crunch' in the U.S.?" (part two) *Journal of Money, Credit and Banking* (August 1994), pp. 585-628.

Bernanke, Ben S. "Credit in the Macroeconomy," Federal Reserve Bank of New York *Quarterly Review* (spring 1993), pp. 50-70.

________. "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression," *The American Economic Review* (June 1983), pp. 257-76.

________ and Alan S. Blinder. "The Federal Funds Rate and the Channels of Monetary Transmission," *The American Economic Review* (September 1992), pp. 901-21.

________ and ________. "Credit, Money, and Aggregate Demand," *The American Economic Review* (May 1988), pp. 435-39.

________ and Mark Gertler. "Agency Cost, Net Worth, and Business Fluctuations," *The American Economic Review* (March 1989), pp. 14-31.

________ and ________. "Financial Fragility and Economic Performance," *Quarterly Journal of Economics* (February 1990), pp. 87-114.

________, ________ and Simon Gilchrist. "The Financial Accelerator and the Flight to Quality," *Review of Economics and Statistics* (forthcoming).

________ and Harold James. "The Gold Standard, Deflation, and Financial Crisis in the Great Depression: An International Comparison," in R. Glenn Hubbard, ed., *Financial Markets and Financial Crises.* University of Chicago Press, 1991.

________ and Cara S. Lown. "The Credit Crunch." *Brookings Papers on Economic Activity* (1992:2), pp. 205-39.

Bizer, David S. "Regulatory Discretion and the Credit Crunch," working paper (April 1993), U.S. Securities and Exchange Commission.

Blinder, Alan S., and Joseph E. Stiglitz. "Money, Credit Constraints, and Economic Activity," *The American Economic Review* (May 1983), pp. 297-302.

Bond, Stephen, and Costas Meghir. "Dynamic Investment Models and the Firm's Financial Policy," *Review of Economic Studies* (April 1994), pp. 197-222.

Boyd, John H., and Mark Gertler, "Are Banks Dead? Or, Are the Reports Greatly Exaggerated?" working paper (May 1994), Federal Reserve Bank of Minneapolis.

________ and Edward Prescott. "Financial Intermediary-Coalitions," *Journal of Economic Theory* (April 1986), pp. 211-32.

________ and Bruce D. Smith. "Capital Market Imperfections in a Monetary Growth Model," *Working Paper No. 533* (August 1994), Federal Reserve Bank of Minneapolis.

Brainard, William C., and James Tobin. "Financial Intermediaries and the Effectiveness of Monetary Controls," *The American Economic Review* (May 1963), pp. 383-400.

Cagan, Phillip. *The Channels of Monetary Effects on Interest Rates.* Columbia University Press, 1972.

[28] For recent analyses of the future of banking, see Gorton and Pennacchi (1993), Edwards (1993) and Boyd and Gertler (1994). Thornton (1994) discusses likely effects of recent financial innovations on the bank lending channel.

Calomiris, Charles W., Charles P. Himmelberg and Paul Wachtel. "Commercial Paper and Corporate Finance: A Microeconomic Perspective," *Carnegie-Rochester Conference Series on Public Policy* (forthcoming).

________ and R. Glenn Hubbard. "Firm Heterogeneity, Internal Finance, and 'Credit Rationing,'" *Economic Journal* (March 1990), pp. 90-104.

________ and ________. "Price Flexibility, Credit Availability, and Economic Fluctuations: Evidence from the United States, 1894-1909," *Quarterly Journal of Economics* (August 1989), pp. 429-52.

________ and ________. "Tax Policy, Internal Finance, and Investment: Evidence from the Undistributed Profits Tax of 1936-37," *Journal of Business* (forthcoming).

________ and Charles Kahn. "The Role of Demandable Debt in Structuring Optimal Banking Arrangements," *The American Economic Review* (June 1991), pp. 497-513.

Cantor, Richard. "Effects of Leverage on Corporate Investment and Hiring Decisions." Federal Reserve Bank of New York *Quarterly Review* (summer 1990), pp. 31-41.

________ and Anthony P. Rodrigues. "Nonbank Lenders and the Credit Slowdown," in *Studies on Causes and Consequences of the 1984-1992 Credit Slowdown.* Federal Reserve Bank of New York, 1994.

Carpenter, Robert, Steven M. Fazzari and Bruce C. Petersen. "Inventory (Dis)investment, Internal Finance Fluctuations, and the Business Cycle," *Brookings Papers on Economic Activity* (1994:2).

Cecchetti, Stephen G. "Distinguishing Theories of the Monetary Transmission Mechanism," this *Review* (May/June 1995), pp. 83-100.

Chirinko, Robert S. "Business Fixed Investment Spending: A Critical Survey," *Journal of Economic Literature* (December 1993), pp. 1875-911.

Christiano, Lawrence, and Martin S. Eichenbaum. "Liquidity Effects and the Monetary Transmission Mechanism," *The American Economic Review* (May 1992), pp. 346-53.

________, ________, and Charles Evans. "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *Review of Economics and Statistics* (forthcoming).

Cohen, Gerald, and John Wenninger. "The Relationship Between the Federal Funds Rate and Economic Activity," working paper (December 1993), Federal Reserve Bank of New York.

Cover, John Perry. "Asymmetric Effects of Positive and Negative Money Supply Shocks," *Quarterly Journal of Economics* (November 1992), pp. 1261-82.

Cummins, Jason G., Kevin A. Hassett and R. Glenn Hubbard. "A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments," *Brookings Papers on Economic Activity* (1994:2), pp. 1-74.

Diamond, Douglas W. "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies* (July 1984), pp. 393-414.

Eckstein, Otto, and Allen Sinai. "The Mechanisms of the Business Cycle in the Postwar Era," in Robert J. Gordon, ed., *The American Business Cycle: Continuity and Change.* University of Chicago Press, 1986.

Edwards, Franklin R. "Financial Markets in Transition—Or the Decline of Commercial Banking," in *Changing Capital Markets: Implications for Monetary Policy.* Federal Reserve Bank of Kansas City, 1993.

Estrella, Arturo, and Gikas Hardouvelis. "Possible Roles of the Yield Curve in Monetary Policy," *in Intermediate Targets and Indicators of Monetary Policy: A Critical Survey, 1990.* Federal Reserve Bank of New York, 1990, pp. 339-62.

Fama, Eugene F. "Banking in the Theory of Finance," *Journal of Monetary Economics* (January 1980), pp. 39-57.

Fama, Eugene F. "What's Different About Banks?" *Journal of Monetary Economics* (June 1985), pp. 29-39.

Farmer, Roger E.A. "Implicit Contracts with Asymmetric Information and Bankruptcy: The Effect of Interest Rates on Layoffs," *Review of Economic Studies* (July 1985), pp. 427-42.

Fazzari, Steven M., and Bruce C. Petersen. "Working Capital and Fixed Investment: New Evidence on Financing Constraints." *RAND Journal of Economics* (autumn 1993), pp. 328-42.

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Petersen. "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity* (1988:1), pp. 141-95.

Federal Reserve Bank of New York. *Studies on Causes and Consequences of the 1989-1992 Credit Slowdown*, February 1994.

Fisher, Irving. "The Debt-Deflation Theory of Great Depressions." *Econometrica 1* (October 1933), pp. 337-57.

Friedman, Benjamin M., and Kenneth N. Kuttner. "Economic Activity and the Short-Term Credit Markets: An Analysis of Prices and Quantities," *Brookings Papers on Economic Activity* (1993:2), pp. 193-266.

Gertler, Mark. "Comment" on Christina D. Romer and David H. Romer, "Credit Channel or Credit Actions?: An Interpretation of the Postwar Transmission Mechanism," in *Changing Capital Markets: Implications for Monetary Policy.* Federal Reserve Bank of Kansas City, 1993.

________. "Financial Capacity and Output Fluctuations in an Economy with Multi-period Financial Relationships," *Review of Economic Studies* (1992), pp. 455-72.

________. "Financial Structure and Aggregate Economic Activity: An Overview," *Journal of Money, Credit and Banking* (August 1988, part 2), pp. 559-88.

________ and Simon Gilchrist. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics* (May 1994), pp. 309-40.

________ and ________. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence," *Scandinavian Journal of Economics* (No. 1, 1993), pp. 43-64.

Gertler, Mark, and R. Glenn Hubbard. "Corporate Financial Policy, Taxation, and Macroeconomic Risk." *RAND Journal of Economics* (summer 1993), pp. 286-303.

________ and ________. "Financial Factors in Business Fluctuations," *Financial Market Volatility*. Federal Reserve Bank of Kansas City, 1988.

Gorton, Gary, and George Pennacchi. "Money Market Funds and Finance Companies: Are They Banks of the Future?" in Michael Klausner and Lawrence J. White, eds., *Structural Change in Banking*. Irwin Publishing, 1993, pp. 173-214.

Greenwald, Bruce C., and Joseph E. Stiglitz. "Financial Market Imperfections and Business Cycles," *Quarterly Journal of Economics* (February 1993), pp. 77-114.

________ and ________. "Information, Finance Constraints, and Economic Activity," in Meir Kohn and S.C. Tsiang, eds., *Finance Constraints, Expectations, and Economic Activity*. Oxford University Press, 1988.

Gurley, John, and Edward Shaw. *Money in a Theory of Finance*. Brookings Institution, 1960.

________ and ________. "Financial Aspects of Economic Development," *The American Economic Review* (September 1955), pp. 515-38.

Hancock, Diana, Andrew J. Laing and James A. Wilcox. "Bank Capital Shocks: Dynamic Effects on Securities, Loans, and Capital," working paper (August 1994), Board of Governors of the Federal Reserve System.

Hardouvelis, Gikas, and Thierry Wizman. "The Relative Cost of Capital for Marginal Firms Over the Business Cycle," Federal Reserve Bank of New York *Quarterly Review* (autumn 1992), pp. 59-68.

Hart, Oliver, and John Moore. "A Theory of Debt Based on the Inalienability of Human Capital," *Discussion Paper No. 129* (1991), London School of Economics, Financial Markets Group.

Hirtle, Beverly, and Jeanette Kelleher. "Financial Market Evolution and the Interest Sensitivity of Output." Federal Reserve Bank of New York *Quarterly Review* (summer 1990), pp. 56-70.

Hoover, Kevin D., and Stephen J. Perez. "Post Hoc Ergo Propter Once More: An Evaluation of `Does Monetary Policy Matter?' in the Spirit of James Tobin," *Journal of Monetary Economics* (August 1994), pp. 47-73.

Hoshi, Takeo, Anil K. Kashyap and David Scharfstein. "Corporate Structure, Liquidity and Investment: Evidence from Japanese Panel Data," *Quarterly Journal of Economics* (February 1991), pp. 33-60.

Hubbard, R. Glenn. *Money, the Financial System and the Economy*. Addison-Wesley, 1994.

________ and Anil K. Kashyap.. "Internal Net Worth and the Investment Process: An Application to U.S. Agriculture," *Journal of Political Economy* (June 1992), pp. 506-34.

________, ________ and Toni Whited. "Internal Finance and Firm Investment," *Journal of Money, Credit and Banking* (forthcoming).

Jaffee, Dwight, and Thomas Russell. "Imperfect Information, Uncertainty and Credit Rationing," *Quarterly Journal of Economics* (November 1976), pp. 651-66.

James, Christopher. "Some Evidence on the Uniqueness of Bank Loans," *Journal of Financial Economics* (1987), pp. 217-36.

Jensen, Michael, and William Meckling. "Theory of the Firm: Management Behavior, Agency Costs, and Ownership Structure," *Journal of Financial Economics* (October 1976), pp. 305-60.

Kashyap, Anil K., and Jeremy C. Stein. "Monetary Policy and Bank Lending," in N. Gregory Mankiw, ed., *Monetary Policy*. University of Chicago Press for the National Bureau of Economic Research, 1994a, pp. 221-62.

________ and ________. "The Impact of Monetary Policy on Bank Balance Sheets," *Carnegie-Rochester Conference Series on Public Policy* (forthcoming).

________, ________ and David Wilcox. "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance," *The American Economic Review* (March 1993), pp. 78-98.

________, Owen A. Lamont and Jeremy Stein. "Credit Conditions and the Cyclical Behavior of Inventories: A Case Study of the 1981-82 Recession," *Quarterly Journal of Economics* (August 1994), pp. 565-92.

King, Robert G., and Charles Plosser. "Money, Credit and Prices in a Real Business Cycle," *The American Economic Review* (June 1984), pp. 363-80.

________ and Ross Levine. "Finance and Growth: Schumpeter Might Be Right," *Quarterly Journal of Economics* (August 1993), pp. 717-38.

Kiyotaki, Nobuhiro, and John Moore. "Credit Cycles." mimeo (March 1993), London School of Economics.

Kliesen, Kevin L., and John A. Tatom. "The Recent Credit Crunch: The Neglected Dimensions," this *Review* (September/October 1992), pp. 18-36.

Lamont, Owen S. "Corporate Debt Overhang and Macroeconomic Vulnerability," working paper (1993), Massachusetts Institute of Technology.

Lucas, Robert E., Jr. "Liquidity and Interest Rates," *Journal of Economic Theory* (1990), pp. 237-64.

Lucas, Deborah J., and Robert L. McDonald. "Bank Financing and Investment Decisions with Asymmetric Information About Loan Quality," *RAND Journal of Economics* (winter 1991), pp. 86-105.

Lummer, Scott, and John McConnell. "Further Evidence on the Bank Lending Process and Capital Market Response to Bank Loan Agreements," *Journal of Financial Economics* (1989), pp. 99-122.

Mauskopf, Eileen. "The Transmission Channels of Monetary Policy: How They Have Changed," *Federal Reserve Bulletin* (December 1990), pp. 985-1008.

Minsky, Hyman P. *John Maynard Keynes*. Columbia University Press, 1975.

________. "Financial Crisis, Financial Systems, and the Performance of the Economy," in *Commission on Money and Credit, Private Capital Markets*. Prentice-Hall, 1964.

Mishkin, Frederic S. "The Household Balance Sheet and the Great Depression," *Journal of Economic History* (1978), pp. 918-37.

Mishkin, Frederic S. "What Depressed the Consumer?: The Household Balance Sheet and the 1973-75 Recession," *Brookings Papers on Economic Activity* (1977:1), pp. 123-64.

Modigliani, Franco, and Merton Miller. "The Cost of Capital, Corporation Finance and the Theory of Investment," *The American Economic Review* (June 1958), pp. 261-97.

Morgan, Donald P. "The Lending View of Monetary Policy and Bank Loan Commitments." working paper (July 1993), Federal Reserve Bank of Kansas City.

________. "Asymmetric Effects of Monetary Policy." Federal Reserve Bank of Kansas City *Economic Review* (second quarter 1993), pp. 21-33.

Myers, Stewart, and Nicholas Majluf. "Corporate Financing and Investment Decisions When Firms Have Information that Investors Do Not Have," *Journal of Financial Economics* (1984), pp. 187-221.

Oliner, Stephen D., and Glenn D. Rudebusch. "Is There a Bank Credit Channel for Monetary Policy?" Board of Governors of the Federal Reserve System, Finance and Economics Division *Discussion Paper No. 93-8* (February 1993).

________ and ________. "Sources of the Financing Hierarchy for Business Investment," *Review of Economics and Statistics* (November 1992), pp. 643-54.

Owens, Raymond, and Stacey Schreft. "Identifying Credit Crunches," Federal Reserve Bank of Richmond *Working Paper No. 92-1* (March 1992).

Peek, Joe, and Eric Rosengren. "The Capital Crunch: Neither a Borrower Nor a Lender Be," *Journal of Money, Credit and Banking* (forthcoming).

________ and ________. "The Capital Crunch in New England." Federal Reserve Bank of Boston *New England Economic Review* (May-June 1992), pp. 21-31.

Perry, George L., and Charles L. Schultze. "Was This Recession Different? Are They All Different?" *Brookings Papers on Economic Activity* (1993:1), pp. 145-211.

Petersen, Mitchell A., and Raghuram G. Rajan. "The Benefits of Firm-Creditor Relationships: Evidence from Small Business Data," *Journal of Finance* (March 1994), pp. 3-38.

Ramey, Valerie. "How Important is the Credit Channel in the Transmission of Monetary Policy?" *Carnegie-Rochester Conference Series on Public Policy* (December 1993), pp. 1-45.

Romer, Christina D., and David H. Romer. "Credit Channel or Credit Actions?: An Interpretation of the Postwar Transmission Mechanism," in *Changing Capital Markets: Implications for Monetary Policy.* Federal Reserve Bank of Kansas City, 1993.

________ and ________. "New Evidence on the Monetary Transmission Mechanism," *Brookings Papers on Economic Activity* (1990:1), pp. 149-213.

________ and ________. "Does Monetary Policy Matter?: A New Test in the Spirit of Friedman and Schwartz," in Olivier J. Blanchard and Stanley Fischer, eds., National Bureau of Economic Research *Macroeconomics Annual.* MIT Press, 1989, pp. 121-70.

Roosa, Robert V. "Interest Rates and the Central Bank," in *Money, Trade, and Economic Growth: Essays in Honor of John H. Williams.* Macmillan, 1951.

Rotemberg, Julio J. "A Monetary Equilibrium Model with Transactions Costs," *Journal of Political Economy* (February 1984), pp. 40-58.

Rothschild, Michael, and Joseph E. Stiglitz. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics* (November 1976), pp. 630-49.

Schreft, Stacey. "Credit Controls: 1980," Federal Reserve Bank of Richmond *Economic Review* (November-December 1990), pp. 25-55.

Shapiro, Matthew D. "Federal Reserve Policy: Cause and Effect," in N. Gregory Mankiw, ed., *Monetary Policy.* University of Chicago Press, 1994, pp. 207-34.

Sharpe, Steven. "Asymmetric Information, Bank Lending, and Implicit Contracts: A Stylized Model of Customer Relationships," *Journal of Finance* (September 1990), pp. 1069-87.

Stiglitz, Joseph E., and Andrew Weiss. "Credit Rationing in Markets with Imperfect Information," *The American Economic Review* (June 1981), pp. 393-410.

Thornton, Daniel L. "Financial Innovation, Deregulation and the "Credit View" of Monetary Policy," this *Review* (January/February 1994), pp. 31-49.

Townsend, Robert. "Optimal Contracts and Competitive Markets with Costly State Verification," *Journal of Economic Theory* (October 1979), pp. 265-93.

Williamson, Stephen. "Costly Monitoring, Optimal Contracts, and Equilibrium Credit Rationing," *Quarterly Journal of Economics* (February 1987), pp. 135-45.

Wojnilower, Albert. "The Central Role of Credit Crunches in Recent Financial History," *Brookings Papers on Economic Activity* (1980:2), pp. 277-326.

Zeldes, Stephen P. "Consumption and Liquidity Constraints: An Empirical Investigation," *Journal of Political Economy* (April 1989), pp. 305-46.

Appendix

THE FINANCIAL ACCELERATOR AND THE CREDIT VIEW

There are three basic conclusions of models of financial frictions relating to asymmetric information between borrowers and lenders: (1) Uncollateralized external finance is more costly than internal finance; (2) the spread between the cost of external and internal funds varies negatively with the level of the borrower's internal funds; and (3) a reduction in internal funds reduces the borrower's spending, holding constant underlying investment opportunities. I illustrate these conclusions (and link them to empirical tests of credit view models) below in a simple model of firm investment decisions adapted from Gertler and Hubbard (1988).

Consider two periods—zero and one. In the first, a risk-neutral borrower uses inputs to produce output Y to sell in the second period. These inputs are hard capital, K—say, machinery—and soft capital, C—inputs which improve the productivity of hard capital (such as organizational or maintenance expenditures). The production technology is risky, with two possible productivity states, "good" and "bad"; uncertainty is realized after the investment decision is made.

To make the example as simple as possible, suppose the firm can increase the chance of a good output realization if it uses a sufficient quantity of soft capital, where sufficient is defined by a level proportional to the quantity of hard capital used. In particular, let output Y satisfy:

(1A) $$Y = f(K), \text{ with probability } \pi^g,$$

and

$$Y = \alpha f(K), \text{ with probability } \pi^b,$$

if

$$C \geq \nu K,$$

and

(2A) $$Y = \alpha f(K),$$

if

$$C < \nu K,$$

where $f(K)$ is twice continuously differentiable, strictly increasing, and strictly concave (where $f(0) = 0, f'(0) = \infty$, and $f'(z) \rightarrow 0$ as $z \rightarrow \infty$); $\pi^g + \pi^b = 1$; $0 < \alpha < 1$; $\nu > 0$; and the random productivity realization is idiosyncratic.

The structure of the problem guarantees that the firm will either use νK units of soft capital or none. For simplicity, assume that it is always efficient to employ soft capital. (Formally, this requires one to assume that $(\pi^g + \pi^b\alpha)/(1+\nu) > \alpha$).

If there are no informational imperfections, the firm's investment decision is intuitive. It chooses K to satisfy

(3A) $$(\pi^g + \pi^b\alpha)f'(K) - (1+\nu)r = 0,$$

where r is the gross interest rate faced by the firm. Equation 2A simply states that, at the optimum, the expected marginal benefit from an additional unit of hard capital (given a complementary addition of ν units of soft capital) equals the marginal cost of investing. The value of K that satisfies equation A2 — call it K^*— does not depend on any financial variables; that is, the Modigliani and Miller theorem applies.

The traditional interest rate channel often identified with the money view mechanism is easy to illustrate in this example. Suppose for simplicity that the interest rate paid on deposits is zero, so that r represents the gross required rate of return on lending. To the extent that an open market sale raises r, investment demand falls. This is the usual textbook interest rate channel for monetary policy.

Under asymmetric information, the story is more complicated. Consider, for example, a simple agency problem: Expenditures on hard capital are observable by outside lenders, while expenditures on soft capital are not. In this case, the manager may be tempted to divert soft capital funds to personal gain. Such perquisite consumption can take a number of forms. For simplicity, assume that the manager can invest the funds (say, in a Swiss bank account) to yield a gross interest rate, r.

Lenders understand this temptation, and modify the financial contract to mitigate incentives to cheat. As shown below, one consequence of this modification is that desired capital, K^*, may exceed actual capital, K, and this gap will depend inversely on the borrower's net worth. Suppose the firm signs a loan contract with a competitive financial intermediary. The firm has some initial liquid asset position, W, and collateralizable future profits, V, in period one, worth a present value of V/r. Hence, the firm's initial net worth is $(W + V/r)$. To make the story interesting, assume that $W < K^*$; that is, the firm would like to borrow. (For a richer description of the role of internal net worth in the contracting problem, see Gertler, 1992.)

The firm-intermediary loan contract specifies the amount borrowed (in this case, $(1 + v)K - W)$), a payment P^g to the intermediary in the event that the project yields the "good" output level, and a payment P^b in the event of the "bad" output level. These contractual features are chosen to maximize the firm's expected profits:

$$(4A) \quad (\pi^g + \pi^b \alpha) f(K) - \pi^g P^g - \pi^b P^b.$$

From the intermediary's perspective, the loan contract must offer an expected return equal to its opportunity cost of funds, which equals the gross interest rate r times the quantity borrowed:

$$(5A) \quad \pi^g P^g + \pi^b P^b = r\big[(1+v)K - W\big].$$

That is, for simplicity, assume that the intermediary simply channels funds from savers to borrowers, and uses no resources.

Given the underlying incentive problem, the contract must give the firm the incentive to invest in soft capital as a complementary input to hard capital. That is, the contract must satisfy the "incentive constraint:"

$$(6A) \quad (\pi^g + \pi^b \alpha) f(K) - (\pi^g P^g + \pi^b P^b) \geq \left(\alpha f(K) - P^b\right) + rvK.$$

Equation 6A just states that the manager's expected gain from honest action exceeds the gain from diverting the soft capital funds to personal use.

One way in which the intermediary could reduce the entrepreneur's temptation to cheat is to increase the amount of P^b that the firm must pay the intermediary in the event of a bad outcome. The firm, however, can only credibly promise to pay available assets in the bad state. That is, a limited liability constraint influences the contract:

$$(7A) \quad P^b \leq \alpha f(K) + V.$$

To summarize, the contracting problem involves the selection of K, P^g and P^b to maximize equation 4A subject to equations 5A, 6A and 7A. One case is easy: As long as the incentive constraint does not bind, actual investment, K, simply adjusts to desired investment K^*. In addition, the pattern of contract payments is indeterminate. (For simplicity, I am abstracting from a richer structure that would lead to both debt and equity contracts and tax considerations; see, for example, Gertler and Hubbard, 1993, for such a treatment.)

When the incentive constraint in equation 6A binds, financing and investment decisions are no longer independent. First, note that when the incentive constraint binds, it is desirable to raise P^b to the maximum extent possible; therefore, the limited liability constraint in equation 7A also binds. Using 5A and 7A, one can eliminate P^g and P^b from equation 6A, and thereby obtain a relation among K, the interest rate and internal net worth:

$$(8A) \quad \left(\pi^g + \pi^b \alpha\right) f\left(K\right) - \left[r\left(1+2v\right)\right]K + r\left(W + V/r\right) = 0.$$

As long as equation 8A holds, investment K is an increasing function of the borrower's net worth $(W + V/r)$, holding investment opportunities constant:

$$(9A) \quad \frac{\partial K}{\partial (W + V/r)} = \left[\left(1+2v\right) - \left(\pi^g + \pi^b \alpha\right) f'\left(K\right)/r\right]^{-1} > 0.$$

The explanation for this effect is that, when the incentive constraint binds, an increase in internal net worth increases the amount of feasible investment.

The existence of the net worth channel precludes neither the traditional interest rate channel nor the bank lending channel. To see the former, note an increase in lenders' opportunity cost of funds on account of a monetary contraction reduces desired investment K^* (since K^* is determined by $(\pi^g + \pi^b\alpha)f'(K) = (1 + v)r$). To see the latter, note that, to the extent that banks face a higher marginal opportunity cost of funds because of a less than perfectly elastic supply schedule for managed liabilities (and borrowers lack access to nonbank finance), the increase in r lowers both desired and actual investment.

This simple framework is consistent with the description of the financial accelerator mechanism: The cost of uncollateralized external finance exceeds that for internal finance. This gap varies inversely with the internal net worth of the borrower and a decline in net worth reduces the borrowers' spending, all else equal. The framework also yields simple testable predictions related to these money view and credit view arguments:

(1) When informational imperfections are ignored, an increase in real interest rates following a monetary contraction should affect investment (broadly defined) similarly for borrowers of a given type (for example, with similar technology and risk characteristics).

(2) If informational imperfections are significant only on the borrower side, all else equal, spending by borrowers with lower levels of internal net worth should fall relative to spending by borrowers with higher levels of internal net worth.

(3) For bank-dependent borrowers, the availability of monitored bank credit can be thought of as a substitute for internal net worth. Changes in the availability of bank credit can influence the ability of bank-dependent borrowers to finance spending.

(4) The model's intuition can apply to banks as well as nonfinancial borrowers. A decline in banks' net worth raises banks' opportunity cost of external funds (say, in the CD market). As a result, the cost of funds to bank-dependent borrowers rises.

(5) If relationships between borrowers and specific banks are important, shocks to the balance sheet positions of individual lenders affect credit availability (at any given open market interest rate) to their borrowers.

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Commentary

Bruce D. Smith

Glenn Hubbard's paper considers what is perhaps the most basic question in monetary economics: How does monetary policy "work"? It suggests that informational frictions affecting capital markets create additional mechanisms—beyond those of conventional textbook models—through which monetary policy operates. In particular, Hubbard suggests that "realistic models of financial constraints on firms' decisions imply potentially significant effects of monetary policy beyond those working through conventional interest rate channels." Now I personally feel that there are a number of serious issues about what these "conventional interest rate channels" are,[1] but that takes us beyond the scope of the present paper. So, for the purpose of discussion, let's imagine that we accept that there are such channels,[2] and consider how the presence of financial constraints impacts the scope for monetary policy to have other effects.

As the previous quotation suggests, there ought to exist models in which there are informational (or other) frictions affecting firm investment decisions, and in which there is scope for monetary policy to operate. This requires a model with—at a minimum—money, capital and a credit market friction. Moreover, I would argue that an interesting model for analyzing the role of monetary (or other) policies in an economy with a financial market friction should be a general-equilibrium model, since we would like to know the answers to at least two questions: not only

(1) What *can* monetary policy do?
but also,
(2) What *should* monetary policy do? (That is, what are the welfare implications of alternative methods of conducting monetary policy?)

While the Hubbard paper cites any number of references on financial market imperfections and their effects on firm investment behavior, to my knowledge *none* of the papers he cites presents a general-equilibrium model of an economy with money, capital and a credit market friction. So, at this point, I have the following questions:

- What are the models of financial constraints implying these magnified effects of monetary policy (presuming, of course, the need for general-equilibrium models)?
- What are the implications of these models for the effects (and welfare consequences) of various methods for conducting monetary policy?

The Hubbard paper comes in two parts: Its appendix contains a suggestive model of a single firm undertaking credit-financed investment, subject to a moral hazard problem, along with a proposed list of empirical implications derived from the literature that the model represents. The text of the paper presents a discussion of the empirical literature on how monetary policy does (or can) affect the investment behavior of individual firms. To a large extent, I very much like both the model of the paper and the discussion of the empirical evidence. I do think, however, there is a serious question about how these two parts of the paper fit together. Let me therefore add to my list of questions:

- If we do have general-equilibrium models of capital accumulation in the presence of money and financial market frictions, what do these models imply about the consequences of various monetary policy actions?
- What is (or could be) the empirical evidence on these implications?
- How does the empirical evidence discussed in the Hubbard paper bear on them?

Before proceeding to a discussion of these issues, let me say that I intend to focus my discussion most where the Hubbard discussion focuses least—on the theoretical aspects of monetary growth models with

[1] For example, some monetary models give rise to Modigliani and Miller's theorems for open market operations. These theorems state conditions under which open market activity has *no* implications for interest rates, or anything else. For a discussion of such theorems, and their empirical relevance, see Wallace (1981), Chamley and Polemarchakis (1984), Sargent (1982, 1987), Sargent and Smith (1987) or Smith (1994).

[2] The issue in the literature discussed in footnote 1 is: Under what conditions would there be such channels? That literature suggests that these channels exist only if policy is conducted in a way which is intentionally redistributive.

informational frictions. In large part, this is because Glenn is a pioneer in, and a major continuing contributor to, the empirical literature on these topics, and his discussion of this literature is thoughtful and easy to follow. Thus, while admitting Glenn may have absolute advantage along both dimensions, considerations of comparative advantage suggest that I should primarily concentrate on theoretical issues.

The Hubbard paper identifies three common implications of the models he has in mind, and which he identifies with the credit view:

1. "Uncollateralized external finance is more costly than internal finance.
2. "The spread between the cost of external and internal funds varies negatively with the level of the borrower's internal funds.
3. "A reduction in internal funds reduces the borrower's spending, holding underlying investment opportunities constant."

While the discussion on these points is somewhat vague, from my knowledge of the literature I take these to be partial equilibrium results that apply to a particular borrower, holding aggregate conditions fixed. What monetary growth models exist, then, that would deliver these as implications at the level of an individual firm?

To my knowledge, there is exactly one such model—that of Boyd and Smith (1994). Let me sketch the main features of this model and then describe its implications for the kinds of issues that come up in the Hubbard discussion.

The Boyd and Smith model uses as its basic framework the neoclassical growth model of Diamond (1965), which allows for outside assets in a general-equilibrium model of capital accumulation. The Diamond model is a two-period, overlapping-generations model in which all agents supply one unit of labor inelastically when young, earning the prevailing real wage rate. These agents are retired when old. They save for old-age retirement by accumulating either capital or money (or, more generally, outside assets).

Capital accumulation in the Diamond model—as in most traditional monetary growth models[3]—is a "black box"; one unit of consumption foregone today becomes one unit of capital after one period. And, again as in traditional monetary growth models, there is no role for banks or other financial market institutions.

Boyd and Smith modify the Diamond model to allow for two classes of agents in each generation. One class of agent has access to a stochastic linear technology for converting current goods into future capital, the other type does not. In all other respects, the two types are identical.

The capital production technology considered by Boyd and Smith is subject to a standard costly state verification (CSV) problem of the type considered by Townsend (1979) and, more specifically, Gale and Hellwig (1985), Williamson (1986, 1987) and Bernanke and Gertler (1989). As is conventional in such models, each operator of the capital production technology must produce at some fixed, indivisible scale. Thus, to finance capital investments, young investors must combine their own young period income, along with funds obtained externally.

Under the assumption of risk-neutral firms and fixed verification costs, this setup yields an optimal capital structure and financing arrangement for firms producing capital goods. Such firms should be (completely) debt-financed, and it is efficient for them to borrow from financial intermediaries. Presumably this captures the notion of "bank-dependent borrowers" discussed by Hubbard. Moreover, this model would produce, at the individual firm level, the three key results of models that Hubbard associates with the credit view.

In this model, the amount of internal finance provided by investors is endogenous, depending on the young period wage income of borrowers. Internal finance is valuable because it helps to mitigate the CSV problem. In addition, as in Gale and Hellwig (1985) and Williamson (1986, 1987), the presence of the CSV problem permits credit rationing to be observed for exactly the reasons discussed by Stiglitz and Weiss (1981): Because of the costs of verifying project returns when borrowers default, raising the interest rate charged on loans affects a lender's expected return in a non-monotonic fashion. Thus,

[3] See, for instance, the models of Sidrauski (1967 a,b), Brock (1974) or Tirole (1985).

the interest rate charged on loans can be "bid up" to a level that maximizes the expected return to a lender; thereafter, increases in the interest rate reduce a lender's expected return and are counterproductive. As a result, if the demand for credit exceeds its supply and interest rates are raised to their expected return maximizing level, there is no action that an unfunded (or rationed) borrower can take to obtain a loan. This presumably maximizes the scope for monetary factors to "matter," since availability of credit becomes an issue of central concern.

Boyd and Smith consider the situation where credit is rationed, and examine the following policy regime. The monetary authority fixes, once and for all, a rate of money growth. In the Diamond model, the fixed rate of money growth determines the steady-state real rate of interest. This formulation gives the Hubbard analysis its best case scenario, parenthetically, since it allows the monetary authority—at least potentially—the power to control real interest rates directly.[4]

The Boyd and Smith modification of the Diamond model is, superficially, very minor. But it has dramatic implications for the properties of monetary equilibria in the Diamond model. Most of these implications are, I think, bad news from the standpoint of the kind of analysis conducted in the Hubbard paper, although there is one piece of good news. I will now review some of the relevant implications.

THE BAD NEWS

Traditional monetary growth models have the property that there is a unique monetary steady-state equilibrium, which is a saddle. Thus, one can unambiguously identify *the* monetary equilibrium of such a model, and can unambiguously discuss the effects of monetary policy actions on the equilibrium. The kind of model that Hubbard apparently has in mind may, however, have multiple equilibria, and multiple possible effects of a monetary policy action.

The Boyd and Smith model has (typically) two monetary steady state equilibria. It can easily transpire that one is a sink and one is a saddle, so both can be approached. Thus, there is a continuum of monetary equilibria. The effects of a monetary policy action depend—very strongly, as it turns out—on which equilibrium path the economy is following. Moreover, for some parameter configurations there exist equilibria which approach no steady state; that is, limit cycles can be observed. Changes in monetary policy can change the entire set of equilibria, creating scope for equilibria that did not exist under other configurations of policy.

These possibilities are of some interest from a theoretical perspective. They imply that the interaction of policy choices with the operation of financial markets subject to frictions creates a scope for the indeterminacy of equilibrium and for "excessive fluctuations," a point emphasized by Simons (1948) and Friedman (1960). However, they also imply that there is no unique answer to the question: How do credit channels affect the consequences of monetary policy?

Why do credit market frictions create indeterminacies and render questions about their effects on policy actions problematic? The answer has to do with exactly the feature most emphasized by Hubbard: the importance of internal finance, and the fact that the ability to provide internal finance is going to be (at least partly) endogenous in a general equilibrium model. In the Boyd-Smith model, the monetary authority controls the real rate of interest (at least in steady-state equilibria). Borrowers are then forced to deliver this policy-determined real rate of return on funds they obtain. In a steady-state equilibrium, there are typically two ways to do this. One is to have a low capital stock, a correspondingly high marginal product of capital, and low incomes (low levels of internal finance). The other is to have a high capital stock, a correspondingly low marginal product of capital, and high incomes enabling borrowers to provide a lot of internal finance. Since internal finance mitigates the CSV problem, it offsets the low marginal product of capital and permits borrowers to offer lenders the necessary expected return.

The key element in this analysis, of course, is the endogeneity of the amount of internal finance. Once this is endogenous, models representing what Hubbard calls the credit view cannot generally be expected to deliver

[4] Notice that this does not require the existence of any nominal rigidities, as Hubbard asserts.

unique equilibria, and questions about "the effects" of monetary policy will not be well-posed.

To underscore this point, a monetary expansion in the Boyd and Smith model (a higher rate of money growth) increases the capital stock, output, and credit extension in the low-capital-stock steady state. All of these effects are reversed in the high-capital-stock steady state.

SOME GOOD NEWS AND SOME BAD NEWS

The good news is that—in the low-capital-stock steady state, where expansionary monetary policy actions are actually expansionary—the Boyd and Smith model predicts that capital market imperfections will enhance the effects of a given change in monetary policy. In particular, a given change in the rate of money growth has a larger effect on output in the presence of the credit market friction than is the case under full information. In this sense, one prediction of the credit view is borne out.

However, even this effect does not occur for the reasons discussed by Hubbard. According to his analysis,

> "...the crux of models of information-related financial frictions is a gap between the cost of external and internal finance for many borrowers. In this context, the credit view offers channels through which monetary policy can affect this gap."

In the Boyd and Smith model, monetary policy can have heightened effects, but not because it affects the differential between the cost of internal and external funds in this way. Indeed, it is possible to show that, in the steady state equilibria they examine, monetary policy cannot affect this differential (appropriately defined). Nonetheless, in one of their steady state equilibria, credit market frictions do magnify the impact of monetary policy.

EMPIRICAL IMPLICATIONS

Since the credit view applied to monetary models seems prone to delivering multiple equilibria, any discussion of its empirical implications must confront the difficulties associated with the empirical analysis of models displaying multiple equilibria. This is a difficult issue, and one that I am not currently prepared to take on. However, Hubbard argues that the money and the credit views have the following implications:

> "When informational imperfections are ignored, an increase in real interest rates following a monetary contraction should affect investment (broadly defined) similarly for borrowers of a given type (for example, with similar technology and risk characteristics).[5]

> "If informational imperfections are significant only on the borrower side, all else equal, spending by borrowers with lower levels of internal net worth should fall relative to spending by borrowers with higher levels of net worth.[6]

> "The model's intuition can apply to banks as well as non-financial borrowers. A decline in banks' net worth raises banks' opportunity cost of external funds (say in the CD market). As a result, the cost of funds to bank-dependent borrowers rises."

I am not sure what the practical empirical content of the first implication is likely to be, since we do not typically observe the technological characteristics or demand conditions of individual firms directly. I am also unclear as to why borrowers with similar net worth cannot be affected differentially by monetary policy under the credit view. (This is, in fact, what happens in the Boyd and Smith model.) And, indeed, it is easy to produce certain kinds of counter-examples to the second claim in models that seem perfectly consistent with the credit view.[7] Finally, credit-view models, like Williamson's (1987), tell us that the effects of increases in the costs of external funds can depend very heavily on the nature of how interest rates are determined. In particular, the "incidence" of higher costs depends heavily on whether credit is rationed, on the interest elasticity of the supply and the demand for funds, and so on. It is therefore not clear to me why it follows that an

[5] This implication applies, of course, to the money view.

[6] This implication applies under the credit view.

[7] For example, the Boyd and Smith model can easily be modified to allow for borrowers with different levels of net worth. In that model, increases in interest rates will affect only the spending of marginal borrowers (who, in many data sets, would then disappear from the sample). Changes in interest rates would not affect infra-marginal borrowers. This point is illustrated, for example, in the model of Ma and Smith (1993).

increase in the costs of external funds for banks must be borne by borrowers.

In short, it is not transparent that there exist any sharp empirical hypotheses distinguishing the money view from the credit view at the firm level. Perhaps we are best advised to take seriously the notion that the credit view predicts the possibility of multiple equilibria, with some equilibria displaying endogenously enhanced volatility and to pursue the empirical implications of that idea.

REFERENCES

Bernanke, Ben S., and Mark Gertler. "Agency Costs, Net Worth, and Business Fluctuations," *The American Economic Review* (March 1989), pp. 14-31.

Boyd, John H., and Bruce D. Smith. "Capital Market Imperfections in a Monetary Growth Model," working paper (1994), Federal Reserve Bank of Minneapolis.

Chamley, Christophe, and Heraklis Polemarchakis. "Assets, General Equilibrium, and the Neutrality of Money," *Review of Economic Studies* (January 1984), pp. 129-38.

Diamond, Peter A. "National Debt in a Neoclassical Growth Model," *The American Economic Review* (December 1965), pp. 1126-50.

Friedman, Milton. *A Program for Monetary Stability.* Fordham University Press, New York, 1960.

Gale, Douglas, and Martin Hellwig. "Incentive-Compatible Debt Contracts: The One-Period Problem," *Review of Economic Studies* (October 1985), pp. 647-63.

Ma, Chien-hui, and Bruce D. Smith. "Credit Market Imperfections and Economic Development: Theory and Evidence, *Journal of Development Economics* (forthcoming).

Sargent, Thomas J. *Dynamic Macroeconomic Theory.* Harvard University Press, 1987.

_______. "The Ends of Four Big Inflations," in Robert E. Hall, ed., *Inflation: Causes and Effects.* National Bureau of Economic Research, University of Chicago Press, 1982.

_______ and Bruce D. Smith. "Irrelevance of Open Market Operations in Some Economies with Government Currency Being Dominated in Rate of Return," *The American Economic Review* (March 1987), pp. 78-92.

Simons, Henry. *Monetary Policy for a Free Society.* University of Chicago Press, 1948.

Smith, Bruce D. "Mischief and Monetary History: Friedman and Schwartz Thirty Years Later," *Journal of Monetary Economics* (August 1994), pp. 27-45.

Stiglitz, Joseph, and Andrew Weiss. "Credit Rationing in Models with Imperfect Information," *The American Economic Review* (June 1981), pp. 393-410.

Tirole, Jean. "Asset Bubbles and Overlapping Generations," *Econometrica* (November 1985), pp. 1499-528.

Townsend, Robert M. "Optimal Contracts and Competitive Markets with Costly State Verification," *Journal of Economic Theory* (October 1979), pp. 265-93.

Wallace, Neil. "A Modigliani-Miller Theorem for Open Market Operations," *The American Economic Review* (June 1981), pp. 267-74.

Williamson, Stephen D. "Costly Monitoring, Loan Contracts, and Equilibrium Credit Rationing," *Quarterly Journal of Economics* (February 1987), pp. 135-45.

_______. "Costly Monitoring, Financial Intermediation, and Equilibrium Credit Rationing," *Journal of Monetary Economics* (September 1986), pp. 159-79.

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Distinguishing Theories of the Monetary Transmission Mechanism

Stephen G. Cecchetti

Traditional studies of monetary policy's impact on the real economy have focused on its aggregate effects. Beginning with Friedman and Schwartz (1963), modern empirical research in monetary economics emphasizes the ability of policy to stabilize the macroeconomy. But casual observation suggests that business cycles have distributional implications as well. One way of casting the debate over the relative importance of different channels of monetary policy transmission is to ask if these distributional effects are sufficiently important to warrant close scrutiny.

The point can be understood clearly by analogy with business cycle research more generally. If recessions were characterized by a proportionate reduction of income across the entire employed population—for example, everyone worked 39 rather than 40 hours per week for a few quarters—then economists would pay substantially less attention to cycles. It is the allocation of the burden or benefit of fluctuations, with some individuals facing much larger costs than others, that is of concern. There are two ways for an economist to address this problem. The first is to attempt to stabilize the aggregate economy, the traditional focus of policy-oriented macroeconomics. The second is to ask why the market does not provide some form of insurance.

The recent debate over the nature of the monetary transmission mechanism can be thought of in similar terms. According to the original textbook IS-LM view of money, changes in policy are important only insofar as they affect aggregate outcomes. Only the fluctuation in total investment is important since policies only affect the required rate of return on new investment projects, and so it is only the least profitable projects (economy-wide) that are no longer funded. But since the most profitable projects continue to be undertaken, there are no direct efficiency losses associated with the distributional aspects of the policy-induced interest rate increase.

In contrast, the "lending" view focuses on the distributional consequences of monetary policy actions. By emphasizing a combination of capital market imperfections and portfolio balance effects based on imperfect asset substitutability, this alternative theory suggests the possibility that the policy's incidence may differ substantially across agents in the economy. Furthermore, the policy's impact has to do with characteristics of the individuals that are unrelated to the inherent creditworthiness of the investment projects. An entrepreneur may be deemed unworthy of credit simply because of a currently low net worth, regardless of the social return to the project being proposed. It is important to understand whether the investment declines created by monetary policy shifts have these repercussions.[1]

In this essay, I examine how one might determine whether the cross-sectional effects of monetary policy are quantitatively important. My goal is to provide a critical evaluation of the major contributions to the literature thus far. The discussion proceeds in three steps. I start in the first section with a description of a general framework that encompasses all views of the transmission mechanism as special cases, thereby highlighting the distinctions. In the second section, I begin a review of the empirical evidence with an assessment of how researchers typically measure monetary policy shifts. The following two sections examine the methods

[1] The financial accelerator, in which the impact on investment of small interest changes is magnified by balance sheet effects, is also an important part of many discussions of the lending view.

used for differentiating between the theories. Studies fall into two broad categories depending on whether they use aggregate or disaggregate data. The third section discusses the aggregate data, while the fourth section describes the use of disaggregate data. A conclusion follows.

MONETARY POLICY: THEORY

A General Framework

One way of posing the fundamental question associated with understanding the monetary transmission mechanism is to ask how seemingly trivial changes in the supply of an outside asset can create large shifts in the gross quantity of assets that are in zero net supply. How is it that small movements in the monetary base (or nonborrowed reserves) translate into large changes in demand deposits, loans, bonds and other securities, thereby affecting aggregate investment and output?

The various answers to this puzzle can be understood within the framework originally proposed by Brainard and Tobin (1963). Their paradigm emphasizes the effects of monetary policy on investor portfolios, and is easy to present using the insights from Fama's (1980) seminal paper on the relationship between financial intermediation and central banks.

Fama's view of financial intermediaries is the limit of the current type of financial innovation, because it involves the virtual elimination of banks as depository institutions. The setup focuses on an investor's portfolio problem in which an individual must choose which assets to hold given the level of real wealth. Labeling the portfolio weight on asset *i* as w_i, and total wealth as W, then the holding of asset, *i*—the asset demand—is just $X_i = w_i W$.

In general, the investor is dividing wealth among real assets—real estate, equity and bonds—and outside money. Each asset has stochastic return, $\tilde{z}_i$, with expectation $\bar{z}_i$; and the vector of asset returns, $\tilde{z}$, has a covariance structure Γ. Given a utility function, as well as a process for consumption, it is possible to compute the utility maximizing portfolio weights. These will depend on the mean and variance of the returns, $\bar{z}_i$ and Γ, the moments of the consumption process, call these μ_c, and a vector of taste parameters that I will label ϕ and assume to be constants. The utility maximizing asset demands can be expressed as $X^*_i = w^*_i(\bar{z}, \Gamma, \mu_c, \phi)W$.[2]

This representation makes clear that asset demands can change for two reasons. Changes in either the returns process ($\bar{z}, \Gamma$) or macroeconomic quantities (μ_c, W) will affect the X^*_i's.[3]

At the most abstract level, financial intermediaries exist to carry out two functions. First, they execute instructions to change portfolio weights. That is, following a change in one or all of the stochastic processes driving consumption, wealth or returns, the intermediary will adjust investors' portfolios so that they continue to maximize utility. In addition, if one investor wishes to transfer some wealth to another for some reason, the intermediary will effect the transaction.

What is monetary policy in this stylized setup? For policy to even exist, some government authority, such as a central bank, must be the monopoly supplier of a nominally denominated asset that is imperfectly substitutable with all other assets. I will call this asset "outside money." In the current environment, it is the monetary base. There is a substantial literature on how the demand for outside money arises endogenously in the context of the type of environment I have just described.[4] But in addition, as Fama emphasizes, there may be legal requirements that force agents to use this particular asset for certain transactions. Reserve requirements and the use of reserves for certain types of bank clearings are examples.

Within this stylized setup, a *policy action* is a change in the nominal supply of outside money. For such a change to have any effects at all, (1) the central bank controls the supply of an asset that is both in demand and for which there is no perfect substitute, and (2) prices must fail to adjust fully and instantaneously. Otherwise, a change in the nominal quantity of outside money cannot have any impact on the real interest rate, and will have no real effects. But, assuming that

[2] See Ingersoll (1987) for a complete description of this problem.

[3] Following the traditional financial economics approach, I have avoided discussing demand and supply explicitly. Instead, the asset demands are derived from the idea of arbitrage relationships among all of the assets.

[4] These include the limited participation models based on Lucas (1990). See the survey by Feurst (1993), as well as the summary in Christiano and Eichenbaum (1992).

the policymaker can change the real return on the asset that is monopolistically supplied, investors' portfolio weights must adjust in response to a policy change.

The view of financial intermediaries that is implicit in this description serves to highlight the Brainard and Tobin (1963) insight that monetary policy can be understood by focusing solely on the endogenous response of investor portfolios. Understanding the transmission mechanism requires a characterization of how asset holdings change in response to policy actions.

Second, even though there need be no banks as we know them, there will surely be intermediaries that perform the service of making small business loans. The agency costs and monitoring problems associated with this type of debt will still exist, and specialists in evaluation will emerge. While they will have such loans as assets, they most likely will not have bank deposits as liabilities. Such entities will be brokers, and the loans will be bundled and securitized.

With this as background, it is now possible to sketch the two major views of the monetary transmission mechanism. There are a number of excellent surveys of these theories, including Bernanke (1993a), Gertler and Gilchrist (1993), Kashyap and Stein (1994a) and Hubbard (1995). As a result, I will be relatively brief in my descriptions.

THE MONEY VIEW

The first theory, commonly labeled the *money* view, is based on the notion that reductions in the quantity of outside money raise real rates of return.[5] This, in turn, reduces investment because fewer profitable projects are available at higher required rates of return—this is a movement along a fixed marginal efficiency of investment schedule. The less substitutable outside money is for other assets, the larger the interest rate changes.

There is no real need to discuss banks in this context. In fact, there is no reason to distinguish any of the "other" assets in investors' portfolios. In terms of the simple portfolio model, the money view implies that the shift in the w_i^*'s for all of the assets excluding outside money are equal.

An important implication of this traditional model of the transmission mechanism involves the incidence of the investment decline. Since there are no externalities or market imperfections, it is only the least socially productive projects that go unfunded. The capital stock is marginally lower. But, given that a decline is going to occur, the allocation of the decline across sectors is socially efficient.

This theory actually points to a measure of money that is rarely studied. Most empirical investigations of monetary policy transmission focus on M2, but the logic of the portfolio view suggests that the monetary base is more appropriate. It is also worth pointing out that investigators have found it extremely difficult to measure economically significant responses of either fixed or inventory investment to changes in interest rates that are plausibly the result of policy shifts. In fact, most of the evidence that is interpreted as supporting the money view is actually evidence that fails to support the lending view.

THE LENDING VIEW: BALANCE SHEET EFFECTS

The second theory of monetary transmission is the *lending* view.[6] It has two parts, one that does not require introduction of assets such as bank loans, and one that does. The first is sometimes referred to as the *broad* lending channel, or financial accelerator, and emphasizes the impact of policy changes on the balance sheets of borrowers. It bears substantial similarity to the mechanism operating in the money view, because it involves the impact of changes in the real interest rate on investment.

According to this view, there are credit market imperfections that make the calculation of the marginal efficiency of investment schedule more complex. Due to information asymmetries and moral hazard problems, as well as bankruptcy laws, the state of a firm's balance sheet has implications for its ability to obtain external finance. Policy-induced increases in interest rates (which are both real and nominal) can cause a deterioration in

[5] Terminology has the potential to create confusion here. I have chosen the traditional term for this textbook IS-LM or "narrow" money view. I do not mean to imply that this is the "monetarist" view of the transmission mechanism.

[6] I follow Kashyap and Stein's (1994a) terminology rather than the more common credit view to emphasize the importance of loans in the transmission mechanism. Bernanke and Gertler (1989, 1990) provide the original theoretical underpinnings for this view.

the firm's net worth, by both reducing expected future sales and increasing the real value of nominally denominated debt. With lower net worth, the firm is less creditworthy because it has an increased incentive to misrepresent the riskiness of potential projects. As a result, potential lenders will increase the risk premium they require when making a loan. The asymmetry of information makes internal finance of new investment projects cheaper than external finance.

The balance sheet effects imply that the shape of the marginal efficiency of investment curve is itself a function of the debt-equity ratio in the economy and can be affected by monetary policy.[7] In terms of a simple textbook analysis, policy moves both the IS and the LM curves. For a given change in the rate of return on outside money (which may be the riskless rate), a lender is less willing to finance a given investment the more debt a potential borrower has. This points to two clear distinctions between the money and the lending views—the latter stresses both the distributional impact of monetary policy and explains how seemingly small changes in interest rates can have a large impact on investment (the financial accelerator).

Returning to the portfolio choice model, the presence of credit market imperfections means that policy affects the covariance structure of asset returns. As a result, the w_i^*'s will shift differentially in response to monetary tightening as the perceived riskiness of debt issued by firms with currently high debt-equity ratios will increase relative to that of others.[8]

THE LENDING VIEW: LOANS FROM INTERMEDIARIES

The second mechanism articulated by proponents of the lending channel can be described by dividing the "other" assets in investors' portfolios into at least three categories: outside money, "loans" and all the others. Next, assume that there are firms for which loans are the only source of external funds—some firms cannot issue securities.[9] Depending on the solution to the portfolio allocation problem, a policy action may directly change both the interest rate and the *quantity* of loans. It is not necessary to have a specific institutional framework in mind to understand this. Instead, it occurs whenever loans and outside money are complements in investor portfolios; that is, whenever the portfolio weight on loans is a negative function of the return on outside money for given means and covariances of other asset returns.[10]

The argument has two clear parts. First, there are borrowers who cannot finance new projects except through loans, and second, policy changes have a direct effect on loan supply. Consequently, the most important impact of a policy innovation is cross-sectional, as it affects the quantity of loans to loan-dependent borrowers.

Most of the literature on the lending view focuses on the implications of this mechanism in a world in which banks are the only source of loans and whose liabilities are largely reservable deposits. In this case, a reduction in the quantity of reserves forces a reduction in the level of deposits, which must be matched by a fall in loans. The resulting change in the interest rate on outside money will depend on access to close bank deposit substitutes. But the contraction in bank balance sheets reduces the level of loans. Lower levels of bank loans will only have an impact on the real economy insofar as there are firms without an alternative source of investment funds.

As a theoretical matter, it is not necessary to focus narrowly on contemporary banks in trying to understand the different possible ways in which policy actions have real effects. As I have emphasized, bank responses to changes in the quantity of reserves are just one mechanism that can lead to a complementarity between outside money and loans. As pointed out by Romer and Romer (1990), to the extent that there exist ready substitutes in bank portfolios for reservable deposits such as CDs, this specific channel could be weak to nonexistent.[11] But it remains a real possibility that the optimal response of investors to a policy contraction would be to reduce the quantity of loans in their portfolios.

The portfolio choice model also helps to make clear that the manner in which policy actions translate into loan changes need not

[7] Bernanke, Gertler and Gilchrist (1994) refer to this as a financial accelerator since it causes small changes in interest rates to have potentially large effects on investment and output.

[8] It may be particularly difficult to distinguish these effects from those that arise from varying cyclicality of different firms' sales and profitability.

[9] See James (1987) for a discussion of the uniqueness of bank loans.

[10] With nominal rigidity, a decrease in outside money reduces the price level slowly, and so the real return to holding money increases. This channel of transmission requires that investors shift away from loans in response.

[11] Kashyap and Stein (1994b) point out that large banks can issue CDs in a way that insulates their balance sheets from contraction in deposits, but small banks cannot. So long as small banks are an important source of funds for some bank-dependent firms, there will still be a *bank* lending channel. In other words, for bank lending to be an important part of the transmission mechanism, credit market imperfections must be important for banks.

be a result of loan rationing, although it may.[12] As Stiglitz and Weiss (1981) originally pointed out, a form of rationing may arise in equilibrium as a consequence of adverse selection. But the presence of a lending channel does not require that there be borrowers willing to take on debt at the current price who are not given loans. It arises when there are firms which do not have equivalent alternative sources of investment funds and loans are imperfect substitutes in investors' portfolios.

Obviously, the central bank can take explicit actions directed at controlling the quantity of loans. Again, lowering the level of loans will have a differential impact that depends on access to financing substitutes. But the mechanism by which explicit credit controls influence the real economy is a different question.[13]

DISTINGUISHING THE TWO VIEWS: GENERAL CONSIDERATIONS

Distinguishing between these two views is difficult because contractionary monetary policy actions have two consequences, regardless of the relative importance of the money and lending mechanisms. It both lowers current real wealth and changes the portfolio weights.[14]

Assuming that there are real effects, contractionary actions will reduce future output and lower current real wealth, reducing the demand for all assets. In the context of standard discussions of the transmission mechanism, this is the reduction in investment demand that arises from a cyclical downturn.[15]

The second effect of policy is to change the mean and covariance of expected asset returns. This changes the w_{it}'s. In the simplest case in which there are two assets, outside money and everything else, the increase in the return on outside money will reduce the demand for everything else. This is a reduction in real investment.

The lending view implies that the change in portfolio weights is more complex and in an important way. There may be some combination of balance sheet and loan supply effects.

This immediately suggests that looking at aggregates for evidence of the right degree of imperfect substitutability or timing of changes may be very difficult. What seems promising is to focus on the other distinction between the two views—the lending view's assumption that some firms are dependent on loans for financing.

In addition to differences stemming from the relative importance of shifts in loan demand and loan supply, the lending view also predicts cross-sectional differences arising from balance sheet considerations. These are also likely to be testable. In particular, it may be possible to observe whether, given the quality of potential investment projects, firms with higher net worth are more likely to obtain external funding. Again, the major implications are cross-sectional.

EMPIRICAL EVIDENCE: PRELIMINARIES

Before discussing any empirical examination of the monetary transmission mechanism, two questions must be addressed. First, do nominal shocks in fact have real effects? Unless monetary policy influences the real economy, it seems pointless to study the way in which policy changes work. Second, how can we measure monetary policy? In order to calculate the impact of monetary policy, we need a quantitative measure that can reliably be associated with policy changes.

Here I take up each of these issues. In the following section, I will weigh the evidence on the real effects of money. This is followed by a discussion of ways in which recent studies have attempted to identify monetary shocks.

THE REAL EFFECTS OF NOMINAL SHOCKS

Modern investigation of the impact of money on real economic activity began with Friedman and Schwartz (1963). In many ways, this is still the most powerful evidence in support of the claim that monetary policy plays an important role in aggregate fluctuations. Through an examination that spanned

[12] Since there must be firms that are loan-dependent, there is still some form of rationing in the security market.

[13] See Romer and Romer (1993) for a concise discussion of recent episodes in which the Federal Reserve has attempted to change the composition of bank balance sheets through means other than standard policy actions.

[14] The change in portfolio weights can arise either from any combination of a change in the return on the outside asset, a change in the covariance structure of returns, or a shift in the consumption process.

[15] In general equilibrium, there is an offsetting effect that arises from the increase in the interest rate. All other things equal, this would increase saving and therefore investment. But we can be fairly confident that so long as monetary policy tightening can cause a recession, the impact of the income and wealth declines will be large enough that investment will fall.

numerous monetary regimes, they argue that apparently exogenous monetary policy actions preceded output movements.

Recent researchers use more sophisticated statistical tools to study the correlations between money and income. This "money-income causality" literature is largely inconclusive, because it fails to establish convincingly either that money "caused" output or the reverse. In the end, the tests simply establish whether measures of money *forecast* output, not whether there is causation. Given that outside money—the monetary base—is less than 10 percent of the size of M2, it is not surprising that economists find the simultaneity problems inherent in the question too daunting and give up.

Two pieces of evidence seem reasonably persuasive in making the case that money matters. First, the Federal Reserve seems to be able to change the federal funds rate virtually without warning. (I am not arguing that this is necessarily a good idea, just that it is possible.) In the very short run, these nominal interest rate changes cannot be associated with changes in inflationary expectations, and so they must represent real interest rate movements. Such real interest rate changes almost surely have an impact on real resource allocations.[16]

The second piece of evidence comes from the examination of the neutrality of money in Cecchetti (1986, 1987). In those papers, I establish that output growth is significantly correlated with money growth at lags of up to 10 years! There are several possible interpretations of these findings, but they strongly suggest that monetary shocks have something to do with aggregate real fluctuations.

MEASURING INNOVATIONS TO MONETARY POLICY

It stands to reason that before one can study the monetary transmission mechanism, it is necessary to identify monetary shocks. A number of authors have argued convincingly that policy disturbances cannot be gauged by examining movements in the monetary aggregates. The reason is that the variance in the innovations to broad measures of money are a combination of endogenous responses to real shocks (King and Plosser, 1984) and shifts in money demand (Bernanke and Blinder, 1992).

There have been two reactions to the fact that monetary aggregates provide little insight into policy actions. Both begin by looking at the functioning of the Federal Reserve and examining how policy is actually formulated. The first, due to Bernanke and Blinder (1992), note that the federal funds rate is the actual policy instrument that is used on a day-to-day basis. This suggests that innovations to the federal funds rate are likely to reflect, at least in part, policy disturbances. The main justification for their conclusion comes from examining the institutions of how monetary policy is carried out.

Romer and Romer (1989) suggest a second method. By reading the minutes of the Federal Open Market Committee (FOMC) meetings, they have constructed a series of dates on which they believe policy became contractionary.[17]

Innovations to the Federal Funds Rate

To understand the shortcomings of these two approaches, I will describe how each is used. In the first, researchers begin by specifying a vector autoregression. For the purposes of the example, I will use the formulation in Bernanke and Blinder's (1992) Section IV. They employ a six-variable specification with the total civilian unemployment rate, the log of the CPI, the federal funds rate, and the log of three bank balance sheet measures, all in real terms: deposits, securities and loans. The assumption is that the federal funds rate is a "policy" variable, and so it is unaffected by all other contemporaneous innovations.[18]

Following Bernanke and Blinder, I estimate the VAR with six lags using seasonally adjusted monthly data.[19] Figures 1 and 2 plot some interesting results from this VAR. The first figure shows the estimated residuals from the federal funds rate equation. The solid vertical lines are National Bureau of Economic Research (NBER) reference cycle peaks and troughs, while the dashed vertical lines are the Romer and Romer dates, intended to indicate the onset of contractionary

[16] The equivalent open economy observation is that in small open economies, exchange rates move in response to changes in policy.

[17] Boschen and Mills (1992) describe a related technique.

[18] See Hamilton (1994) for a complete description of the methodology.

[19] The exact measures and sample follow those of Kashyap and Stein (1994a), who kindly supplied the data.

monetary policy episodes.

This series looks extremely noisy and it is hard to see how it could represent policy changes. The 1979-82 period is the only one with large positive or negative values. Although it is surely the case that there are unanticipated policy changes both when the Federal Reserve acts and when it does not, one would expect small normal shocks with occasional spikes. If decisions are really this random, there is something fundamentally wrong with the policymaking apparatus. Furthermore, since the federal funds rate itself is the equilibrium price in the reserves market, given technicalities of the way that monetary policy is actually carried out, the market-determined level of the funds rate is not a policy instrument.[20]

The second figure shows the response of the log of the CPI to a positive one percentage point innovation in the federal funds rate. To understand how this is computed, begin by writing the vector autoregression as

$$A(L)y_t = \varepsilon_t,$$

where $A(L)$ is a matrix of polynomials in the lag operator L ($L^i y_t \equiv y_{t-i}$), y_t is the vector of variables used in the estimation, and ϵ_t is mean zero independent (but potentially heteroskedastic) error. The first step is to estimate the reduced form version of equation 1 by assuming that no contemporaneous variables appear on the right-hand side of any equations ($A(0) = I$). This results in an estimate $\hat{A}(L)$ along with an estimated covariance matrix for the coefficient estimates—call this $\hat{\Omega}$. The impulse response functions are obtained by inverting the estimated lag polynomial $\hat{B}(L) = \hat{A}^{-1}(L)$.[21]

But the point estimate of the impulse response function is not really enough to allow us to reach solid conclusions. It is also important to construct confidence intervals for the estimates. There are two ways to do this. The first involves the technique that has been called Monte Carlo Integration. This is a Bayesian procedure that involves presuming that the distribution of the vector of errors in equation 1—the ϵ_t's—is i.i.d. normal.[22] To avoid making such stringent assumptions, I choose to estimate confidence bands using an alternative technique grounded

Figure 1

Estimated Innovations to the Federal Funds Rates

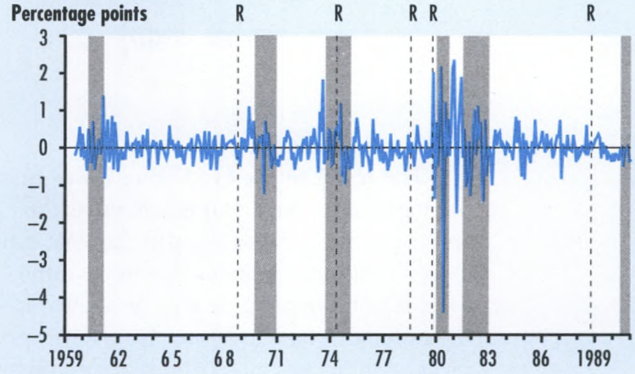
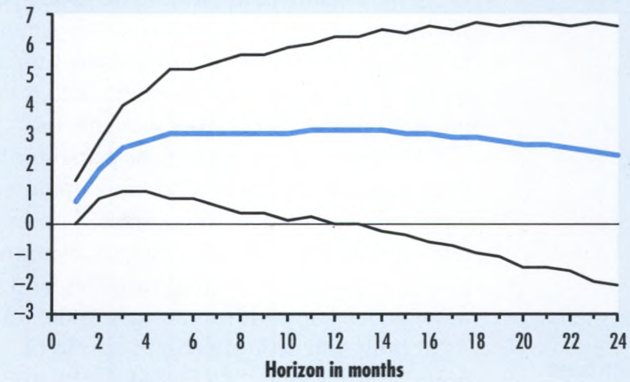


Figure 2

Response of the Log CPI to a Change in the Federal Funds Rate



in classical statistics.

The delta method is the simple procedure that comes from noting that if the estimates of the coefficients in lag polynomials are asymptotically normally distributed, then any well-behaved function of these parameters will also be asymptotically normally distributed. Stacking all of the parameters in $A(L)$ and calling the result θ, then

$$\sqrt{T}(\hat{\theta} - \theta) \overset{A}{\sim} N(0, \Omega).$$

It follows that any function of these parameters $f(\theta)$—for example, the impulse response function—will be asymptotically normally distributed,

[20] This entire discussion ignores the possibility that *anticipated* monetary policy matters— something that researchers should consider bringing into the discussion.

[21] A simple way to calculate the vector moving-average form of equation 1 is to construct the companion form of the VAR as described in Sargent (1987). This is also discussed in Hamilton (1994).

[22] See Doan (1990).

$$\sqrt{T}\left(f\left[\hat{\theta}\right]-f\left[\theta\right]\right) \stackrel{A}{\sim} N\left(0,\Omega_f\right),$$

where

$$\Omega_f = \frac{\partial f[\theta]}{\partial \theta'} \Omega \frac{\partial f[\theta]}{\partial \theta},$$

which can be estimated numerically.

The result plotted in Figure 2 was first pointed out by Sims and is known as the "price puzzle." Paradoxically, the VAR estimates imply that monetary policy contractions lead to price *increases*! As is clear from the estimated standard-error bands, this price rise is significantly positive for approximately the first year. After two years, however, it is not possible to reject the hypothesis that a funds rate increase has no effect on the price level.[23]

The standard conclusion is that the VAR is misspecified in some way. One strong possibility is that the funds rate is not exogenous in the way that is required for this identification to be valid, and so these innovations do not accurately reflect policy movements.[24]

My conclusions may be too harsh for the following reason. As Ben Bernanke pointed out in the conference, the estimated innovations are the sum of true policy innovation, policy responses to omitted variables, and more general specification errors in the VAR. As a result, one would expect them to be noisy. Furthermore, as pointed out by Adrian Pagan, since one is primarily interested in the impulse response functions—the impact of unanticipated policy on output, prices and the like—then it may be immaterial that the estimated policy innovations are noisy even if the true innovations are not.

The Romer and Romer Dates

The Romer and Romer dates have been both widely used and extensively criticized.[25] They suffer from both technical and substantive problems. First, they are discrete. Presumably, policy changes have both an intensity and a timing. Ignoring the size of policy changes must have an impact on results. Second, Romer and Romer choose to focus their inquiry only on policy contractions, because they feel that expansions were more ambiguous. Since most models predict symmetric responses to positive and negative monetary innovations, this strategy throws out information.

But the main issue is the exogeneity of the policy shifts. It is difficult to believe that the actions of the FOMC, as reported in the minutes of the meetings, are truly exogenous events. There have been two responses to this. First, Hoover and Perez (1991) provide a lengthy discussion of why Romer and Romer's methods are not compelling in identifying output fluctuations induced by exogenous monetary shocks.

Taking a slightly different approach, Shapiro (1994) examines whether the FOMC is responding to changes in economic conditions, and so there is some reaction function implicit in policy. He estimates a probit model for the Romer and Romer dates using measures of inflation and unemployment, both as deviations from a carefully constructed target level, as determinants. Figure 3 reproduces his estimates of the probability of a date, with the vertical lines representing the dates themselves. The unanticipated policy action is 1 minus the estimated probability. As is clear from the figure, several of the dates were largely anticipated, and there were some periods when policy shifts were thought to be likely, and then did not occur. Overall, Shapiro's results suggest that the standard interpretation of the dummy variables as exogenous is incorrect to varying degrees over time.

There seems to be no way to measure monetary policy actions that does not raise serious objections. Given this, it might seem difficult to see how to proceed with the study of different theories of the transmission mechanism. But the literature proceeds in two directions. The first uses these measures directly in an attempt to gauge the influence of policy changes directly. The conclusions of these studies must be viewed with some degree of skepticism. The alternative approach is to note that investment declines account for the major share of output reductions during recessions. If one is able to show that the distribution of the contraction in investment is correlated with variables

[23] A test for whether all of the reactions are jointly zero rejects at the 5 percent level for the first seven months, and then fails to reject. The test for whether all the effects are zero simultaneously for all 24 months fails to reject with a p-value of 0.77.

[24] There is a further reason to view this measure of policy with some skepticism. Because of the large number of parameters estimated, the regressions are usually overfitted. As a result, they normally have very poor out-of-sample forecasting properties.

[25] See Friedman (1990) for a discussion of the strategy of using policymakers' statements to gauge their actions.

related to a firm's balance sheet and its access to bank loans, then this strongly suggests the existence of a lending channel.

USING AGGREGATE DATA

Numerous studies have used aggregate data in an attempt to distinguish the channels of monetary transmission. This literature can be divided into three categories: The first looks at the relative forecasting ability of different quantity aggregates; the second studies differences in the timing of the response of aggregate quantities to presumed policy shocks; and the third examines the behavior of interest rates.

Before examining the work on quantities, I will discuss the use of interest rate data.[26] As is clear from the discussion in the first section, the lending view does allow for movements in market interest rates. Furthermore, these movements are in the same direction as those predicted by the money view, and their magnitude depends solely on the degree of substitutability between outside money and various other assets. Where the two views differ is in their predictions for movements in the interest rate on loans. But since there is currently no secondary market for these securities, it is impossible to determine the interest rate on these loans.[27] This implies that market interest rates are of virtually no use in this exercise. There is no sense in which the behavior of interest rates could serve to distinguish between the money or lending views.

I now turn to the work on quantities. In the following section, I examine tests involving the relative forecasting ability of measures of money and credit. This is followed by a discussion of papers that emphasize aggregate timing relationships.

Relative Forecasting Ability

A number of papers have examined the ability of different financial aggregates to forecast output (or unemployment) fluctuations. Ramey (1993) is a recent example. The main methodology here is to ask whether measures of credit are informative about future output movements, once money has been taken into account. The problem with this is that credit is usually just a broader measure of money. To put it slightly differently, the balance sheet identity of the banking system implies that bank assets equal bank liabilities. As Bernanke (1993b) points out, monetary aggregates are a measure of bank liabilities, while credit aggregates are measures of bank assets. Since these are calculated slightly differently, they will not be identical. But it is these technical measurement differences that are likely to account for the differences in forecasting ability, not anything about the transmission mechanism.

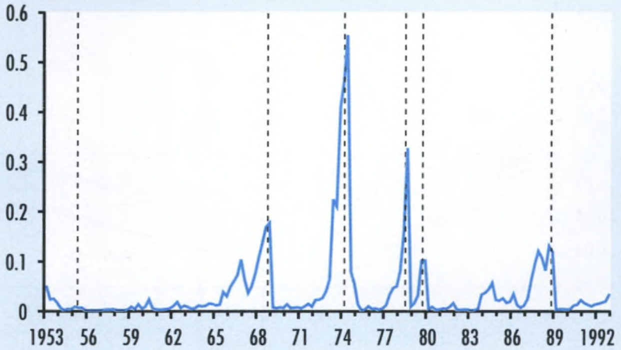
More generally, the main finding is that credit lags output. Unfortunately, this tells us nothing about the transmission mechanism. The aggregate data do show that aggregate credit is *countercyclical*, but it is easy to find explanations for this that are consistent with the lending view. For example, Kiyotaki and Moore (1993) present a model in which individuals must continue to service credit even after income falls, and so credit falls after income even though it is the fundamental source of fluctuations. In the end, it is difficult to see how aggregate timing relationships can tell us anything at all about the way in which monetary policy affects real activity.[28]

Aggregate Timing Relationships

The second use of aggregate data has been to examine the response of various

Figure 3

Estimated Probability of a Romer and Romer Date
(Shapiro probit model using inflation and unemploymnt)



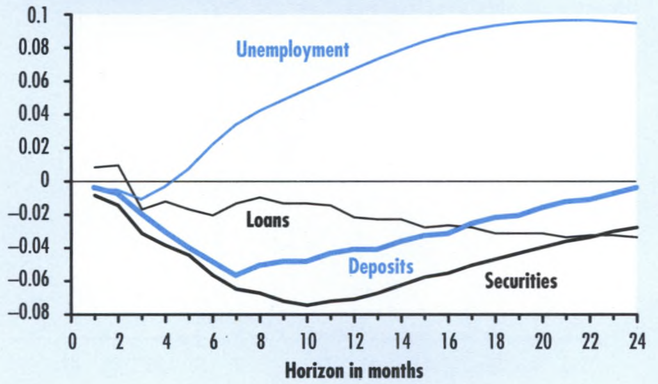
[26] Miron, Romer and Weil (1994) study pre-World War II interest rates in an attempt to address these questions.

[27] In the presence of rationing, there is the added complication that one would need observations on the shadow price for a loan to a borrower who is deemed not to be creditworthy given the economic environment. Obviously, there is no easy way to infer such a price.

[28] This point is also made by Bernanke, Gertler and Gilchrist (1994).

Figure 4

Bernanke and Blinder Plot of Responses to Federal Funds Rate Shock



financial quantities to policy innovations. Returning to Bernanke and Blinder (1992), they study whether bank loans and securities respond differently to federal funds rate innovations.[29] The standard methodology is to calculate the impulse responses for the two variables and note that they look different. Figure 4 reports the common finding, calculated using the six-variable Bernanke and Blinder VAR estimated over the 1959-90 sample. In response to a positive 1 percentage point innovation in the federal funds rate, the unemployment rate rises by nearly 0.1 percentage point after one-and-a-half years, while bank securities fall 0.07 percent and loans decline 0.02 percent. Securities fall both by a larger amount and more quickly than loans.

But point estimates of these impulse responses do not tell the entire story. In Figure 5, I plot the point estimate and two standard error bands for the difference between the impulse response for loans and securities. This allows an explicit test of whether these two assets are imperfectly substitutable in response to the shock. The differences are individually greater than zero in only a few months, and a joint test of the first 24 months of the impulse response, which is asymptotically distributed as a Chi-squared, has a p-value of 0.70.

My conclusion is that reduced-form vector autoregressions are nearly incapable of providing convincing evidence of a differential impact of federal funds rate innovations on various parts of bank balance sheets. These results are based on the estimation of a large number of parameters with a relatively small amount of data—this VAR has 237 parameters and 354 data points—and so the estimates are fairly imprecise.[30]

But even if one were to find that the impulse responses differed significantly, this would only bear on the substitutability of the assets, and not directly on the validity of the lending view. Both the prices and quantities of perfect substitutes must have the same stochastic process, and so finding that this particular partial correlation is different would be evidence of imperfect substitutability. As Bernanke and Blinder (1992) make clear in discussing their findings, this is a necessary but not a sufficient condition for the lending view to hold. It is not possible, using reduced-form estimates based on aggregate data alone, to identify whether bank balance sheet contractions are caused by shifts in loan supply or loan demand. What is needed is a variable that is known to shift one curve but not the other.

Kashyap, Stein and Wilcox (1993) also provide evidence based on aggregate timing. They compare the response of bank loans to that of commercial paper issuance following policy innovations. They find that monetary policy contractions seem to decrease the mix of loans relative to commercial paper. Borrowers that can move away from direct bank finance following a tightening appear to do so. Both Friedman and Kuttner (1993), and Oliner and Rudebusch (1993) take issue with these findings and show that changes in the mix are due to increases in the amount of commercial paper issuance during a recession, but that the quantity of bank loans does not change. In addition, Oliner and Rudebusch show that once firm size is taken into account, and trade credit is included in the debt of the small firms, the mix of financing is left unaffected by policy changes.

It is worth making an additional point about the commercial paper market. First, Post (1992) documents that all commercial paper rated by a rating agency must have a backup source of liquidity, which is generally a bank line of credit or a standby letter of

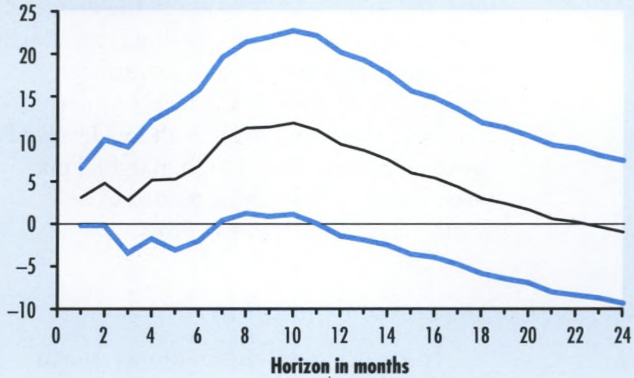
[29] Morgan (1992) and Strongin (1991) are also examples of this type of work.

[30] I have tried two variants of the Bernanke and Blinder VAR method that might seem promising ways of addressing the problem of measuring monetary policy changes. In the first, I substituted the funds rate *target* as reported in Sellon (1994) for the actual funds rate. This has very little impact on the results, as the Fed comes extremely close to hitting the targets. Second, I made the alternative extreme assumption that the funds rate itself is exogenous. This has very dramatic effects on the results, as Bernanke and Blinder's conclusions are completely unsupported. If all movements in the funds rate are assumed to represent exogenous policy actions, it would be extremely difficult to claim that loans and securities responded differently to policy shifts.

credit. This means that commercial paper is an indirect liability of banks, albeit one that is not on their balance sheet. Furthermore, Calomiris, Himmelberg and Wachtel (1994) suggest that increases in commercial paper issuance are accompanied by an increase in trade credit. This means that a policy contraction may simply cause a re-shuffling of credit by forcing banks to move liabilities off of their balance sheet such that large firms issue commercial paper in order to provide trade credit to small firms that would have otherwise come from banks.

Figure 5

Difference Between Loan and Security Response to Federal Funds Rate Shock
(percentage change at annual rate with two standard-deviation bands)



USING CROSS-SECTIONAL DATA

There is a large empirical literature using cross-sectional data that is relevant to understanding the channels of monetary policy. These studies fall into groups that separately address the two parts of the lending view. The first set of papers tries to gauge the importance of capital market imperfections on investment, and so is related to the balance sheet effects described in the first section. The second set, which is fairly small, examines time-series variation in cross-sectional data in an attempt to characterize the distributional effects of monetary policy directly. I will briefly describe each of these strategies.

Measuring Capital Market Imperfections

The literature on capital market imperfections is an outgrowth of the vast work done on the determinants of investment. The general finding in this literature is that internal finance is less costly than external finance for firms that have poor access to primary capital markets.

The empirical studies fall into two categories. The first examines reduced-form correlations, while the second looks directly at the relationship between the cost and expected return to a marginal investment project—they estimate structural Euler equations.

Reduced-Form Correlations

Fazzari, Hubbard and Petersen (1988) pioneered the technique of dividing firm-level data into groups using measures thought to correspond to the project monitoring costs created by information asymmetries, and then seeing if the correlation between investment and cash-flow measures varies across the groups. The finding in a wide range of studies is that investment is more sensitive to cash-flow variables for firms who have ready access to outside sources of funds.[31]

The main issue in interpreting these results is whether the characteristics of the firm used to split the sample are exogenous to financing decisions. Measures of firm size, dividend policies, bond ratings and the like may be related to the quality of investment projects a firm has available, and so lender discrimination may not be a consequence of asymmetric information.

There are several examples in which researchers identify potentially constrained firms based on institutional characteristics, and so the endogeneity problems are mitigated. I will mention two. Hoshi, Kashyap and Scharfstein (1991) find that investment by Japanese firms that were members of a *keiretsu,* or industrial group, was not influenced by liquidity effects. Using data on individual hospitals, Calem and Rizzo (1994) find that investment depends more heavily on cash-flow variables for small, single-unit hospitals than for large, network-affiliated ones.

In the most convincing study of this type, Calomiris and Hubbard (1993) study

[31] Bernanke, Gertler and Gilchrist (1994) survey the large number of studies that use this approach.

the undistributed corporate profits tax in 1936 and 1937 to estimate the differences in financing costs directly from firms' responses to the institution of a graduated surtax intended to force an increase in the dividend payout rate. Their results, holding investment opportunities fixed, are that investment spending is affected by the level of internal funds only for those firms with low levels of dividend payments and high marginal tax rates. Furthermore, these tended to be smaller and faster growing firms.

Structural Estimation

The neoclassical theory of investment allows one to derive the complex equilibrium relationship among the capital stock, rates of return, future marginal value products and project costs that form the first-order conditions for a firm's problem. With the appropriate data, it is then possible to see whether these Euler equations hold. Hubbard and Kashyap (1992) is an interesting use of this technique. Following the work of Zeldes (1989) on consumption, they examine whether the ability of agricultural firms to meet this first-order condition depends on the extent of their collaterizable net worth. They find that during periods when farmers have high net worth, and so have better access to external financing, their investment behavior is more likely to look as if it is unconstrained.

These investment studies have been very successful in establishing the existence of capital market imperfections as well as their likely source in information asymmetries arising from monitoring problems. While the work has little to say about monetary policy directly, it does provide an excellent characterization of the distributional effects of changes in the health of firms' balance sheets regardless of the source.

Time-Series Evidence

The strategy in the second set of studies is to use the cross-sectional dimension to identify the transmission mechanism. The goal is to determine whether the reduction in loans during monetary contractions is a consequence of shifts in loan demand or loan supply. My conclusion is that these studies fail to establish the desired result in a convincing way. Instead, they provide further evidence of capital market imperfections.

Three major studies use data on manufacturing firms. In the first, Gertler and Hubbard (1988) find that the impact of cash flow on investment is higher during recessions for firms that retain a high percentage of their earnings. The second, by Kashyap, Lamont and Stein (1992), shows that during the 1981-82 recession, the inventories of firms without ready access to external finance fell by more when their initial level of internal cash was lower. On the other hand, the inventory investment behavior of firms with ready access to primary capital markets showed no evidence of liquidity constraints. In the third, Gertler and Gilchrist (1994) use the *Quarterly Financial Report for Manufacturing Corporations (QFR)* to divide firms into asset-size categories and find that small firms account for a disproportionate share of the decline in manufacturing following a monetary shock.[32]

Both Kashyap and Stein (1994b) and Peek and Rosengren (forthcoming) focus on the behavior of lenders rather than borrowers. By examining the cyclical behavior of banks, Kashyap and Stein hope to find evidence for the importance of loan supply shifts. The strongest result in their paper is that, following a monetary contraction, the total quantity of loans held by small banks falls while that of large banks does not. By contrast, Peek and Rosengren study New England banks during the 1990-91 recession and find that poorly capitalized banks shrink by more than equivalent institutions with higher net worth. My interpretation is that both of these show that the capital market imperfections commonly found to apply to manufacturing firms apply to banks as well.

There are two difficulties inherent in any attempt to establish that the important transmission mechanism for monetary policy shocks is through bank loan supply shifts. First, as described at length in the second section, there is the problem of empirically identifying monetary policy. Beyond this, there is the subtlety of distinguishing loan

[32] Oliner and Rudebusch (1994) and Bernanke, Gertler and Gilchrist (1994) obtain similar results using the *QFR* data as well.

supply shifts from the balance sheet effects. Is the observed reduction in loans a consequence of their complementarity with outside money caused by the structure of the banking system, or is it the result of changes in the shape of the marginal efficiency of investment schedule brought on by the balance sheet effects? Kashyap, Lamont and Stein (1992) suggest one possible way of distinguishing these possibilities. If one can find a recessionary period that was *not* preceded by a monetary contraction, and show that interest rates rose but that bank dependence was irrelevant to individual firms' experiences, this would mean that banks are responsible for the distributional effects induced by monetary shocks. Unfortunately, such evidence is not readily available.

CONCLUSION

After a survey of the work that attempts to distinguish theories of the monetary transmission mechanism, where do we stand? My conclusion is that the myriad studies have succeeded in establishing the empirical importance of credit market imperfections. This means that monetary policy shifts have an important distributional aspect that cannot be addressed within the traditional money view. It is the smaller and faster growing firms that bear a disproportionate share of the burden imposed by a recession. Since these are likely to be firms with highly profitable investment opportunities, this has important implications for social welfare. Not only are recessions associated with aggregate output and investment declines, but the declines are inefficient.

Beyond this, there is the issue of distinguishing the two parts of the lending view. Do we care if we can distinguish changes in investment opportunities resulting from financial accelerator effects from bank loan supply shifts per se? Does the conclusion have implications for the actual conduct of monetary policy? I believe the answer is yes. If the complementarity of bank loans and outside money arises largely as a result of the financial regulatory environment, then, with financial innovation and liberalization, these effects are likely to become less important over time. With the introduction of interstate banking and the development of more sophisticated instruments aimed at trading pools of loans, it is only the balance sheet effects that will remain. As a result, it is important to know which is the more important channel of monetary policy transmission.

REFERENCES

Bernanke, Ben S. "How Important is the Credit Channel in the Transmission of Monetary Policy? A Comment," *Carnegie-Rochester Conference Series on Public Policy 39* (December 1993) pp. 47-52.

_______. "Credit in the Macroeconomy," *Federal Reserve Bank of New York Quarterly Review* (spring 1993) pp. 50-70.

_______ and Mark Gertler. "Financial Fragility and Economic Performance," *Quarterly Journal of Economics* (February 1990), pp. 87-114.

_______ and Mark Gertler. "Agency Cost, Net Worth and Business Fluctuations," *The American Economic Review* (March 1989), pp. 14-31.

_______ and Alan S. Blinder. "The Federal Funds Rate and the Channels of Monetary Transmission," *The American Economic Review* (September 1992), pp. 901-21.

_______ Mark Gertler and Simon Gilchrist. "The Financial Accelerator and the Flight to Quality," National Bureau of Economic Research *Working Paper No. 4789* (July 1994).

Brainard, William C., and James Tobin. "Financial Intermediaries and the Effectiveness of Monetary Controls," *The American Economic Review* (May 1963), pp. 383-400.

Boschen, John F., and Leonard O. Mills. "The Effects of Countercyclical Monetary Policy on Money and Interest Rates: An Evaluation of Evidence from FOMC Documents," working paper (1992), College of William and Mary.

Calem, Paul, and John A. Rizzo. "Financing Constraints and Investment: New Evidence from Hospital Industry Data," working paper (1994), Yale University, School of Medicine, Department of Epidemiology and Public Health.

Calomiris, Charles W., Charles P. Himmelberg and Paul Wachtel. "Commercial Paper and Corporate Finance: A Microeconomic Perspective," working paper (April 1994), Stern School of Business, New York University.

_______ and R. Glenn Hubbard. "Tax Policy, Internal Finance, and Investment," Internal Finance and Investment: Evidence from the Undistributed Corporate Profits Tax of 1936-37, National Bureau of Economic Research *Working Paper No. 4288* (March 1993).

Cecchetti, Stephen G. "Testing Short Run Neutrality: International Evidence," *Review of Economics and Statistics* (February 1987) pp. 135-40.

________. "Testing Short Run Neutrality," *Journal of Monetary Economics* (May 1986) pp. 409-23.

Christiano, Lawrence, and Martin S. Eichenbaum. "Liquidity Effects and the Monetary Transmission Mechanism," *The American Economic Review* (May 1992) pp. 346-53.

Doan, Thomas A. User's Manual, RATS Version 3.10. VAR Econometrics, 1990.

Fama, Eugene F. "Banking in the Theory of Finance," *Journal of Monetary Economics* (January 1980) pp. 39-57.

Fazzari, Steven M., R. Glenn Hubbard and Bruce C. Petersen. "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity* (1988:1) pp. 141-95.

Feurst, Timothy. "Liquidity Effect Models and Their Implications for Monetary Policy," working paper (April 1993), Bowling Green State University, Department of Economics.

Friedman, Benjamin M. "Discussion of `New Evidence on the Monetary Transmission Mechanism," *Brookings Papers on Economic Activity* (1990:1), pp. 204-9.

________and Kenneth N. Kuttner. "Economic Activity and the Short-Term Credit Markets: An Analysis of Prices and Quantities," *Brookings Papers on Economic Activity* (1993:2), pp. 193-266.

Friedman, Milton, and Anna Schwartz. *A Monetary History of the United States,* 1867-1960. Princeton University Press, 1963.

Gertler, Mark, and Simon Gilchrist. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics* (May 1994) pp. 309-40.

________ and ________. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence," *Scandinavian Journal of Economics* (1993) pp. 34-64.

________ and R. Glenn Hubbard. "Financial Factors in Business Fluctuations," National Bureau of Economic Research *Working Paper No. 2758* (November 1988).

Hamilton, James D. *Time Series Analysis.* Princeton University Press, 1994.

Hoover, Kevin D., and Stephen J. Perez. "Post Hoc Ergo Propter Hoc Once More: An Evaluation of 'Does Monetary Policy Matter?' in the Spirit of James Tobin," *Journal of Monetary Economics* (February 1992), pp. 3-24.

Hoshi, Takeo, Anil K. Kashyap and David Scharfstein. "Corporate Structure, Liquidity and Investment: Evidence from Japanese Panel Data," *Quarterly Journal of Economics* (February 1991), pp. 33-60.

Hubbard, R. Glenn. "Is There a `Credit Channel' for Monetary Policy?" this Review (May/June), pp. 63-82.

________ and Anil K. Kashyap. "Internal Net Worth and the Investment Process: An Application to U.S. Agriculture," *Journal of Political Economy* (June 1992) pp. 506-34.

Ingersoll, Jonathan E. *Theory of Financial Decision Making.* Rowman and Littlefield, 1987.

James, Christopher. "Some Evidence on the Uniqueness of Bank Loans," *Journal of Financial Economics* (1987), pp. 217-36.

Kashyap, Anil K., and Jeremy C. Stein. "Monetary Policy and Bank Lending," in N. Gregory Mankiw, ed., *Monetary Policy.* University of Chicago Press for the National Bureau of Economic Research, 1994, pp. 221-62.

________ and ________. "The Impact of Monetary Policy on Bank Balance Sheets," working paper (March 1994), University of Chicago, Graduate School of Business.

________, Jeremy C. Stein and David W. Wilcox. "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance," *The American Economic Review* (March 1993), pp. 78-98.

________, Owen A. Lamont and Jeremy C. Stein. "Credit Conditions and the Cyclical Behavior of Inventories: A Case Study of the 1981-1982 Recession," National Bureau of Economic Research *Working Paper No. 4211* (November 1992).

King, Robert G., and Charles I. Plosser. "Money, Credit and Prices in A Real Business Cycle," *The American Economic Review* (June 1984), pp. 363-80.

King, Stephen R. "Monetary Transmission: Through Bank Loans or Bank Liabilities?" *Journal of Money, Credit and Banking* (August 1986), pp. 290-303.

Kiyotaki, Nobuhiro, and John Moore. "Credit Cycles," working paper (March 1993), London School of Economics .

Lucas, Robert E., Jr. "Liquidity and Interest Rates," *Journal of Economic Theory* (1990), pp. 237-64.

Miron, Jeffrey, Christina D. Romer and David Weil. "Historical Perspectives on the Monetary Transmission Mechanism," in N. Gregory Mankiw, ed., *Monetary Policy.* University of Chicago Press for the National Bureau of Economic Research, 1994, pp. 263-306.

Morgan, Donald P. "The Lending View of Monetary Policy and Bank Loan Commitments," working paper (December 1992), Federal Reserve Bank of Kansas City.

Oliner, Stephen, and Glenn D. Rudebusch. "Is There a Bank Credit Channel for Monetary Policy?" Board of Governors of the Federal Reserve System, Finance and Economics Division *Discussion Paper No. 93-8* (February 1993).

Peek, Joe, and Eric Rosengren. "The Capital Crunch: Neither a Borrower Nor a Lender Be," *Journal of Money, Credit and Banking* (forthcoming).

Post, Mitchell A. "The Evolution of the U.S. Commercial Paper Market Since 1980," *Federal Reserve Bulletin* (December 1992), pp. 879-91.

Ramey, Valerie. "How Important is the Credit Channel in the Transmission of Monetary Policy?" *Carnegie-Rochester Conference Series on Public Policy* (December 1993), pp. 1-45.

Romer, Christina D., and David H. Romer. "Credit Channels or Credit Actions? An Interpretation of the Postwar Transmission Mechanism," in *Changing Capital Markets: Implications for Monetary Policy.* Federal Reserve Bank of Kansas City, 1993.

________ and ________. "New Evidence on the Monetary Transmission Mechanism," *Brookings Papers on Economic Activity* (1990:1), pp. 149-213.

________ and ________. "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," National Bureau of Economic Research *Macroeconomics Annual.* MIT Press, 1989, pp. 121-70.

Sargent, Thomas J. *Macroeconomic Theory,* Second Edition. Academic Press, 1987.

Sellon, Gordon H., Jr. "Measuring Monetary Policy," working paper (August 1994), Federal Reserve Bank of Kansas City.

Shapiro, Matthew D. "Federal Reserve Policy: Cause and Effect," in N. Gregory Mankiw, ed., *Monetary Policy.* University of Chicago Press for the National Bureau of Economic Research, 1994, pp. 307-34.

Sims, Christopher. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review* (May 1992), pp. 975-1000.

Stiglitz, Joseph E., and Andrew Weiss. "Credit Rationing in Markets with Imperfect Information," *The American Economic Review* (June 1981), pp. 393-410.

Strongin, Steven. "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle," Federal Reserve Bank of Chicago *Working Paper No. 92-27* (November 1992).

Zeldes, Stephen P. "Consumption and Liquidity Constraints: An Empirical Investigation," *Journal of Political Economy* (April 1989), pp. 305-46.

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Commentary

Mark Gertler

Steve Cecchetti has written a very nice survey. A central point of his article, with which I completely agree, is that in assessing the empirical relevance of the credit channel literature, it is incorrect to focus on credit aggregates. Perhaps contrary to conventional wisdom, these theories do not imply that credit aggregates should forecast output better than standard indicators of monetary policy, nor do they imply that credit aggregates should lead output over the business cycle.[1] Because I agree with virtually everything Steve said, I would like to take the opportunity to clarify what I believe are the central elements of the literature.

In my view, a credit channel for monetary policy is a special case of a financial propagation mechanism. To understand the former, therefore, it is first useful to define the latter. Suppose that $1 + \rho_t$ is the gross borrowing rate that an economic agent would face at time t if capital markets were perfect. The net rate ρ_t equals the sum of the safe rate plus a premium that depends on the systematic risk of the agent's investment.

Suppose now that we allow for the possibility that the agent may have imperfect access to the capital market. In this instance, due to information and enforcement problems, the price of external funds will exceed the (risk-corrected) opportunity cost of internal funds.[2] The effective borrowing rate that the agent faces may be expressed as $Q_t(1 + \rho_t)$, where $Q_t \geq 1$. This rate is the explicit cost of funds if there are no non-price terms to the loan. Otherwise, it is the implicit cost, after taking into account the effect of the non-price terms.

The multiplier Q_t is interpretable as the shadow cost of a unit of internal funds. It is the maximum the agent would be willing to pay for an additional unit of internal funds. In the benchmark case of perfect capital markets, $Q_t = 1$. As credit constraints tighten, internal funds become more valuable and, consequently, Q_t rises. Notice that the spread between the cost of external and internal funds is approximately $Q_t - 1$.

Now suppose that X_t is a decision variable in an intertemporal choice problem. In the case of a firm, for example, X_t could represent either capital investment or inventory investment. In the case of a household, it could represent saving or the acquisition of a consumer durable. At the optimum, the agent adjusts X_t to the point where the marginal cost equals the discounted marginal benefit:

$$(1)\quad MC_t(X_t) = [1/Q_t(1 + \rho_t)]E\{MB_{t+1}(X_t)\}.$$

Since Q_t influences the effective discount rate, it ultimately influences the choice of X_t.

Up to this point, we have taken Q_t as given. In the theoretical literature on the financial propagation mechanism, Q_t is derived endogenously, and in equilibrium it is determined jointly with X_t. Roughly speaking, the theory suggests that Q_t should depend on financial variables such as the agent's net worth (that is, collateral and internal funds) and the availability of intermediary credit. That is, we can write:

$$(2)\quad Q_t = Q(NW_t, IC_t),$$

where NW is the agent's net worth and IC is an indicator of the availability of intermediary credit.

Now to the point: A financial propagation mechanism amplifies the impact of a primitive disturbance on X_t via an impact on Q_t. One example is Bernanke's (1983) theory of the Great Depression. The bank runs associated with the initial downturn reduced the availability of intermediary credit, forcing up Q_t, further depressing spending and output. Another example is the financial accelerator theory of investment described in Bernanke and Gertler (1989). In that framework, endogenous procyclical movements

[1] In addition to Cecchetti (1995), see the discussion in Bernanke, Gertler and Gilchrist (forthcoming), and Kashyap and Stein (1994).

[2] For more detail, see Bernanke, Gertler and Gilchrist (forthcoming)

in the strength of firm balance sheets induce countercyclical movements in Q_t. The resulting countercyclical movements in the spread between the cost of external and internal funds serve to amplify investment fluctuations.

A credit channel for monetary policy is a financial propagation mechanism, in which the primitive impulse is monetary policy. A credit channel thus amplifies the impact of a shift in interest rates induced by monetary policy by causing an associated movement in the spread between the cost of external and internal funds; that is, by altering how smoothly funds flow between lenders and borrowers. In my view, the variety of types of mechanisms in the literature that have received the label "credit channel" fit this broad definition.

Let me illustrate the impact of a credit channel with the following simple neoclassical investment problem. Let Y be the firm's output, K its capital stock, I the rate of investment, θ a technology parameter and δ the rate of depreciation. Then suppose

$$Y_t = \tilde{\theta}_t K_t^{\alpha},$$

where by definition

$$K_{t+1} = I_t + (1-\delta)K_t.$$

At the optimum, the firm chooses investment to equate the marginal cost of a unit of capital, normalized at unity, with the discounted expected marginal gain:

$$1 = \left[1/Q_t\left(1+\rho_t\right)\right]\cdot E\left\{\alpha\tilde{\theta}K_{t+1}^{\alpha-1} + Q_{t+1}\left(1-\delta\right)\right\}.$$

The marginal benefit of a unit of capital in the next period is the sum of the marginal product of the next period and the value of the undepreciated capital. The latter is valued at the shadow price of internal funds of the next period, Q_{t+1}. This reflects the fact that credit market imperfections make a unit of capital worth more if it is already inside the firm than if the firm had to borrow to buy it.

In the conventional description of the transmission mechanism, both Q_t and Q_{t+1} are fixed at unity. A shift in monetary policy alters the short-term interest rate, directly influencing the discount rate $1/(1+\rho_t)$ and, in turn, the firm's investment decision. With a credit channel present, however, Q_t and possibly also Q_{t+1} change in a way that magnifies the overall impact.

The key point I wish to emphasize is that relatively small changes in Q_t may have a large effect (that is, the propagation mechanism may be strong). A numerical example is helpful. Consider the impact of 1 percentage point change in Q_t on the firm's investment decision. This corresponds to a 100 basis point rise in the cost of external funds relative to internal funds. If the rise in Q_t is persistent (so that Q_{t+1} adjusts to keep Q_t unchanged), then investment drops 12.5 percent, assuming conventional values for the exogenous parameters.[3] That is a large effect.

If the rise in Q_t is purely transitory, so that Q_{t+1} is unchanged, then investment drops a whopping 250 percent. In this latter case, there is a strong intertemporal substitution effect. Because the shadow price of internal funds is high today relative to tomorrow, the firm defers investment. More informally, if credit constraints are tight today but expected to be lax tomorrow, then the firm has a strong incentive to defer investment. To be sure, in constructing this example, I have abstracted from factors such as physical adjustment costs that will dampen the impact. Nonetheless, it is interesting that movements in the spread can have such a large impact in a fairly conventional framework.

Finally, let me fill in the details of how a credit channel may produce a shift in the spread between external and internal funds that complements the movement in interest rates associated with monetary policy.[4] There are two distinct but complementary ways in which the credit channel may work. The first is via the impact on borrower balance sheets. A rise in short-term interest rates induced by monetary tightening may weaken borrower balance sheets in several different ways. The rise in interest expenses on short-term debt directly reduces the supply of internal funds by reducing net cash flows (after interest payments). In addition, the

[3] In particular, I take $\alpha = 0.33$, $\delta = 0.1$, $\rho = 0.04$ and the steady-state growth rate of the economy equal to 0.02.

[4] See the discussion in Gertler and Gilchrist (1993), and the Cecchetti and Hubbard papers in this issue of the *Review* (May/June 1995).

associated decline in asset prices may reduce the value of the borrower's collateral. Either of these effects works to raise the shadow price of internal funds and, in this way, magnifies the impact of monetary policy on the borrower's effective discount rate. The magnified impact on the discount rate translates into a magnified effect on spending.

The second and perhaps more controversial way in which the credit channel may work is via the impact of a shift in bank reserves on the loan supply schedule that commercial banks may offer. Here, tightening of monetary policy forces banks to contract reservable deposits, reducing banks' source of funds available to service loan demand. This forces the bank loan rate up relative to the open market rate, raising the cost of capital for bank-dependent borrowers. In terms of the language here, the rise in the bank loan rate due to the contraction in deposits raises the shadow price of internal funds for bank-dependent borrowers. As pointed out by Romer and Romer (1993), Gertler and Gilchrist (1993) and Thornton (1994), however, a critical premise is that banks cannot perfectly decouple deposits from loans by elastically issuing managed liabilities at the margin. Although this premise seems to be a reasonable description of financial markets prior to the financial deregulation that began in 1980, it is less clear that it is applicable in the contemporary financial climate. The key issue concerns the liquidity of the market for large CDs. None of the existing studies have really addressed this difficult question.

REFERENCES

Bernanke, Ben S. "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression," *The American Economic Review* (June 1983), pp. 257-76.

________ and Mark Gertler. "Agency Costs, Net Worth and Business Fluctuations," *The American Economic Review* (March 1989), pp. 14-31.

________, ________ and Simon Gilchrist. "The Financial Accelerator and the Flight to Quality," National Bureau of Economic Research *Working Paper No. 4789* (July 1994).

Gertler, Mark, and Simon Gilchrist, "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence," *Scandanavian Journal of Economics* (No. 1, 1993), pp. 43-64.

Hubbard, R. Glenn, "Is There A "Credit Channel" for Monetary Policy," this *Review* (May/June 1995), pp. 63-82.

Kashyap, Anil, and Jeremy Stein. "Monetary Policy and Bank Lending," in N. Gregory Mankiw, ed., *Monetary Policy*. University of Chicago Press for the National Bureau of Economic Research, 1994, pp. 221-62.

Romer, Christina, and David Romer. "Credit Channels or Credit Actions?: An Interpretation of the Postwar Transmission Mechanism," in *Changing Capital Markets: Implications for Monetary Policy*. Federal Reserve Bank of Kansas City, 1993.

Thornton, Daniel L. "Financial Innovation, Deregulation and the "Credit View" of Monetary Policy," this *Review* (January/February 1994), pp. 31-49.

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Information, Sticky Prices and Macroeconomic Foundations

Allan H. Meltzer

For decades, macroeconomists have listened to criticism from their professional colleagues about the absence of microfoundations from most of what they say and do. A typical comment is: "I don't understand much about macroeconomics; how is it related to economics?" A possibly less-frivolous comment is that nothing can be said about macroeconomic policy until economists develop a macroeconomic theory from a microeconomic foundation. Anything less is branded "ad hoc" and dismissed.

Much of the work in macroeconomics of the past two decades has responded to these criticisms by attempting to build macroeconomics on an explicit micro-foundation. That is a worthwhile goal but it opens the question: Which foundation should that be? The current generation of academic researchers are as divided about the appropriate analytic model as their predecessors. Analytic paradigms now include multiple equilibrium, real business cycle, neo-Keynesian, monetary-rational expectations, and eclectic models. Most have a micro-foundation, but it is not the same foundation.

I do not question the presumption that a micro-foundation is useful. At issue is what the foundation should be. I question the relevance for monetary and macroeconomics of micro-foundations which feature a representative agent who trades on a complete set of Arrow-Debreu markets. Despite some limited successes, it is time to question whether this now widely accepted approach is likely to be fruitful and to suggest why I believe its success will be limited. Success is relative, of course. Real business cycle theory has developed an explicit analysis of the transmission of productivity and terms of trade shocks. These shocks, though widely recognized earlier, had not been made the subject of an explicit model. Neo-Keynesians and others have produced some suggestions about pricing. Overlapping-generations models of money, intertemporal substitution theories of unemployment, and productivity shock theories of the business cycle have not proved fruitful. These models have not produced either an accepted foundation for macro theory or a verified theory of aggregate output, prices and interest rates. Perhaps they will in the future, but the results to date are not promising.

There are two main ways to tie micro and macro theories. The first is aggregation. Aggregation is an important and much neglected issue, but it is not my main theme. Most current or recent research dispenses with the aggregation problem by assuming a representative individual. Here the old and new macroeconomics are equally deficient and open to charges of "arm waving" and "ad hocery." The representative individual is a useful working assumption for some purposes, but the representative individual discards an important difference between markets and individuals.

The second problem is the specific micro-foundation used for macro theory. Most of my discussion is directed there. I do not attempt to survey a large literature on micro theory, uncertainty and industrial organization. The implications of some of this literature for price stickiness is ably summarized in Gordon (1990). This paper is a personal statement, reflecting joint work as noted earlier.

The problem with existing micro-foundations that I emphasize is the neglect of costs of information. In Walrasian micro-foundations, all trades take place at market clearing prices, and there is no cost of acquiring information. An auctioneer calls out the prices at zero cost and does not close transactions until all transactors are at an equilibrium. There is a numeraire, but there is no way for money to disturb the real value of production or purchases. Non-neutrality cannot arise. Attempts to graft a monetary disturbance onto these micro-foundations seem misdirected.

The hypothesis that all observed prices are market clearing prices does not imply that all individuals, behaving rationally, know those prices and fully adjust to them. Information is costly to acquire; time and resources must be used to collect, process and interpret—the latter especially—new data. Even in markets dominated by price takers, there are differences between the information processed and known to arbitragers and specialists and what is known to non-specialists. The representative individual paradigm ignores this distinction.

One way to proceed is by aggregating heterogenous individuals who face different costs of acquiring information, and much new work has taken this path. As Gordon (1990) emphasizes, at any time there are many different layers of pricing and output included in aggregate prices and output—suppliers, suppliers of suppliers, foreign producers, and so on. Instead of trying to aggregate over these many, diverse and changing levels of decisions, it may prove more useful to treat them as part of a stochastic process.

One of the problems with the hypothesis that "sticky" prices reflect decisions at different levels of aggregation comes out clearly in Gordon's paper. He argues that sluggish price adjustment reflects marginal cost pricing. "[Agents] care about the relation of their own price to their own costs, not to aggregate nominal demand. Unless a single agent believes that the actions of all other agents will make its marginal costs mimic the behavior of nominal demand with minimal lags, the aggregate price level cannot mimic nominal demand, and Keynesian output fluctuations result."

This argument has a perverse implication. Farmers or farms that operate in commodity markets with many competitors should be slowest to adjust to aggregate demand shocks. Yet commodity prices typically adjust quickly. Large industrial firms—General Motors, Mitsubishi—know that they are a relatively large part of the economy, so they should adjust to aggregate demand more promptly than commodity producers. Typically, they do not.

Missing from Gordon's analysis is the difference in information and in costs of acquiring information. Commodities are traded on open markets, so prices promptly reflect changes in the factors affecting demand and supply. Prices of autos, steel, heavy industrial products and consumer durables are not set in organized markets. Information on which to base prices is more uncertain.

As Keynes recognized, a principal missing element is uncertainty about the future. Uncertainty and its twin, costs of information, make it rational for some firms to adjust prices slowly. Prices may be "sticky," as economists have observed for about as long as there has been a discipline.

Some economists will scoff that sticky prices are irrational or equivalent to leaving five, 50 or 500 dollar bills in the street. This is an error arising from dependence on Walrasian foundations and neglect of information costs. Yet, there is nothing novel about invoking costs of acquiring information to explain sluggish price adjustment or sticky prices. The positive slope of Lucas' (1972) aggregate supply curve arises from confusion between relative and absolute price changes; prices in that model do not immediately adjust to new information. The cost of learning whether a change in demand is an aggregate or relative change is infinite for one period and zero thereafter. In the neo-Keynesian models discussed in Ball and Mankiw (1994), costs of price adjustment—so-called menu costs—and "real rigidities" are assumed to be present. The authors accept that one of the principal costs of price adjustment is the cost of acquiring information relevant for a decision about how much to change price.

Given this widespread acceptance of information or transaction costs, what remains to be done? Lucas' (1972) model implies more rapid adjustment of prices and output to new information than we observe in practice. Could it be rational to adjust more slowly than in one week or month? Is the compelling fact that data on the price level are released monthly? Or is this information subject to error so that it takes longer to disseminate, interpret and act on these data? Neo-Keynesian models build on the model of an imperfectly competitive firm, with strong implications for profits and excess capacity that do not find empirical support at the micro level. If monopolistic elements and menu costs are the source of sticky prices, there are testable implications for the profits of different types of firms; there is a significant problem of reconciling continuous excess capacity with rational behavior. Further, as Gordon (1990) has noted, costs of adjusting output are neglected in these models. Yet these costs may be larger for many firms than costs of price adjustment.

My principal criticism of both neoclassical and neo-Keynesian approaches is that they seek to explain why firms delay using available information. By putting the issue in that framework, they neglect the uncertainty that surrounds much of the aggregate and disaggregated data. This paper uses several strands of earlier work to explain rational price setting and gradual adjustment as a response to uncertainty about what current information implies. Information is costly to acquire and to interpret as in Brunner and Meltzer (1971) or Alchian (1977). As in Bomhoff (1983), a principal difficulty in interpreting information is uncertainty about how long changes will persist. This is the central idea developed in Brunner, Cukierman and Meltzer (1983), but we took the idea from Muth's (1961) seminal paper on rational expectations. In Meltzer (1982), I used these ideas to discuss price setting.

There are three separable aspects of pricing to consider. First, (some) prices are set by firms. Second, firms choose nominal values; they do not index or set a relative price. Third, prices that are set change less frequently than prices in auction markets.

Each aspect is important for macroeconomics. If some prices were not fixed in nominal value for at least one period, relative prices would be invariant to a monetary change. Delays in recognizing permanent changes in money or its growth rate would affect only real balances. At best, we would be forced to fall back on the real balance effect in consumption to explain short-term real effects of changes in money. A rational reason for setting some, but not all, nominal prices permits a more direct effect through inventory adjustment. Firms that hold inventories can both anticipate future price changes and buffer current transitory price changes by varying inventories. Because some prices are determined in auction markets, price setting introduces different speeds of adjustment and relative price changes. My extensive work with Brunner emphasized the relative prices of assets and output. This introduces the difference between the replacement cost, or the cost of current production, and the market price of existing assets. Asset prices adjust more rapidly than output prices particularly for assets that trade in organized markets. Hence, information costs (and transaction costs) are implicit in that framework as an explanation of changes in relative prices. My emphasis here is on information as in Brunner, Cukierman and Meltzer (1983). Relative price changes in response to nominal shocks are part of that story, but they remain in the background.

HOW STICKY ARE PRICES?

Postwar recessions typically last about nine months on average. Costs of information or other explanations of sluggish adjustment must be able to explain this timing, and estimates of price stickiness should be consistent with data on cyclical fluctuations. I digress therefore to consider a recent attempt to measure stickiness. Blinder (1991) reports preliminary findings from a survey of pricing decisions by managers of a random sample of corporations with annual sales of $10 million located in the northeastern United States. Blinder's survey produced two very different sets of estimates.

First, Blinder reports the answer to a question about how frequently a firm changes its price. He finds that the median firm changes price about once a year. Nearly

40 percent of the firms were at the median. More than one-sixth of the firms changed prices less frequently than once a year, so 55 percent of the prices change no more than once a year.

Second, Blinder also reports the respondents' estimate of the mean lag of actual prices behind increases and decreases in demand and cost. There is considerable uniformity in these responses. The mean lag for increases or decreases in demand and cost is three to four months.

The second set of data suggest considerable uniformity of response to the four shocks. There is little evidence of the asymmetric adjustment associated with Keynesian downward price inflexibility. The data also suggest an inconsistency that Blinder does not mention. How do we reconcile a mean delay of three to four months in response to changes in demand and cost with the report that 76 percent of the sample changes price no more than twice a year and, as noted, 55 percent changes price no more than once a year? Are demand and cost changes infrequent? It is difficult to reconcile the assumption that costs change infrequently with evidence showing that commodity prices and other open market prices change daily and typically fall in recessions and rise in expansions.

Blinder did not ask whether firms adjust their prices fully in response to changes in demand and cost. They may adjust partially, as implied by rational behavior under uncertainty about the persistence or permanence of announced changes, or they may anticipate future changes and adjust prices more than current changes in cost or demand. One way to reconcile the different responses is to assume that respondents answer the two questions in different ways. Suppose they treat price as a scalar when asked about the frequency of price changes but include in price adjustment more than just price setting. On this interpretation, quoted prices are one component of a vector of terms and conditions relevant to sellers and buyers. The theoretical term price used in economics typically subsumes delivery time, discounts, advertising allowances, volume rebates, payment terms and other conditions used to adjust the buyer's cost and the seller's net receipts. Blinder's early results confirm that delivery lags and service are moderately important for 65 percent of the firms in his sample; he reports delivery lags and service are the most commonly cited reason for *price* stickiness.[1] Delivery lags and service are one way of adjusting the theoretical term "price" while leaving the quoted price unchanged.

Assume that firms initially respond to changes in cost and demand by adjusting deliveries, advertising allowances, discounts, and so on while leaving quoted prices unchanged for several months or longer. If managers are uncertain about the duration of changes in demand or cost, they can change other components of the price vector to test the market's response. By changing delivery terms, or offering or removing discounts, firms can change their revenues or the buyers cost without changing the quoted price. This pricing model can be used to rationalize the familiar Keynesian supply curve—a reverse L—when quoted prices are distinguished from other terms in the price vector. Equally, the model can explain the difference in response to the questions in Blinder's survey.

Figure 1 shows the initial response to an increase in demand. On the left, the quoted price (ρ) does not respond to a perceived change in demand when output is below capacity; the firm (or industry) increases output (q) with little or no change in quoted price. On the right, the price vector (p), includes other dimensions of the firm's price; supply is drawn as a positively sloped linear function. An increase in perceived demand from d_0 to d_1 induces the firm to reduce advertising allowances, remove discounts, or change some other component of the price vector, so (p) increases.

If the firm's initial response reflects uncertainty about the persistence of increased demand, the response changes as information accrues. An increase in the quoted price may substitute for or supplement other components of the price vector. As perception of the magnitude of the permanent increase becomes clearer, the firm may recognize that the new demand curve is at, or to the right of, d_1. Or the firm may raise ρ, with p unchanged.

[1] Beaulieu and Mattey (1994) estimate the effects on price dispersion of factors such as advertising, transport costs, and concentration using cross-section data for specific commodities. They find effects of some of these elements on price dispersion.

We need not explore the many possibilities. The main point is that uncertainty about the degree of persistence and the use of a price vector permit this hypothesis to account for very different responses within a rational expectations framework. In particular, the firm's revenues may respond instantly to increases in demand, but quoted prices may adjust with a long lag, as Blinder found. The reasoning is symmetric. Perceived reductions in demand may induce firms to offer discounts and allowances with ρ unchanged. As information accrues and perceptions change, the actual price, ρ, is reduced.

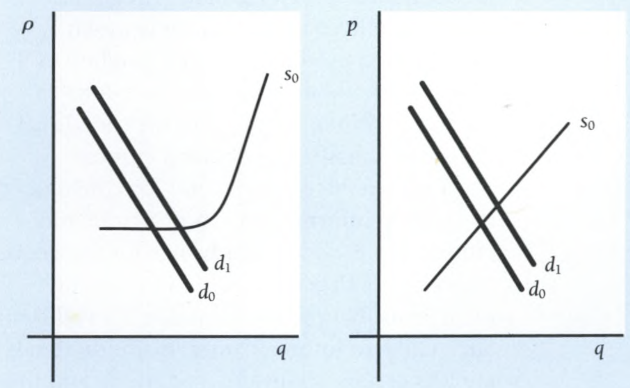
The Keynesian supply function does not work for changes in cost if the demand curve is not kinked. Changes in cost shift the supply curve, so prices change instantly, whether the supply has a reverse L-shape or is monotonically increasing. Since Blinder's survey finds that price responds about as promptly to changes in cost as to changes in demand, this evidence rejects the Keynesian supply curve.[2]

The distinction between price as a vector and a scalar does not reconcile the differences in timing reported in the survey. Although I believe that prices, terms and conditions change at different rates when there is uncertainty about the persistence of the market conditions inducing firms to change prices, those differences are neglected hereafter. Price stickiness will mean that it takes about three or four months on average for prices to respond to demand and cost changes. The three-to-four month delay that Blinder reports includes at least one quarterly reporting period at which managements announce earnings and sales and, most importantly, observe reported earnings, inventories and sales of competing firms.[3] Knowledge of competitors' results helps the firm to supplement trade gossip and other informal data sources to decide whether a persistent change in market demand (or industry costs) has occurred.

INFORMATION AND PRICE SETTING

Anyone familiar with literature on the behavior of firms knows that there are many rational reasons for firms to set prices. This section discusses one reason that is rather general and can be incorporated readily into macroeconomics. Price setting is considered as a response to uncertainty or costs of acquiring information about the market clearing price by at least one (large) group of market participants.[4] At times, prices convey information known to the seller but not to the buyer. At times, neither the buyer nor the seller is certain about the market clearing price. Among the possible reasons on the cost and demand sides, this section emphasizes rational reasons why buyers and sellers do not instantly know the permanence of changes in demand. They develop contracts and market arrangements to deal with this uncertainty.

Figure 1



This approach differs from the literature on so-called menu costs. The menu cost literature emphasizes costs of changing prices.[5] These costs are recognized as relatively small (Ball and Mankiw, 1994). Moreover, the menu cost model does not explain why sellers face different costs and adjust at different speeds. I do not challenge the existence of menu costs, but the emphasis here is on uncertainty and information costs—the cost of learning about current and prospective market conditions. Information costs differ by firm and industry. They depend on the way in which markets are organized and the types of contracts that emerge to reduce costs of uncertainty, information and moral hazard.

[2] Ball and Mankiw (1994) use the ability to generate a reverse L-shape (Keynesian) supply curve as evidence for a model of menu costs and imperfect competition.

[3] This should not suggest that the timing is constant. As in Muth (1961), the timing of the response depends on the relative variances of permanent and transitory components. See below.

[4] Much of this section is taken from Meltzer (1982), and especially Brunner and Meltzer (1993). Additional examples of rational price setting when information is costly to acquire can be found in these references. A recent paper by Heaton and Lucas (forthcoming) analyzes the effects of transaction costs, such as bid-ask spreads, investor heterogeneity and persistence of shocks. They find that many puzzles in asset pricing can be reduced or removed by using models with transaction costs and persistence. Balvers and Cosimano (1990) model price adjustment when firms must learn about the persistence of changes in demand.

[5] See McCallum (1989) for a critical discussion of menu costs as a basis for rational price-level stickiness.

Market Organization

Frank Knight was an early expositor of the economics of information. Knight (1933), argued that decisions about how much and when to produce require a pooling of information about individual decisions to purchase. When aggregated, the individual decisions constitute a demand curve.

Firms reduce uncertainty for consumers by pooling information. In principle, individuals can contract in advance for the goods and services that they want. Organizing retail firms that pool information is an efficient alternative to futures contracts if individuals are less certain about the magnitude and timing of their purchases than firms are about market demand. Knight appeals to the law of large numbers to explain firms' advantage. He compares pooling by firms to insurance and concludes that the two differ in an important way; a firm's pricing and output decisions are non-insurable because they require more subjective judgment, and errors are less likely to cancel across firms.

In Knight's view, firms produce for inventory using pooled information about expected demand. This arrangement shifts uncertainty from individuals to firms and, by pooling, reduces the social cost of bearing uncertainty.

Knight's argument is one of several that links information costs and uncertainty to price setting. A non-uniform distribution of information is critical for these arguments. In an auction market, all market participants must have information about the qualities of the goods traded and their prices. In the standard Walrasian model, this is accomplished by: (1) assuming the presence of an auctioneer who calls out the prices; (2) allowing recontracting; and (3) letting all trades be made simultaneously. These assumptions are necessary for equilibrium. They leave no role for monetary disturbances.

The necessary conditions are frequently violated in practice. Some people have a comparative advantage in acquiring information. Some receive information about market conditions as a by-product of other activity. For example, in securities markets, there are brokers, dealers and market makers who acquire specialized information in the course of trading. Assembling all or a sufficiently large number of market participants also imposes severe constraints. For many reasons, including the law of large numbers, people choose different times for their market activities. The commitment to assemble at pre-specified times for all marketing purposes is costly, if not impossible. The use of an agent introduces costs of monitoring and supervision.

In practice, markets operate in many different ways. One alternative commonly found in oriental countries is called a bazaar. Prices are not posted, and there is no auctioneer mechanism. Buyers and sellers negotiate (haggle) until a transaction is completed or the negotiation terminates. Considering a bazaar brings out the importance of information.

The bazaar requires an investment of time by transactors. Where the auction market requires simultaneous arrival of all participants or their agents, the bazaar depends on a trickle of arrivals. It cannot cope with large groups arriving simultaneously because each negotiation is separate. It is not surprising that the bazaar is found in comparatively simple, low-income economies. In these circumstances, the allocation of time to the bargaining process may be partly a consumption good. With rising opportunity costs of time, the disadvantages of the bargaining process exceed the benefits.

The working of a bazaar restricts its application. There are severe limits on the number of transactions per period. Sellers cannot serve several customers simultaneously. Delegating bargaining to employees poses both an incentive and a moral hazard problem. Buyers incur costs to learn about reservation prices, since information is revealed only by commitments to transact firm offers to buy or sell. An accepted offer to purchase may be above the seller's reservation price; a refusal to sell may be based on an incorrect inference that the buyer is willing to pay more. Learning the reservation price and negotiating the market price often requires a series of offers. There is no certainty that the reservation price is revealed. Subsequent transactors on one side of the market do not know the history of past transactions. They must invest their own time.

A seller who posts prices reduces the buyers' costs of acquiring information about prices. Buyers' costs of comparing prices by different sellers are reduced. The social advantage of price setting is greatest where one party to the transaction has more information about market conditions. Some examples illustrate this argument.

Information about prices conveys more than just purchase cost. Posted prices can also reduce costs of acquiring information about quality. For example, a restaurant owner must decide on the market he wants to serve. This decision influences the kind and quality of food served, the services offered, and the prices charged. By posting prices, the owner informs the buyer about his choices. Although the buyer must sample to judge quality, the correlation between quality and price helps the buyer to decide whether to sample. A policy of frequently changing prices reduces information and places the restaurant at a competitive disadvantage.

The organization of the diamond market provides additional evidence on the role of information in market organization. The wholesale diamond market is an auction market dominated by buyers and sellers who are specialists. Traders rely on their own skill in judging quality, knowledge of prices and other attributes. The retail market is very different. The sellers are mainly specialists; the buyers typically have much less information than the sellers. By posting prices, sellers exploit the correlation between quality and price to inform buyers. Buyers find it less costly to invest in information about the seller than to invest in information about the quality of diamonds, so sellers use resources to build reputation. If costs of acquiring information about the quality of diamonds were to fall to a minimal value, these arrangements would change. Diamonds might be sold in supermarkets or in retail auction markets.

Price setting is valued by transactors even in some auction markets. In well-organized auction markets, we find people willing to pay for the right to purchase or sell at fixed nominal prices. The contracts expressing these rights, known as "put" and "call" options, give the owner the right to buy or sell at a fixed price within a fixed time period. The prices of the puts and calls are determined in auction markets. The price of these options is the cost that people pay for the right to trade in the future at prices fixed today. Similarly, in commodity markets, hedgers pay to change uncertain future prices into known values. They pay a fee for the right to buy or sell at fixed nominal prices. In such markets, information about current and currently anticipated future prices is available. The fee permits transactors to avoid uncertain future price changes.

Costs of information and transactions are not uniform across goods, so no single form of market organization dominates all others. The specific reasons transactors are willing to pay for puts and calls differ from the reason for price setting in the diamond market, just as the diamond market differs from the restaurant. Each is related, however, to costs of information. The organization of the diamond market reduces the costs of bearing uncertainty about quality. The market for puts and calls permits asset owners or speculators to limit risk of wealth changes. And there are other market arrangements where price setting is useful. Catalogues must post prices. Contracts fix prices for a year or more on housing rentals, magazine subscriptions, and automobile leases. These many different examples suggest that there are advantages in different types of contracts.

The examples suggest a way to model price setting formally. The seller has information that is costly for the buyer to acquire. The seller internalizes the cost of acquiring the information; it is part of his specialized knowledge and he revises his information in the process of buying inputs. By posting a price, he exploits the correlation between price and quality. In goods markets, the seller may offer a particular type of put—an option for the buyer to return the merchandise if the quality is not as represented or, perhaps, if the buyer finds the same merchandise at a lower price. The buyer pays for the good and for the put, but the purchase cost is lower than under alternative forms of organization. In service markets, the buyer may purchase increased certainty that he will not have to relocate or search for a particular input at an inconvenient time.

Labor Markets

The conditions leading to price setting also apply to the labor market. The terms negotiated and the time horizon built into an agreement depend on the assessments of the parties. There are no organized futures markets for labor. Both parties use all available information to form their uncertain assessments. An assessment of the market is a (subjective) probability distribution. The more diffuse the distribution, the shorter the time covered by the arrangement.

Realizations often deviate from the expectations implied by the subjective probability distributions. Both parties have to infer from realizations whether the unexpected changes are transitory or permanent.

A transitory change does not change the expected value, so the unanticipated gains and losses do not change the information on which the agreement was based. Either party may believe that a costless revision of the bargain to adjust to a transitory change would be beneficial, but attempts at revision for each such change raise the cost of transacting and eliminate the benefits of a longer-term agreement.

A more permanent change in conditions poses a different problem. The initial assessment of at least one party must be revised in the light of the new information. If the stakes are sufficiently high, the permanent change may justify the cost of renegotiation.

Negotiations proceed more smoothly when both parties share the reassessment of market conditions. Differences in assessment provide evidence on the extent of uncertainty. Strikes and lockouts increase with differences in assessment, for example, at the start of a period of inflation or disinflation. If both parties could agree on the actual shocks that occurred in the past and on how long they will persist, they could contract in advance to compensate for unanticipated changes after they occur. Permanent changes in nominal values would not be allowed to affect real wages. Permanent changes in productivity would be paid to workers if positive and by workers if negative. That we do not observe contracts of this kind suggests that assessments differ even after the event and that reaching a common assessment of the past is costly. Of course, setting nominal wages is not costless either. Bargaining or negotiating to correct for unforeseen events can be costly, privately and socially, if there are strikes or layoffs.[6]

Differences in information can explain price setting, but they do not fully explain why firms and employees often set nominal wages or prices. There must be some additional cost of setting relative prices or benefit from setting nominal wages (or prices). One explanation is that the parties do not agree on the interpretation of real wages and, particularly at low rates of inflation, have difficulty agreeing on an appropriate index.

There are two different meanings of real wages. One meaning expresses real wages in terms of the product of the firm at which the worker is employed. The second refers to the basket of goods and services that the worker can purchase. The problems of setting contract terms differ in the two cases.

Contracts that set wages in relation to productivity require a satisfactory solution to the measurement of productivity. Where precise measurement is difficult, as in service industries or managerial tasks, real wage contracts are difficult to write. Even when productivity is measured reliably as in piece-work systems, the measure does not translate directly into a real wage rate. Valuation is required; often some (more or less) arbitrary system must be used to impute the price of the final product to the various inputs. Imputation and valuation bring two additional problems. One is moral hazard; the employer has some incentive to adopt a cost accounting system that benefits him. The other is the difference between relative and absolute prices. The employer is mainly concerned with the relation of wages to product prices. The employee is concerned also, and perhaps most, about the relation of wages to the price of consumables—the second meaning of real wages. A frequent compromise in periods of inflation is partial indexation to the price of consumables.

Real wage setting with full indexation

[6] Large Japanese firms that offer lifetime employment partially index by tying bonuses to some measure of the firm's profitability. With lifetime employment, it may be rational to assume that errors will (approximately) cancel over time. Lifetime employment contracts impose costs on firms (owners) if output falls below some expected value and impose costs on workers if output is above the expected value. The latter can be compensated more readily by adjusting bonuses, but negative bonuses are not observed. An unexpectedly long period of slow growth eliminated some of these contracts.

is rare. This suggests that at low levels of inflation, buyers and sellers prefer ex post adjustment through negotiation to reliance on an imprecise or imperfect index. As inflation increases, costs of non-indexation rise relative to costs of indexation. More parties choose a mixed strategy of partial indexation. Experience in Israel and Brazil suggests that at relatively high rates of inflation, indexation is nearly, but never fully, complete. There is always some lag in adjustment. Data for countries with high inflation also suggest that workers willingly forego indexation if offered relatively stable prices.

The choice of an index is a problem for both parties. Some of the problem would be removed if shocks could be identified unambiguously, if one-time price changes (transitory changes in the rate of inflation) could be separated from permanent changes in inflation, or if all shocks were of one kind—for example, permanent, nominal or real aggregative, or real allocative. The absence of reliable information prevents settlement on an optimal indexation formula.

Nominal wage contracting is also not ideal. Different types of contracts are used to adjust nominal wages for inflation. In periods of low or moderate inflation, we observe contracts that differ in duration, in the extent of formal indexation, and in the use of clauses permitting reopening of the wage agreement during the life of the contract. We observe also that the types of contracts change with the rate of inflation and that employers can be induced to compensate for (some) past price changes when (non-indexed) contracts are renewed. At high rates of inflation, firms and other market participants monitor the rate of inflation. Costs that were previously marginal costs of information became fixed or quasi-fixed costs of information. Nominal prices adjust more frequently.

Retail store leases differ from wage contracts. Leases are often indexed to the volume of sales. Sales are more easily monitored and therefore less subject to moral hazard. Valuation is based on receipts, so measurement is not as much of a problem as for profits or productivity. Both parties have an interest in maintaining the property.

Bond contracts provide another example of the problem of choosing an index. Private parties do not issue price-level linked bonds. Under the gold standard, however, firms offered to pay in gold. Buyers and sellers could agree on this index of long-term value. Once this common measure, related to the value of money, became less relevant, indexed bonds were rare. Inability to agree on an index left no agreement. In Britain, Israel, Brazil and a few other countries, the government resolved this problem by issuing an indexed bond.

Comparison of the choices made in markets for labor, rental property and bonds suggests that agreement on an index is most difficult when prices can change because of real and nominal shocks, and changes can be permanent or transitory. This should not suggest that non-indexation is optimal. Contracting parties find many different solutions but, as experience in labor markets shows, full indexation is rare.

A Stylized Model

In several papers, I have used a model of permanent and transitory changes based on Bomhoff (1983) to study the frequency of shocks and their interaction. A main conclusion of this work is that there is no reason to expect constancy or even repetition in the frequency distribution of shocks. The public cannot use data from the past to anticipate the future relative frequency of permanent and transitory shocks or real and nominal shocks. These frequencies change with public policy decisions, policy rules at home and abroad, weather, inventions or innovations, changes in market structure, and other factors affecting an economy's structural relations.

The model has three types of shocks: transitory shocks to the level; permanent shocks to the level (which are transitory shocks to the growth rate); and permanent shocks to the growth rate. Let x_t be the current value of real output and p_t the current value of the price level. Both prices and output can be affected by each of the three shocks so that

$$\hat{x}_t = \bar{x}_t + \varepsilon_t$$
$$\bar{x}_t = \bar{x}_{t-1} + \hat{x}_t + \gamma_t$$
$$\hat{x}_t = \hat{x}_{t-1} + \rho_t$$

and

$$p_t = \overline{p}_t + u_t$$
$$\overline{p}_t = \overline{p}_{t-1} + \hat{p}_t + v_t$$
$$\hat{p}_t = \hat{p}_{t-1} + z_t .$$

There are stochastic elements in the growth paths of output and inflation in addition to transitory and permanent changes in the levels of output and prices. Much confusion in the discussion of inflation has been caused by the use of "inflation" to refer both to level changes such as oil shocks (distributed over time) and persistent changes in the maintained rate of change.

Suppose we now introduce a common type of Phillips relation between p and x in the neighborhood of $p_t = 1.0$.

$$x_t - \hat{x}_t = \alpha(p_t - p_{t-1}) .$$

The way in which prices will change over time depends on the permanence of the shocks. It takes time for agents to learn whether the shocks change u_t, v_t or z_t and, from the simultaneity of x and p, shocks to ε_t, γ_t and ρ_t. The path by which prices adjust—or the degree to which they are sticky—depends on the nature of the shocks. It is entirely rational in this framework for prices to be sticky and for the speed of adjustment to differ from one episode to another.

The model in Brunner, Cukierman and Meltzer (1983) conveys some of the ideas just discussed. The main idea of the model can be written in a general way. Consider the following system of simultaneous equations for a macroeconomic system. In the underlying micro model, firms set price at the start of the period and hold inventories. Shocks are revealed after production decisions are made.

$$(1) \quad f[y_t, p_t, \Delta h_t, h_{t-1}, i_t, r_t, x_t, m_t] = 0,$$

where y = output, p = price level, h = stock of inventories, i = nominal interest rate, r = real interest rate, x = exogenous real shock, and m = nominal money stock. Under full information about the structure of the shocks and in the absence of transaction costs, the price level reflects current information about money. Money is neutral. Incomplete information of some sort is a necessary condition for significant monetary effects, but it is not sufficient.

Lucas' (1972) hypothesis about incomplete information restricts uncertainty to misperception of current shocks; people do not know whether a shock to demand is specific to their product or is a general increase in demand. It is now generally recognized that Lucas' hypothesis produces a response of real output to a nominal shock but does not generate as much persistence as is found in cyclical fluctuations of output and prices. Persistence must be introduced. The problem is to introduce persistence without introducing an implausible reason for neglecting information in current output, prices, interest rates and other variables.

In Brunner, Cukierman and Meltzer (1983), a representative producer sets price and output at the start of each period using all available information at the time. This includes, in particular, the variables in equation 1—inventory levels and changes, interest rates and current policy. When making price and output decisions, producers are uncertain about the permanence of observed shocks. As in the earlier discussion, they do not respond to changes that are perceived to be transitory.

Let x^* and m^* denote the perceived permanent components of x and m. Knowing these values, producers set output and the price level; y^* and p^* denote the producers' decisions. They are determined from a subset of the system of simultaneous equations:

$$(2) \quad f[y_t^*, p_t^*, \Delta h_t^*, h_{t-1}, i_t^*, r_t^*, x_t^*, m_t^*] = 0.$$

The actual values are x and m, but $x - x^*$ and $m - m^*$ are ignored in adjusting prices and output. Transitory changes are not innocuous. With y^* and p^* adjusted to x^* and m^*, nominal and real interest rates and the change in inventories adjust to the perceived transitory changes, shown as equation 3:

$$(3) \quad f[y_t^*, p_t^*, \Delta h_t, h_{t-1}, i_t, r_t, x_t, m_t] = 0.$$

Output, inventories and other real values respond to both nominal and real shocks in this model by amounts that depend on the size of the misperception. As new information arrives, producers revise their beliefs about the permanence of shocks; p^*, y^* and all other variables adjust to the changed perception.

An econometrician examining the data generated by this model would at times find serially correlated changes in output and serially correlated errors. Serial correlation arises following a large permanent real or nominal shock if the shock is believed for a time to be transitory. As time passes, and errors are repeated, perceptions adjust. Even if the unconditional error in the population is serially uncorrelated, misperception of the permanence of shocks can lead producers to make errors that, ex post, are serially correlated. A model of this kind may explain why some researchers have found ex post real effects of anticipated changes in money. See, inter alios, Mishkin (1983).

Although prices do not fully adjust to shocks when they occur, decisions are entirely rational. Producers use all available information, but they misinterpret the nature of the shock. Once they perceive that the shock is permanent, prices and output fully reflect the information.

The length of the recognition lag depends on the relative variance of permanent and transitory shocks. The larger the variance of permanent shocks, relative to transitory shocks, the shorter the recognition lag. If all shocks were permanent, prices and output would adjust to p^* and y^* values as soon as the shocks occurred. The lag in our model would be one period, as in the Lucas model. If all shocks are transitory, y and p change, but y^* and p^* never adjust.

In Keynesian models, inflexible prices (or wages) and gradual adjustment are taken as evidence of disequilibrium. The information structure of the model here implies that this inference is invalid. Buyers and sellers use all available information and adjust to a market equilibrium.

There are three types of equilibrium. At any moment, there is a permanent stock equilibrium characterized by the state variables x^* and m^*. This equilibrium occurs when $\Delta h = 0$. The values of all variables are adjusted to the perceived permanent shocks and the condition of unchanging inventories. Each firm uses resources at the profit maximizing rate. No firm seeks to expand or contract output or change its price and inventory position.

A permanent equilibrium is less encompassing. The state variables in this case are x^*, m^* and h_{t-1}. All other variables adjust to these conditions. If x^* and m^* remain unchanged, the permanent equilibrium converges over time to the permanent stock equilibrium.

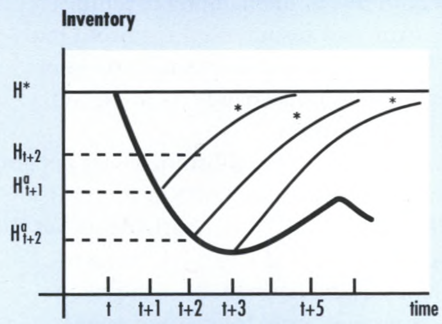
A transitory equilibrium imposes an adjustment of the system to given values, $m \neq m^*$, $x \neq x^*$, y^*, p^* and h_{t-1}. Inventory adjustment and interest rate changes produce the transitory short-run equilibrium.

In Brunner, Cukierman and Meltzer (1983) we show how real variables respond to monetary shocks in a model of this kind. All expectations are rational. No information is wasted once it is correctly perceived. Misperceptions occur, so the system adjusts sluggishly to information that, ex post, turns out to be permanent. The discussion here, following the original, uses inventories as a representative real variable but the response of real output is similar.

Figure 2 shows the adjustment path. Asterisks denotes permanent values, and a superscript a denotes actual values.

> "Up to period t, the economy is at an equilibrium: $H_t = H_t^p$. During period t, there is an unanticipated increase in money growth. Interest rates fall; with prices fixed for the period, aggregate demand increases, and inventories are reduced. Inability to identify permanent shocks means that the perceived value of m changes as information about the rate of monetary expansion becomes available. Forecast errors remain on one side of zero for several periods. Forecast errors reinforce the cyclical deviation of inventories. A large permanent increase in money growth, that is not immediately recognized as permanent, increases m_t, and adds to the cyclical deviation of inventories.

Figure 2



An asterisk in the table indicates the expected path of inventories. The outer envelope shows the actual path.

"The reduction in inventories sets off a process of adjustment of output and inventories. The path along which inventories are expected to adjust at the onset of period t+1 is shown by the positively sloped line from H^a_{t+1} to the permanent level of inventories, H^p. Along this path, a typical firm plans to produce output in excess of expected sales and build inventories. The expected value of inventories by the end of period t+1 is shown as H_{t+2}. If the monetary shock is correctly perceived as transitory and there are no further shocks, firms adjust along the planned path and achieve the values of inventories, H_{t+2}, H_{t+3}, in successive periods until the permanent value, H^p, is restored.

"Suppose, however, that the increase in money growth persists. In period t+2, interest rates are again pushed below the value expected for the period, and actual inventories, H^a_{t+2}, are, again, below the value expected, H_{t+2}, as shown in fig. 2. At the beginning of period t+2, firms and households expect the economy to adjust along the new path, from H^a_{t+2} to H^p. The new path reflects all the available information about the shocks, including beliefs about the permanence of the change in money growth and knowledge of the structural parameters...If the variance of the transitory component of money growth is large relative to the variance of the permanent component, adjustment to permanent changes is relatively slow. Inventories can fall below their expected value for several periods and, thus, move away from H^p.

"Additional information about the permanence of the shock that first occurred in period t is revealed each period, so the path of adjustment toward H^p is not smooth. As time passes, however, the addition to information is small. After t+3 in fig. 2, inventories adjust toward H^p unless another shock—another unanticipated increase in money growth—lowers inventories and starts a new process of learning and adjusting.

"Actual inventories follow the outer envelope in fig. 2; expected inventories, H, follow the adjustment paths that start at the actual values for each period. The figure shows principal features of our model of inventory behavior, augmented by the effect of permanent-transitory confusion. Deviations from H^p are on one side of H^p for several periods because of the slow adjustment of inventories. This feature occurs even if all shocks are white noise. In addition, information about the permanence of shocks becomes available gradually. People use all information and their beliefs about permanent values to determine the adjustment path, but they make unavoidable errors because they learn about the permanence of shocks gradually."

SUMMARY

My emphasis in this section is on microfoundations that lead to price setting and to gradual adjustment. I do not claim to have uncovered a unique structure that produces sticky prices under rational behavior. There are many reasons and many valid hypotheses that make both price setting and gradual price adjustment compatible with rational behavior.

Price setting is sufficient for real effects of monetary shocks. I have discussed several reasons for price setting—menu costs, Knight's uncertainty argument for the existence of firms, producers' desire to signal quality, purchasers' gains from lower cost of information and bargaining, and other differences in costs of acquiring information.

In principle, sellers or buyers could set relative, not absolute, prices. To do so efficiently, buyers and sellers have to agree on an index. Price index numbers are subject to real and nominal shocks that are sometimes permanent, sometimes transitory, and sometimes alter the rate of price change persistently. If these shocks could be correctly identified ex post, and if their expected duration were known, the parties might agree to adjust prices after shocks occur. Far more often, ex post adjustment is done by negotiation, or the parties agree to partial indexation and negotiate about the remainder. These arrangements are consistent with the presence of relatively large costs of acquiring information and agreeing on what has occurred, whether the change is permanent or transitory and how long and how large future price changes will be. Among these costs are the costs associated with moral hazard if one party controls relevant data.

Economic contractions typically last nine months to one year. Considerable evidence suggests that price changes may lag as much as two years behind monetary shocks. To yield the patterns of price and output change observed in actual economies, price setting must be joined to a rational reason for persistence.

Permanent-transitory confusion—uncertainty about the duration or persistence of shocks—provides one such condition. Under this hypothesis, lags can be long or short and ex post errors can be serially correlated, if a large permanent shock is perceived as transitory. If the variance of t he permanent shocks is high relative to the variance of transitory shocks, the lag is relatively short, and there is no reason for significant serial correlation to be observed ex post. In this case, price setters believe that most shocks are permanent, so they adjust promptly.

Table 1

Revisions to Reported Inflation
(percentage points)

Horizon (quarters following)	Average Revision	Range
1	0.2	-1.0 to 1.5
2	0.3	-1.2 to 1.7
3	0.3	-0.6 to 1.7
4	0.3	-0.6 to 1.7

SOME EVIDENCE

We cannot directly observe how people decide on the degree of persistence in the rate of inflation (or other variables). However, we can measure some of the errors that contribute to permanent-transitory confusion and use econometric methods to estimate the variance of permanent and transitory errors in the price level (or other variables). This section considers these sources of evidence on the relative size of permanent and transitory changes.

Bullard (1994) reported the size of revisions to quarterly reports of the rate of change of the GNP deflator for the years 1986 through 1992. He found that the mean revision for the 28 quarters was positive in this period; early reports understated the rate of inflation and later revisions added additional amounts. Bullard also reports the range of revisions for each of the four quarters following the period considered. The reported ranges exclude the most extreme 5 percent of the revisions in each tail. Table 1 reproduces Bullard's results.

The average rate of inflation for the period is approximately 3 percent. The range of revisions (excluding extreme values) is 2.3 to 2.9 percentage points. The revisions are from 70 percent to 130 percent of the (3 percent) average reported change. The relatively large size of the revisions suggests that it is rational for the public to act as if the initial announcement is a very noisy indicator of the true rate of inflation.

In several papers summarized in Brunner and Meltzer (1993), we report forecast errors for the rate of change of output or inflation using different models, methods of forecast and countries. The forecasting methods include state-of-the-art econometric modeling, time-series analysis, judgment and combinations of these methods. A rule-of-thumb summary is that mean absolute errors for output growth in the major industrial countries is 50 percent or more of the average rate of change one quarter or one year ahead. Inflation is less variable than output over short periods, and its forecast error is a smaller fraction of the average rate of change. Still, errors in both growth and inflation forecasts are large.

The data on forecast errors make a persuasive case that forecasters frequently misperceive future values. Data on revisions suggest that current reports are subject to large errors. Errors may be unbiased, but that is a small consolation for those who adjust to events that are found later not to have occurred or those who do not adjust to changes that did occur. The permanent-transitory distinction implies that partial adjustment is optimal. Ex post, it will seem that adjustment has been sluggish. Indeed, as noted, errors may appear to be serially correlated following large changes.

A filter can be used to separate permanent and transitory components.[7] Let the error term in an aggregate such as the price level or output have a permanent and transitory component,

$$\varepsilon_t = \varepsilon^{p_t} + \varepsilon^{\tau_t}, \qquad (4)$$

where p and τ denote the two components. The transitory component is white noise. The permanent component has the property of zero mean and constant variance, σ^2.

$$\Delta\varepsilon^{p_t} \sim N(0, \sigma_p^2) \qquad (5)$$

At any time t, the expected change in the permanent component is zero.

People observe prices and output. As in the model of the previous section, they cannot separate the levels or changes of the permanent or transitory components. The rate at which they adjust depends on the relative variances of the transitory and permanent components of inflation or output growth. The larger the variance of the permanent component relative to the variance of the transitory component, the quicker the economy adjusts to permanent changes. A relatively large transitory variance slows the response.

Meltzer (1986) estimated the variances of the permanent and transitory components of inflation and growth for Canada, Germany, the United Kingdom, and the United States under fixed and fluctuating exchange rates. The fixed exchange rate period runs from the first quarter of 1960 through the third quarter of 1971. Fluctuating rates begin in the fourth quarter of 1971 and end in the fourth quarter of 1984.[8]

Table 2 shows the ratios computed from these data using the adjustment equations in Muth (1960). The estimated variance ratios for inflation and growth changed under fluctuating rates, but the direction of change is not uniform across countries. The length of the adjustment lag required to distinguish permanent from transitory shocks changed much less. For inflation, seven of the eight values of the adjustment lag (λ) lie between 0.41 and 0.56. These values imply that, consistent with Blinder's survey data, about half of the shock to inflation is seen in the current quarter. Between 82 percent and 96 percent of the adjustment of permanent inflation occurs within four quarters of the initial shock to the inflation rate. This adjustment is faster than the two-year average lag commonly suggested. For real growth, seven of the eight values of λ lie between 0.45 and 0.67; within four quarters, 91 percent to 99 percent of the adjustment occurs. The speed of output adjustment is broadly consistent with the length of post-war recessions if these recessions are interpreted as the cumulative adjustment set off by a monetary or real shock. Inflation adjusts more slowly than growth as many studies have shown.

Clarida and Gali (1994) studied the response of real exchange rates to nominal shocks in four countries. For Canada and the United Kingdom, they were unable to find any structural effects—real or nominal—on real exchange rates.

For Germany and Japan, the evidence suggests that nominal shocks explain 45 percent and 34 percent, respectively, of the four-quarter-ahead forecast error variances of the log level of bilateral real dollar exchange

[7] See Bomhoff (1983) for a discussion of the Bayesian multi-state Kalman filter.

[8] λ is the adjustment lag given by

$$\lambda = \sqrt{a + \frac{a^2}{4}} - \frac{a}{2}$$

and a is the ratio of the variance of the permanent component to the variance of the transitory component.

rates. Clarida and Gali note that their estimates are consistent with the evidence from vector autoregressions reported in Eichenbaum and Evans (1992).

Clarida and Gali (1994) use a trivariate vector autoregression to estimate the transitory component of real exchange rates.[9] Their model includes shocks to aggregate demand and supply. The authors report the ratio of the variance of transitory shocks to the variance of actual shocks. Using their data, we can compute the ratio of the variance of permanent shocks to the variance of transitory shocks. The ratio covers a wide range in these countries—from 0.42 in Germany to 3.76 in Canada. These findings suggest that most shocks to the Canadian real exchange rate have been permanent while most shocks to the German real exchange rate were transitory. Hence, the Canadian real exchange rate should adjust more rapidly to shocks than the German real rate.

Meltzer (1993) used the permanent-transitory distinction to model the U.S. multilateral real exchange rate. For both levels and first differences under fixed and fluctuating rates from 1960 to 1991, the data suggest that there is a large permanent component in the change of the real exchange rate and a significant transitory component. Further, the data suggest that the multilateral real exchange rate responds to changes in the nominal stock of money. The effect eventually vanishes, but monetary changes have real effects until prices adjust. These findings are consistent with short-run non-neutrality and long-run neutrality of money if permanent changes in money were perceived as transitory at the time they occurred or conversely.

The studies of prices, output and exchange rates support the principal arguments of the article. They are only a small part of the evidence supporting ex post, short-run non-neutrality. They are of interest because they attribute slow adjustment of nominal values and real effects of nominal shocks to the difficulty of discerning the persistence of shocks. With a non-trivial cost of acquiring information, price setting and permanent-transitory confusion imply that nominal changes have real effects that persist for a time.

Table 2

Relative Variances of the Permanent and Transitory Components

	Canada	Germany	U.K.	U.S.
1960-71				
Inflation	0.29	1.56	0.37	0.71
λp	0.41	0.69	0.45	0.56
Real growth	0.62	0.65	0.36	1.11
λy	0.57	0.54	0.45	0.64
1971-84				
Inflation	0.56	0.30	0.31	0.71
λp	0.52	0.42	0.42	0.56
Real growth	1.35	1.00	0.04	0.86
λy	0.67	0.62	0.18	0.59

Other recent studies find evidence of costs of acquiring information. Investors frequently pay a premium to buy country-specific mutual funds. The premium implies that they could buy the individual securities at lower cost. If they are uncertain about which securities to buy and when to buy or sell, it may be rational to pay for the services of traders who specialize in the particular market.

Smith (1991) uses costs of acquiring information as one reason for the absence of optimal portfolio diversification of world market securities. The degree of diversification depends on costs of acquiring information. People know much more about values and earnings in their own market than in foreign markets. Prices in foreign markets may reflect full information, but some investors either do not have this information or cannot assess whether changes are permanent. Hence, they do not respond promptly to information about each of these markets. They do not hold the "true" equilibrium portfolio they would hold if information costs were zero. A principal cost in this case, as in others, is the interpretation of available information. Permanent-transitory confusion is one part of the interpretation problem.

In Fuhrer and Moore (1993), the inflation

[9] The trivariate system has four lagged values of the change in the log real exchange rate, the change in the log ratio of United States - home country real GDP, and the difference between U.S. and foreign inflation. Data are quarterly from mid-1970 to the fourth quarter of 1992.

rate is sticky. Firms adjust relative prices to the average of other sectors' expected relative prices over the life of existing contracts. Firms also adjust for the current and expected level of output. The autocorrelation functions based on their model have very similar shapes to the autocorrelations generated by an unconstrained vector autoregression. In particular, they show considerable persistence in inflation and output movements and sustained effects of inflation on real output. In short, Fuhrer and Moore provide evidence that is consistent with a model in which there are costs of learning about the permanence or persistence of changes, and in which people adopt strategies that leave room for misperception and real effects of nominal changes.

Earlier work by Boschen and Grossman (1982), Gordon (1982) and Mishkin (1983) also provide evidence that supports sticky prices. Indeed, the evidence of gradual adjustment of prices and of short-term real effects of monetary change is common. These studies lack micro-foundations. Price-setting in part of the economy and permanent-transitory confusion, as in Brunner, Cukierman and Meltzer (1983), reconciles this evidence with rational behavior.

CONCLUSION

The examples in the preceding section are a small part of the recently accumulated evidence showing that there is much more than casual observation to support the main propositions in this paper: Nominal prices adjust with a lag. The lag is sufficiently long that real variables respond to nominal changes. Costs of acquiring information about the persistence of observed changes—permanent-transitory confusion—is a main component of the cost and a main reason for the lag. Even where prices reflect information fully, all individuals or firms may not have adjusted fully to available but costly information.

The oft-repeated comment that macroeconomics should be built on micro-foundations is correct if and only if the micro-foundations are appropriate for the task. Standard micro theory, such as Arrow-Debreu, imposes complete markets and market clearing in each market. There is no role for monetary disturbances. This is not the appropriate micro-foundation for macroeconomics. No amount of squeezing, cutting and pasting will make it so.

Rational behavior and rational expectations are entirely consistent with costs of acquiring information and the inability to fully identify permanent and transitory shocks either when they occur or for several quarters after. Indeed, Muth's (1961) initial formulation of rational expectations is based on the latter distinction.

One alternative explanation of sticky prices in recent literature relies on menu costs and imperfect competition. This explanation is a foundation for the so-called L-shaped supply curve familiar from Keynesian theories. I show that the evidence in Blinder's (1991) survey rejects the L-shaped supply curve. Further, the implications of monopolistic competition, such as widespread excess capacity, do not explain gradual price adjustment in most service industries.

Gordon (1990) proposes a disaggregated system to take account of the information at many levels of the economy. He argues that prices respond to marginal cost but that marginal cost for any firm depends on the pricing strategy of its suppliers. Hence, such information enters firms' decisions about price and output adjustment. Information from macrodata is much less relevant.

This argument captures some of the dynamics of pricing, but it poses unresolved challenges for aggregation over different industry structures. Moreover, Gordon's framework implies that commodity producers should adjust slowly to aggregate shocks and that large firms in durable goods industries should adjust promptly. The stylized facts suggest that the opposite is true. One reason is that organized commodity markets increase the information available to commodity producers. There are no comparable markets for consumers' and producers' durable goods output. Differences in information and the costs of acquiring information are consistent with the stylized facts on speed of adjustment.

[9] The trivariate system has four lagged values of the change in the log real exchange rate, the change in the log ratio of United States - home country real GDP, and the difference between U.S. and foreign inflation. Data are quarterly from mid-1970 to the fourth quarter of 1992.

The micro-foundations suggested in this article use costs of acquiring information to explain three common observations. First, many prices are set. Second, price setters choose nominal values. Third, the daily, weekly, monthly or quarterly variances of "set prices" are small fractions of the variance of prices in auction markets; set prices are stickier.

Households and firms do not operate in a world of full information. Incomplete information and costs of acquiring information are central problems of a monetary economy. Information and transaction costs explain why people hold and use money as a medium of exchange (Brunner and Meltzer, 1971). There is considerable evidence that these costs are not trivial. The article cites revisions to reported data, forecast errors, incomplete information about costs, profits and strategies of competing firms. These examples do not exhaust the costs that firms and individuals face.

Some of these costs can be reduced by institutional and contractual arrangements. The arrangements that people choose may be optimal when contracts are written but, with changes in the environment, there are unforeseen gains and losses. If the gains and losses are transitory, their expected value is zero. It may not be worthwhile to change the contract or the method of contracting. Once the change is considered persistent, gains and losses are expected to cumulate. Adjustment or re-negotiation becomes more appealing to at least one party.

Information about permanent and transitory changes in profits, prices, wages and other variables is costly to acquire. The distribution of shocks between real and nominal, permanent and transitory may differ from one sample period to the next. People learn to monitor events or changes that are costly to ignore. But learning requires a continuous process of monitoring both what has happened and what should be observed. This is a basic problem for firms and households. As such, it is a more appropriate micro-foundation for macroeconomics.

REFERENCES

Alchian, Armen A. "Why Money?" *Journal of Money, Credit and Banking* (February 1977, part 2), pp. 133-40.

Ball, Laurence, and N. Gregory Mankiw. "A Sticky Price Manifesto," *Carnegie Rochester Conference Series on Public Policy* (December 1994), pp. 127-52.

Balvers, R. J., and T. F. Cosimano. "Actively Learning About Demand and the Dynamics of Price Adjustment," *Economic Journal* (September 1990) pp. 882-98.

Baumol, William J. "The Transactions Demand for Cash: An Inventory Theoretic Approach," *Quarterly Journal of Economics* (November 1952), pp. 545-56.

Beaulieu, Joe., and Joe Mattey. "The Effects of General Inflation and Idiosyncratic Cost Shocks on Within-Commodity Price Dispersion: Evidence from Microdata," *Finance and Economic Discussion Series No. 94-12* (May 1994), Board of Governors of the Federal Reserve System.

Blinder, Alan S. "Why Are Prices Sticky? Preliminary Results from an Interview Study," *The American Economic Review* (May 1991), pp. 89-96.

Bomhoff, Eduard J. *Monetary Uncertainty.* North Holland, 1983.

Boschen, John F., and Herschel I. Grossman. "Tests of Equilibrium Macroeconomics Using Contemporaneous Monetary Data," *Journal of Monetary Economics* (November 1982), pp. 309-33.

Brunner, Karl, and Allan H. Meltzer. *Money and the Economy: Issues in Monetary Analysis.* Cambridge University Press, for the Raffaele Mattioli Lectures, 1993.

_______ and _______. "The Uses of Money: Money in the Theory of an Exchange Economy," *The American Economic Review* (December 1971), pp. 784-805.

_______ and _______. "Economies of Scale in Cash Balances Reconsidered," *Quarterly Journal of Economics* (August 1967), pp. 422-36.

_______, Alex Cukierman and Allan H. Meltzer. "Money and Economic Activity: Inventories and Business Cycles," *Journal of Monetary Economics* (May 1983), pp. 281-319.

Bullard, James B. "How Reliable Are Inflation Reports?" Federal Reserve Bank of St. Louis *Monetary Trends* (February 1994), p. 1.

Clarida, Richard, and Jordi Gali. "Sources of Real Exchange Rate Fluctuations: How Important Are Nominal Shocks?" *Carnegie Rochester Conference Series on Public Policy* (December 1994), pp. 1-56.

Eichenbaum, Martin, and Charles Evans. "Some Empirical Evidence on the Effects of Monetary Policy Shocks on Exchange Rates," Federal Reserve Bank of Chicago *Working Paper No. 92-32* (December 1992).

Fuhrer, Jeffrey, and George Moore. "Inflation Persistence," *Finance and Economic Discussion Series No. 93-17* (May 1993), Board of Governors of the Federal Reserve System.

Gordon, Robert J. "What Is New-Keynesian Economics?" *Journal of Economic Literature* (September 1990), pp. 1115-71.

_______. "Price Inertia and Policy Ineffectiveness in the United States, 1890-1980," *Journal of Political Economy* (December 1982), pp. 1087-1117.

Heaton, John, and Debra Lucas. "The Importance of Investor Heterogeneity and Financial Market Imperfections for the Behavior of Asset Prices," *Carnegie Rochester Conference Series on Public Policy* (forthcoming).

Knight, Frank H. *Risk, Uncertainty and Profit* (No. 16 in reprints of *Scarce Classics in Economics*). London School of Economics, 1933.

Lucas, Robert E., Jr. "Expectations and the Neutrality of Money," *Journal of Economic Theory* (April 1972), pp. 103-24.

McCallum, Bennett T. "New Classical Macroeconomics: A Sympathetic Account," *Scandinavian Journal of Economics* (June 1989), pp. 223-52.

Meltzer, Allan H. "Real Exchange Rates: Some Evidence from the Postwar Years," this *Review* (March/April 1993), pp. 103-17.

________. "Size, Persistence and the Interrelation of Nominal and Real Shocks: Some Evidence from Four Countries," *Journal of Monetary Economics* (January 1986), pp. 161-94.

________. "Rational Expectations, Risk, Uncertainty and Market Responses," in Paul Wachtel, ed., *Crises in the Economic and Financial Structure.* Lexington Books, 1982, pp. 3-22.

Mishkin, Fredrick S. *A Rational Expectations Approach to Macroeconometrics: Testing Policy Ineffectiveness and Efficient Markets Models.* University of Chicago Press, 1983.

Muth, John F. "Rational Expectations and the Theory of Price Movements," *Econometrica* (July 1961), pp. 315-35.

________. "Optimal Properties of Exponentially Weighted Forecasts," *Journal of the American Statistical Association* (June 1960), pp. 299-306.

Smith, Clifford W., Jr. "Globalization of Financial Markets," *Carnegie Rochester Conference Series on Public Policy* (spring 1991), pp. 77-96.

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Commentary

Randall Wright

Allan Meltzer raises a variety of issues, and reviews and extends some research he and his collaborators have been pursuing over the years. Some of the more or less technical points he presents, both with regard to the theory and the evidence, will undoubtedly be of interest to many macroeconomists. He does a good job of presenting these technical points, and so my plan is not to discuss them in any detail here. Instead, I want to address some more general methodological issues. That is, I plan to comment mainly on some remarks Meltzer makes on the state of macroeconomics.

To provide some motivation for the discussion, I would like to begin with a few quotations from the Introduction to his paper. Meltzer says that "For decades, macroeconomists have listened to criticism from their professional colleagues about the absence of micro-foundations for most of what they say and do...It is time to question whether this now widely accepted approach is likely to be fruitful."

He appears from his remarks to be of the opinion that the answer is no. While conceding that we may have learned one or two things over the years, the suggestion is that much of modern macroeconomics is at a dead end. For example, "Overlapping generations models of money, intertemporal substitution theories of unemployment and productivity shock theories of the business cycle *have not proved fruitful*...[and] the results to date *are not promising*" [emphasis added]. He further suggests that the current state of affairs compares to the Keynesian-monetarist debates of a generation or so ago.

Presumably, he puts forward this assertion so that the reader will be more sympathetic to the alternative approach provided in his paper. But what I want to do is question the assertion itself. To focus the discussion, I propose to debate the following position: *We have made little progress in macroeconomics since the Keynesian-monetarist debates, and existing models built on micro-foundations are neither fruitful nor promising.* I perceive this position to be a fair reflection of the view expressed in the paper. But even if this is not exactly what Professor Meltzer had in mind, I believe that it is an interesting issue to debate. I hope the reader will forgive me if it appears I am debating a straw man, and indulge me the opportunity to present some of my own views on the state of macroeconomics.

As I see it, economists have made remarkable progress in understanding things that bewildered us just two or three decades ago. I will describe this progress in four of the most important areas of macroeconomics: business cycles; the labor market; monetary economics; and growth. I will also discuss some more general methodological issues toward the end. This is not meant to say that I am totally unsympathetic to the views of Professor Meltzer, merely that I think he overstates the case when he asserts that existing macroeconomic models are neither fruitful nor promising.

BUSINESS CYCLES

Two decades ago, few would have believed the following assertion: A frictionless, competitive, non-monetary model built around the one-sector growth model, abstracting from heterogeneity, distortionary taxation, and many other features of reality, can generate time series that look like those in the data when hit by impulses that seem like a reasonable representation of stochastic technological progress. Since the work of Kydland and Prescott (1982), Hansen (1985) and others, we know that the assertion is true. But I am sure that even Kydland and Prescott would not have expected it ex ante.

Consider the original version of what I will call their dynamic general-equilibrium (GE) model. (This is a more accurate label than the more common real business cycle, or RBC, model, given that many people work with monetary versions of the model). It included many complications, such as time-to-build, non-time-separable utility, and signal extraction problems, which, while still included in some applications, are not parts of the current standard benchmark model. Why were those complications there? They thought a simple model wouldn't stand a chance. On one interpretation, the entire exercise was to see just how bad things were, so we would have some idea where to go next (for example, in terms of adding other impulses and propagation mechanisms).

To everyone's surprise, however, even very simple dynamic GE models do quite well at replicating key aspects of the macro time series. Output is more volatile than consumption, not as volatile as investment, and about as volatile as the labor input; and, the coherence of all these series is high. Furthermore, the model is consistent with these features of the data at a quantitative level, not just a qualitative level.

Traditional macroeconomists, especially Keynesians, reacted to these findings with much suspicion, and virtually every aspect of the analysis was called into question. In retrospect, many controversial issues turned out to be red herrings, including the following:

(1) Abstracting from heterogeneity (that is, focusing on a representative agent) is an assumption that, depending on the questions, is sometimes appropriate and sometimes inappropriate, but is never good or bad as a matter of principle.

(2) Abstracting from market failures, frictions and money is a proper first step—no one should advocate complication for its own sake—and the fact that simple models can be solved efficiently by exploiting the welfare theorems does not mean that users of these models believe the real world is "first best" nor that policy is unworthy of discussion.

(3) Calibration is a way of taking models to the data that avoids many complications; although these days many of us are estimating dynamic GE models using traditional econometric methods (see, for example, McGrattan, 1994).

(4) The HP filter is simply a convenient tool, and obsessing over its merits or demerits is like debating whether the mean, median or mode is the "correct" measure of central tendency.

The consensus today is that the dynamic GE models are useful tools for studying business cycles. Of course, this does not mean that business cycle research is a solved problem. There are many unanswered or partially answered questions, such as the correlation between employment hours and productivity, the equity premium, and the relations between real and nominal variables. Much work has been done to address these questions with some, but not total, success. There are still interesting puzzles out there—but this is why working in the area is exciting. The point is that we now have a *standard model* of the business cycle, a base case from which to generalize when the situation warrants it.

The dynamic GE approach is a tool for macroeconomics the way that the supply-and-demand approach is a tool for microeconomics. One should not ask: "Is the model true?" but only: "Is it useful?" Have we made progress understanding business cycles? Yes. Are these models based on microeconomic foundations? Yes. They are based on the standard economic principles of constrained optimization (which, in a dynamic context, obviously concerns intertemporal substitution) and a coherent concept of equilibrium. Can the base model accommodate frictions, money, heterogeneity, private information and so on? Yes. Do we need to throw out dynamic GE theory in favor of new micro-foundations or a retrograde macro approach? No, no more than we need to throw out supply-and-demand curves.

Of course, a base model is always simplistic. In the case of supply and demand, for example, suppose we want to know what will happen to the price of orange juice after a frost in Florida or a Vitamin C craze. Is it OK to abstract from private information, strategic issues, reputation and so on, and proceed by shifting the supply or demand curve? I don't know the answer definitively, but I think, provisionally, yes. Similarly, if we want to ask something basic about business cycles, it seems reasonable to use the basic dynamic GE framework as the benchmark. To readers interested in studying this in more detail, I recommend the book *Frontiers of Business Cycle Research,* edited by Thomas Cooley.

THE LABOR MARKET

It is commonly believed that unemployment is a major economic and social problem. We have not come up with a definitive model that explains unemployment or gives us a panacea to cure unemployment. That is, we have not *solved* the problem. But we know something about it and can study it scientifically. We know that incentives matter, whereby I mean things like unemployment insurance, dismissal restrictions, tax policy and so on. These things can be built into economic models built on standard micro-foundations (constrained optimization and coherent equilibrium concepts), and analyzed both qualitatively and quantitatively.

Some of the issues are more or less static: for example, the incentive effects of unemployment insurance on layoffs and hours per worker (see, for example, Burdett and Wright, 1989). Others are intrinsically dynamic. A major recent success concerns the application of search models of labor market dynamics to worker and job flow data. Combining the job creation-job destruction data analysis of Davis and Haltiwanger (1990) with the theoretical framework laid out, for example, in Pissarides (1990) has proved fruitful. These authors have used dynamic GE models based on search theory to account for the main empirical features of the labor market, like the job creation and job destruction data (see, for example, Mortensen, 1994). These models can be used to study policy interventions qualitatively and quantitatively.

Of course, as I stated earlier, there is more than one model of unemployment. This is as it should be. There is more than one type of unemployment. Efficiency wage considerations, insider-outsider considerations, multiple equilibrium considerations, and so on, each may have some elements of truth to them. Moreover, these models are not mutually inconsistent, but are complimentary special cases of a general framework (see Mortensen, 1989). We should not look for a simple single answer.

Are frictions in the labor market important, as Meltzer suggests? Yes. Can private information be a relevant consideration, as Meltzer suggests? Yes. Does this mean a move away from micro-foundations, or a move to new micro-foundations, is the answer? No. Many researchers have been working on incorporating frictions and informational considerations into the standard paradigm for years. It has been successful. Given this success, I do not see any reason to argue to return to a reduced-form Phillips Curve approach. My preferred alternative is to learn search theory and forge ahead.

MONETARY ECONOMICS

Not so long ago, there did not exist in the literature a serious formal model of a dynamic monetary economy. The overlapping-generations (OLG) model, invented by Samuelson (1958) and developed by many people (see, for example, Wallace, 1980), has remedied this deficiency. That model has been and continues to be an extremely useful framework within which to illustrate theoretical properties of monetary economies, to interpret episodes in economic history, to shed light on policy debates, and to discover new things about economics generally. Concerning the latter, it is worth remarking that many technical discoveries, such as the possible inefficiency of competitive equilibrium, or the potential for endogenous limit cycles and sunspot equilibria, revolved closely around the analysis of OLG models (see, for example, Azariadis, 1993). These discoveries seem important for macroeconomics.

When Meltzer criticizes the OLG model, perhaps what he has in mind is that there are certain phenomena for which it is ill-designed to explain. One could belabor the obvious and argue that money in the OLG model is only a store of value and not a medium of exchange. But a model need not capture every feature or nuance of money in order to teach us something about monetary theory or policy. More to the point, we now have theoretical models in which money clearly and indisputably is a medium of exchange. Some of these models are built around search frictions that capture Jevons' famous "double coincidence of wants" problem with direct barter; see, for example, Kiyotaki and Wright (1989) or Trejos and Wright (1995). Others are built around private information problems; see, for example, Williamson and Wright (1994).

Allan Meltzer, along with Karl Brunner, is on record as saying that private information is the driving force behind the use of money in modern economies. He reiterates this position in the current paper. Some of us who work in monetary theory have taken his position to heart and have attempted to formalize these ideas. We do not think of ourselves as abandoning micro-foundations; the models are built on search or private information frictions incorporated into microeconomic models with optimizing agents and coherent equilibrium concepts.

I agree with Professor Meltzer when he argues that we need to develop theories that incorporate not only money, but also other aspects of the real world, like brokers, dealers, market makers, intermediaries and so on. Given this, it seems that search-based models of the sort analyzed by Rubinstein and Wolinsky (1987), for example, are promising. Like much of the search-based monetary theory, these models are primitive, but they do address many of the issues that Meltzer correctly identifies as important.

Due to their rudimentary nature, the models to which I am referring are not yet very good at providing policy guidance. They do not answer, "What should we do at the discount window next week?" I for one do not think that this is the most interesting question in monetary economics. Even if one is interested mainly in policy, there is potential value in building qualitative models that help edify us and our students regarding more basic issues. At the same time, monetary dynamic GE models currently exist that, although not as well-grounded in terms of first principles of microeconomics, can be brought to bear on more mundane policy affairs. We have seen some of them discussed at this conference.

Is it a problem that pure and applied monetary economics have not converged? In any science, it should not be too surprising that progress in pure and applied theory proceeds in counterpoint and not in unison. That is why monetary economics today is vibrant and flourishing.

GROWTH

It was only about a decade ago that macroeconomists were relatively uninterested in growth theory and in policy directed toward economic growth. One reason may be that our attention was directed toward other issues—business cycles, unemployment and money. Another reason is that we were looking at the wrong models. Although models with perpetual growth have been around for decades, the standard Solow model in the textbooks is in the unfortunate position of not explaining growth, except as a transitory phenomenon on the way to a steady state or as the outcome of exogenous technical progress. We owe something to Romer (1986) and Lucas (1988) for redirecting our attention.

There is now a plethora of endogenous growth theories—arguably, too many. However, these models all have common threads that I hope will allow us to distill common essence. We know that growth is important as a matter of welfare. As compared to eliminating cyclical fluctuations in GNP, getting the growth rate up a few percentage points is an order of magnitude more important. Can we achieve higher growth by better policy? Can we understand why different economies grow at different rates? The jury is still out, but these are obviously interesting questions. The way to answer them is with standard economic theory.

When I say "standard economic theory," I do not mean that we should stick to the status quo when confronting issues for which the textbook model is inappropriate. But going from Solow's leading example to a model with non-decreasing returns is hardly a scientific revolution. Is there a role for private information or other frictions in modern growth theory? Potentially. The interaction of growth with financial development and intermediation may be interesting and important. Some work has been done and more is in progress. But I did not see anything in Meltzer's approach that makes me want to stray from mainstream growth theory.

GENERAL METHODOLOGICAL ISSUES

There have been many technical developments that have paved the way for these successes in macroeconomics. One obvious innovation involves computational ability. Graduate students now have machines on their desks that allow them to solve and simulate dynamic GE models as homework in a good first year macro-course. If one really thinks that heterogeneity, incomplete markets, income distribution or related issues are important, we now have the technology and the power to solve models with these complications; see Rios-Rull (1995).

There have been developments outside the domain of hardware. The publication of Stokey and others (1989) illustrates how we now all have access to a set of tools that few macroeconomists were comfortable with not so long ago. The analysis of multiple equilibria, including dynamic multiplicity, endogenous limit cycles and phenomena like sunspot equilibria have given us a new set of ways to think about the world. Game theory has provided us with new ways of posing and solving strategic questions, including bilateral bargaining problems that are central to some of the phenomena that Meltzer emphasizes (see the references in the section of monetary economics). Analysis of data, like the job creation and destruction data, or the cross-country growth data, have given us new things to think about and new ways of confronting our models with reality.

Lucas (1980) emphasized the interplay between technical developments, on the one hand, and deviations between theory and facts, on the other hand, as what leads to progress and change. He argues that this interplay was behind the emergence in the 1970s of "rational expectations" macroeconomics and the downfall of the IS-LM approach. We have been since then mostly engaged in what Kuhn (1962) calls "normal science." To be sure, there are disagreements, but there is a core of good people working on interesting and important questions and making progress.

The bottom line is that macroeconomics has made impressive advances on a large number of fronts. Today, we have models built on first principles—that is, on constrained optimization and a consistent concept of equilibrium—of business cycles, unemployment, money and growth. It is still true that good economists often have difficulty with questions like, "What should we do at the discount window next week?" This may suggest the questions are ill-posed (although I do understand and have sympathy for the many professional economists who cannot ignore such questions because they get paid to come up with answers).

Perhaps I am too sanguine. How about our failures? One thing that Meltzer emphasizes that we are not so good at explaining is sticky prices. This may be because we sometimes take the pricing aspect of the Arrow-Debreu paradigm too seriously. We know that there are many ways to decentralize a given allocation. Contracts, core-like coalitions, reputation and several other institutions are also possibilities, as Meltzer mentions. It may be that agents get the allocation right without using prices in the way that our textbooks assume. That is, in principle, prices may "look" sticky but this need not have implications for welfare or policy.

When do sticky prices matter? Sticky prices can be studied in dynamic GE models, as Ohanian and Stockman (1994), Cho and Cooley (1994) and others have shown. These authors do not explain *why* prices are sticky; rather, they investigate the implications of varying degrees of exogenous stickiness. Should we try to explain stickiness endogenously? Maybe, but I was not convinced by Meltzer's current article.

I would like to conclude by saying that I have always learned from Professor Meltzer, especially on questions in monetary economics. It is worthwhile trying to take seriously his notions of information theory as a foundation for monetary theory. In other areas, he is also posing interesting questions. Standard macroeconomic GE models provide a venue for their analysis.

REFERENCES

Azariadis, Costas. *Intertemporal Macroeconomics.* Blackwell, 1993.

Burdett, Kenneth, and Randall Wright. "Unemployment Insurance and Short-Time Compensation: The Effects on Layoffs, Hours per Worker, and Wages," *Journal of Political Economy* (December 1989), pp. 1479-96.

Brunner, Karl, and Allan H. Meltzer. "The Uses of Money: Money in the Theory of an Exchange Economy," *The American Economic Review* (December 1971), pp. 784-805.

Cho, Jang-Ok, and Thomas F. Cooley. "The Business Cycle with Nominal Contracts," working paper (1994).

Cooley, Thomas F. *Frontiers of Business Cycle Research.* Princeton University Press, 1995.

Davis, Steven J., and John Haltiwanger. "Gross Job Creation and Destruction: Microeconomic Evidence and Macroeconomic Implications," National Bureau of Economic Research *Macroeconomics Annual* (1990).

Hansen, Gary D. "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics* (November 1985), pp. 309-27.

Lucas, Robert E., Jr. "On the Mechanics of Economic Development," *Journal of Monetary Economics* (July 1988), pp. 3-42.

________. "Methods and Problems in Business Cycle Theory," *Journal of Money, Credit and Banking* (November 1980, part 2), pp. 696-715.

Kiyotaki, Nobuhiro, and Randall Wright. "On Money as a Medium of Exchange," *Journal of Political Economy* (August 1989), pp. 927-54.

Kuhn, Thomas S. *The Structure of Scientific Revolutions.* University of Chicago Press, 1962.

Kydland, Finn E., and Edward C. Prescott. "Time to Build and Aggregate Fluctuations," *Econometrica* (November 1982), pp. 1345-70.

McGrattan, Ellen R. "The Macroeconomic Effects of Distortionary Taxation," *Journal of Monetary Economics* (June 1994), pp. 573-601.

Mortensen, Dale T. "The Cyclical Behavior of Job and Worker Flows," *Journal of Economic Dynamics and Control* (November 1994), pp.1121-42.

________. "The Persistence and Indeterminacy of Unemployment in Search Equilibrium," *Scandinavian Journal of Economics* (June 1989), pp. 347-70.

Ohanian, Lee E., and Alan C. Stockman. "Short Run Independence of Monetary Policy under Pegged Exchange Rates," working paper (1994).

Pissarides, Christopher. *Equilibrium Unemployment Theory.* Blackwell, 1990.

Rios-Rull, Jose-Victor. "Models with Heterogeneous Agents," in Thomas F. Cooley (ed.) *Frontiers of Business Cycle Research.* Princeton University Press, 1995, pp. 98-125.

Romer, Paul M. "Increasing Returns and Long-Run Growth," *Journal of Political Economy* (October 1986), pp. 1002-37.

Rubinstein, Ariel, and Asher Wolinsky. "Middlemen," *Quarterly Journal of Economics* (August 1987), pp. 581-93.

Samuelson, Paul. "An Exact Consumption-Loan Model of Interest With or Without the Social Contrivance of Money," *Journal of Political Economy* (December 1958), pp. 467-82.

Stokey, Nancy L., Robert E. Lucas, Jr., and Edward C. Prescott. *Recursive Methods in Economic Dynamics.* Harvard University Press, 1989.

Trejos, Alberto, and Randall Wright. "On the State of Macroeconomics," *Journal of Political Economy* (No. 1, 1995), pp. 118-41.

Wallace, Neil. "The Overlapping Generations Model of Fiat Money," in John H. Kareken and Neil Wallace, eds. *Models of Monetary Economies.* Federal Reserve Bank of Minneapolis, 1980.

Williamson, Steve, and Randall Wright. "Barter and Monetary Exchange Under Private Information," *The American Economic Review* (March 1994), pp. 104-23.

Reply to Wright's Commentary

Allan H. Meltzer

Randall Wright has several complimentary things to say about some of my earlier work. I thank him for those remarks. Most of his comment, however, fails to discuss my current paper, and the main comments he makes about the paper are untrue. Specifically, my paper does not attack theory or oppose the development of micro-foundations for macroeconomics. It is not about economic policy. I am at a loss to understand how a reader could come away with either an idea or with a belief that I am critical of recent work on economic development and growth.

The paper proposes specific hypotheses for analyzing the role of money and uncertainty. The foundation is a micro-theory in which there is production for inventory. Uncertainty about the duration of observed changes gives rise to costs of information. The reason is that permanent and transitory changes cannot be distinguished for some time after a change occurs. In this model, money is privately and socially valuable because it reduces costs of transacting and bearing uncertainty.

I use this framework to discuss three problems related to the questions that the organizers asked me to address: (1) why some prices are set; (2) why some firms set nominal prices; and (3) why some prices are sticky–have substantially less variance weekly or monthly than prices in auction markets. I give explicit references to papers in which the framework is more fully developed or in which it has been used fruitfully in empirical studies.

I contrast this framework with others in which there are no sticky prices, no productive or useful mediums of exchange, no differences in costs of acquiring information, and no distinction between money, bonds and capital that would enlarge the role of relative price changes in the transmission of monetary and real shocks. I am critical of models with one open market interest rate and no sticky prices, and models in which money is introduced as a socially costly way to overcome frictions in an otherwise frictionless Walrasian model. I am skeptical of some of the conclusions drawn from such models.

Wright gives considerable space to methodological issues. Although the models we use influence the way we look at the world, it is a mistake to confuse the model with the world. Science, well done, does not equate the model to the world; it recognizes that all useful models generate refutable propositions. The weak testing procedure called calibration that is now fashionable is a distant substitute for serious, careful assessment of competing hypotheses.

Much recent work, including real business cycle models or overlapping generation models of money, have implications that are readily refuted. For example, it is well established that all correlations between money and income are not the result of "reverse causation" and that all unemployment is not the result of intertemporal substitution.

I have proposed an alternative model in which uncertainty and costs of transactions and information have a large role. Monetary arrangements (and other institutions) reduce these costs, but some costs are unavoidable.

Wright's comment reports on some of the research that is now under way or that has been published in the recent past. As always, some of this work will prove fruitful, some not. There is a high cost of information and great uncertainty about which will be successful.

It is my view that progress on the important issue about how a monetary economy adjusts to changes or shocks will require more attention to uncertainty about the permanence of shocks and to costs of information and transactions. That view may prove right or wrong, but it is neither atheoretical nor anti-theory.

I respect Wright's past work and looked forward to his comments. I regret that he avoided discussion of the issues raised in my article and my proposals for dealing with them. Such a discussion is overdue.

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A Conference Panel Discussion: What Do We Know About How Monetary Policy Affects the Economy?

Ben S. Bernanke

This conference addressed two broad issues. First, can Fed policies affect real and nominal interest rates; and, if so, by what mechanisms? Second, by what channels do Fed actions affect real economic activity (if they do)?

On the issue of whether the Fed can affect interest rates: We have always been pretty sure that it could, but it's nice that we now have formal econometric methods that can both verify the existence of a "liquidity effect" and perhaps also obtain quantitative measures of the linkage between interest rate changes and changes in output, prices and other key macro variables. Since I have the opportunity, let me put in a few good words for one of these methods, the semi-structural VAR approach employed by Bernanke and Blinder (1992), Strongin (1992) and Christiano, Eichenbaum and Evans (1994), and discussed further here by Larry Christiano in his comment on Adrian Pagan's paper. This method, as described in more detail in the above-mentioned sources, involves three basic steps. First, based on institutional analysis (for example, of Fed operating procedures), identify a variable or combination of variables that measure the stance of policy (for example, Bernanke and Blinder opt for the federal funds rate; Strongin uses a measure closely related to the ratio of nonborrowed reserves to total reserves). Second, estimate a standard VAR system including the relevant endogenous variables and the policy variable, with the policy variable ordered last. This structure imposes the assumptions that the policymaker (potentially) responds to contemporaneous information, but that shocks to policy feed back to the economy with at least a one-period delay. Finally, calculate the implied impulse response functions for the endogenous variables in the system; these provide estimates of the dynamic response of the economy to an unanticipated policy change.

There are now a number of studies that show that this method can give robust and plausible measures of the behavior of interest rates, output and many other variables to a monetary policy shock, despite the minimalist identifying assumptions. Several caveats should be offered, however:

(1) The method depends on the choice of policy measure being a valid one. No simple or mechanical criterion, such as forecasting power, can determine the optimal policy measure. For the case of monetary policy, the choice of policy measure depends on the way the Fed chooses to implement its policies, for example, by an interest rate targeting rule or by targeting a component of bank reserves. As is well-known, the Fed's operating procedures have changed over time and, hence, no single policy measure may be best for an extended sample period. In ongoing research, Ilian Mihov and I have estimated models of the Fed's operating procedure for different sub-periods. We find that the funds rate is an excellent indicator of the stance of monetary policy for the 1965-79 period but, more recently, the best indicator is one that combines information from both the funds rate and measures of reserves.

(2) As Sims (1992) was the first to note, the VAR approach to identifying the results of policy shocks will give invalid results if the policy innovation is dominated by the policymaker's response to information not

captured in the VAR. This problem is the source of the infamous "price puzzle," the finding in some cases that a tightening of monetary policy is followed by a rise in the price level. Sims showed that this problem can be eliminated by including a variable in the VAR that proxies for the Fed's information about future inflation (for example, a commodity price index or the exchange rate). Christiano, Eichenbaum and Evans (1994) find that including a commodity price index and measuring the general price level by an index that treats housing costs correctly (for example, the GDP or Personal Consumption Expenditure, PCE, deflator) largely eliminates the price puzzle. My own experimentation with these systems suggests that the Christiano, Eichenbaum and Evans result is quite robust.

(3) Finally, although the identification method works by tracing out the effects of unanticipated policy shocks, this approach takes no stand on whether it is only unanticipated monetary policy that "matters." It may well be the case that forecastable changes in policy have a stabilizing effect on the economy; measuring this effect, however, requires the imposition of more economic structure in the analysis. Because the semi-structural VAR method does not account for the possibly stabilizing effects of predictable policy changes, this approach cannot tell us whether policy has, on net, been stabilizing or destabilizing during the sample period. Thus, mechanical variance decompositions that attribute a given percentage of the variance of output or prices to monetary policy can be misleading. At best, variance decomposition exercises may suggest the amount by which more predictable policies could have reduced the variance of output and prices in a given sample period.

Given the empirical support for the existence of a liquidity effect, the next task is to find theoretical models that rationalize this effect. Alan Stockman and Lee Ohanian's paper in this conference does a nice job of surveying the leading approaches. I was particularly interested in their model which assumes the existence of both flexible-price and sticky-price sectors; it seems both realistic and a promising source of empirical applications. A small suggestion: Stockman and Ohanian find in some of their simulations that the effect of a monetary shock on interest rates is ambiguous because of countervailing liquidity and Fisher effects. This ambiguity may be the result of the assumption of one-period price stickiness. I suspect that allowing multi-period, overlapping price contracts (thus adding more inertia to inflation) would generate a finding that monetary expansion unambiguously lowers the nominal interest rate in their model.

Stockman and Ohanian also discuss limited-participation models as an alternative theory of the liquidity effect. I find much interest in this approach also. In particular, it is quite realistic to assume that, in the short run, Federal Reserve purchases and sales of securities are absorbed by a relatively small number of Treasury dealers and other financial market participants. My main objection to existing limited-participation models is that they combine the limited-participation assumption with the "wrong" friction, that is, most of these models are closed by a structure that imposes a cash-in-advance constraint on consumers and firms. Not only is the cash-in-advance constraint not particularly plausible economically, but models that assume this constraint have great difficulty generating persistent effects of monetary policy changes.

I think a more promising approach would be to combine the limited-participation assumption with the assumption of sticky prices. Allan Meltzer's paper gives a spirited defense of the price-stickiness assumption based on the notions of pervasive economic uncertainty and the difficulty in distinguishing between permanent and transitory shocks. More formally, recent work by Lucas and Woodford (1994) shows how price stickiness and monetary non-neutrality can be an equilibrium outcome in a non-Walrasian setting with sequential service of customers. Allegorically, one may illustrate the Lucas and Woodford model by thinking of the owner of a general store in a gold-mining town, who must set prices without knowing how much gold will be discovered in the surrounding hills that day. Although the general-store owner is free to raise prices during the day if business is brisk, his inability to re-contract with earlier customers guarantees that unexpectedly high gold discoveries (positive monetary shocks) will be reflected in higher economic activity.

The second broad issue considered at this conference concerns the channels by which monetary policy has its effects on the economy. A common comparison is between the "money view" and the "credit view" of monetary transmission. Unfortunately, this terminology has created a great deal of confusion (in particular, what some have called the money view does little justice to the views of people like Milton Friedman, Karl Brunner and Allan Meltzer), and it should be abandoned. A better distinction is between the view represented by the standard textbook IS-LM model and what might be termed the capital-market-imperfections approach. The capital-market-imperfections approach is based on the premise that the same informational and agency problems that explain many aspects of financial structure (for example, the existence of financial intermediaries) also play a role in monetary transmission. A notable difference between the two approaches is that the IS-LM model assumes the existence of only two assets (money and "bonds"), while models based on capital market imperfections generally require a richer menu of assets.

As ably discussed in the papers by Glenn Hubbard and Steve Cecchetti, the capital market-imperfections approach suggests two new channels of influence for monetary policy, above and beyond the standard IS-LM-type effects. The first of these may be referred to as the balance sheet or net-worth channel: Here, the idea is that increases in interest rates weaken the financial conditions of consumers and firms, making it more difficult or costly for them to obtain credit. More formally, reductions in borrower net worth associated with a rise in interest rates increase the agency and information costs of making loans; see Bernanke, Gertler and Gilchrist (1994) for more discussion. For example, increased interest rates worsen the cash flows of indebted firms (if their debt is short-term or floating-rate) and reduce the capital values of assets (such as land) that are commonly used as collateral for loans. Reduced access to credit may lower both aggregate demand (because of declines in purchases of capital goods, consumer durables, and so on) and aggregate supply (because of reductions in working capital). As was discussed at this conference, there is a good deal of evidence for the balance sheet channel. In particular, it seems clear that monetary policy differentially affects agents who are more subject to agency and informational problems in credit markets, such as small firms and potential homebuyers.

The second channel suggested by the capital-market-imperfections approach may be referred to as the bank lending channel (Bernanke and Blinder, 1988). Briefly, put, the premise here is that a reduction in bank reserves by the Fed also reduces bank deposits and, hence, banks' loanable funds. To the extent that bank loans are imperfect substitutes for other forms of short-term credit (which seems incontrovertible), a reduced supply of bank loans will lower economic activity by bank-dependent borrowers.

Critics have noted that institutional changes and financial innovation have likely weakened the bank lending channel, if it ever existed (Romer and Romer, 1990; Thornton, 1994). Their strongest point is that, under current arrangements, banks need not rely on core deposits for funds. Large banks, at least, are able to raise funds by issuing certificates of deposits (CD), against which no reserve requirements are imposed. The response to this point is that the bank lending channel survives (at least in theory) as long as the demand by investors for bank CDs is not infinitely elastic: If demand is not perfectly elastic, that is, larger issuances of CDs require banks to pay higher rates, then the level of core deposits will be relevant to banks' willingness to supply loans. Indeed, the spread between CD rates and Treasury bill rates does increase, sometimes spectacularly, during periods of tight money.

There have been a number of interesting attempts to test for a bank lending channel, as Hubbard and Cecchetti describe. While the evidence does not contradict the existence of this channel, a generic difficulty is that most tests of the bank lending channel do not cleanly distinguish it from the balance sheet channel. For example, Kashyap and Stein (1994) find that small banks reduce lending following a monetary tightening more than large banks do. Since small banks have less access to the CD market, this finding is consistent with the view that a drain of reserves forces a reduced supply of loans by small banks. Unfortunately, since a larger share of small bank loans goes to small borrowers, this result might also be explained by the differential effect of monetary tightening on small firms' balance sheets, which disproportionately reduce the effective credit demand by those firms. Matched bank-borrower data will probably be needed to resolve this issue.

Despite the difficulties, there are several reasons to continue to do empirical work on the links between credit market imperfections and monetary policy. First, as was discussed at this conference, there are serious quantitative problems with the IS-LM approach and other leading models of the transmission process; channels based on credit market imperfections may be necessary to explain the apparent strength and persistence of monetary policy effects on the economy. Second, making monetary policy in an environment of ongoing institutional change and financial innovation requires a sophisticated appreciation of how those changes affect the potency of policy and the interpretation of policy indicators. Models based on credit market imperfections, because they analyze monetary transmission using the same information-based theories that underlie our understanding of financial structure and function, are best placed to help us attain that appreciation.

REFERENCES

Bernanke, Ben S., and Alan S. Blinder. "The Federal Funds Rate and the Channels of Monetary Transmission," *The American Economic Review* (September 1992), pp. 901-21.

________and________. "Credit, Money, and Aggregate Demand," *The American Economic Review* (May 1988), pp. 435-9.

________, Mark Gertler and Simon Gilchrist. "The Financial Accelerator and the Flight to Quality," National Bureau of Economic Research *Working Paper No. 4789* (July 1994).

Christiano, Lawrence J., Martin Eichenbaum and Charles Evans. "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," working paper (March 1994), Northwestern University.

Kashyap, Anil K., and Jeremy C. Stein. "The Impact of Monetary Policy on Bank Balance Sheets," working paper (March 1994), University of Chicago.

Lucas, Robert E., Jr., and Michael Woodford. "Real Effects of Monetary Shocks in an Economy with Sequential Purchases," working paper (April 1994), University of Chicago.

Romer, Christina D., and David H. Romer. "New Evidence on the Monetary Transmission Mechanism," *Brookings Papers on Economic Activity* (1990:1), pp. 149-213.

Sims, Christopher A. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review* (June 1992), pp. 975-1011.

Strongin, Steven. "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle," working paper (November 1992), Federal Reserve Bank of Chicago.

Thornton, Daniel L. "Financial Innovation, Deregulation and the 'Credit View' of Monetary Policy," this *Review* (January/February 1994), pp. 31-49.

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Thomas F. Cooley

How do changes in monetary policy get transmitted to the real economy? The papers presented at this conference have been sharply focused on this question and on three candidate answers. New research was presented on the liquidity effects channel. There was abundant discussion of the credit channel and several summaries of research on the sticky-price channel. The only transmission mechanism not discussed in these papers is the most venerable one: rigid wages.

The discussion has been focused with almost surgical precision on the circuitry of monetary policy—how actions of the Federal Reserve affect the behavior of banks, firms and consumers. Taken almost for granted in this discussion—I assume—is the view that shifts in monetary policy have important consequences for the real economy. Steve Cecchetti summarized some of the recent empirical research on the output effects of monetary policy. But, in general, the papers do not address very explicitly the sense in which monetary policy is important. Are there important growth effects associated with monetary policy? Are there important distributional consequences of monetary policy? Are there significant output effects at business cycle frequencies? These are quite distinct questions and all of them are important. Unfortunately, the papers presented here are unnecessarily vague about these bottom line issues.

If there is a liquidity effect in the sense that monetary expansions cause nominal interest rates to rise, but output is left unchanged over a horizon of two quarters or more as in the model economies studied by Ohanian and Stockman—aside from the descriptive value of understanding these liquidity effects, why should we care? Correspondingly, if some investment projects are not undertaken as a consequence of a shift in monetary policy, as occurs in some of the environments that Glenn Hubbard discussed, why is that important? One obvious answer is that there could be important growth or welfare consequences of these policy shifts, even though they may have little consequence for output at the business cycle frequency.

The traditional view is that monetary policy does have important effects on real economic activity at the business cycle frequency. Certainly the recent actions of the Federal Reserve suggest that the current interest rate smoothing policy is predicated on the belief that the Fed can moderate the growth of real output. The theoretical evidence for this is somewhat weak and the empirical evidence is extremely fragile. There is also theoretical evidence that monetary policy and the nature of financial institutions are important for economic growth but, again, the empirical evidence is thin. But these are the reasons why monetary economics is so appealing: We believe monetary policy is important but the evidence is elusive. For that reason it is important that we consider evidence from a variety of sources.

MONEY AND THE BUSINESS CYCLE

First, I want to discuss very briefly the empirical evidence on the role of money in business cycles and the efficacy of monetary policy. The empirical evidence based on VARs or structural VARs is well-known and known to be very sensitive to the set of conditioning variables, the sample period used, and the identification restrictions imposed. Pure reduced-form estimates which treat money as exogenous are meaningless. Structural VARs based on just identifying restrictions seem to be consistent with the proposition that money is neutral in the long run, but has a short-run effect on output. This evidence too is fragile (Cooley, 1994). More recently, economists have shifted to studying specific monetary episodes rather than time-series models to identify more clearly when monetary policy shifts are taking place. Friedman and Schwartz (1963) have become the darlings of the new Keynesians because of their documentation of specific historical episodes when deliberate monetary actions were followed by declines in real economic activity. Romer and Romer (1989) follow a similar methodology to identify monetary disturbances in the post-war United States. They associate these episodes with recessions. But this evidence, like the Friedman and Schwartz evidence, is far from clear. Steve Cecchetti discussed some of the objections to their analysis in his article. There are other objections as well, some of them touched on by Kevin Hoover. Many of the episodes identified by the Romers are also associated with changes in reserve requirements, tax reforms, and other things that are at least arguably regarded as real shocks. Moreover, Hoover and Perez (1994a, b) have shown that the evidence of the Romers does not sustain the causal interpretation given to it and that the methodology cannot distinguish monetary shocks and oil shocks as a cause of recessions.

Whenever one raises these qualms about the evidence on monetary policy, advocates of the monetary view resort to their ultimate weapon—the Volcker recession.

A Real View of the Volcker Recession

The Volcker recession seems to be regarded as the incontrovertible evidence that monetary policy—in this case, the Volcker disinflation—can cause a decline in real economic activity. The case seems pretty strong. Paul Volcker announced his intention to squeeze inflationary expectations out of the economy and the FOMC acted to tighten monetary policy in a decisive way. This episode is a serious challenge for those who view real shocks as the most powerful driving forces of business cycles.

Could technology shocks also explain the Volcker recession? To answer this question, I conducted an exercise similar to that reported by Hansen and Prescott (1993), who asked the question, "Can technology shocks explain the 1990-91 recession?"

To address this question, I use a model similar to the basic real business cycle (RBC) model but modified to take account of some important features of the post-war U.S. economy. The most important modification is that there are three sectors producing consumption goods, consumer durables and producer durables. The technologies for producing these goods include land explicitly as a factor of production:

$$(1)\qquad \begin{aligned} C_t &= Z_t K_{1t}^{\theta_1} h_{1t}^{\theta_2} L_{1t}^{1-\theta_1-\theta_2} \\ X_{dt} &= Z_{dt}\, Z_t K_{2t}^{\theta_1} h_{2t}^{\theta_2} L_{2t}^{1-\theta_1-\theta_2} \\ X_{kt} &= Z_{kt}\, Z_t K_{3t}^{\theta_1} h_{3t}^{\theta_2} L_{3t}^{1-\theta_1-\theta_2}, \end{aligned}$$

where K, h and L denote the stock of capital, the hours and the stock of land employed in each sector, respectively. The variables Z_{dt} and Z_{kt} are the investment-good, sector technology shocks relative to the consumption-goods sector technology shock. Their inverses give the relative prices of consumer durables and capital relative to consumption. Specifying technology shocks in this way makes it possible to capture the fact that the relative prices of consumer and producer durables have declined over the post-war period. The processes for the Z's are:

$$\begin{aligned} Z_t = \lambda^t z_t,\; Z_{dt} &= \lambda_d^t z_{dt},\; Z_{kt} = \lambda_k^t z_{kt} \\ \log z_{t+1} &= (1-\rho)\log \bar{z} + \rho \log z_t + \varepsilon_{t+1} \\ \log z_{dt+1} &= \rho_d \log z_{dt} + \varepsilon_{dt+1} \\ \log z_{kt+1} &= \rho_k \log z_{kt} + \varepsilon_{kt+1}. \end{aligned}$$

The economy is populated by a continuum of identical households of measure N that grows at the rate η-1. Households have utility given by

$$u(C_t, D_t, h_t) = \alpha \log C_t + (1-\alpha)\log D_t - Ah_t,$$

where D represents the service flow provided by the stock of durables and the linear term in hours results from assuming that labor is indivisible, as in Rogerson (1988) and Hansen (1985). The rest of the details of the model economy are exactly as in Hansen and

Prescott (1993) so I won't repeat them here.

The important features of the calibration follow the procedures outlined in Cooley and Prescott (1995), except that for this exercise we choose the parameters so that the steady state for the model matches the data for the first quarter of 1987. We then construct the sequence of technology shocks, Z_t. These shocks are then fed into the model to generate a sequence for consumption, investment, productivity, hours and output for the actual economy. The results of this exercise are shown in the next two figures.

Figure 1 shows the path of real GNP as predicted by the basic real business cycle model and as it is in the data. The vertical line is approximately the trough of the Volcker recession. Figure 2 shows the path of hours worked as predicted by the model and as in the data. Hours in the model are much less smooth than in the data because the indivisible labor assumption causes them to respond sharply to the technology shocks. The behavior of the other variables is much the same; the model tracks actual values quite closely.

As the figures show, the basic real business cycle model can account quite well for the Volcker recession without recourse to a monetary mechanism. What are we to conclude from this? One might assert that this exercise reveals that the RBC modeling strategy is completely vacuous: The identification of technology shocks is so imprecise that monetary shocks—along with any other economic variables legitimately affecting output—are included in the estimated technology shock series. There are several reasons why I think such a conclusion would be wrong. First, we know that there were important real shocks occurring over this period. There were oil price increases in 1979 and 1981 and changes in reserve requirements in 1979 and 1980. There were also some credit controls imposed in 1979-80. These are all the kinds of events that would legitimately show up as technology shocks because they change the productivity of existing inputs. Second, the tax treatment of capital changed fairly dramatically during this period. The Economic Recovery Act of 1981 introduced major changes in the economic life and cost recovery rules for capital assets. The Act of 1982 reversed, at least partially, many of those changes, effectively increasing again the tax on capital income. These were real shocks to the economy that had a big affect on the investment decisions of firms and, again, would legitimately show up as technology shocks in a highly aggregated model.

A better conclusion to draw from these results is that models like this don't go far enough—they rely on a formulation of the technology shock that is too abstract. Any variable that helps to track output can get rolled into the technology shock. To better exploit their potential as analytical tools for

Figure 1

Gross National Product: Model and Data 1979:1=100

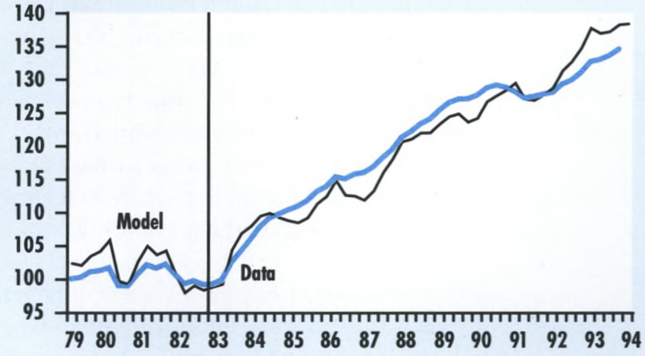
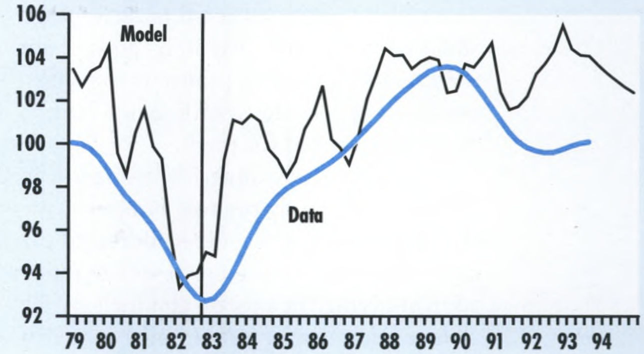


Figure 2

Hours Worked: Model and Data 1979:1=100



understanding the role of money in the macroeconomy, we need to do two things. First, if we want to understand a broader set of observations than those captured by the basic neoclassical growth model, then we have to add more theory—theory that admits the possibility that monetary shocks get transmitted. Second, if we want to understand the role of "shocks" in these models, we need a more explicit account of what these shocks are. Obviously, the nature of technology shocks is such that a lot of things can get rolled into them. As noted above, one obvious example is oil price shocks. A recent paper by Finn (forthcoming) does an impressive job of documenting how explicitly accounting for oil price shocks and capacity utilization improves the ability of models to match features of the data and account for the behavior of Solow residuals. What about changes in reserve requirements, borrowing constraints, the tax treatment of depreciation? These also may be reflected in technology shocks and the only way to try to sort out their quantitative importance is to try to construct economic environments that explicitly account for them.

One of the advantages of using artificial economies to study the role of monetary shocks is that the questions addressed can be made fairly precise. Thus, if we are interested in studying the precise channels by which changes in monetary policy affect the real economy, then the challenge is to construct plausible models that address this question.

CHANNELS OF MONETARY POLICY

It is easy to think of many objections to the economic environment I used previously to simulate the Volcker recession. Nevertheless, the study of similar economic environments that include money has yielded some useful insights about the channels of monetary policy. The evidence is far from conclusive, but it probably compares favorably with empirical evidence based on aggregate data. Accordingly, it seems worthwhile to review briefly some of the evidence from artificial economies that have tried to incorporate monetary transmission mechanisms.

Signal Extraction

For a long period, the main mechanism that macroeconomic theory focused on as the transmission mechanism for monetary policy was signal extraction problems of the sort made famous by Lucas. Kydland (1989) was the first to study signal extraction problems in the context of an equilibrium business cycle.[1] Signal extraction problems caused by monetary policy are proxied by confronting agents with a signal extraction problem. In these models, agents only observe a noisy version of the shocks to technology. This is intended to reflect the signal extraction problem caused by imperfectly observed monetary policy. Cooley and Hansen (1995) studied a similar model. The conclusion of this work is that signal extraction problems provide very little propagation of monetary shocks. In fact, the addition of "monetary noise" can actually reduce the size of fluctuations in the economy.

Wage Rigidities

Cho (1993) and Cho and Cooley (forthcoming) study a standard real business cycle model in which money is introduced by a cash-in-advance constraint, and workers and firms agree to some contracting rule which specifies the nominal wage in advance. Workers cede to firms the right to determine the level of employment. In this setting, monetary shocks do get propagated and the most interesting finding is that it doesn't take a lot of rigidity for these shocks to have substantial output effects. The major problem with this account of how monetary shocks have real effects is that the cross-correlations in the data generated by these models are inconsistent with the properties of U.S. data. This suggests that money is not a primary cause of output fluctuations.

Sticky Prices

Cho (1993), Cho and Cooley (forthcoming) and King (1991) followed a similar approach in studying sticky prices as a propagation channel for monetary shocks. Workers and firms agree in advance to fix prices, firms agree to supply all that is demand-

[1] Kydland and Prescott (1982) built this feature into their models but didn't do much with it because it didn't seem very important. Their paper was actually written much earlier in the 1980s. It pioneered the analysis of monetary transmission in real business cycle models.

ed at that price. Money does have big output effects in such economies as long as the equilibrium quantities are determined by the demand curve rather than the supply curve. Only a very small amount of rigidity is necessary for monetary shocks to have a big output effect. Again, however, the cross-correlations don't match those observed in U.S. data and this casts doubt on monetary shocks as the mechanism that produces real effects of monetary shocks.

Ohanian, Stockman and Kilian (1994) extend these sticky-price models in a useful way. They consider a two-sector version in which consumer goods prices are sticky for one period but investment goods prices are perfectly flexible. In this setting, they find that monetary shocks have no big output effects. This seems to cast further doubt on this propagation mechanism. Monetary shocks are more powerful in the multiple-equilibrium setting of Beaudry and Devereux (1994). In their model, final goods are produced under monopolistic competition between firms using a technology that exhibits increasing returns and requires multiple intermediate goods as inputs. There is a rudimentary intermediation sector in which the Fed can manipulate total reserves. One of the model's equilibria in which prices are fixed one period in advance, seems to match the dynamic responses in the data very well. However, the equilibrium selection story seems very weak and the model requires an implausibly high degree of increasing returns.

Limited-Participation Models

These models have been developed and exploited by Lucas (1990), Fuerst (1992) and Christiano and Eichenbaum (1992). Christiano and Eichenbaum have done the most in exploiting the quantitative implications of these models for output. In these models, the financial arrangements break the temporal link between the consumption decisions of households and monetary injections. This generates a transient liquidity effect in which both real and nominal interest rates change. The controversies regarding the existence and size of this liquidity effect have been pretty thoroughly represented in Adrian Pagan's article and the ensuing discussion. What seems clear is that the empirical evidence for a liquidity effect is pretty strong but the magnitude of it is probably very small. More importantly, the empirical evidence has been focused almost exclusively on the liquidity effect itself without much discussion of the corresponding output effects. The quantitative evidence from studying artificial economies in which this channel is present shows that monetary shocks will have small but significant effects on real output.

Endogenous Monetary Policy

One of the biggest problems that plagues empirical researchers is the issue of defining exactly what monetary policy shifts are and the extent to which changes in monetary policy can be treated as exogenous. Artificial economies also help to understand this issue. Coleman (1994) studies an artificial economy in which monetary policy is endogenous. The monetary authority chooses a supply of currency to meet inflation and nominal interest rate targets. Banks provide checkable deposits in the amounts desired by households, given the supply of currency. In this environment, the Federal Reserve can raise interest rates in response to changes in output. Coleman then estimates the parameters of his model economy to determine how the Fed responds. The estimated parameter values imply that a substantial portion of the conditional and unconditional variance of nominal interest rates is endogenous, but not all of it is. Coleman analyzes the implications of his estimated parameters for the cross-correlations between money and output. He finds that endogenous money creation causes money growth to be more strongly correlated with current and past output than with future output growth. In U.S. data, it is more strongly correlated with future output growth. This at least suggests that endogenous money creation cannot by itself explain the observed correlations between money and output.

The Credit Channel

The research on the credit channel for monetary policy was well-summarized in the papers by Hubbard and Cecchetti. In a typical credit channel model, informational asymmetries between borrowers and lenders in credit markets imply that loan contracts are constrained by moral hazard or adverse selection. Entrepreneurs who must borrow in credit markets to finance new investments pay a higher price for borrowed funds or may be denied credit altogether. These asymmetries vary in degree over the business cycle: In periods of expansion, the information asymmetries are mitigated. A key feature of the credit view is that most of the empirical implications are cross-sectional and the mapping between time-series and cross-sectional evidence is not obvious or direct. There have been only a few attempts to incorporate this view into artificial economies.

Fisher (1994) constructs a model economy in which there is costly state verification by lenders. He finds that this does lead to asymmetric response of firms to monetary shocks, but he also finds that the quantitative impact of monetary shocks on output are quite small. Fuerst (1994) studied the property of a model economy which incorporates some elements of the credit channel view. He finds that adding these features to the basic real business cycle model adds little or nothing to the basic, real business cycle propagation mechanism.

I don't think this is the final story because there are aspects of the credit channel view that Fuerst's model may miss. As the papers and discussions made clear, the cross-sectional implications of credit issues are manifest in the wealth of different agents in the economy. It is difficult to capture this heterogeneity in wealth and make it fit in the context of a representative-agent type of business cycle model. Introducing heterogeneity in a serious way and keeping capital accumulation in the model is at the frontier of what we can analyze. The curse of dimensionality restricts our ability to analyze a heterogeneous–agent economy with capital accumulation.

Furthermore, even if the output effects at business cycle frequencies are small, previous experience with heterogeneous-agent models of money suggests that heterogeneity and asymmetric information problems may have very important welfare consequences. Finally, a lot of the theoretical work referred to stresses the important long-term growth effects of financial intermediation and borrowing constraints. In that respect, I think a lot of the discussion has been focused far too narrowly on the output effects at the business cycle frequency and not enough on these welfare and growth implications.

REFERENCES

Beaudry, Paul, and Michael B. Devereux. "Monopolistic Competition, Price Setting and the Effects of Real and Monetary Shocks," working paper (1994), Queens University.

Cho, Jang-Ok. "Money and the Business Cycle with One-Period Nominal Contracts," *Canadian Journal of Economics* (August 1993), pp. 638-59.

_______ and Thomas F. Cooley , "The Business Cycle With Nominal Contracts," *Economic Theory* (forthcoming).

Coleman, Wilbur John. "Money and Output: A Test of Reverse Causation," working paper (1994), Duke University.

Cooley, Thomas F. "Data Analysis Without Much Theory: A Critique of Structural VARs," working paper (1994), University of Rochester.

_______ and Gary D. Hansen. "Money and The Business Cycle" in Thomas F. Cooley, ed., *Frontiers of Business Cycle Research.* Princeton University Press, 1995, pp. 175-216.

_______ and _______. "Tax Distortions in a Neoclassical Monetary Economy," *Journal of Economic Theory* (December 1992), pp. 290-316.

_______ and Edward C. Prescott. "Economic Growth and Business Cycles", in Thomas F. Cooley, ed., *Frontiers of Business Cycle Research.* Princeton University Press, 1995, pp. 1-38.

Christiano, Lawrence J., and Martin Eichenbaum. "Liquidity Effects, Monetary Policy and the Business Cycle," National Bureau of Economic Research *Working Paper No. 4129* (August 1994).

Finn, Mary. "Variance Properties of Solow's Productivity Residual and Their Cyclical Implications," *Journal of Economic Dynamics and Control* (forthcoming).

Fisher, Jonas D.M. "Credit Market Imperfections and the Heterogeneous Response of Firms to Monetary Shocks," working paper (1994), University of Western Ontario.

Friedman, Milton, and Anna J. Schwartz. *A Monetary History of The United States, 1867-1960.* Princeton University Press, 1963.

Fuerst, Timothy S. "Monetary and Financial Interactions in the Business Cycle," working paper (1994), Federal Reserve Bank of Cleveland.

_______. "Liquidity, Loanable Funds and Real Activity," *Journal of Monetary Economics* (February 1992), pp. 3-24.

Fullerton, Don, and Roger H. Gordon. "A Reexamination of Tax Distortions in General Equilibrium Models" in Martin Feldstein, ed., *Behavioral Simulation Methods in Tax Policy Analysis.* University of Chicago Press, 1983, pp. 369-426.

________and Mario Karayannis. "United States," in Dale W. Jorgenson and Ralph Landau, eds., *Tax Reform and the Cost of Capital: An International Comparison.* Brookings Institution, 1993.

Gomme, Paul. "Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model," *Journal of Monetary Economics* (August 1993), pp. 51-77.

Hansen, Gary D. "Indivisible Labor and The Business Cycle," *Journal of Monetary Economics* (November 1985), pp. 309-25.

________ and Edward C. Prescott. "Did Technology Shocks Cause the 1990-1991 Recession?" *The American Economic Review* (May 1993), pp. 280-6.

Hoover, Kevin D., and Stephen J. Perez. "Post Hoc Ergo Propter Once More: An Evaluation of `Does Monetary Policy Matter?' in the Spirit of James Tobin," *Journal of Monetary Economics* (August 1994a), pp. 47-73.

________ and ________. "Money May Matter But How Could You Know?" *Journal of Monetary Economics* (August 1994b), pp. 89-99.

King, Robert E. "Money and Business Cycles," working paper (1991), University of Rochester.

Kydland, Finn E. "The Role of Money in a Competitive Model of Business Fluctuations," working paper (1989), The Institute for Empirical Macroeconomics.

________ and Edward C. Prescott. "Time To Build and Aggregate Fluctuations," *Econometrica* (November 1982), pp. 1345-70.

Lucas, Robert E., Jr. "Lotteries and Interest Rates," *Journal of Economic Theory* (April 1990), pp. 237-64.

Ohanian, Lee E., Alan Stockman and Lutz Kilian. "The Effects of Real and Monetary Shocks in Business Cycle Model With Some Sticky Prices," working paper (1994).

Rogerson, Richard. "Indivisible Labor, Lotteries and Equilibrium," *Journal of Monetary Economics* (January 1988), pp. 3-16.

Romer, Christina D., and David H. Romer. "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," National Bureau of Economic Research *Macroeconomics Annual.* MIT Press, pp. 121-70.

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The recent undertaking by the proponents of the credit view of broadening the simple Keynesian transmission mechanism is to be welcomed. Adding the credit channel to the traditional money channel permits studying the effects of monetary policy on the process of intermediation and provides a richer description of the transmission of policy actions to the real economy. Studying the interdependence of various types of credit markets appears to rank highly on the research agenda of this new literature. Although this is of interest in itself, from a macroeconomic point of view, it remains an unsettled issue how far to go in disaggregation, hence, differentiation of financial assets.

I divide my contribution to this panel into two parts. First, I will examine the aggregative structure of the new credit view and compare it with other theories of transmission, notably the monetarist analysis. The conclusion will be that the latter theory is the more comprehensive one and permits studying the issues that are on the research agenda of the credit view. Thereafter, I will discuss whether this new view of the transmission mechanism has any novel implications for monetary policy. I believe that this is not the case.

THE CREDIT VIEW IN COMPARISON TO OTHER THEORIES OF TRANSMISSION

To understand the contribution of this recent literature to our knowledge about the channels of monetary transmission, I believe that it is useful to put the recent credit vs. money debate into the broader perspective of the transmission theory of relative prices. This theory dates from the early 1960s, when a growing dissatisfaction with the narrow Keynesian transmission channel of a single interest rate led neo-Keynesians (for example, Tobin, 1961) as well as monetarists (for example, Brunner, 1961) to adopt a broader view.

The theory of relative prices provides an encompassing view of the transmission mechanism. It assumes that all assets, financial and real, are imperfect substitutes. This implies that a change in the stock supply of base money or government debt affects all relative prices and sets in motion a process of portfolio adjustment that extends to the full array of financial and real assets. The speeds of adjustment may differ between markets due to differential adjustment costs. As Brunner (1970, 1971) pointed out, the degrees of imperfect substitutability are shaped by differences in the levels of transactions costs and marginal information cost. These costs are generally low for money and securities, but much higher for loans and non-securitized real assets. Brunner conjectured that the relative magnitude of these costs changes with the level of interest rates. This led him to assume that securities are close substitutes to money when interest rates are low, but closer substitutes to real capital than to money when interest rates are high.

Although macroeconomic analysis can only deal with a few, highly aggregated asset markets, there is no compelling reason for ignoring intermediate assets by restricting the analysis to the components of private net wealth. In fact, both Tobin (1961) and Brunner (1961) already considered private debt, the difference being that private debt in Tobin's pure-asset model has no particular role to play, while the bank credit market in Brunner's analysis is a cornerstone of monetary transmission to aggregate demand.

Against the background of the general transmission theory of relative prices, any specific view or model of the transmission mechanism rests on simplifying assumptions that permit aggregating assets into a small number of representative assets. Different aggregative structures yield different visions of the way in which the economy works (Leijonhufvud, 1968). I will compare three specific views of the transmission process: the traditional money view; the new credit view; and the monetarist view.

The money view was introduced by Keynes in his *General Theory*. This view aggregates all assets into two categories: money and non-money. The non-money asset represents all other financial assets as well as existing capital goods. The distinction between financial and physical non-money assets is eliminated by the straightforward assumption of perfect substitutability. For Keynes the non-money asset was long-term in nature, while Keynesians became used to equating the non-money asset with a short-term bond within the IS-LM framework.

The Keynesian IS-LM model provides the most restrictive analysis of monetary policy transmission. Due to the assumption that non-money assets are perfect substitutes, monetary policy is transmitted to aggregate demand through a single interest rate, the bond rate, and the efficacy of policy actions depends solely on the interest elasticity of money demand. The classroom interpretation of the result is: A reduction in the money stock raises the "cost of borrowing," which reduces investment demand by eliminating marginal projects. However, taken literally, the model does not contain a banking sector—hence, there are no bank loans and the money variable neither represents M1 nor M2, but just currency. The narrowness of the setup is rightly criticized by the proponents of the new credit view as it was before by monetarists during the debate of the late 1960s on whether money matters.

The credit view adds the credit channel to the Keynesian money channel by introducing bank loans as a third (intermediate) asset. In Table 1, I take the model by Bernanke and Blinder (1988) as representative of this view and compare it with the monetarist view as presented by the Brunner and Meltzer (1972, 1976) model. To be sure, the monetarist view of transmission is not to be equated with the money view, contrary to Gertler and Gilchrist (1993), because the monetarist model also contains the bank credit market.

Table 1

Alternative Views of Transmission

Variable	IS-LM	Peer Group Credit	Monetarist
Markets			
Money	x	x	x
Government bonds	x	x	x
Bank loans		x	
Real assets			x
Prices			
Bond rate (i_B)	x	x	x
Bank loan rate (i_L)		x	
Asset price (P_A)			x
Real wealth (w)			
Financial		x	x
Real assets			x
Aggregate demand	$d(i_B)$	$d(i_B, i_L)$	$d(i_C, P_A, w)$
	$-$	$-\ -$	$-\ +\ +$

Note: The credit view is based on Bernanke-Blinder (1988) and the monetarist view based on Brunner-Meltzer (1972, 1976)

The credit view concentrates on the substitution relations between money, bonds and bank loans. Accordingly, the real loan rate, i_L, supplements the bond rate, i_B, as a determinant of aggregate demand. With the additional credit channel, the transmission of monetary policy no longer depends on the interest responsiveness of money demand alone. This is an improvement over the money view. But note that the credit view is silent on the role of existing real capital. Apparently, the implicit assumption is that the relevant transactions costs are infinite.

The monetarist analysis, in contrast, lumps together government bonds and bank loans and extends the range of substitution to the existing stock of real assets (equity, real estate, and so on). The asset price level, P_A, enters the aggregate demand function directly, reflecting the substitution between existing and new capital goods, and indirectly as a determinant of real wealth, w.

What are the implications of the credit and the monetarist models regarding the transmission of shocks to aggregate demand? In both models, monetary policy shocks and money demand shocks affect the money stock, the stock of bank loans and aggregate demand in a comparable fashion regarding the signs of first derivatives. However, the early monetarist model of Brunner and Meltzer implies much stronger effects than the new credit model of Bernanke and Blinder, because the former permits substitution over the full array of financial and real assets. The asset price level is a particularly important transmission variable. Leaving it out of the picture is leaving out Hamlet. Changes in this price affect investment demand by changing the relative price of new capital goods (Tobin's *q*), and they affect the net worth of firms and households—hence, creditworthiness and investment demand as well as consumption demand.

Qualitative differences between the two views arise when we study shocks to loan demand (see Table 2). The credit view attaches importance to such shocks, although the origins of such shocks need clarification. Let us assume these shocks reflect productivity shocks. Both models imply that an exogenous shock to the demand for bank loans raises the loan rate and the stock of loans. However, the credit view predicts a contraction of the money stock, while the monetarist view predicts a rise. More importantly, since the credit view assumes that the impact of the loan rate on aggregate demand dominates the impact of the bond rate, this view predicts a fall in real income. The monetarist view, in contrast, derives the opposite conclusion. A loan-demand shock effects an increase in real income, because it induces a rise in the asset price level, which dominates the contractionary effect on aggregate demand of the simultaneous increase in the loan rate. In the following section, we will check whether this conflicting result has any policy implication.

Before I turn to this, however, let me briefly point out two aspects of the credit versus money debate which I find puzzling. To begin with, I do not see why there is a need to search for evidence in support of the existence of the credit channel (Bernanke, 1993). Since neither the existence of the credit market nor the existence of differences between financial assets regarding transactions and information costs can be disputed, so cannot the existence of the credit channel. Once this is acknowledged, the effort put in testing for existence or relative importance of this channel is surprising.

Next, the evidence collected by the credit literature (for example, Bernanke and Blinder, 1992) on timing relationships between changes in monetary policy, banks' securities holdings and bank loans confirms the important role of differential information cost, and it may be noted that the principal pattern of adjustment—first securities, then loans—was predicted by Brunner (1970) as an implication of his theory of the relative price process. Banks hold stocks of information about customers and, hence, are reluctant to respond to monetary tightening by immediately cutting tailored loans instead of selling standardized securities first. Moreover, when finally forced to adjusting the loan portfolio, they will prefer to lend less to borrowers whose activities are less well-known or are less diversified and, hence, more risky.

However, in contrast to the credit view, the encompassing transmission mechanism of relative prices implies that the observed temporal pattern of adjustment is not exclusively determined by the banks' behavior. Instead, it is the result of the interaction of loan supply and loan demand. Any monetary policy change affects the asset price level, which is a determinant of loan demand (as well as of aggregate demand). A negative policy shock, for example, reduces the asset price level which, in turn, induces a rise in loan demand. Given that monetary policy shifts both curves, loan supply and loan demand, I do not see what we can learn from the attempt at identifying whether bank balance sheet contractions are due to shifts in supply or in demand, not to mention the identification problem raised by Cecchetti (1995).

Summing up, I conclude that the monetarist view provides a more comprehensive theory of transmission than the new credit view. Moreover, I believe that this new literature would gain from accepting the monetarist framework and from employing the monetarist credit market theory of the money supply (Brunner and Meltzer, 1966) as a point of departure for the analysis of the issues that are on the new view's research agenda.

POLICY IMPLICATIONS

Does the credit view have any novel implications for monetary policy making? I believe not, at least not if one compares the credit view to the monetarist analysis instead of the standard textbook model.

Suppose, first, that the monetary authorities follow the traditional monetarist advice of concentrating on the objective of providing stable money rather than trying to dampen business fluctuations. The most extreme proposal is to provide a permanent rate of inflation of zero or some low level. In this case, under either view of the transmission mechanism, it is sufficient to estimate the long-run money demand function and use it for determining the target rate of money growth. Though the market for bank loans is an important channel of transmission, this has no bearing on the question of which particular monetary aggregate to chose for targeting. Also, implementation procedures are unaffected.

However, let us consider the issue of dampening the impact of money demand shocks and of loan demand shocks on aggregate demand. Regarding the negative impact of money demand shocks, all views of the transmission mechanism imply that stabilizing the money supply path makes things worse. Bernanke and Blinder (1988) find that stabilizing the path of bank loans provides a superior alternative. However, since the analysis by Poole (1970), we know that the ideal policy for this case is stabilizing the interest rate. Above, we saw that the competing views of the transmission mechanism deliver contradictory predictions regarding the impact of stochastic loan demand shocks on aggregate demand. Nevertheless, both views imply that stabilizing the money supply path would be an appropriate policy response. Ironically, the monetarist view permits stabilizing the aggregate loan portfolio of banks as an alternative while the credit view does not.

Table 2

Effects of a Loan-Demand Shock

	Credit View	Monetarist View
Bank loan rate	+	+
Bond rate	–	
Asset price level		+
Stock of bank loans	+	+
Money stock	–	+
Aggregate demand	–	+

Note: The credit view is based on Bernanke-Blinder (1988) and the monetarist view is based on Brunner-Meltzer (1972, 1976)

This is not to say that I recommend targeting a loan aggregate instead of the money stock. To make this change, one would need to know much more, notably the source of shocks to the demand for bank loans. Are they produced by productivity shocks or do they reflect shifts from credit markets outside the banking system into the market for bank loans? In the latter case, it would require integrating the outside credit markets into the analysis to know what would be the net effect on money stocks, bank loan aggregates, interest rates and aggregate demand. Apart from this, and more generally, my reading of the empirical literature is that the attempts at detecting loan demand functions that are more stable than money demand functions have been unsuccessful.

As a final remark, the credit view collects evidence on the unfavorable cross-sectional results of monetary tightening. Not unexpectedly, the smaller and financially weaker firms are hit the hardest. Due to the global nature of monetary policy, the authorities can do nothing to avoid this except, of course, that the results provide backing for the monetarist advice to be steady and to avoid, in particular, unnecessarily large swings in the creation of reserves or the monetary base.

REFERENCES

Bernanke, Ben S. "Credit in the Macroeconomy," Federal Reserve Bank of New York *Quarterly Review* (spring 1993), pp. 50-70.

________ and Alan S. Blinder "The Federal Funds Rate and the Channels of Monetary Transmission," *The American Economic Review* (September 1992), pp. 901-21.

________ and ________. "Credit, Money, and Aggregate Demand," *The American Economic Review* (May 1988), pp. 435-39.

Brunner, Karl. "A Survey of Selected Issues in Monetary Theory," *Schweizerische Zeitschrift für Volkswirtschaft und Statistik* (March 1971), pp. 1-146.

________. "Eine Neuformulierung der Quantitätstheorie des Geldes - Die Theorie der relativen Preise, des Geldes des Outputs und der Beschäftigung," *Kredit und Kapital 1* (1970), pp. 1-30.

________. "Some Major Problems in Monetary Theory," *The American Economic Review* (May 1961), pp. 47-56.

________ and Allan H. Meltzer. "An Aggregative Theory for a Closed Economy," in Jerome L. Stein, ed., *Monetarism.* North-Holland Publishing Co., 1976, pp. 69-103.

________ and ________. "A Monetarist Framework for Aggregative Analysis," in Proceedings of the First Konstanzer Seminar on Monetary Theory and Monetary Policy (supplement to *Kredit und Kapital* 1). Duncker & Humblot, 1972, pp. 31-88.

________ and ________. "A Credit Market Theory of the Money Supply and an Explanation of Two Puzzles in U.S. Monetary Policy," in Tullio Bagiotti, ed., *Essays in Honour of Marco Fanno*, vol. 2. Padova, 1966, pp. 151-76.

Cecchetti, Stephen G. "Distinguishing Theories of the Monetary Transmission Mechanism," this *Review* (May/June 1995), pp. 83-100.

Gertler, Mark, and Simon Gilchrist. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence," *Scandinavian Journal of Economics* (No. 1, 1993) pp. 43-64.

Leijonhufvud, Axel. *On Keynesian Economics and the Economics of Keynes: A Study in Monetary Theory.* Oxford University Press, 1968.

Poole, William. "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model," *Quarterly Journal of Economics* (May 1970), pp. 197-216.

Tobin, James. "Money, Capital, and Other Stores of Value," *The American Economic Review* (May 1961), pp. 26-37.

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