Vol. 29, No. 4

ECONOMIC REVIEW

1993 Quarter 4

FEDERAL RESERVE BANK
OF CLEVELAND

ECONOMIC REVIEW

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Economic Review is published quarterly by the Research Department of the Federal Reserve Bank of Cleveland. Copies of the *Review* are available through our Public Affairs and Bank Relations Department. Call 1-800-543-3489, then immediately key in 1-5-3 on your touch-tone phone to reach the publication request option. If you prefer to fax your order, the number is 216-579-2477.

ISSN 0013-0281

Required Clearing Balances

by E.J. Stevens

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Introduction

Few people realize that in addition to complying with a Federal Reserve System regulation for holding a required reserve balance, many banks simultaneously meet an additional requirement to hold a clearing balance in their account at a Federal Reserve Bank. This clearing balance requirement differs from the familiar reserve requirement in three significant ways. First, a bank's agreement to meet the requirement is typically a business decision, not a legal necessity. Second, the amount of the requirement is mostly discretionary, not a fixed percentage of the bank's deposit liabilities. And third, the rate of return on a clearing balance is about equal to the federal funds rate, not zero, although a bank can use the earnings only to pay for services it buys from a Federal Reserve Bank.

About 5,000 banks now maintain required clearing balances, ranging from small retail depositories with a $25,000 minimum requirement to giant money center banks with clearing balance requirements of several hundred million dollars.[1] Forty-five percent of all required reserve balances and 85 percent of all required clearing balances are held by banks that use a mixed deposit account at a Federal Reserve Bank to comply with the combined requirements. For each of these institutions, the consequences of modest account deficiencies or surpluses are reckoned on the basis of required clearing balance rules. Only if a bank fails to meet *any* of its clearing balance requirement does it face the familiar "discount rate plus 2 percent" penalty for a required reserve deficiency. Likewise, such a bank wastes surplus balances by earning no rate of return only if its actual balance exceeds its required balance by more than a preestablished margin.

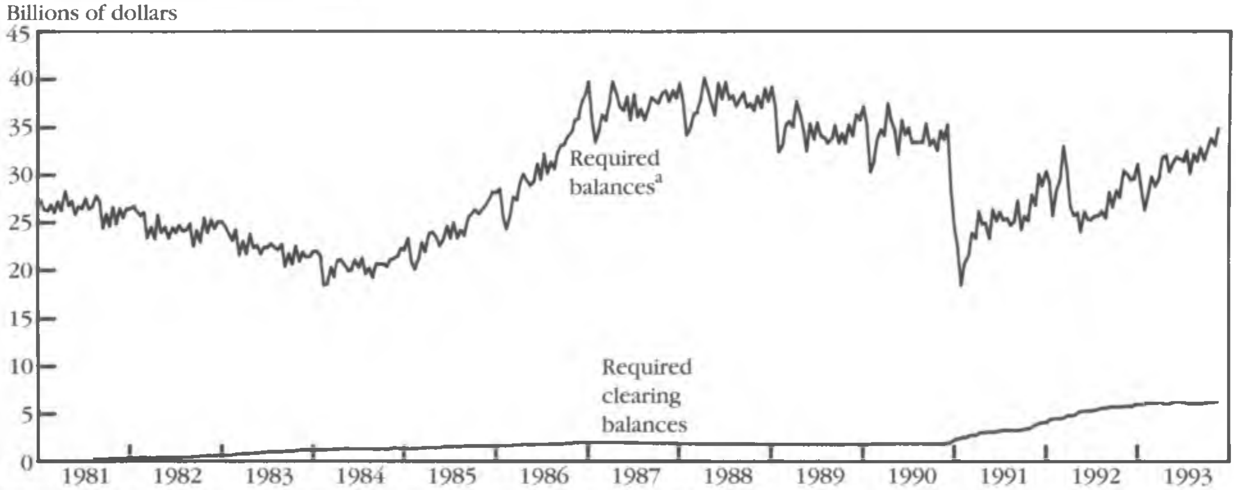
Almost all analyses of bank reserve management behavior focus entirely on reserve requirements, ignoring clearing balances because they are a relatively recent innovation.[2] Clearly, however, an important set of banks now maintains balances at the Fed following a somewhat different set of rules than they would if they held only required reserve balances. Knowledge of these rules is of more than accounting interest. For one thing — contrary to most models of the banking

■ 1 For simplicity, I use the term banks to mean all depository institutions.

■ 2 A good survey might start with Poole (1968) and include Coats (1976), Spindt and Tarhan (1978), Friedman and Roberts (1983), Evanoff (1989), and Feinman (1993).

FIGURE 1

Required Balances at Federal Reserve Banks



a. Required balances equal required reserve balances plus required clearing balances.
SOURCE: Board of Governors of the Federal Reserve System.

system and of monetary policy implementation — standard indicators of Federal Reserve policy, including total and excess reserves and the monetary base, probably contain a growing (albeit very small) component that effectively has a positive rate of return.

For another thing, banks seem to be substituting required clearing balances for required reserve balances. In the aggregate, banks now hold about $33 billion of required balances at the Federal Reserve, including $27 billion of required reserve balances and $6 billion of required clearing balances. Required reserve balances have declined about $6 billion over the past three years, while required clearing balances have almost tripled (see figure 1).[3] Although banks surely welcome lower reserve requirement taxes, the Federal Reserve must deal with the payment system risk and monetary policy implementation repercussions of a banking system operating on a smaller cash deposit base. These repercussions may be muted, however, to the extent that banks replace required reserve balances with required clearing balances. The question, then, is why have required clearing balances grown so rapidly, and, more particularly, would further cuts in reserve requirements be offset by further growth of required clearing balances?

■ 3 The dollar volume of required clearing balances is reported as footnote 3 in *Factors Affecting Reserve Balances of Depository Institutions and Condition Statement of F.R. Banks* (Federal Reserve Release H.4.1), and as part of the larger "service-related balances and adjustments" item in the data table "Reserve and Depository Institutions and Reserve Bank Credit" (*Federal Reserve Bulletin,* table 1.11). Clearing balance data are also reported in the pro forma balance sheet for Federal Reserve priced services in the Board of Governors' *Annual Report.*

This article is intended primarily to describe the little-known rules governing required clearing balances and to introduce some related issues. The first two sections include background information about clearing balances and a look at how a bank might manage a combined required reserve and required clearing balance. More precise institutional details are spelled out in the appendix. The third section outlines three areas in which issues warrant further investigation. One is the way in which measures of bank reserves and the monetary base have come to include an interest-bearing component as a result of required clearing balances. The next points to ambiguity in explanations of the rapid growth of required clearing balances. A third sketches some related central banking concerns about monetary policy implementation and payment service delivery.

I. Some Background

The Depository Institutions Deregulation and Monetary Control Act of 1980 extended coverage of Federal Reserve System reserve requirements from member banks to all depository institutions. At the same time, all depositories gained access to the Federal Reserve discount window and to Reserve Bank payment services. Services had to be priced at levels intended to recover their full cost of provision, including an allowance for the interest costs and profit required by competing private suppliers, such as correspondent banks.

Fair pricing requires a careful cost-accounting distinction between Federal Reserve nonpriced, *central bank* activities such as reserve requirements and the discount window, and its *priced service* activities such as check clearing. Both activities may lead a bank to maintain a deposit balance in an account at a Federal Reserve Bank.

Banks whose vault cash is not sufficient to satisfy their reserve requirement can meet the remainder of the requirement in either of two ways. They can maintain funds in a deposit account at a correspondent bank on a pass-through basis, making it easier for them to use the services of correspondents without also having to maintain an account at a Federal Reserve Bank to handle their payment needs. Alternatively, banks can maintain the required funds on deposit at a Federal Reserve Bank.

The Federal Reserve's priced service activities are those for which it is not the sole supplier. These include collection of commercial checks, processing of commercial automated clearinghouse items, wire transfer of funds and government securities, safekeeping of definitive securities, collection of noncash items, and transportation of cash.[4]

A bank that uses these priced services needs an account to which its payments and receipts can be posted. Three possibilities exist. First, a bank can contract to have its activity posted to a correspondent bank's Fed account. As just noted, this might be especially appealing to those institutions already maintaining required reserve deposits at a correspondent on a pass-through basis. Second, a bank that maintains a required reserve deposit at a Federal Reserve Bank might have its activity posted to that account. Historically, this has been the typical choice of banks using the Reserve Banks' payment services. Third, if required reserve deposits are unnecessary or inadequate for transaction purposes, a bank might maintain additional balances in its Fed account under the required clearing balance arrangement.[5] Since 1981, banks have been able to pay for priced services with earnings credits on required clearing balances.

Whatever its choice, a bank will want to ensure that unexpected charges to its account do not result in either penalties for daylight or overnight overdrafts or reserve deficiencies, and that unexpected receipts do not lead to "wasted" excess reserves. Moreover, the Federal Reserve Bank will need some assurance, as a prudent banker, that charges to a bank's account are made against a sufficient balance. Required clearing balances address these needs.

The mechanism for maintaining required clearing balances and receiving earnings credits was introduced in 1981 and modified in 1982 to include a penalty-free band.[6] (See the appendix for a more detailed description.) This arrangement is comparable to the compensating balance method that some respondent banks and commercial firms use to pay for commercial bank services. A required clearing balance is an average amount that a bank contracts to hold in a deposit account during a reserve maintenance period. This balance is over and above any required reserve balance it must hold in that period. A bank's required reserve balance is determined by deducting its holdings of vault cash from its total required reserve, which in turn is a percentage of the bank's deposits specified by regulation. A bank's required clearing balance is self-determined, presumably so that it may avoid overdrafts and receive earnings credits commensurate with its monthly bill from the Federal Reserve Bank.

Periodically, a bank's actual maintained balance is compared with its required balance. Each business day, payments flow into and out of a bank's Federal Reserve account. For each institution, the Reserve Bank records end-of-day account balances and then averages these maintained balances for a reserve maintenance period of one or two weeks, depending on the size of the bank. If the bank has no required clearing balance, its average maintained balance (after certain "carryover" adjustments discussed below) should equal or exceed the required re-

■ 4 The Reserve Banks also provide fiscal agent services for the U.S. Treasury. A bank may use its Fed account to make and receive payments associated with these services, whose costs are covered by fees paid by either the banks or the Treasury.

■ 5 Federal Reserve Banks have always been able to provide an account for customers who do not need to keep a required reserve balance but who wish to make and receive payments there. Historically, this normal banking practice apparently involved only an incidental aggregate amount of overnight balances in clearing accounts.

■ 6 Each of the 12 District Banks provides official circulars and other marketing materials informing customer banks about the terms on which priced services are available, including the required clearing balance option. Operating to some extent as 12 distinct businesses, Banks have followed procedures for maintaining clearing balances that have differed somewhat in detail in the past. The most notable difference was in allocating maintained balances between reserve and clearing requirements. Some Banks allocated balances first to the required and then to clearing requirements, while others did the reverse. This practice affected the penalty structure on the initial amount of a deficiency, with some Banks assessing required clearing balance penalties and others assessing required reserve penalties. However, banking consolidation across Federal Reserve District lines, as well as consolidation of some operations among the 12 Banks, has led to the uniform current set of procedures described here (see Conference of First Vice Presidents [1993]).

serve balance (required reserves minus applied vault cash). If the bank also has a required clearing balance, the average maintained balance, after carryover, should equal or exceed the total required balance plus or minus a penalty-free band.[7]

Maintained balances satisfy the reserve requirement first, and the remainder is used to satisfy the clearing balance requirement. A bank is penalized if its balance falls short of the required amount by more than a penalty-free band, at the rate of 2 percent on amounts up to 20 percent of the required clearing balance, then 4 percent on amounts up to the whole required clearing balance, and at the discount rate plus 2 percent on any remaining deficiencies in required reserves. The bank receives earnings credits, based on the daily effective federal funds rate, on balances in excess of its required reserve up to the amount of its required clearing balance plus the penalty-free band (adjusted according to the bank's marginal reserve ratio; see appendix).[8] Beyond that point, a bank penalizes itself for balances in excess of the required amount plus the penalty-free band, because the excess funds receive no earnings credits.

The penalty-free band is the greater of 2 percent of a bank's required clearing balance or $25,000. Thus, a bank with a minimum required clearing balance of $25,000 could satisfy the requirement and receive earnings credits on the amount by which its balance exceeds its required reserve by anywhere from zero to $50,000, without penalty. A bank with a $200 million required clearing balance would receive earnings credits on any balance above its required reserve up to $204 million, and would satisfy its clearing balance requirement without penalty when this balance reached $196 million.

Required clearing balances affect the Fed's cost of providing priced services in two largely offsetting ways. Total cost includes the earnings credits that Reserve Banks grant on clearing balances ($177.8 million in 1992), reduced by an offset for unused credits. Total cost also is lowered by an offset for the income that Reserve Banks earn on assets financed with required clearing balances. This offset is imputed at the coupon-equivalent yield on three-month Treasury bills ($180.2 million in 1992).[9]

II. Managing a Bank's Fed Balance

In general, managing a bank's balance at its Federal Reserve Bank is rather like managing one's fuel supply on an extended automobile trip. Frequent stops to fill up take time and may preclude unforeseen opportunities to buy gas at a lower price. However, buying gas at a low price only when the tank is nearly empty risks running out of gas. So, too, a bank that buys and sells funds frequently in order to keep its balance close to the required amount at all times may waste opportunities to buy or sell at bargain rates, while buying or selling only when the funds rate is a bargain raises the risk of overdrafts and failure to satisfy requirements, or of wasted balances.

Banks work toward a target balance over seven or 14 calendar days (normally, five or 10 banking days), depending on the size of the institution. Thus, a bank's cumulative required balance is seven or 14 times its average required balance. During the period, the account manager has a daily opportunity to target the day's closing balance to add to the cumulative maintained balance.

The cost of financing an extra dollar of balances is essentially the rate at which a bank might borrow or lend in the federal funds market. This rate can vary noticeably over the course of a single banking day, over differing risk categories of borrower, and over days of a maintenance period. A bank does better, the more likely its manager is to "hit" the market when the rate is attractive, in effect filling up the fuel tank at places where gas is cheapest. Clearly, the attractiveness of the rate depends on the manager's judgment about how expensive funds are relative to what they might be over the remainder of the period (and, with carryover, over the following period).

Ultimately, at the end of a maintenance period, the value of an extra dollar of balances is determined by the structure of penalties and earnings credits within which the Reserve Banks administer requirements, including their permissiveness in waiving penalties. For a bank operating with only a required reserve balance, ignoring carryover, a deficiency would be penalized at a rate 2 percent above the discount rate, and frequent deficiencies would bring consultations aimed at changing management's be-

7 Hereafter, "required balance" will be used to indicate the sum of a required reserve balance and a required clearing balance.

8 Earnings credits are not added to the balance in the account, but accumulate for use in offsetting charges for priced services (on a first-in, first-out basis) within 52 weeks.

9 The amounts of these two items for calendar years are reported as components of "Other income and expenses" in the pro forma balance sheet for Federal Reserve priced services, published in the Board of Governors' *Annual Report*.

havior. An excess would be wasted, costing something to finance but earning no interest.

With this general background, the rationale for a bank's decision to hold a required clearing balance can be investigated in three different time dimensions—a day, one or two maintenance periods, and the long run of many maintenance periods.

A Day

Uncertainty can be a dominant factor in a single banking day. For a full-service bank, particularly a very large one, the level of its final end-of-day balance results from its last-minute interbank loan market maneuvering. A bank is likely to be involved in daily payments and receipts whose aggregate value is thousands of times larger than the required reserve balance. Thus, even slight deviations of payments or receipts from projected levels might flood or drain the bank's Fed account during a day relative to the typical desired end-of-day balance. The manager of this account nonetheless must be able to come close to a targeted daily balance by arranging overnight borrowing or lending in the waning hours of the banking day in amounts that can be far larger than the target balance itself, and at attractive rates.

The protection that required clearing balances provide against daylight and overnight overdrafts has become increasingly important over the past decade. Reductions in reserve requirements and increased use of vault cash to satisfy requirements have left banks with smaller required reserve balances, but with no necessary change in the volume, time pattern, or predictability of charges and receipts for transactions. All else equal, this would be expected to increase the size and incidence of overdrafts, both daylight and overnight.

The Federal Reserve Banks have measured and monitored daylight overdrafts with increasing precision over the last 10 years, with amounts in excess of a minimum slated to become subject to a fee in April 1994. Overnight overdrafts already are subject to penalty (the greater of 2 percentage points above the discount rate or 10 percent). A bank without a required clearing balance might employ a variety of strategies to reduce the probability of overdrafts, including targeting a higher level of noninterest-bearing excess reserves. Contracting to hold a required clearing balance would accomplish the same thing at almost no net cost, as long as the bank could use its earnings credits.

A Maintenance Period

A bank needs a strategy for maintaining a set of overnight Fed balances whose average will most profitably satisfy its balance requirements for the period, taking into account both the previous period's reserve surplus or deficiency and the possibility of carrying a reserve deficiency or surplus into the next period.

No single reserve management strategy appears to dominate banking practice. Some banks target the average daily balance necessary to meet the required balance (perhaps including a margin of safety), recalculated daily for the remaining days of the maintenance period. Others try to accumulate balances toward requirements only when the funds rate seems low relative to the expected rate for the period. Still others deliberately keep a lean position early in a period, lest a negative surprise in required reserves or a positive surprise in receipts provide more excess reserves than they could work off over the remainder of the period without overnight overdrafts. Also, some banks try to alternate surplus and deficient periods, while others aim for a stable positive average balance, using the carryover feature only to deal with big surprises.

Carryover. Without a required clearing balance, a large bank's average balance for a maintenance period could be above or below the required level by as much as 8 percent of its required reserves (not just its required reserve *balance*). Large banks are permitted to carry over to the next period a surplus or deficiency of up to 4 percent of required reserves, but they cannot carry any resulting surplus or deficiency into the following period. Eight percent would result from using the maximum allowable carryover of a surplus/deficiency from the previous period and carryout of the maximum deficiency/surplus to the next period.

Adding a required clearing balance widens the range within which a bank can allow its maintained balance to fluctuate from one period to the next while still satisfying requirements. With the addition of a required clearing balance, the bank could be above or below the (higher) required level by as much as 8 percent of required reserves plus 8 percent of the required clearing balance. This is because the clearing balance requirement itself provides a penalty-free band of plus or minus 2 percent of the required clearing balance, and maximum allowable carryover is 4 percent of required reserves, plus 4 percent of the required clearing balance, minus the penalty-free band of 2 percent of the required clearing balance.

A smaller bank (required reserves less than $1.25 million) without a clearing balance requirement could be above or below the required level of balances by as much as $100,000, because banks may carry over the *larger* of 4 percent of required reserves or $50,000. However, adding a $25,000 minimum clearing balance requirement would not change the range within which that same small bank could allow its balance to vary. Allowable carryover would actually decrease to $25,000 ($50,000 net of the minimum $25,000 penalty-free band), offset by the ability to utilize that penalty-free band.

The Long Run

Opting to maintain a required clearing balance has obvious advantages for a bank. It can earn a market rate of return on relatively small balances that might not fetch such an attractive rate if sold as odd lots. Targeting a larger balance means, on average, *holding* a larger balance, thereby creating a greater buffer against daylight and overnight overdrafts. Moreover, the bank gains flexibility in managing its balance, with the penalty-free band providing a convenient, costless margin of error around the targeted balance that would be absent if it were targeting a zero balance or only a required reserve balance.

With these benefits in mind, it might seem surprising that all banks do not obligate themselves for as large a clearing balance as their need for earnings credits would support. Presumably, this is because a bank's capital is a scarce resource, if for no other reason than that banking regulations specify minimum levels of capital per dollar of total assets. Banks may restrict the volume of their required clearing balances to the level at which, at the margin, it is more profitable to allocate scarce capital coverage to other assets that promise a better return than the expected spread between the earnings credit rate on required clearing balances and their cost of financing.

Adopting a required clearing balance thus has the following effects on a bank's management of its Fed balance:

- It holds a larger balance, with the addition likely to be financed at little or no net out-of-pocket cost, but requiring a modest allocation of capital.
- Its incidence of daylight and overnight overdrafts would likely be lower.
- Allowable carryover, whether positive or negative, may be greater, providing a larger base either for interperiod rate arbitrage or for a bigger pool of funds from which to absorb unforeseen shocks to the closing balance on the last day, as well as for the period.
- The penalty-free band absorbs small deviations of actual from target balances without either penalty or wasted earnings.

III. Three Issues Related to Required Clearing Balances

Measuring Bank Reserves and the Monetary Base

Traditional measures of Federal Reserve monetary policy activity, including total and excess reserves and the monetary base, are being affected by the growing influence of required clearing balances. The required clearing balance facility can create an interest-bearing component of measured bank reserves quite distinct from the traditional non-interest-bearing reserve assets.

The potential influence of clearing balances can be seen by considering how the reserve and monetary base aggregates are constructed from six measured values, each of which is an average for a two-week reserve maintenance period. In addition to required clearing balances, the other five measured values include

1) Fed balances: The aggregation of overnight balances of all depository institutions.

2) Applied vault cash: The amount of prior-period vault cash holdings being used to satisfy current-period reserve requirements.

3) Other vault cash: The difference between banks' current and applied vault cash.[10]

4) Currency in M1: The portion of currency in circulation held by the nonbank public.

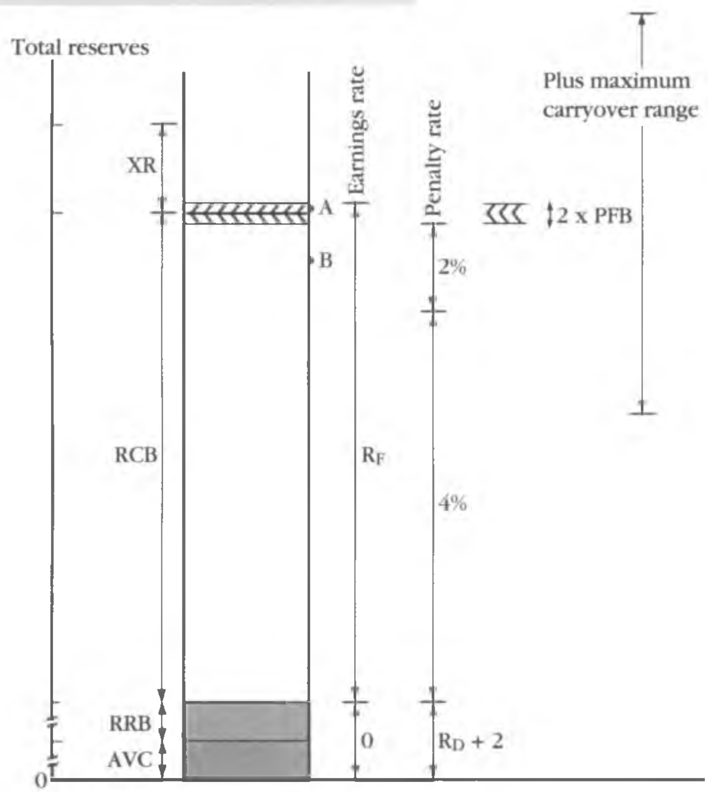
5) Required reserves: The total amount of reserves that banks are required to hold, as specified in Federal Reserve Regulation D.

Data are derived from banks' reports of deposits to the Federal Reserve and are assembled with and without "adjustments to eliminate the effects of discontinuities," or "breaks," associated with changes in reserve requirements. The *adjusted* series estimates the amount of transaction deposit reserve requirements that would have prevailed in the past, had current reserve requirements been in effect; the *unadjusted* se-

10 This is not the same as surplus vault cash (see Garfinkel and Thornton [1991]).

FIGURE 2

Reserve and Clearing Balance Requirements: The Rules



NOTE: XR = excess reserves; RCB = required clearing balance; RRB = required reserve balance; AVC = applied vault cash; PFB = penalty-free band; R_F = federal funds rate; and $R_D + 2$ = discount rate.
SOURCE: Author.

ries reports the then-current actual requirements.

Required clearing balances are *excluded* from all measures of reserves, by definition, and from the adjusted monetary base, but are *included* in the unadjusted monetary base. This treatment is consistent with the differing purposes of the two measures of the monetary base.

The adjusted series emphasizes the role of base money as actual or potential reserve assets. These are the high-powered "tickets" that banks must hold when issuing reservable deposits, with the amount issued per ticket constrained by a reserve requirement. The adjusted monetary base includes the reserve assets held both by banks (adjusted total reserves plus vault cash not being used to meet reserve requirements) and by the nonbank public (currency in M1). A historically consistent measure of adjusted total reserves has been derived by adding the actual historical quantity of excess reserves to adjusted required reserves. Similarly, because banks' balances held to meet a clearing balance requirement cannot be used to satisfy reserve requirements, the adjusted monetary base excludes required clearing balances.

The unadjusted monetary base emphasizes the federal government's role in providing monetary assets directly to users in the private sector, rather than distinguishing between the quantities of private and public issues of money. The monetary base consists of all federally issued currency held by banks and the public (applied vault cash plus other vault cash plus currency in M1), plus all deposit liabilities of Federal Reserve Banks to private banks (Fed balances, including required clearing balances). The associated measure of total reserves adds applied vault cash to Fed balances and then subtracts required clearing balances (because they are not reserves). Excess reserves is the difference between this measure of total reserves and required reserves.

Measuring total or excess reserves thus involves distributing aggregate account balances between reserve balances and clearing balances. The current method does so by measuring reserve balances as all current balances other than *required* clearing balances.[11] Any excess of maintained balances above the required clearing balance level, even within the penalty-free band (for example, point A in figure 2), thus augments aggregate total and excess reserves. Similarly, any deficiency of maintained balances from the required clearing balance level, both within and below the penalty-free band (for example, point B in figure 2), reduces aggregate total and excess reserves, even though the bank may have satisfied its reserve requirement.

A potential implication of this measurement convention can be illustrated by imagining an extreme case. Suppose that *all* banks were to move simultaneously from the upper to the lower edge of their respective penalty-free bands between adjacent maintenance periods. Within a 2 percent penalty-free band above and below the current $6 billion of required clearing balances, actual total and excess reserves would vary by about a quarter of a billion dollars, with banks largely indifferent to the change. That is, their earnings loss from holding a lower balance at the Fed would be approximately equal to their earnings gain from financing a lower balance. With many banks, some holding more and some holding less than their required clearing balances, positive and negative deviations from required clearing balances within penalty-free bands would likely

11 *Adjusted* total reserves equals adjusted required reserves plus actual excess reserves, which in turn equals applied vault cash plus Fed balances net of required reserves and required clearing balances. *Unadjusted* total reserves equals applied vault cash plus Fed balances net of required clearing balances.

tend to be offsetting. More generally, however, the greater the participation in required clearing balance arrangements, the more probable that modest variations either in the supply of bank balances at the Fed, in total and excess reserves, or in the adjusted monetary base would be a matter of little moment to banks, since their net earnings would be unaffected.[12]

The essential issue here is whether total and excess reserves, as now measured, match any useful economic concept. The measures have no necessary counterpart at the level of an individual bank managing its reserve position, because carryover and penalty-free bands are unrecognized. Banks that perpetually maintain current balances in excess of current requirements truly have current-period "excess" reserves. Other banks, however, will be in different stages of using carryover, either satisfying some of their current reserve requirements with surplus balances from adjacent periods, or using current surplus balances to satisfy some of their reserve requirements in adjacent periods.

Carryover itself does not destroy the utility of the current measures: A positive shock to the supply of reserves in one period, for example, tends to imply a comparable negative shock to demand for total and excess reserves in the next period, and the System can rely on that carryover relationship in managing next-period supply. The difficulty comes from the addition of a penalty-free band, which makes it impossible to know whether a shock to reserve supply will affect next-period demand through carryover, or simply be accommodated as earning assets this period through the penalty-free band.

Sources of Growth in Required Clearing Balances

Managing a bank's required reserve balance at successively lower levels of reserve requirements has been likened to landing an airplane on a shrinking aircraft carrier. As the target balance gets closer to zero, there is less room for error. Averaging within a maintenance period provides less opportunity to absorb surprises, as does the possibility of carrying forward excesses and deficiencies. Overall, the banking system becomes less effective in smoothing interest rates.[13]

With these impediments in mind, the rapid growth of required clearing balances in recent years might be linked to the cuts in reserve requirements of December 1990 and April 1992.[14] Banks increased their required clearing balances by more than a third in the month following the December 1990 cut and doubled their requirements within a year (see figure 1). However, it would not be easy to distinguish the impact of lower reserve requirements from that of either rising bills for priced services or declining interest rates.

The utility of earnings credits lies in paying bills for priced services, so the size of these bills places an upper limit on the volume of clearing balances that banks could find useful. In the aggregate, the percentage of total sales of priced services paid with earnings credits, while growing, was still less than 20 percent in 1992. There is some indication that banks, including some with the largest required clearing balances, do tend to adjust their requirements in concert with the magnitude of their bills. What would be difficult to discover, however, is the extent to which annual growth of billings has "caused" the growth of required clearing balances. More important for the future would be to determine what portion of the remaining 80 percent of the priced services revenue billed to banks would be capitalized as additional required clearing balances if reserve requirements were cut further.[15]

Many banks could be expected to adjust balances to keep pace with bills because their required clearing balances are likely to be financed at a slightly positive rate spread, making priced services cheaper when paid from earnings credits. Earnings credits are calculated on the basis of the daily effective federal funds rate, which is the quantity-weighted average rate paid by all borrowers of unsecured overnight balances each day. Large banks operating actively in the interbank funds markets

■ 12 Paying interest on total or excess reserves would not preclude effective monetary policy. See Dotsey's (1991) investigation of monetary policy operating procedures in New Zealand, where there are no reserve requirements and where banks settle using a below-market interest-bearing asset whose supply is controlled by the central bank.

■ 13 Feinman (1993) provides an excellent analysis of these relationships.

■ 14 The 1990 action reduced the 3 percent reserve requirement against nontransaction deposits to zero, lowering required reserves by an estimated $13.7 billion. The 1992 action reduced from 12 percent to 10 percent the highest marginal reserve requirement on net transaction deposits, cutting required reserves by an estimated $8.9 billion.

■ 15 Hilton, Cohen, and Koonmen (1993) have investigated this question, as well as a variety of techniques that might expand the use of required clearing balances.

thus might expect to acquire marginal financing at rates averaging less than the effective rate, because foreign buyers and some others typically pay risk premiums that large domestic banks, for example, do not pay. This would insert a profit wedge between the effective rate used in calculating earnings credits and the cost of financing required clearing balances. With this in mind, some of the past growth in required clearing balances probably reflects the increase in total sales of priced services and the attraction of paying with earnings credits. In fact, if this relationship were one for one, about 14 percent of the growth of required clearing balances since 1990 might reflect growth of total sales of priced services.

Putting aside billing magnitudes, the level of the federal funds rate can also exert an independent, powerful influence on the size of a required clearing balance needed to produce a dollar's worth of earnings credits. For example, to hold earnings credits constant at their 1990 value, the substantially lower federal funds rate would have called for a 61 percent increase in required clearing balances by 1992.

Even if, for purposes of argument, demand for required clearing balances had been directly proportional to billings and inversely proportional to the level of the federal funds rate, banks added about $1 billion more to their holdings of required clearing balances after 1990 than the hypothetical amounts these two forces would have produced. This suggests that banks have been induced to replace required reserve balances with required clearing balances. The relative influences of the three forces are not clear, however, because their movements have been correlated. Clarifying their relative importance will be crucial in dealing with some of the policy issues with which required clearing balances may become associated.

Monetary Policy Issues

Reserve requirements are a tax whose cost has become a serious issue in the United States in recent decades, as the competitive niche of traditional banking has faded in financial markets. Lower requirements can increase Federal Reserve payment system risk exposures through daylight and overnight overdrafts, can contribute to volatile overnight interest rates that could hamper monetary policy implementation, and can degrade the value of central bank payment services (Stevens [1989, 1991b, 1993]). Further cuts in reserve requirements might bring significant institutional changes in banking and payment arrangements, with increased privatization of payment services to avoid daylight overdrafts, or with new Federal Reserve arrangements to ensure that deposit balances at the Fed remain an effective vehicle for monetary policy implementation (Meulendyke, ed. [1993], Stevens [1991a, 1992]).

Additional cuts in required reserves could reduce the System's effectiveness in interperiod smoothing of short-term interest rates. Reserve carryover plays a role in this smoothing process, allowing the banking system to absorb unintended variations in the System's supply of balances. The penalty-free band can serve the same purpose, but has different implications for policy implementation. Banks tend to "make up" reserve deficiencies and surpluses in the next period, providing the System with a vital clue to interperiod variations in demand for the balances it supplies.[16] This is lacking in the operation of the penalty-free band. Thus, the System could face multiperiod runs of demand for balances below or above a required level.

An additional policy implementation problem may arise from the earnings credit feature of required clearing balances. Restrictive policies will carry within themselves the seeds of their own disorganization. That is, as the federal funds rate rises, the quantity of clearing balances needed to pay for a given quantity of Reserve Bank priced services will decline, increasing the possibility of the interest-rate variability associated with low balances. A high interest-rate policy might also discourage use of some Federal Reserve payment services, by reducing the nominal quantity of Fed balances available for immediate transfer within overdraft limits.

Relying on required clearing balances as the vehicle for implementing monetary policy thus raises a more general question. Is a bank's required clearing balance a by-product of its choice of the Fed as the best among alternative suppliers of services, or is the choice of the Fed's priced services a by-product of the bank's need for a larger balance? In either case, the Monetary Control Act's neat distinction between central bank activities and priced service activities is not as clear-cut as it once appeared.

16 Feinman (1993) finds that for a sample of large banks from 1987 to 1991, excess reserves and carry*in* had opposite signs about 90 percent of the time.

IV. Conclusion

The emergence of required clearing balances is changing the institutional setting in which individual banks manage their Fed balances. Banks are able to hold balances substantially larger than dictated by reserve requirements, providing greater flexibility in avoiding overdrafts and meeting reserve requirements—and at minimal cost.

Familiar aggregate data series are being affected by bank holdings of required clearing balances. In effect, a definable, probably small, but as yet unmeasured portion of the total and excess reserves of the banking system is now earning assets, rather than being held as non-interest-bearing vault cash or reserve deposits. More important, marginal variations in banks' Fed balances increasingly take place within the earnings and cost structure of required clearing balances, not required reserve balances.

Growth of required clearing balances relative to required reserve balances raises questions that need further investigation. Can required clearing balances be expected to replace required reserve balances if reserve requirements are cut further? How would monetary policy implementation be influenced when a change in the money market stance of policy affects not only the marginal cost but also the marginal revenue of many banks' Fed balances? To what extent does the demand for clearing balances reflect a desire to pay bills with earnings credits, and to what extent does it reflect a demand for larger balances? If demand is mainly for convenient bill paying, could Federal Reserve priced services generate a pool of balances large enough to maintain a smoothly operating money market when interest rates are high? On the other hand, if demand is mainly for a level of balances high enough to accommodate transaction needs, could banks use all of the Federal Reserve priced services their balances could buy when interest rates are high?

Congress created the Federal Reserve System as a single response to the joint desire for a more uniform national payment system and for a regulator of the nation's money supply. The mandate of the Monetary Control Act of 1980 was that these two functions should exist independently, in the sense that the Federal Reserve Banks could no longer provide free payment services to offset banks' costs of maintaining required reserves. Subsequent cuts in reserve requirements have allowed the banking system to reduce its holdings of non-interest-bearing required reserve balances at the Federal Reserve Banks to historically low levels relative to bank deposits and the monetary base. All else equal, continuing along this trend would require some combination of changes in monetary policy implementation and in the payment system to accommodate the absence of cash inventories in the banking system. Alternatively, required clearing balances could provide a new basis for banks to hold deposits at the Federal Reserve Banks, but whether this is feasible remains to be demonstrated.

Appendix

Required Balances: The Rules[17]

Current reserve and clearing balance requirements include two types of rules: those for computing and maintaining required balances and those for calculating earnings credits and penalties.

Many banks are "unbound"—that is, either they have a zero reserve requirement or they meet the requirement entirely with vault cash. These banks nonetheless may maintain a required clearing balance. Other banks are "bound" by a positive reserve requirement that exceeds their vault cash. They must maintain a required reserve balance, but do not hold a required clearing balance. A large number of banks, however, are both bound to hold a required reserve balance and elect (or have been asked) to hold a required clearing balance.

The rules laid out here, and summarized in figure 2, are for a bank that must meet a combined reserve and clearing balance, maintained on the biweekly basis that is typical of a relatively large institution. The other two cases may be derived by dropping all references to a required reserve balance or to a required clearing balance, as the case may be. Note that in maintaining a balance, a bank that holds only a required clearing balance cannot use the carryover feature, and a bank that holds only a required reserve balance cannot use the penalty-free-band feature.

■ 17 From Standard Operating Procedure 10.0, Conference of First Vice Presidents (1993). See also Board of Governors of the Federal Reserve System, *Monetary Policy and Reserve Requirements Handbook*, Washington, D.C.: Federal Regulatory Service.

Computing and Maintaining a Required Balance

A bank's required balance, *RB*, is not a unique dollar amount, but a range around the combined required balance.

$$RB = (RRB + RCB) \pm PFB.$$

The combined required balance includes a required reserve balance, *RRB*, that is the bank's total reserve requirement, *RR*, net of its applied vault cash, *AVC*.

$$RRB = RR - AVC.$$

The total reserve requirement is computed by applying appropriate marginal reserve requirement ratios to the amount of a bank's transaction deposit liabilities in each of three "tranches." In 1993, requirements are zero on the first $3.8 million of deposits, 3 percent on additional deposits up to $46.8 million, and 10 percent on deposits in excess of $46.8 million.

Requirements typical of large banks are computed on the basis of daily average transaction deposit liabilities outstanding during successive two-week reserve computation periods ending every other Monday. Applied vault cash is the bank's daily average holdings during the 14-day period that ends three days before the beginning of the maintenance period.

The required clearing balance, *RCB*, is normally a dollar amount agreed to by the bank and its Federal Reserve Bank, with a $25,000 minimum. As stated by the Federal Reserve Bank of Cleveland (1992),

> The prescribed level of an institution's clearing balance will be determined in consultation with the institution on the basis of the deposit size of the institution, the volume and type of services that are or will be used, and the need to avoid account overdrafts.... This Bank may make adjustments in the prescribed level of an institution's clearing balance from time to time as may be appropriate. Such adjustments will normally be made no more than once a month and will be effective on the first Thursday of the month that coincides with the first day of a maintenance period.

The penalty-free band, *PFB*, for required clearing balances establishes a range of balances that will satisfy the combined required balance, because actual holdings are allocated first toward the required reserve balance, with the remainder allocated toward the required clearing balance. The band is 2 percent of the required clearing balance, or $25,000 if the required clearing balance is less than $1.25 million.

A bank's maintained balance, *MB*, is the average daily closing balance in its Fed account, averaged over a two-week maintenance period (for a typical large bank) that begins on a Thursday and ends on a Wednesday, two days after the end of the required reserve computation period.

Carryover provisions allow a bank to carry forward to the next maintenance period an excess or deficiency in its maintained balance to the extent that it is offset by a deficiency or excess in the next period. The amount of carryover can be no more than $(0.04\,[RR + RCB] - PFB)$ and cannot be carried forward more than one period. Note that the limit on eligible carryover is based on a bank's reserve requirement, *RR*, not on its reserve *balance* requirement.

Earnings Credits, Penalties, and Wasted Balances

Earnings credits provide a return on required clearing balances that can be used only to pay for Federal Reserve Bank priced payment services.[18] Required reserve and surplus balances earn nothing. The return is based on the average federal funds rate during the maintenance period in which the required clearing balance was held. The funds rate is applied on an annualized basis to the actual average daily clearing balance (within the upper limit of the penalty-free band), adjusted by the bank's marginal reserve requirement ratio. A bank subject to the 10 percent marginal reserve requirement will earn the funds rate on its entire allowable clearing balance, a bank subject to a 3 percent marginal requirement will earn the funds rate on only 93 percent of that balance, and a bank subject to a zero marginal reserve requirement will earn the funds rate on only 90 percent of the balance.

The marginal reserve requirement adjustment incorporates two factors that allow Federal Reserve Banks and correspondent banks to provide similar services to customer banks on the "level playing field" envisioned in the Mone-

18 More specifically, earnings credits *cannot* be used to pay penalties for clearing balance deficiencies or to cover charges related to nonpriced service functions of the Federal Reserve Banks, such as penalties for deficient required reserve balances, interest on discount window loans, and cost recoveries for providing accounting information services.

tary Control Act. To illustrate, first suppose that correspondent banks have a 10 percent marginal reserve ratio and that the incidence of the cost of a correspondent's reserve requirement is on its respondent customer banks. This suggests that the Reserve Banks might give earnings credits on only 90 percent of a required clearing balance to avoid placing themselves at an advantage relative to correspondent banks in providing priced services.

Second, recognize that a bank paying for correspondent bank services with earnings credits on balances held with the correspondent is able to deduct the amount of those balances from its own deposit liabilities subject to reserve requirements. (Deducting amounts "due from other banks" avoids double-reserving of interbank deposits.) If the same bank were to buy services of equal value from a Federal Reserve Bank and pay for them with earnings credits on a required clearing balance, it would lose the deduction. This is irrelevant for a bank with a zero marginal reserve requirement, but not for those reserving 3 percent or 10 percent at the margin. Therefore, the Fed should give earnings credits on 93 percent or 100 percent of required clearing balances, depending on the customer's marginal reserve ratio, to avoid placing itself at a disadvantage relative to correspondents in providing priced services.

Penalties are imposed on a bank whose maintained balance is deficient, to the extent that the deficiency is not offset by carryover from the previous period or to the next period. Maintained balances are allocated first toward the required reserve balance, with the remainder allocated toward the required clearing balance. A bank pays a penalty at an annual rate that rises with the size of the deficiency: no penalty on the first 2 percent (or $25,000) of the required clearing balance (the penalty-free band), 2 percent of the next 18 percent of the required clearing balance (or of the next 20 percent minus $25,000), and 4 percent of the remainder of the required clearing balance. Deficiencies that extend into the required reserve balance are penalized at a rate 2 percentage points above the discount rate.

Balances can be said to be wasted to the extent that they exceed the required range and are not carried forward to the next period. Such balances do not contribute to satisfying a reserve or clearing balance requirement and do not receive earnings credits.

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The Consumer Price Index as a Measure of Inflation

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The authors wish to thank Mark Watson for helpful discussions and for providing his software. This paper benefited from the suggestions of Martin Feldstein, Dennis Fixler, Spencer Krane, Pok-sang Lam, Nelson Mark, Angelo Melino, Alan Viard, and Mark Wynne. In addition, the authors thank Edward Bryden, Christopher Pike, and Matthew Mercurio for research assistance.

Introduction

As the economy approaches the Federal Reserve's stated objective of price stability, it has become necessary to examine carefully the price indices on which policy is based. The most popularly used aggregate price statistic in the United States is the Consumer Price Index (CPI). This fact alone probably accounts for the prominence it has achieved as a measure of inflation and as a focal point in the Federal Reserve's inflation fight. As an expenditure-weighted index of cost-of-living changes, though, the CPI was never intended to be used as an indicator of inflation.

Broadly speaking, there are two problems associated with using the CPI to measure inflation. The first concerns the transitory noise created by nonmonetary events, such as sector-specific shocks and sampling errors. The second involves a potential bias in the index that results both from the expenditure-based weighting scheme the CPI employs (weighting bias) and from persistent errors in measuring certain prices (measurement bias). In an earlier paper, Bryan and Cecchetti (1993), we study the first of these issues.[1] Here, we examine the second.

The existence of bias, or deviations between the trend in the price indices and inflation, implies that *any* fixed-weight price index will be an imperfect long-run target for a policy aimed at aggregate price stability. The magnitude of the bias in the CPI is an empirical matter. Previous researchers have addressed the issue of bias in price statistics by performing calculations based on highly disaggregated information.[2] This approach provides at best only a broad approximation. Moreover, the bias in price statistics depends on the severity and origin of supply shocks, on changes in technology and tastes, and on other time-varying phenomena, so the time-invariant estimates derived from these studies are of only limited value to policymakers.

Our strategy is different. Using a simple statistical framework, we compute a price index that is immune to the weighting bias inherent

■ 1 That paper shows how the use of limited-influence estimators, such as the median of the cross-sectional distribution of individual consumer goods prices, removes transitory elements that create difficulties with interpreting month-to-month movements in the aggregate CPI. We find that the median CPI performs well as a high-frequency measure of the persistent component of inflation.

■ 2 See Wynne and Sigalla (1993) for a thorough review of the literature.

in the CPI as a measure of inflation. The recent work of Stock and Watson (1991) provides a method for combining information in many time series to generate an index of coincident economic conditions. This paper attempts to do for prices what Stock and Watson have done for output. We use a dynamic factor model analogous to theirs to compute the common inflation element in a broad cross-section of consumer price changes.

Unlike expenditure or output-weighted price indices, the dynamic factor index is an unbiased estimate of the component common to each of the individual price changes in the cross-section of data we examine. By comparing the trend in the dynamic factor index with the trend in the CPI, we are able to gauge the extent of the weighting bias in the CPI as a measure of inflation. Our results suggest that over the 25-year period from 1967 to 1992, the weighting bias in the CPI averaged roughly 0.6 percentage point per year. But, since we can construct a time series for the dynamic factor index, we are able to estimate the bias over two economically distinct periods. We find that there was a large positive weighting bias during the 15 years beginning in 1967, but that the weighting bias has been insignificant since 1981.

The following section discusses the sources of bias in fixed-weight price indices. We continue with a brief description of the dynamic factor model employed to construct an unbiased measure of consumer price inflation together with its standard error, and then present a summary of our results.

I. Bias and Expenditure-Weighted Price Indices

In order to understand the bias in fixed-weight price indices as measures of inflation, we begin by defining measured inflation, π_t, as a constant expenditure-weighted index of price changes from period t–1 to t, or

$$(1) \quad \pi_t = \sum_j w_{jo}\, \dot{p}_{jt},$$

where w_{jo} is a set of base-period expenditure weights and $\dot{p}_{jt}$ is the percentage change in the price of good j from period t–1 to t.[3] The expenditure weights are defined to sum to one.

The next step is to note that changes in the individual goods prices, the $\dot{p}_{jt}$'s, share a common inflation component and an idiosyncratic relative price movement, represented as

$$(2) \quad \dot{p}_{jt} = \dot{m}_t + \dot{x}_{jt},$$

where $\dot{m}_t$ is inflation and $\dot{x}_{jt}$ is a relative, or real, price disturbance.

Substituting equation (2) into (1), and noting that $\sum w_{jo} = 1$, we can write measured inflation as

$$(3) \quad \pi_t = \dot{m}_t + \sum_j w_{jo}\dot{x}_{jt},$$

which states that the growth rate of a standard fixed-weight price statistic sums inflation and a weighted average of relative price disturbances. For purposes of policy formulation, we need to obtain a measure of the common element $\dot{m}_t$ or, alternatively, a measure of π_t constructed so that the expectation of the sum on the right side of equation (3) is zero.[4]

Unfortunately, the expectation of π_t does not equal $\dot{m}_t$: $E(\sum w_{jo}\dot{x}_{jt}) \neq 0$. There are two reasons for this "bias." First, the individual prices may, on average, be measured incorrectly. We broadly refer to this as a "measurement bias." In addition, actual expenditure shares, w_{jt}, and $\dot{x}_{jt}$ are correlated, producing a "weighting bias." In either case, the expectation of the observed $\dot{x}_{jt}$'s will be nonzero. Our approach is designed to minimize errors caused by weighting bias. And although the dynamic factor approach we have chosen will have little directly to say about measurement biases—inasmuch as they are unrelated to the choice of weighting schemes employed—we can make inferences about certain types of these biases by examining subsets of the data.

■ 3 Strictly speaking, the weights used by the Bureau of Labor Statistics (BLS) in the construction of the CPI vary slightly with relative price changes from year to year. This is necessary in order to hold constant the implicit real quantity of any item used in the calculation of the index. This fixed-weight price index also differs slightly from the CPI because we are summing the weighted logs of the individual prices rather than the weighted levels.

■ 4 If the $\dot{x}_{jt}$'s are mean zero and the weights are constant, then $E(\pi_t) = \dot{m}_t$. However, realizations of π_t are unlikely to equal $\dot{m}_t$, and we can also think of π_t as a *noisy* measure of inflation. There are several reasons why realizations of $\sum w_{jo}\dot{x}_{jt}$ will not equal zero period by period. First, there is simple sampling error in the individual price data. But in its absence, $\sum w_{jo}\dot{x}_{jt}$ may not equal zero period by period because of the way the economy adjusts to real shocks. In our earlier paper, we use a simple model derived from Ball and Mankiw (1992) to describe how supply shocks may cause price indices such as π_t in equation (1) to contain transitory movements away from $\dot{m}_t$.

It should be clear at this point that the bias in a price statistic as a measure of inflation, which is a statistical concept, is distinct from the bias as a measure of the cost of living, although the two may share similar origins, as we explain shortly. In a strict sense, the choice of the term "bias" may be somewhat unfortunate here, as it does not reflect an error in the calculation of the CPI per se, but rather an error caused by applying the CPI to a problem it was never intended to address. Bias in the CPI as a measure of *inflation* is simply the deviation in the trend of π_t from $\dot{m}_t$, whereas bias in the CPI as a measure of *the cost of living* is defined as the deviation in the CPI trend from a constant utility price index.

Consider the case of substitution bias, in which the price of a single good rises. Label this as good k, so that $\dot{x}_{kt} > 0$. In the absence of monetary accommodation, the household budget constraint requires the sum of the relative price disturbances weighted by actual expenditure shares to be zero, or

$$(4) \quad \sum_j w_{jt}\dot{x}_{jt} = 0.$$

For each relative price increase $\dot{x}_{kt}$, the relative price of the remaining goods must fall proportionately such that $w_{kt}\dot{x}_{kt} + \sum_{j \neq k} w_{jt}\dot{x}_{jt} = 0$. Yet, consumer theory implies that expenditure shares will change depending on the price elasticity of demand for the product: Goods having an elasticity greater than one will experience declines in their relative expenditure, and vice versa. The implication here is that if an actual expenditure weight tends to fall for a product whose relative price rises, it reduces the *exactly* offsetting relative price influence of the remaining set of commodities when applied to their original expenditure weights and creates a positive bias in the inflation statistic: $w_{k0}\dot{x}_{kt} + \sum_{j \neq k} w_{j0}\dot{x}_{jt} > 0$.

Substitution bias is simply a specific form of a general weighting bias. To see this more clearly, consider a simple two-period example. We can represent actual expenditure weights in period 1 as a function of the base period weight and the relative price disturbance in period 1,

$$(5) \quad w_{j1} = w_{j0} + \beta_j \dot{x}_{j1},$$

where β_j measures the covariation of actual expenditure weights and relative price disturbances. Substituting equation (5) into (4) yields

$$(6) \quad \sum_j w_{j0}\dot{x}_{j1} + \sum_j \beta_j \dot{x}_{j1}^2 = 0$$

or

$$(6') \quad \sum_j w_{j0}\dot{x}_{j1} = -\sum_j \beta_j \dot{x}_{j1}^2.$$

This is the weighting bias—only if $\beta_j = 0$ will the sum of the base-period weights and the relative price disturbances be zero. Otherwise, a weighting bias will arise that has the opposite sign of the covariation of the expenditure weights and the relative price disturbance. Nevertheless, there exists a set of weights, w_{jt}, such that

$$(7) \quad E\left(\sum_j w_{jt}\dot{x}_{jt}\right) = 0.$$

The w_{jt}'s can be thought of as the inflation weights—those that yield a price index without a weighting bias.

II. Origins of Bias in the CPI

In general, we think of all of the biases in the CPI as a measure of inflation as arising from some combination of weighting and measurement bias. As we have already described, weighting bias is the consequence of covariation between relative price changes and a set of properly constructed weights. The classic example of such a weighting bias is substitution bias, where the β_j's are negative and the weighting bias is positive.

Studies of the size of the commodity substitution bias conducted in recent years have concluded that the amount of substitution bias in the CPI is relatively small. For example, Manser and McDonald (1988) estimate that the commodity substitution bias averaged between 0.14 and 0.22 percentage point per year over the period 1959 to 1985. This is largely a confirmation of Braithwait's (1980) earlier estimate of 0.1 percentage point per year over the 1958 to 1973 period. Moreover, Manser and McDonald find the level of the bias to be one-third greater for the high-inflation period (1972 to 1985) than for the more moderate inflation period of 1959 to 1972.

It is entirely conceivable that there are cases in which the correlation between expenditure weights and measured relative price changes is positive, imparting a downward weighting bias in fixed-weight inflation measures. One such case would be a demand-induced relative price increase resulting from a change in tastes, where the relative price of a commodity rises *because* the relative expenditure on it has risen.

Consider also the case in which new goods are introduced. The market basket purchased by households will expand to include items not given any weight in the current index or, alternatively, actual expenditure weights on the included goods will fall. As a consequence, price changes for the goods included in the price index are given too much weight relative to a correctly measured price index. If the relative price change for the new good is negative, the new good produces a positive bias in the price index that is analogous to substitution bias. But it is possible to imagine a case in which the relative price change of the new good is positive, resulting in a negative bias in the price statistic. This would hold true if new goods cause a substitution away from, as well as a decrease in the relative price of, the goods included in the index.

Similarly, changes in *relative* product quality produce a weighting bias by introducing a correlation between actual expenditure weights and relative prices. Quality changes imply that the same effective quantity is available for a generally lower price and, depending on the elasticity of demand for the product, the share of expenditure on such a good could either rise or fall as its effective price drops.[5]

In many instances, weighting bias is not the sole source of the error from using the CPI as a measure of inflation. A number of potential biases arise when the prices of individual commodities are mismeasured. To see how this affects the indices we are studying, consider the case in which measured price changes have three components: the common element, $\dot{m}_t$, the correctly measured relative price change, $\dot{x}_{jt}$, and a common, nonzero measurement error, $\dot{e}_t$. We can write this as

$$(8) \quad \dot{p}_{jt} = \dot{m}_t + \dot{x}_{jt} + \dot{e}_t .$$

It is readily apparent that the measured price index will be

$$(9) \quad \pi_t = \dot{m}_t + \dot{e}_t + \sum_j w_{j0}\dot{x}_{jt} .$$

That is, measurement error will be embedded in the inflation statistic independent of the weighting scheme. New goods (and other excluded goods more generally) introduce the potential for measurement bias to the extent that the set of prices is no longer complete. Moreover, insofar as *average* quality changes are reflected in the price data, they also create a measurement bias by producing a common trend in the price data that is unrelated to inflation.[6]

So-called "outlet substitution bias," arising from the tendency of consumers to escape some part of price increases by shifting purchases toward lower-priced (discount) stores, is another recently identified source of measurement bias. We can think of this bias as some combination of new-goods bias and quality bias, as the goods sold by the discount retailers might be considered separate commodities from those sold by full-service, higher-priced stores.[7]

5 As an empirical matter, measuring new goods bias is much more difficult than measuring commodity substitution bias, since new goods prices are unobservable prior to their introduction. As noted in Diewert (1987), Hicks (1940) suggests that the price of the new good prior to its introduction should be the shadow price at which demand is equal to zero. While this is an excellent theoretical criterion, implementation is simply not possible. As a result, little work has been done on estimating the importance of new goods bias. There are, however, several rough estimates of the size of this problem. Diewert (1987) suggests that the bias caused by new goods could be as high as 0.5 to 1.0 percentage point annually, while Lebow, Roberts, and Stockton (1992) gauge the amount as *no more than* 0.5 percentage point per year.

6 The quality adjustment problem has been the subject of the bulk of academic work on price measurement bias. Beginning with Griliches' (1961) study of automobile prices, this literature has concentrated on estimating the quality bias in the prices of specific durable goods, presumably because the quality of durable goods is more easily quantifiable and data are usually readily available. Estimates of quality bias in the aggregate price index are then extrapolated from the measurements derived for specific commodity groups. For example, Gordon (1992) estimates that quality changes account for slightly more than 1.5 percentage points of the average rise in the prices of consumer durable goods over the 1947 to 1983 period. By applying this estimate to goods that they presuppose to be subject to quality improvements, Lebow, Roberts, and Stockton (1992) estimate aggregate quality bias in the CPI to be 0.3 percentage point annually.

7 The recent growth in the discount retail business has led economists to increase their concern over outlet substitution bias. When consumers substitute between retail outlets on the basis of price, and this shift in the buying pattern is not captured in the point-of-purchase survey conducted by the BLS, the CPI overstates inflation. While the Labor Department adjusts its sample over time, no more than 20 percent of the change in outlet patterns is incorporated into a particular year's survey. Consequently, this measurement problem can affect the aggregate price statistic for a period of several years. A recent study by Reinsdorf (1993) examines the effect of outlet substitution during the 1980s on food and fuel commodities. Assuming that none of the price differences among outlets reflect quality differentials, he concludes that outlet bias accounts for between 0.25 and 2.0 percentage points annually for food, and between 0.25 and 1.0 percentage point annually for energy.

III. A Dynamic Factor Index Approach

Our objective is to compute a reduced-bias estimate of inflation from consumer price data. Recall from equation (3) that we can write a fixed expenditure-weight price index as the sum of common inflation, $\dot{m}_t$, and a term representing the weighted sum of relative price changes, $\sum w_{j0}\dot{x}_{jt}$. This makes clear that the measurement of inflation requires a set of weights that allow us to construct an estimate of the common element in all price changes. Price indices such as the CPI, the Producer Price Index (PPI), or the implicit price deflator for personal consumption expenditures (PCE) share a common core, but as a result of their weighting methodologies, each has a unique weighting bias as a measure of inflation.

As an alternative to the expenditure weighting schemes generally used, we propose weighting commodity prices based on the strength of the inflation signal, $\dot{m}_t$, relative to the noise, $\dot{x}_{jt}$, in each time series. To do this, we assume that the log of each individual product price is the sum of two components: a nonstationary, common core, and a nonstationary, idiosyncratic component measuring movements in relative prices. Taking first differences, the model can be written as

$$(10)\quad \dot{p}_t = \dot{m}_t + \dot{x}_t\,,$$

$$(11)\quad \psi(L)\,\dot{m}_t = \delta + \xi_t\,,$$

$$(12)\quad \theta(L)\dot{x}_t = \beta + \eta_t\,,$$

where $\dot{p}_t$ and $\dot{x}_t$ are vectors; Ψ and θ are, respectively, a vector and matrix of lag polynomials with stationary roots; ξ and η are i.i.d. random variables; and β and δ are vector and scalar constants.[8] We identify $\dot{m}_t$ by assuming that relative price disturbances are uncorrelated with common inflation at all leads and lags. This is what is meant by a common component. If $\dot{m}_t$ were correlated with any of the $\dot{x}_t$'s, then they would contain a part of the common core. In addition, it is necessary to restrict the β's to sum to zero. For computational convenience, we further assume that $\theta(L)$ is a diagonal matrix of lag polynomials, that η_t is serially uncorrelated, and that the covariance matrix of η_t is diagonal.[9]

Maximum likelihood estimation of $\dot{m}_t$ is accomplished by applying a Kalman filter to a set of either aggregate or individual price data. The result is an estimate of both the parameter vector, $\hat{\alpha} = \{\hat{\Psi},\hat{\theta},\hat{\Gamma}\}$, where Γ is the diagonal covariance matrix of η and the common factor, $\hat{\dot{m}}_t$. We can write $\hat{\dot{m}}_t$ as a weighted sum of current and past individual $\dot{p}_{jt}$'s. Expressly,

$$(13)\quad \hat{\dot{m}}_t = \sum_j \hat{w}_j(L)\,\dot{p}_{jt}\,,$$

which is an unbiased estimate of $\hat{\dot{m}}_t$. Put slightly differently, the dynamic factor index is an estimate of the common trend in the individual inflation series such that $E\left(\sum_j \hat{w}_j(L)\,\dot{x}_{jt}\right) = 0.$

Our main interest is in measuring the average weighting bias in the CPI over various sample periods. This is the difference between the average inflation in the CPI and the average $\hat{\dot{m}}_t$, which we label $\bar{\dot{m}}_t$. We would also like to construct an estimate of the standard error of this bias.

Rewriting (13) in matrix form, we have

$$(14)\quad \hat{\dot{m}}_t = \hat{W}(L)\,\dot{p}_t\,.$$

It follows that

$$(15)\quad \bar{\dot{m}} = \hat{W}(1)\,\hat{\mu}_p\,,$$

where $\hat{\mu}_p$ is the vector of estimated means of inflation in the individual component price series and $\hat{W}(1)$ is a function of the elements of $\hat{\alpha}$.[10]

It is useful to rewrite the CPI in a way analogous to (15). From equation (1), we have

$$(16)\quad \bar{\pi} = W_o\,\hat{\mu}_p\,,$$

which is the estimate of average inflation in the CPI constructed as a constant weighted log-linear index. An estimate of the bias follows as

$$(17)\quad \widehat{Bias} = \bar{\pi} - \bar{\dot{m}} = W_o\hat{\mu}_p - \hat{W}(1)\,\hat{\mu}_p = [\,W_o - \hat{W}(1)\,]\,\hat{\mu}_p\,.$$

The construction of standard error estimates is slightly more complicated, but still straightforward. To do this, we require an estimate of all

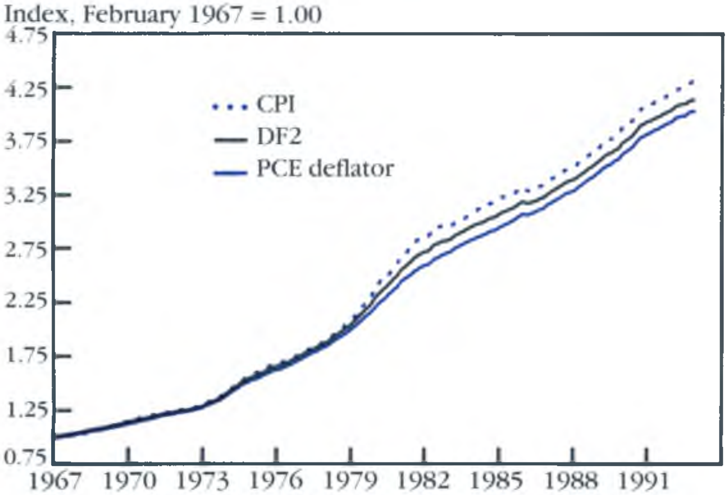
8 See Stock and Watson (1991) for details.

9 Throughout, we assume that both $\dot{m}_t$ and the $\dot{x}_{jt}$'s can be modeled as AR(2)'s.

10 The notation $W(1)$ represents the evaluation of the lag polynomials at $L = 1$, and so is the sum of the polynomial coefficients.

FIGURE 1

Comparison of the CPI, PCE Deflator, and DF2



SOURCES: U.S. Department of Labor, Bureau of Labor Statistics; U.S. Department of Commerce, Bureau of Economic Analysis; and authors' calculations.

TABLE 1

Comparisons of the CPI and the CPI/PCE Dynamic Factor Index (annualized percent changes)

	Feb. 1967– Dec. 1981	Jan. 1982– Dec. 1992	Full Sample
CPI all items	7.05	3.75	5.65
	(0.94)	(0.33)	(0.71)
PCE deflator	6.36	4.05	5.38
	(0.71)	(0.26)	(0.53)
DF2	6.65	3.75	5.48
	(0.81)	(0.33)	(0.59)
Weighting bias	0.39	0.00	0.17
	(0.23)	(0.00)	(0.15)

NOTE: Numbers in parentheses are standard errors. The covariance matrix of the means of the two components was computed using a Newey and West (1987) robust covariance estimator with 24 lags. Subperiod calculations were made independently from the full sample. All values are the average annual difference in the natural log of the index.
SOURCE: Authors.

of the parameters used to calculate $\overline{m}$ and $\overline{\pi}$. This includes the estimated covariance matrix of $\hat{\alpha}$ as well as an estimate of the covariance matrix of the vector of estimated means $\hat{\mu}_p$. The first of these is a by-product of the maximum likelihood estimation of $\hat{\alpha}$, while the second can be constructed from the raw inflation data.

Calculation of the covariance matrix of $\hat{\mu}_p$ is complicated by the fact that the $\dot{p}_{jt}$'s have substantial serial correlation. In fact, the model (10)–(12) implies that when $\Psi(L)$ and the $\theta(L)$'s are all second-order polynomials, the individual inflation series will follow an ARMA(4,2).[11] This leads us to use the Newey and West (1987) heteroskedasticity and autocorrelation consistent covariance estimator, with 24 lags.

We can now construct an estimate of the covariance matrix of the entire parameter vector $\hat{\gamma} = \{\hat{\alpha}, \hat{\mu}_p\}$, called $\hat{\Sigma}$. Assuming that $\hat{\alpha}$ and $\hat{\mu}_p$ are independent, then $\hat{\Sigma}$ is block diagonal. Because $\overline{m}$ and $\overline{\pi}$ are both functions of $\hat{\gamma}$, we can construct standard errors by computing the vector of first partial derivatives of each with respect to $\hat{\gamma}$. The variance estimates follow by pre- and post-multiplying $\hat{\Sigma}$ by this vector of derivatives.

It is worth noting that the uncertainty in $\widehat{Bias}$ comes from variation in $\hat{W}(1)$, which is a function of $\hat{\alpha}$, and variation in $\hat{\mu}_p$. But the uncertainty in the mean vector creates variation in the estimation of mean CPI inflation as well, and so the variance in the estimated bias is likely to be lower than the variance in either $\overline{m}$ or $\overline{\pi}$.[12]

IV. The Results

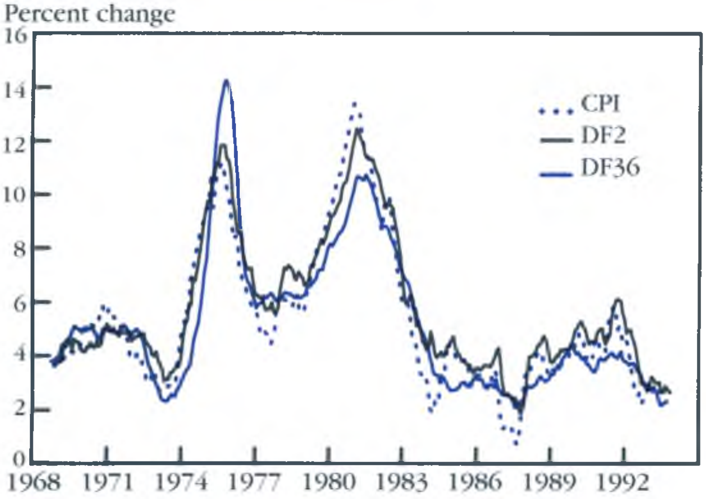
We constructed two alternative dynamic factor indices of inflation based on consumer price data from 1967 to 1992. The first, labeled DF2, is the common element derived from the CPI and the PCE deflator, two aggregate consumer

11 It is simple to show that the model implies that, ignoring constants, each individual inflation series can be written as $\theta_j(L)\,\Psi(L)\,\dot{p}_{jt} = \theta_j(L)\xi_t + \Psi(L)\,\eta_{jt}$, which is a restricted ARMA (4,2).

12 As implied by the discussion at the end of the previous section, the block diagonality of the covariance matrix allows us to measure the relative contribution of variation in the model parameters, the elements of $\hat{\alpha}$, and the mean vector, $\hat{\mu}_p$, to the estimated variance of the bias. In virtually all of the cases we examine, the uncertainty from estimation of the means accounts for more than 95 percent of the uncertainty in $\widehat{Bias}$.

FIGURE 2

12-Month Growth Rates of the CPI, DF2, and DF36



SOURCES: U.S. Department of Labor, Bureau of Labor Statistics; U.S. Department of Commerce, Bureau of Economic Analysis; and authors' calculations.

TABLE 2

Comparisons of the CPI and the 36-Component Dynamic Factor Index (annualized percent changes)

	Feb. 1967– Dec. 1981	Jan. 1982– Dec. 1992	Full Sample
CPI[a]	6.93	4.04	5.71
	(0.85)	(0.26)	(0.63)
DF36	6.05	4.11	5.11
	(0.68)	(0.25)	(0.52)
Weighting bias	0.88	–0.07	0.60
	(0.26)	(0.13)	(0.17)

a. The CPI used here was constructed as the weighted sum of the difference of the natural logs of the individual components (1985 weights).
NOTE: Numbers in parentheses are standard errors. The covariance matrix of the means of the 36 components was computed using a Newey and West (1987) robust covariance estimator with 24 lags. Subperiod calculations were made independently from the full sample. All values are the average annual difference in the natural log of the index.
SOURCE: Authors.

price statistics that are constructed from essentially the same price data, but that employ different weighting schemes (figure 1). Over the full sample, this dynamic factor index averaged 5.48 percent per year with a standard error of 0.59 percentage point. This yields a weighting bias over the period of 0.17 percentage point with a standard error of 0.15 percentage point (table 1). Subperiod estimates, which are computed separately using data for only the subsamples, reveal more bias in the 1967 to 1981 interval, about 0.4 percentage point annually. Over the latter period, there appears to have been no bias in the CPI.

The aggregate CPI and the PCE deflator may not provide a rich enough set of price data to measure the common element accurately. As an alternative, we calculated the dynamic factor index from disaggregated price data for 36 components of the CPI (DF36), spanning the complete set of the consumer market basket over the same January 1967 to December 1992 period.[13] The 12-month growth rates of the CPI, DF2, and DF36 are reproduced in figure 2.

The average rate of increase of this more comprehensive dynamic factor index over the sample period is 5.11 percent, compared with 5.71 percent for the CPI, implying an average annual bias in the CPI of 0.60 percentage point over the 1967 to 1992 period with a standard error of 0.17 percentage point (table 2). Using 36 rather than two indices increases the estimated weighting bias with virtually no change in precision. But again, we find substantial differences in the magnitude of the CPI weighting bias between the two subperiods. Between 1967 and 1981, we estimate the weighting bias at 0.88 percentage point annually (with a standard error of 0.26). But since 1981, we fix the bias in the CPI to be nearly zero (–0.07 percentage point with a standard error of 0.13 percentage point).

The dynamic factor indices have limitations, of course. First, the degree of disaggregation and the extent of the sample covered by the price data used are incomplete. More generally, our calculations do not account for the potentially important measurement biases that arise when goods are systematically excluded or when there is a common measurement error, such as unmeasured aggregate quality changes. While we cannot address such measurement biases directly, we can gauge their severity by

13 A catalog of the 36 components can be found in Bryan and Cecchetti (1993).

TABLE 3

Comparisons of the Dynamic Factor Indices of Goods and Services Prices (annualized percent changes)

	Feb. 1967–Dec. 1981	Jan. 1982–Dec. 1992	Full Sample
CPI[a]	6.93	4.04	5.71
	(0.85)	(0.26)	(0.63)
DF36	6.05	4.11	5.11
	(0.68)	(0.25)	(0.52)
DFGOODS	5.43	3.55	4.47
	(0.69)	(0.30)	(0.54)
DFSERVICES	7.06	4.90	6.02
	(0.70)	(0.27)	(0.53)
Estimated Bias			
CPI–DF36	0.88	−0.07	0.60
	(0.26)	(0.13)	(0.17)
CPI–DFGOODS	1.50	0.49	1.23
	(0.30)	(0.15)	(0.20)

a. The CPI used here was constructed as the weighted sum of the difference of the natural logs of the individual components (1985 weights).
NOTE: Numbers in parentheses are standard errors. The covariance matrix of the means of the 36 components was computed using a Newey and West (1987) robust covariance estimator with 24 lags. Subperiod calculations were made independently from the full sample. All values are the average annual difference in the natural log of the index.
SOURCE: Authors.

comparing dynamic factor indices computed from commodity subsets of the data.[14]

In our statistical model, equations (10) to (12), relative price changes are taken to be stationary. With the additional assumption that relative price changes are zero on average (that is, that the β's in equation [12] are all zero), we can estimate the common factor from any subset of the data. Some economists have suggested that the most serious problem may be in measuring service output. This means that services prices are unreliable, and we use that insight to examine the size of this potential measurement bias.[15]

To test the hypothesis that there is a systematic bias in the measurement of services prices, and to evaluate the recommendation that these prices be excluded from the calculation of inflation, we have split the CPI into goods and services components and have computed a dynamic factor index for each. The results are reported in table 3.

Assuming that the difference between inflation in goods prices and inflation in services prices is entirely a result of measurement bias in the latter category, we can gauge the weighting bias in the CPI from the difference between the dynamic factor index estimated using goods only (DFGOODS) and the aggregate CPI. Again, while we note rather substantial differences between the two prior to 1982, for the recent period, we estimate the weighting bias in the CPI at less than 0.5 percentage point per year.

These results also allow us to estimate the size of the measurement bias in services prices directly by comparing the dynamic factor indices for goods only (DFGOODS) and services only (DFSERVICES). Curiously, the deviation between the dynamic factor indices calculated from the component data, while relatively large for the 1967 to 1981 period (1.63 percentage points annually), is slightly smaller in the post-1981 period (1.35 percentage points annually). While there appears to have been a systematic bias in services prices before 1982, which may be attributable to their mismeasurement, that difference was reduced after 1981.[16]

V. Conclusion

Gauging the accuracy of price indices, which has a long tradition in economics, has taken on new enthusiasm in the recent era of relatively moderate inflation. At issue is whether a goal of zero inflation literally means zero or whether, because of various biases in the calculation of inflation, some low but nonzero rate of measured inflation is sufficient.

We have computed dynamic factor indices of consumer prices, which are constructed by essentially weighting commodities on the strength

14 Measurement bias might manifest itself as low-frequency components in the $\dot{x}_{it}$'s of certain series. The implication is that the single-factor model we employ may not be sufficiently general to capture the time-series behavior of some prices. If this were a serious problem, then we should find that some of the roots of the estimated AR(2) coefficients in $\hat{\theta}(L)$ imply nearly nonstationary behavior. Our estimates suggest that this may be a problem for medical commodities, motor fuel, and transportation services, but is unlikely to affect the commodities generally thought to suffer from significant measurement difficulties.

15 A recent example is in Poole (1992).

16 In the early 1980s, the methodology used to construct the shelter component of the CPI, which accounts for roughly half of all services in the index, was changed from a relatively volatile purchase-price basis to a rental equivalence basis. To account for this change, we reconstructed the shelter component to conform to a rental equivalence basis for the entire sample. This change, not surprisingly, had little impact on the dynamic factor index calculations. Nevertheless, the results reported here are on the adjusted basis.

of a common inflation signal, in an attempt to assess a potentially important source of bias in the CPI as a measure of inflation—weighting bias. Our estimate of weighting bias in the CPI is roughly 0.6 percent annually in the 1967 to 1992 period, but the size of that bias varies substantially within subperiods. In fact, on the basis of the estimates provided here, we conclude that since 1981, weighting bias in the CPI as a measure of inflation has been negligible.

If there is measurement bias common to the consumer prices in our data set, such as may occur from the systematic mismeasurement of quality changes, it would still be embedded in the estimates presented here. We found significant differences between the dynamic factor estimates derived from all items and the dynamic factor indices derived from goods prices only.

In this paper, we have considered only the case of consumer prices, given their importance in the monetary policy setting and also allowing for comparisons with other studies of bias. Conceivably, a measurement bias common to all consumer prices caused by, say, a reallocation of the economy's resources between investment and consumption goods may be embedded in the dynamic factor indices presented here.[17] This could presumably be corrected by allowing the dynamic factor index to include a broader range of prices, particularly asset prices. An area of future research, then, would involve the integration of investment goods into these dynamic factor calculations.

■ 17 The potential for a systematic measurement bias, caused by the exclusion of investment goods in the CPI, has been suggested by Alchian and Klein (1973).

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The Inaccuracy of Newspaper Reports of U.S. Foreign Exchange Intervention

by William P. Osterberg and Rebecca Wetmore Humes

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The authors thank Owen Humpage and Mark Sniderman for helpful comments.

Introduction

Central bank intervention in foreign exchange markets most recently came into prominence during the period of exchange-rate volatility in the autumn of 1992. Speculators doubted that European central banks would be able to defend the exchange rates agreed upon as part of the European Rate Mechanism. After massive intervention, central banks eventually capitulated, and several key exchange rates were allowed to fall radically against the German mark (DM). While this sequence of events would seem to have cast considerable doubt on the usefulness of sterilized intervention, disagreement continues both within policy circles and among researchers as to whether sterilized central bank intervention is a useful tool for exchange-rate management.[1]

Until recently, studies of intervention have been hampered by a lack of official data, as direct measures of central bank intervention have usually not been made available to the public. Now, however, the Board of Governors of the Federal Reserve System provides a time series of U.S. dollar intervention vis-à-vis the DM and the Japanese yen from 1985 to 1992. One consequence of the former lack of immediately available and accurate intervention information has been the use of daily newspaper reports as proxies for actual intervention magnitudes in related studies.

The possibility that intervention is not reported accurately may have important implications for understanding the signaling mechanism of intervention. For example, such inaccuracy may call into question the ability of intervention to signal future monetary policy with precision. In addition, it may reflect differences in the information available to foreign exchange traders, suggesting that some traders may be able to profit from inside information.

In this paper, we begin with a discussion of issues regarding information about intervention. We then describe the data on actual intervention and newspaper reports. In the third section, we outline the procedure that we use to test for systematic differences between reported and actual intervention series. In the final section, we briefly discuss the implications of our results.

■ 1 Researchers would point out that this most recent period was not a good test of intervention's efficacy because exchange-rate management was not the sole objective of the central banks. In addition, some of the intervention may not have been sterilized, making it difficult to isolate its impact. "Sterilization" occurs when the effect of intervention on the money supply is offset by open market operations. Nonsterilized intervention is thus, in some sense, equivalent to monetary policy.

I. Information about Intervention: Reported versus Actual Data

There is by now a substantial literature devoted to understanding the impact of central bank intervention on foreign exchange markets. Recent useful summaries of this literature have been provided by Dominguez and Frankel (1993), Edison (1993), Humpage (1991), and Obstfeld (1990).[2]

While most recent studies, such as Baillie and Humpage (1992), Baillie and Osterberg (1993), and Hung (1992), use official daily intervention data, others, such as Klein and Rosengren (1991) and Kaminsky and Lewis (1993), use daily newspaper reports of intervention.[3] If the focus of a given study is on the signaling role of intervention, then it makes sense to utilize newspaper reports that reflect the information available to the average trader.

One concern is that the choice of intervention data, reported or actual, may influence researchers' conclusions about the efficacy of intervention. However, we would like to raise two other possible concerns, namely, that if there is a systematic difference between actual and reported intervention, 1) the signals as represented by the newspaper reports may be misleading, and 2) some market participants may have more accurate information about intervention than do others. That the latter is possible can be seen simply by considering the mechanisms of intervention. U.S. intervention counterparties are either brokers or commercial banks. If brokers are utilized, they will not reveal that the transaction is official intervention. If commercial banks are utilized, the wire services should accurately reveal that the Federal Reserve has entered the market.[4] In either case, the only market participants with definitive knowledge are the counterparties chosen by the Federal Reserve Bank of New York.

If we are willing to assume that the newspaper reports indicate what is known about intervention by the uninformed trader, then a systematic difference between actual and reported intervention implies a systematic difference in knowledge among market participants. However, it is not clear how much time passes before all market participants learn of the intervention, or even if they ever obtain accurate information short of the official release one year later by U.S. authorities. In addition, it is unclear if the newspaper reports are written during the course of the day and are thus affected by changing and uncertain views about intervention activity, or whether they represent a presumably more accurate, end-of-day assessment.

We know of only three previous comparisons of actual and reported U.S. intervention data. Klein (1993) uses multinomial logit analysis to calculate the probability that intervention is reported, conditional on the size of the intervention. He estimates that, without conditioning on size, the probability that actual intervention is reported is 72 percent, and the probability that reported intervention actually occurred is 88 percent. He also shows that newspaper reports are more likely if the intervention is relatively large. Dominguez (1992) examines the impacts of reported and "secret" intervention on the volatility of the DM/U.S. dollar exchange rate. She assumes that actual intervention not reported in the newspapers is "secret." No significant difference is seen between the impacts of the two categories of intervention on volatility. Dominguez and Frankel (1993) tabulate actual and reported interventions by the United States and Germany from November 1982 through October 1989. The accuracy of newspaper reports varied across different time periods. For example, while all 22 U.S. interventions in the period September through November 1985 were reported, only 73 percent of interventions from March 1989 through October 1989 appeared in the print media.[5]

We make two contributions to the literature on central bank intervention. First, we construct a comprehensive data set from newspaper reports of central bank intervention for the period January 2, 1985 to October 11, 1991. This data set improves on those constructed by other researchers by quantifying qualitative reports (such as "small" intervention) rather than disregarding them. Second, we test for the existence of systematic components in the differences between

2 A consensus of the literature is that if sterilized intervention matters at all, it does so because it signals a change in information about monetary policy.

3 Still others have 1) constructed monthly numbers intended to capture the shift in international portfolios due to intervention (for example, Ghosh [1992]), 2) attempted to define intervention in terms of the monetary authorities' balance sheets (see Danker et al. [1987]), or 3) used measures of central banks' foreign reserves (for example, Glick and Hutchison [1992] and Watanabe [1992]).

4 However, the market sometimes seems to make guesses that confuse intervention operations with correspondent transactions.

5 Dominguez (1992) and Dominguez and Frankel (1993) utilize reports of intervention from *The London Financial Times*, *The New York Times*, and *The Wall Street Journal*. Klein (1993) uses the first two sources.

actual and reported intervention, calculating these differences using either dummy variables or numerical magnitudes. We also either include "rumors" in the reported series or discard them. With few exceptions, we find that there are systematic components; that is, the differences are serially correlated.

II. Data

Actual

The Board of Governors of the Federal Reserve System provided us with time series of U.S. net daily dollar transactions from January 1985 to October 1991. All data are in dollars, representing the actual net dollar purchases (sales) rather than dollar equivalents that have been translated into dollars via application of the exchange rate.[6] These data are now publicly available, with a one-year lag, from the Board of Governors. We report the results of our analyses with three categories of intervention: U.S. intervention vis-à-vis unspecified currencies carried out in terms of U.S. dollars, U.S. intervention vis-à-vis the DM, and U.S. intervention vis-à-vis the yen.

Using these data, we created dummy variables, each of which equals +1 for positive net dollar purchases, –1 for negative net dollar purchases (positive sales), and 0 if the country did not intervene (its net dollar transaction was 0).

Newspaper Reports

After having searched *The Wall Street Journal, The New York Times*, and *The Financial Times,* we ultimately decided to record the daily press reports of intervention from the foreign exchange column of *The Wall Street Journal.*[7] We recorded all mentions of intervention that were indicated as pertaining to the previous day or previous business day. Thus, if there was first mention of intervention a week after its occurrence, we do not record it, on the presumption that it would not have been known by the market at the time.

As in the case with the actual data, for each category of intervention, a buy/sell variable was created to indicate whether a country was a net buyer or seller of dollars. It equals +1 if the country bought dollars, –1 if it sold dollars, and 0 if it did not intervene. To correspond to the way in which the actual intervention data were constructed, we documented U.S. intervention in the DM/dollar and yen/dollar markets. A buy/sell variable was constructed for each market, indicating whether the United States bought (+1) or sold (–1) dollars. Thus, reported U.S. intervention in each of these two markets is recorded in two places. For example, if the United States was reported to be buying yen, we would record this under the United States selling dollars vis-à-vis the yen, and also in the (overall) U.S. selling category described previously (and denoted as U.S. vs. $U.S. in the tables). For all groups, we recorded the size of the intervention if given. This includes qualitative terms such as small, moderate, and large, as well as dollar magnitudes when given.

After all data were recorded, we calculated the minimum, median, and maximum of the reported dollar magnitudes for each U.S. intervention variable when such magnitudes were reported in the newspaper. We substituted for qualitative terms. For terms indicating "small," "light," or "token," we used the minimum for the particular category of intervention. For "modest" or "moderate," we substituted the median. For "large" or "heavy," we substituted the maximum. If no indication of size was given, we used the median. For example, if the United States was reported to be intervening heavily against the yen, we would substitute the maximum of all numeric reports of the United States buying or selling dollars against the yen. We then created a net transaction variable for each category by multiplying the buy/sell dummy variable by that amount. This variable is comparable to the actual net intervention variable. The minimums, maximums, and medians for all of the reported intervention variables are provided in table 1.

We also recorded specific mention of rumors.[8] For a given country A, two types of rumors are recorded: 1) whether country A intervened on its own behalf, and 2) whether country A intervened on behalf of country B (or whether country B intervened on behalf of country A). In the white noise tests that we describe below, we either disregard the rumors (treat them as being nonreports) or count them (treat them the same as other reports). The details of our treatment of rumors and "on behalf of" transactions are described in the appendix.

6 Such a procedure would embed simultaneity into any subsequent analysis of the relation between intervention and exchange rates.

7 This source is the most consistent of the three. While the use of only one source may seem to make our series less comprehensive than it would otherwise be, the amount of information that we obtain from this news report is greater. In addition, we avoid having to determine how to code reports when disparities arise among different sources.

8 Thus, an erroneous report is not the same as an erroneous rumor.

TABLE 1

Minimum, Median, and Maximum for the Size of Reported Intervention (millions of U.S. dollars)

	Minimum	Median	Maximum
U.S. vs. $U.S.	35.00	150.00	600.00
U.S. vs. DM	60.00	118.33	250.00
U.S. vs. Yen	50.00	143.75	200.00

SOURCE: Authors' calculations based on newspaper reports from January 2, 1985 to December 31, 1991.

BOX 1

Calculations of the White Noise Test Statistics

The two test statistics utilized in this article are those calculated by the SAS/ETS routine SPECTRA. They are the Kappa (K) statistic suggested by Fisher (1929) and the Kolmogorov-Smirnov (K–S) statistics suggested by Bartlett (1966). Fuller (1976) presents their formulas as follows:

$$K=[\frac{1}{m}\sum_{k=1}^{m} I_n(\omega_k)]^{-1} I_n(L).$$

$K-S$ = maximum absolute difference of C_k, the cumulative distribution function of a uniform random variable, where

$$C_k=[\sum_{j=1}^{m} I_n(\omega_j)]^{-1}\sum_{j=1}^{k} I_n(\omega_j).$$

$I_n(L)$ is the largest periodogram of a sample of m periodogram ordinates with two degrees of freedom. Here, ω indicates frequency, with $m=(n-1)/2$ and n being the number of observations.

In both K and $K-S$, the periodogram is being used to search for periodicities of unspecified form.[a] Fuller (1976), p. 282, states that "for many nonnormal processes we may treat the periodogram ordinates as multiples of chi-squared random variables." He further discusses how this assumption helps to motivate the formulas given above. However, as we note in the text, the peculiar nature of the data here requires us to qualify our application of these test statistics to our data and to consider alternate sample periods and alternate calculations of the series. Fuller (1976), p. 284, gives the distribution of K, and Birnbaum (1952) gives the distribution of $K-S$.

a. The concept of a periodogram is detailed in Fuller (1976), p. 275.

III. White Noise Tests

The white noise tests focus on the U.S. intervention categories. For each reported intervention variable, we vary the series along two dimensions: First, we either count all rumors (about whether there was intervention or rumored "on behalf of" intervention) or discount all rumors.[9] Second, we use either numerical values or dummy variables. The use of dummy variables may help to ameliorate some problems discussed below regarding the appropriate use of our statistical technique.

Although we could see if errors in reports of intervention were of economic significance by comparing the impacts of actual and reported intervention on exchange rates, that procedure would require us to specify a model of the interaction between intervention and exchange rates. Given the multiplicity of frameworks used to study intervention, we elected to utilize a technique that is not model-specific: testing for whether the differences between reported and actual intervention are white noise. A time series is white noise if it has a mean value equal to zero and if observations are serially uncorrelated.

The two statistics we report below are those of the Kolmogorov–Smirnov and Kappa tests, provided by the SAS/ETS (1990) version 6 routine SPECTRA. A detailed discussion of these tests is found in Fuller (1976), pp. 282–85. The exact calculations are described in box 1. In our application of the tests, a finding that a series is not white noise implies that the series contains serial correlation rather than that it lacks a nonzero average.[10] However, there are some limitations as to how one can interpret these test results.

First, the interpretation of the error equaling zero is ambiguous because it does so whenever 1) there was no intervention and no intervention was reported, and 2) there was intervention that was reported accurately. That this ambiguity is not a desirable characteristic of our procedure can be seen by comparing three scenarios. In one

9 As an example, consider a report that "the Federal Reserve purchased 100 million yen, rumored to be on behalf of the Bank of Japan." In a series that counts rumors, this would be entered as a purchase of yen (sale of dollars) by the Japanese, while in the "no rumors" series, it would count as a U.S. purchase of yen.

10 Utilizing the ADJMEAN option in the SPECTRA routine sets the average of the series to equal zero.

TABLE 2A

Descriptive Statistics for Actual, Reported, and Rumored Intervention: Full Sample Period

	Number of Occurrences			Average Size	
	Total	Buying	Selling	Buying	Selling
Actual intervention					
U.S. vs. $U.S.	294	98	196	160.34	177.74
U.S. vs. DM	203	61	142	111.83	141.21
U.S. vs. Yen	185	66	119	134.73	124.25
Reported intervention					
U.S. vs. $U.S.	184	52	132	148.08	148.56
U.S. vs. DM	38	6	32	140.28	108.64
U.S. vs. Yen	37	12	25	131.25	137.25
Rumored intervention					
U.S. vs. $U.S.	38	16	22	142.81	140.68
U.S. vs. DM	4	1	3	118.33	98.89
U.S. vs. Yen	3	1	2	143.75	143.75

Errors in Reported Intervention	Total	Actual but Not Reported	Reported but Not Actual
Reported intervention			
U.S. vs. $U.S.	160	135	25
U.S. vs. DM	171	168	3
U.S. vs. Yen	158	153	5
Rumored intervention			
U.S. vs. $U.S.	24		
U.S. vs. DM	4		
U.S. vs. Yen	2		

Categories of intervention:
U.S. vs. $U.S.: U.S. intervention vis-à-vis unspecified currencies, carried out in terms of U.S. dollars.
U.S. vs. DM: U.S. purchases or sales of DM in terms of U.S. dollars.
U.S. vs. Yen: U.S. purchases or sales of yen in terms of U.S. dollars.
NOTE: "Buying" and "Selling" columns are in terms of purchases and sales of millions of U.S. dollars.
SOURCE: Authors' calculations.

case, imagine a typical day in the midst of a long period in which there was no intervention and no reason to expect intervention. In the second case, imagine that the newspapers correctly report the cessation of intervention at the end of a period of turbulent markets and frequent intervention. In the third case, assume that a nonzero amount of intervention is correctly reported. In all three cases, the error is zero, although different information is provided in each case.[11]

We hope to ameliorate the impact of this factor on our result by varying the data in two ways. First, we split the sample in half to control in part for changes in the frequency and patterns of intervention. Second, we calculate the errors using both dummy variables and numeric variables. Using dummy variables will reduce the number of errors if the newspapers seldom correctly report the amount of intervention.

Another limitation to our procedure is that our data may violate the maintained hypothesis that they are generated by a continuous random variable. Intervention either takes the value of zero (the vast majority of days) or jumps to a number of the magnitude of 100 (100 million U.S. dollars). Here again, we hope that by using dummy variables, which exhibit smaller jumps, we reduce the impact of such discontinuities.

IV. Intervention Data and Errors

Tables 2A–2C describe the actual intervention data, the reports of intervention, and rumored interventions.[12] The first line, "U.S. vs. $U.S.," denotes U.S. purchases or sales of unspecified currencies. This includes the number of days that the United States intervened in all currencies, including the DM and yen, as indicated on the next two lines.[13] We use this measure in our assessment of the overall accuracy of reports about U.S. intervention, since newspaper reports often do not specify the foreign currency in which the United States is intervening.[14]

In table 2A, we see that there were 294 actual U.S. interventions for the full sample period, 184 reports of intervention, and 38 rumors of intervention. Thus, at most, 76 percent of interventions were mentioned in the newspaper ([184 + 38] /294 = 0.76). At the bottom of the table, we

■ 11 This problem would be ameliorated if we were able to model the joint process governing the intervention/exchange-rate interaction. This process presumably will yield an expected intervention variable and in turn will specify the significance of errors in reported intervention on the exchange rate.

■ 12 We compiled many more categories of reports than are analyzed in the tables. Our comparisons were restricted to those series for which we had actual intervention data.

■ 13 Note that the United States sometimes intervened with more than one currency within one day.

■ 14 The official data are in dollars, so in our comparison of reported and actual intervention, we have restricted ourselves to reports of dollar intervention. Fortunately, when reports specify amounts, they indicate the dollar magnitudes, eliminating the need to convert via application of the exchange rate.

TABLE 2B

Descriptive Statistics for Actual, Reported, and Rumored Intervention: January 2, 1985–May 20, 1988

	Number of Occurrences			Average Size	
	Total	Buying	Selling	Buying	Selling
Actual intervention					
U.S. vs. $U.S.	100	61	39	176.68	119.99
U.S. vs. DM	60	33	27	116.83	115.41
U.S. vs. Yen	78	53	25	130.60	62.53
Reported intervention					
U.S. vs. $U.S.	55	33	22	153.18	138.18
U.S. vs. DM	4	2	2	118.33	109.17
U.S. vs. Yen	8	8	0	132.03	0
Rumored intervention					
U.S. vs. $U.S.	20	12	8	140.42	124.38
U.S. vs. DM	2	0	2	0	89.17
U.S. vs. Yen	0	0	0	0	0

Errors in Reported Intervention	Total	Actual but Not Reported	Reported but Not Actual
Reported intervention			
U.S. vs. $U.S.	65	55	10
U.S. vs. DM	56	56	0
U.S. vs. Yen	72	71	1
Rumored intervention			
U.S. vs. $U.S.	13		
U.S. vs. DM	2		
U.S vs Yen	0		

Categories of intervention:
U.S. vs. $U.S.: U.S. intervention vis-à-vis unspecified currencies, carried out in terms of U.S. dollars.
U.S. vs. DM: U.S. purchases or sales of DM in terms of U.S. dollars.
U.S. vs. Yen: U.S. purchases or sales of yen in terms of U.S. dollars.
NOTE: "Buying" and "Selling" columns are in terms of purchases and sales of millions of U.S. dollars.
SOURCE: Authors' calculations.

report errors, either from comparing actual and reported or from comparing actual and rumored intervention. On the one hand, there were 135 days on which intervention occurred but was not reported, implying that it was reported only 54 percent of the time. On the other hand, only 25 of the 184 reports were erroneous (86 percent accuracy). In the case of rumors, however, most were in error: For 24 of 38 rumors, there was no actual intervention.

Tables 2B and 2C present similar information for the two sample halves.[15] Almost twice as much actual intervention in the U.S. vs. $U.S. category occurred in the second half of the sample as in the first. In the U.S. vs. DM category, intervention was much heavier in the second half of the sample, as the United States shifted to buying DM (selling dollars). Reports of intervention appear to capture these patterns. However, in the U.S. vs. DM and U.S. vs. yen categories, occurrences of reports fall far short of the number of actual interventions. This finding stands in sharp contrast to the findings in the previous paragraph regarding the U.S. vs. $U.S. category.

Table 3 presents the results of the white noise tests, separated by whether the reported series omits or includes rumors and by whether we use numeric or dummy variables.[16] All of the white noise tests were performed on both the full sample and on each half of the sample. Splitting the sample is an attempt to see if the results are sensitive to choosing sample periods that vary regarding either the intensity of intervention or its pattern. In this case, intervention activity was heavier during the second subsample.

Generally, with both tests, the full sample and split samples reject the hypothesis that the time series of errors are white noise. Thus, there are systematic components to the differences between actual and reported intervention. For dummy variables, we reject the hypothesis of white noise in all cases.

V. Summary

Newspaper reports of central bank intervention are often used as if they are interchangeable with actual intervention data. Except in rare cases, actual data have become available only recently for the United States, with a one-year lag. Here we describe detailed time series culled from *The Wall Street Journal* and compare them to actual intervention data. We quantify qualitative reports of intervention for all of the series. To the best of

■ **15** We have also compiled analogous tables for the subperiods January 2–December 31, 1985; January 1, 1986–February 20, 1987; February 21, 1987–February 19, 1990; and February 20, 1990–October 11, 1991. These tables are available from the authors and facilitate comparison with previous research on the effectiveness of intervention over various subsamples.

■ **16** Rumored intervention includes rumors about both "own" and "on behalf of" intervention.

TABLE 2C

Descriptive Statistics for Actual, Reported, and Rumored Intervention: May 23, 1988–October 11, 1991

	Number of Occurrences			Average Size	
	Total	Buying	Selling	Buying	Selling
Actual intervention					
U.S. vs. $U.S.	194	37	157	133.41	192.09
U.S. vs. DM	143	28	115	105.93	147.27
U.S. vs. Yen	107	13	94	151.54	140.66
Reported intervention					
U.S. vs. $U.S.	129	19	110	139.21	150.64
U.S. vs. DM	34	4	30	151.25	108.61
U.S. vs. Yen	29	4	25	129.69	137.25
Rumored intervention					
U.S. vs. $U.S.	18	4	14	150.00	150.00
U.S. vs. DM	2	1	1	118.33	118.33
U.S. vs. Yen	3	1	2	143.75	143.75

Errors in Reported Intervention	Total	Actual but Not Reported	Reported but Not Actual
Reported intervention			
U.S. vs. $U.S.	95	80	15
U.S. vs. DM	115	112	3
U.S. vs. Yen	86	82	4
Rumored intervention			
U.S. vs. $U.S.	11		
U.S. vs. DM	2		
U.S. vs. Yen	2		

Categories of intervention:
U.S. vs. $U.S.: U.S. intervention vis-à-vis unspecified currencies, carried out in terms of U.S. dollars.
U.S. vs. DM: U.S. purchases or sales of DM in terms of U.S. dollars.
U.S. vs. Yen: U.S. purchases or sales of yen in terms of U.S. dollars.
NOTE: "Buying" and "Selling" columns are in terms of purchases and sales of millions of U.S. dollars.
SOURCE: Authors' calculations.

our knowledge, this is the first such treatment of qualitative reports.

Whether we examine numeric values or dummy variables, count or discount rumors, or split the sample, we find that there usually are systematic components in the differences between the actual and reported intervention series. While the economic significance of any such differences is unclear, we believe that these findings may have important implications for understanding the signaling mechanism of intervention. If the newspaper reports reflect the markets' final assessment of intervention activity, then reporting errors imply that the market (with the exception of the intervention counterparties) is misinformed and that intervention is unlikely to signal monetary policy accurately.

TABLE 3

White Noise Tests for Errors in Reported Intervention

Variable	Full Sample			First Half: January 2, 1985– May 20, 1988			Second Half: May 23, 1988– October 11, 1991		
	K	*K-S*	*N*	*K*	*K-S*	*N*	*K*	*K-S*	*N*
No Rumors									
U.S. vs. DM	35.3842[a]	0.2656[a]	884	10.2977[b]	0.1936[a]	442	27.5159[a]	0.2916[a]	442
U.S. vs. Yen	39.7927[a]	0.4142[a]	884	20.3109[a]	0.3673[a]	442	30.1626[a]	0.4367[a]	442
With Rumors									
U.S. vs. DM	33.6817[a]	0.2588[a]	884	8.6115	0.1834[a]	442	27.2551[a]	0.2897[a]	442
U.S. vs. Yen	43.4345[a]	0.4120[a]	884	20.2056[a]	0.3677[a]	442	32.7564[a]	0.4319[a]	442
Dummy Variables									
No Rumors									
U.S. vs. DM	55.6083[a]	0.3180[a]	884	22.2064[a]	0.2790[a]	442	35.7343[a]	0.3340[a]	442
U.S. vs. Yen	58.9862[a]	0.3472[a]	884	39.4540[a]	0.3814[a]	442	27.4339[a]	0.3069[a]	442
With Rumors									
U.S. vs. DM	53.2813[a]	0.3035[a]	884	20.7967[a]	0.2550[a]	442	34.9908[a]	0.3275[a]	442
U.S. vs. Yen	62.6117[a]	0.3479[a]	884	39.1464[a]	0.3866[a]	442	32.4126[a]	0.3013[a]	442

Categories of intervention:
U.S. vs. DM: U.S. purchases or sales of DM in terms of U.S. dollars.
U.S. vs. Yen: U.S. purchases or sales of yen in terms of U.S. dollars.
NOTE: *N* = number of observations. For *K* and *K-S*, see box 1.
a. Significant at the 5 percent level.
b. Significant at the 10 percent level.
SOURCE: Authors' calculations.

Appendix

Treatment of Rumors and "On Behalf of" Intervention

We created two sets of variables from the reported intervention data: The first treats all rumors as true, and the second treats all rumors as false. The first step in the creation of both data sets was the formulation of the net dollar transaction variables for each category of intervention. For the U.S. intervention categories, this variable is equal to the amount variable, which is always non-negative, multiplied by the buy/sell dummy variable.

To compare reported and actual intervention data, we must transfer intervention that was reported as being on behalf of another country to that particular country. For example, if the United States actually purchased yen on behalf of Japan, the data that we receive from the Federal Reserve's Board of Governors will attribute such intervention to Japan rather than to the United States. To accomplish this adjustment, we created two variables for each country, FOR1 and FOR2. FOR1 equals 1 if the country intervened on behalf of another country. FOR2 equals the number of countries reported to be intervening on its behalf.

There is also is a third dummy variable, FORRUMOR, which equals 1 if intervention by the country was rumored to be on behalf of another country. To create the data set in which all rumors are considered true (false), we transferred (did not transfer) all of the intervention that was rumored to be on behalf of another country. Additional details regarding these procedures are available from the authors.

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