Some Issues Involving the Definition and Interpretation of the Monetary Aggregates

Thomas D. Simpson and Richard D. Porter*

I. Introduction

Recently a great deal of attention has been focused on difficulties of interpreting the behavior of the monetary aggregates. The period since the mid-1970s has been characterized by unexpected changes in the relationship between traditional measures of the monetary aggregates and economic activity. Accompanying the disruption of established monetary relationships was an intensified effort by the public to alter the management of its monetary and liquid assets and a highly favorable climate for the promotion and introduction by financial institutions of alternatives to the public's conventional deposit holdings. Many observers have attributed difficulties of interpreting the monetary aggregates to a number of financial assets, such as the emergence of money market mutual funds and the growing use of very short maturity repurchase agreements (RPs), that provide the public with highly attractive alternatives to holding conventional transactions balances and tend to view the resolution of these difficulties largely in terms of the appropriate inclusion of such assets in the definition of money.[1] Some other observers have tended to place more emphasis on the contribution of changes in techniques for managing cash balances and have attached more importance to the need for careful interpretation of the behavior of monetary aggregates.[2]

* Thomas D. Simpson is a Senior Economist and Richard D. Porter is Chief of the Econometric and Computer Applications Section, both of the Division of Research and Statistics at the Board of Governors of the Federal Reserve System. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the Board of Governors of the Federal Reserve System or other members of its staff. The authors have benefited from the very helpful comments received from Eileen Mauskopf, Edward C. Ettin, John Williams, David E. Lindsey, Jared Enzler, Allen Frankel, Fred Jensen, and William White. David Wilcox provided valuable research assistance.

[1] For a variety of views on this subject, see *Measuring the Monetary Aggregates: Compendium of Views,* Subcommittee on Domestic Monetary Policy of the Committee on Banking, Finance and Urban Affairs of the United States House of Representatives, 96th Congress, Second session (Washington, D.C.: Government Printing Office, 1980). See also, Gillian Garcia and Simon Pak, "Some Clues in the Case of the Missing Money," *American Economic Review,* vol. 69 (May 1979), pp. 330–40; John Wenninger and Charles Sivesind, "Changing the M-1 Definition: An Empirical Investigation," (Federal Reserve Bank of New York, April 1979; processed); and Peter A. Tinsley, Bonnie Garrett, and Monica Friar, "The Measurement of Money Demand," (Board of Governors of the Federal Reserve System, Division of Research and Statistics, Special Studies Section, November 1978; processed).

[2] See Richard D. Porter, Thomas D. Simpson, and Eileen Mauskopf, "Financial Innovation and the Monetary Aggregates," *Brookings Papers on Economic Activity,* 1:1979, pp. 213–29.

Many, too, have questioned the usefulness of the monetary aggregates as indicators and targets of monetary policy.

For a number of years, evidence had been accumulating that suggested the most commonly watched old measures — M-1 and M-2 — were undergoing changes that reduced their predictability and reliability. The public's demand for the old M-1 measure — currency plus demand deposits — had displayed pronounced downward shifts relative to GNP — primarily in the period from mid-1974 to early-1977 and in late 1978 and early 1979 — that could not be explained on the basis of historical experience. Indeed, by late 1979 standard specifications of the M-1 equation suggested that M-1 relative to GNP was anywhere from 10 to 17 percent lower than predicted using econometric relationships that explained money demand behavior quite well prior to mid-1974.[3] A detailed examination reveals that weakness in old M-1 was concentrated fully in demand deposits, mostly the holdings of nonfinancial corporations — presumably large ones — and, to a lesser extent, households. Because the downward shift in demand deposits was not mirrored in an upward shift in the other components of old M-2, this broader measure also grew less rapidly than predicted on the basis of historical relationships.[4] Nevertheless, until late 1978 the shortfall in M-2 was comparatively small, when adjustments were made for the size of this aggregate. However, in late 1978 and in 1979 the shortfall in the time and savings deposit components of this aggregate widened considerably, as the public redirected some of its liquid assets from savings and small-denomination time deposits at banks to money market mutual funds and, to a lesser extent, thrift institutions. Also, banks tended to rely less heavily on large-denomination time deposits — about half of which were in the old M-2 — and more on other managed liabilities, including Eurodollar borrowings. The estimated shortfall in old M-2 over the period from the fourth quarter of 1978 to the fourth quarter of 1979 was a full 6 percentage points of the level of this aggregate or $54 billion. In recognition of the inadequacies of the old measures of the money stock, the Federal Reserve in early 1980 introduced new measures of money which reflected many of the changes that had been occurring in the financial system.

The newly adopted measures of money have generally been less vulnerable to the shifts that characterized the old aggregates. The new M-1B measure — which contains other checkable deposits at all depository institutions, as well as currency and demand deposits — has registered a smaller shortfall, since some of the weakness in demand deposit growth has been matched by increases in other checkable deposits (mainly ATS and NOW accounts).[5] Indeed, the inclusion of other checkable deposits appears to cor-

[3] These estimates are based on dynamic simulations of money demand equations, fit through mid-1974. For evidence on the reliability of money demand behavior prior to 1974, see Stephen Goldfeld, "The Case of the Missing Money," *Brookings Papers on Economic Activity*, 3:1976, pp. 683–730.

[4] Old M-2 equalled old M-1 plus savings and time deposits at commercial banks other than negotiable CDs at large banks.

[5] The M-1A measure basically equals old M-1, except that it excludes demand deposits

rect for much of the shortfall in household demand deposits.[6] Nevertheless, since the M-1B aggregate does not contain liquid assets that corporations may have acquired with funds released from demand balances, it has been subject to sizable demand shifts over the 1974 to 1979 period.

The new M-2 measure, however, by including overnight RPs and certain overnight Eurodollars does contain two very liquid assets that serve as attractive alternatives holding demand deposits for large corporations. Also included in the new M-2 aggregate are money market mutual fund shares and savings and small-denomination time deposits at all depository institutions — commercial banks and thrift institutions. Thus shifts between savings deposits and money market mutual fund shares are internalized in this aggregate as are shifts of such savings and small time deposits between commercial banks and thrift institutions. Forecasts of the demand for this aggregate, based on historical experience, have been reasonably close to actual behavior during those periods when the demands for some other aggregates demonstrated pronounced tendencies to shift downward. Both the simulated level and quarter-to-quarter rates of growth of this aggregate during the last half of the 1970s were, by conventional standards, very similar to those actually experienced.[7] Nevertheless, while many of the shifts that disturbed the old measures are internalized in the new M-2, shifts out of the demand deposit component cannot fully be explained by the money market mutual fund or overnight RP and Eurodollar components.[8] Indeed, as suggested later in the paper, the nature of the shifts from demand deposits is such that to internalize them adequately requires turning to a very broad aggregate, such as the

owned by foreign commercial banks and official institutions. M-1B equals M-1A plus other checkable deposits. Two M-1 measures were adopted mainly for purposes of interpreting money growth during the transition period following the nationwide extension of NOW accounts. With nationwide NOW accounts, M-1A growth will tend to understate while M-1B will tend to overstate the underlying growth in transactions balances.

[6] Work done by our colleague, John Williams, suggests that most of the shortfall in household demand deposits beginning in 1975 can be attributed to rapid expansion in other checkable deposits.

[7] See David J. Bennett, Flint Brayton, Eileen Mauskopf, Edward K. Offenbacher, and Richard D. Porter, "Econometric Properties of the Redefined Monetary Aggregates" (Board of Governors of the Federal Reserve System, Division of Research and Statistics, Econometric and Computer Applications Section, February 1980; processed). The equations used to produce such forecasts, however, have certain properties that do not conform to those suggested by *a priori* considerations. In particular, the coefficient of the lagged dependent variable seems to be implausibly large. Consequently, the forecasting record for this measure could worsen.

[8] For example, when money market mutual fund shares and overnight RPs and Eurodollars are added to M-1B, the cumulative simulation error over the period from mid-1974 to mid-1980 is lowered from $63.2 billion to minus $12.4 billion. However, one must be careful about attributing a cumulative error in demand deposits to some other liquid assets that have grown in size over the same period. Indeed, the quarter-to-quarter forecasting ability of the equation for such an augmented measure over the 1974:3–80:2 period is poorer than for M-1B; the root mean square error of quarterly growth rates for this augmented measure is raised from 4.3 to 4.9 percentage points.

new liquid assets measure, L, that includes virtually all liquid assets held by the public.[9]

In the remainder of this paper, we focus mostly on the problems associated with the narrow transactions-related measures of money. These are the measures that have generally been most closely related to spending and economic activity and they are the ones that tend to be watched most closely. We attempt to demonstrate that downward shifts in the principal component of these measures — demand deposits — might continue to occur and that, for the most part, any such shifts are likely to be unpredictable, both in terms of timing and intensity. Recent financial innovations are analyzed in the context of an environment of high market rates of interest, regulatory restrictions on the issuance of deposits serving as money, and exogenous technological developments. This analysis yields certain implications for an alternative specification of the money demand relationship — the inclusion of a variable representing the perceived longer term opportunity cost of holding demand balances which directly affects the profitability of investing in money management techniques. On balance, the econometric results for such an alternative specification are encouraging, especially in comparison with efforts to augment M-1 by including very liquid balances such as RPs. Nevertheless, even such an approach cannot be expected to ameliorate uncertainty about M-1 behavior and sizable forecast errors in this aggregate might well continue.

Clearly, further work must be done in this area to better understand money demand — or velocity — behavior in such an environment and to improve the specification of this key relationship. In the meantime, though, a high degree of uncertainty about M-1 velocity appears likely. Consequently, the precision with which an objective for the economy can be achieved solely with M-1 targeting procedures is lowered. In view of these considerations, a case can be made for a wider range for M-1 growth or for more frequent adjustment of that range. Moreover, the case is strengthened for stabilizing interest rates during periods when it is apparent from incoming evidence that shifts are occurring. Also, in such an environment more attention could be placed on the broader measures of money, especially M-2, although a considerable amount of uncertainty also exists about these broader measures.

Three appendixes follow the text. The first demonstrates in a rigorous fashion the tendency for a stronger long-run money demand response to increases in the opportunity cost of holding money balances and interprets cash management developments in the context of such a theory. The second appendix presents further econometric evidence on alternative specifications of the money demand equation and alternative combinations of assets. The third appendix presents and discusses some econometric evidence on the demand for another asset that can be characterized by an inventory process

[9] Between the new M-2 measure and L is redefined M-3. This aggregate equals M-2 plus large-denomination time deposits at all depository institutions and term RPs at commercial banks and savings and loan associations.

— the demand for inventories of physical goods — but which has not demonstrated a pronounced tendency to shift downward like the demand for M-1 balances.

II. The M-1 Issue

A. Financial Innovations

Economic theory and a variety of historical experience attest to the substantial value that the public places on transactions services provided by money balances. Some of the most dramatic evidence can be found in episodes of very high rates of inflation when the public continued to hold relatively large amounts of money balances, despite enormous opportunity costs. However, historical examples also demonstrate that in the face of persistently high opportunity costs the public develops methods for economizing on such balances. Moreover, in some of these examples substitutes emerge after a while that provide many of the same services as traditional money balances, but at more favorable terms. Expressed alternatively, in the short run the demand for traditional monetary assets is somewhat insensitive to changes in opportunity costs but in the long run the response tends to be much stronger as more substitutes are developed and used.

Many financial innovations of the 1970s and the accompanying downward shifts in money demand relative to GNP might be viewed in this long-run versus short-run context. In the 1970s market rates of interest — both short- and long-term rates — reached record levels, suggesting a record-high opportunity cost of holding currency and demand deposit balances and also high opportunity costs of deposits with fixed-rate ceilings. In response, not only did money holders make the usual efforts to economize on cash balances, but the expectation of continued high opportunity costs encouraged investment in new money management techniques that were designed to lower the amount of transactions balances required for a given amount of spending. Also, the expectation of continued high opportunity costs of holding demand balances improved the climate for financial institutions to promote and introduce alternatives to demand balances having transactions-type properties but with lower opportunity costs.[10]

Indeed, in response it appears that commercial banks adopted the practice of offering implicit compensation on demand deposits at rates tied to market yields to their large customers. Qualitative evidence — based on numerous interviews with corporate cash managers and commercial bankers — suggests that by the mid-1970s many banks were offering their larger balance customers implicit compensation tied to money market rates (most often the Treasury bill rate); this compensation has taken the form of below-

[10] Reinforcing this view is work done at the Board, including work done by our colleague John Williams, that suggests that the shortfall in M-1 demand predates large increases in M-1 substitutes such as RPs and money market mutual fund shares. See Thomas D. Simpson, "The Market for Federal Funds and Repurchase Agreements," Staff Studies 106 (Board of Governors of the Federal Reserve System, July 1979), pp. 44–46.

cost credit and cash management services.[11] Thus with such pricing of demand deposits the effective opportunity cost of holding demand balances for many depositors does not vary to the extent that might be expected. Under the most common arrangements, however, the implicit rate on demand balances is adjusted for the cost of reserve requirements. For example, at a Treasury bill rate of 10 percent, the implicit yield on demand balances could be only as high as 8.4 percent, as the marginal reserve ratio on demand deposits at large member banks had been 16.25 percent.[12] Because of the reserve requirement adjustment, however, the difference between the market yield and the implicit yield — that is, the implicit opportunity cost of holding demand deposits — does tend to vary directly with money market yields. Moreover, since the value to the depositor of these services may be less than their cost to the bank, the perceived return on demand deposits may be even lower and thus the opportunity cost even higher than that suggested by such a formula for the implicit yield.

In the face of expectations of a persistently high opportunity cost of holding narrow money balances, depositors can be expected to actively seek ways to modify their deposit management systems to, in a more permanent sense, reduce their deposit holdings. In other words, under these conditions the perceived rate of return rises on investments in new techniques that enable depositors to conduct a given volume of transactions with smaller amounts of money balances. This is to be contrasted with the short-run response to an increase in the opportunity cost of holding money balances in which the depositor is confronted with a given set of money management techniques and attempts to lower money balances within that constraint.[13] Clearly, the long-run response to a given increase in interest rates is likely to be greater than the short-run response.[14] Thus the short-run money demand schedule can be viewed as drawn for a given set of money management techniques, such as computer hardware and software and trained personnel, and relatively inelastic when compared to the long-run demand schedule, along which

[11] Credit services include lines of credit linked to deposit balances. Cash management services include lock boxes, wire transfers, and balance reporting. Customers with smaller balances also tend to receive a return on their balances, but this return often does not vary with balances in the account. Thus, the marginal return to these customers tends to be small and below the average return.

[12] Under the new reserve requirement structure adopted in connection with the Monetary Control Act, the marginal reserve ratio on demand balances at large member banks will decline to 12 percent, after the phase-in of reserve requirements is complete.

[13] These points are developed more rigorously in Appendix A.

[14] An interesting question arises in connection with reductions in the opportunity cost of holding money balances that are expected to persist. Can it be expected that new techniques adopted previously are going to be abandoned or permitted to wear out so that the increase in money balance holdings in the long run is likely to exceed the increase in the short run or can cash managers be expected to retain previously adopted techniques? In the former case, the long-run demand schedule would be continuous but in the latter case it would have a kink as it would be less sensitive to reductions in interest rates than to increases.

money management techniques vary.[15] The short-run impact of interest rate changes, though, is likely to be more predictable, since the long-run response involves the act of investing in new systems and the timing of the investment process is one that typically is difficult to forecast. Moreover, as noted in Appendix A, investments in some cash management techniques, most notably the cash concentration account, have lumpy effects on money demand.

Serving to reinforce this tendency for a stronger long-run interest rate response is the tendency for suppliers of financial instruments to compete more intensely for the public's balances having the highest opportunity costs, especially demand deposits and savings. In an environment of high market rates of interest, financial intermediaries can attract or retain funds by offering financial instruments with characteristics very similar to the (regulated) high opportunity cost ones, but with more attractive yields. Thus new instruments emerge such as money market mutual funds and overnight Eurodollars — as well as new checkable deposits like NOW accounts — and some existing ones such as RPs are more actively promoted, and these serve to attract funds from demand deposits and from savings accounts. Because these new instruments have characteristics that are similar to both transactions balances and other liquid assets, they tend to blur the distinction between transactions balances and liquid investments, which further complicates the interpretation of monetary behavior.

If interest could be paid on demand deposits and required reserve balances, the marginal yield to large balance depositors would tend to be close to that on very short-term open market instruments, such as RPs or commercial paper. As a consequence, a large increase in market rates of interest would not result in the kind of widening of the opportunity cost of holding demand balances that occurs at present. Thus an increase in interest rates would not encourage the kinds of efforts to pare money balances, both in the short run and the long run, that have been characteristic of the recent past. However, even in such an environment the yield on demand deposits that banks would be willing to offer would fall short of the rate paid on short-term market instruments because demand balances can be withdrawn at any time during the day, by the presentation of checks, wire transfers or conversions to currency. As a result, there exists a considerable amount of intra-day uncertainty about closing balances in customers' demand deposit accounts. Thus banks would continue to be faced with the task of actively managing a reserve position that met the dual needs of satisfying reserve requirements and potential withdrawals from their customers' accounts; by contrast, issuers of short-term market instruments, for the most part, do not face such reserve man-

[15] The rate at which new techniques are adopted will depend, in part, on the size of the change in the perceived longer term opportunity cost of holding money balances. A large jump in the opportunity cost, if expected to persist, would tend to encourage a more rapid conversion to new techniques than a small one.

agement costs.[16] Consequently, even in a highly competitive environment, banks would not offer the same return on demand balances that they and others would be willing to offer on overnight instruments.[17] As a result, depositors would continue to have an incentive to invest in money management techniques that enable them to economize on their demand deposit holdings, as there would still be an opportunity cost associated with such balances.[18]

Viewed somewhat differently, one of the important functions that a bank performs by managing the reserve position against its many customer accounts jointly is to lower the overall reserve management costs associated with their aggregate transactions balances. A bank is in a highly favorable position to contend with much of the uncertainty that arises from the daily variability in each of its customer's cash-flow positions, since some of the variability in individual accounts is offsetting in the aggregate and through the pooling of the disturbances of its many customer accounts aggregate variability can be lowered; thus fewer resources are needed than if each account were managed separately.[19] To the extent that all disturbances to individual customer accounts were always offsetting in the aggregate, virtually no resources would be needed to manage the bank's reserve position, since it would be unchanged from one day to the next (and would equal required reserves). As a result, the yield on demand deposits would tend to equal that on short-term market instruments, because required reserve balances against such deposits would, by assumption, have a yield approximating the market rate. However, since such diversification cannot eliminate completely all uncertainty, reserve management is necessary and consequently the associated costs would likely be passed along to the customer in the form of a lower yield. In this way, the customer would be given an economic incentive, in the form of an opportunity cost on demand balances, to pare deposit holdings by

[16] Other instruments that are settled in immediately available funds — including bank issuance of RPs — generally must be arranged fairly early in the day. Money market mutual funds also ordinarily require that notification of wire transfer withdrawals be made fairly early in the day (to be effective that day) and that placements of funds via the wire also be made early in the day (to earn interest on that day). Thus the issuer of such instruments need not maintain more than frictional amounts of deposit balances and need not incur the higher reserve management costs that banks absorb with demand deposits or NOW or ATS accounts.

[17] It is assumed here that excess reserves do not yield interest and that requirements are met on a weekly average reserve basis so that a shortfall on one statement day can be offset with a reserve surplus on a later day, except the last statement day of the week. Thus, the task of the reserve manager is to just meet required reserves on a weekly average basis, given the pattern of stochastic disturbances.

[18] Basically, the same conclusion would emerge if there were no reserve requirements. In this case, the bank would need to maintain a certain amount of vault cash and other balances to meet potential withdrawals. Thus, the customer would receive a return on demand deposits that falls short of money market yields because of reserve management costs to the bank and the absence of a return on at least a portion of its reserve balances that are held voluntarily.

[19] The same set of influences may also be at work in a large corporation that has many geographically dispersed units. A cash concentration system enables firms to pool variability in accounts with many individual banks in a single concentration account and thereby take advantage of offsetting changes among its many individual accounts. See Appendix A, Part III.

applying resources that reduce uncertainty about the customer's own cash-flow pattern or to restructure transactions in ways that smooth cash flows.

Consequently, even in a world of unregulated interest rates on demand deposits and compensation at market rates on required reserve balances, depositors would have an incentive to invest in money management techniques that lower uncertainty about cash-flow patterns, such as improvements in forecasting and balance monitoring.[20]

In addition, exogenous technological innovations that lower the costs of reducing uncertainty and restructuring payments arrangements would add to the profitability of investing in money management techniques, as they do in the present environment. Consequently, such exogenous technological innovations can be expected to reduce the demand for transactions balances relative to spending by an amount that is directly related to their contribution to the profitability of new cash management investments. Moreover, exogenous technological innovations that lower transactions costs associated with investing funds in demand deposit accounts would also reduce the demand for M-1 relative to total spending or GNP.

Exogenous improvements in money management techniques — ones that would have occurred in any event — likely encouraged investments that contributed to the unexpected weakness in the demand for M-1 as did the combination of high market rates of interest, the prohibition on the payment of explicit interest on demand deposits, and relatively high reserve requirements on large member banks. Significant reductions in the real cost of computer and telecommunications systems and greater access to wire transfers have enabled cash managers to keep closer tabs on deposit balances and to more easily place temporary excess balances in short-term investments. In addition, newly trained cash managers bring to their jobs a knowledge of improved forecasting and other money management techniques.

For the most part, it is difficult to discern the relative contribution of exogenous and induced forces on the financial innovations that have been associated with abnormal behavior of the narrow monetary aggregates in recent years. However, the demands for some other economic quantities are similar to the demand for narrowly defined money balances — in the sense that they can be characterized by an inventory process — and would be influenced by many of the exogenous factors that have affected narrow money balances; however, they would generally not be influenced by some of the important factors that may have induced financial innovations, such as deposit rate ceilings and reserve requirements. The evidence on the behavior of the demand for inventories of goods during the last half of the 1970s, which is discussed in Appendix C, suggests that perhaps only a very small downward shift in inventory demand may have occurred, in contrast to the demand for narrow money balances where the downward shift was substantial.[21] Con-

[20] In such a world there would continue to be incentives for cash managers to increase float by slowing down disbursements and speeding up receipts.

[21] However, some of the developments that have facilitated the reduction in demand deposit holdings, such as those accompanying the cash concentration account, are impractical for inventories of goods.

sequently, one might conclude that the impact on money demand of induced factors relating to opportunity costs has outweighed that of exogenous developments.

In sum, an increase in the opportunity cost of holding money balances — which is magnified by the prohibition on the payment of interest on demand deposits and noninterest-earning required reserve balances — encourages the public to economize on its holdings of these balances in the short run — characterized by a given set of money management techniques — but to respond more vigorously in the long run by investing in new money management techniques. In other words, an increase in the opportunity cost of holding money balances adds to the profitability of investing in new management techniques, as do exogenous reductions in the costs of money management techniques. Reinforcing this behavior is the tendency for suppliers of financial instruments to introduce substitutes for money balances which are hybrids, having characteristics of both transactions balances and liquid investments.[22] With the funds released from traditional money balances, the public can be expected to acquire not only these new money substitutes but other financial assets and perhaps also to pay down debt. Even though new money substitutes do not absorb all of the funds released from traditional money balances, the presence of such substitutes encourages a stronger reaction by the public to actively lower its money holdings, as they permit the public to adopt money management techniques that rely on even smaller amounts of ordinary transactions balances. Because these new financial instruments have some of the characteristics of transactions balances, they attract funds that would otherwise be placed in ordinary transactions deposits and thus are balances that are related to aggregate transactions and spending. Also, because these assets serve as liquid investments, the demand for which at times can be strongly influenced by such portfolio considerations as relative yields, their behavior may often not be a reliable indicator of aggregate transactions in the economy. Thus the presence of such hybrid instruments can cause serious interpretation problems since at times their behavior may be related mainly to transactions and spending while at other times they may be predominantly related to their investment properties. It is worthwhile to note that the above analysis does not imply that other liquid assets — other than ATS and NOW accounts — necessarily supplant demand deposits as transactions balances but rather absorb funds released by efforts to pare demand deposits. Thus, even though the behavior of some liquid assets may be correlated with

[22] An alternative way of viewing these developments is in terms of an attempt on the part of the financial system to economize on the aggregate amount of the clearing balances in the form of required reserve balances held with the Federal Reserve. With binding reserve requirements, the actual amount of clearing balances (required reserves) exceeds the optimal amount as seen by individual institutions. Actual clearing balances can be brought closer into line with optimal balances if there is more rapid growth in nonreservable or low reserve liabilities, which is achieved by greater reliance on RPs, Eurodollars, and by more rapid growth of nonmember depository institutions, money market mutual funds, and the like.

unexplained weakness in demand deposits the public may not view such assets as components of its transactions balances.[23]

In the future, some of the conditions that have encouraged the kinds of innovations that have disturbed the behavior of the narrow monetary aggregates and have caused interpretation difficulties may diminish. A general lowering of the marginal reserve ratio on member bank demand deposits — to 3 percent for smaller banks and 12 percent for others — can be expected to reduce the opportunity cost of demand deposits and thus the incentive for innovations.[24] In addition, households nationwide will be able to open NOW accounts on which explicit interest can be paid. Also, the ceiling rates that can be paid on NOW accounts — and other interest-earning deposits — are scheduled to be phased out over a six-year period ending in 1986. Another development that may tend to enhance the attractiveness of ordinary transactions balances is the debit card. With a debit card, the public will be able to make payments for the items presently charged to credit cards directly from demand or NOW account balances. By maintaining larger balances in these transactions accounts, people will be able to avoid interest payments on charges to credit cards.[25] The demand for deposits by businesses, especially those active in cash management, may also be strengthened by new fees charged for Federal Reserve services. In particular, charges for wire transfers of funds and securities safekeeping and transfers will tend to lower somewhat the returns associated with moving funds into and out of cash concentration accounts and the net returns on short-term RPs involving the transfer of securities.

On the other hand, the further development of electronic funds transfers is likely to reduce by even more the transactions costs associated with the transfer of funds between transactions balances and short-term liquid asset buffers, and thus might further weaken the demand for transactions balances relative to spending. For example, if individuals can more conveniently transfer funds between money market mutual fund accounts and transactions accounts, they will be able to hold smaller amounts of transactions balances and will be able to easily tap their money market mutual fund accounts to cover expected or unexpected cash needs. Clearly, the greater is the oppor-

[23] Indeed, even a portion of ATS and NOW deposits may be viewed by the public more as a savings balance than as a transactions balance.

[24] Also, while the Federal Reserve Board has the added authority to impose a supplemental reserve requirement of up to 4 percent on the transactions accounts of all depository institutions, compensation is to be paid on such reserve balances at a rate tied to the yield on the Fed's portfolio.

[25] The relevant comparison for the individual is the return on additional balances held, say, in a NOW account to cover debit card purchases (that otherwise would have been charged to a credit card account) subtracted from the return that could be received on these funds if placed in an alternative investment relative to the full cost of borrowing this amount using a credit card account. Even in cases where the individual avoids ordinary finance charges by remitting the full outstanding balance, an implicit charge fee tends to be imposed because merchants often establish higher costs for those items being charged as the corresponding slips they send to their banks are discounted when they are submitted.

tunity cost of holding transactions balances, the greater will be the impact of reductions of transactions costs resulting from the further development of electronic payment methods. Thus, on balance, it appears that considerable uncertainty about M-1 velocity is likely to remain in the future.

In light of the developments described above and the inadequacy of standard money demand models, it is clear that further research is needed in the area of money demand. It seems likely that the public's underlying demand for transactions services has not undergone the kinds of shifts that are suggested by standard econometric models of the demand for M-1 balances. These services, though, are being provided for in new ways that are not presently being captured adequately by econometric techniques, even when liquid transactions-type assets such as overnight RP and money market mutual funds are added to the M-1 measure. One change in the specification suggested by the preceding discussion is the inclusion of a variable that captures the incentive to invest in money management techniques. Such a variable represents the perceived opportunity cost of money balances over a longer span of time, one corresponding to the economic life of the money management techniques being considered. Some earlier work on this subject can be viewed in this context and some empirical work reported in the next section indicates that such efforts have promise.[26] Alternatively, in view of the proliferation in recent years of very liquid assets available to the public with transactions-type properties, another promising approach to the M-1 dilemma involves the construction of index numbers — such as a Divisia index — for measures of monetary or liquid assets.[27]

B. Empirical Evidence

Magnitude of the Empirical Problem

This section examines the empirical evidence on money demand behavior at some length and offers an alternative method of specifying money demand, one that attempts to capture the incentive to adopt new money management techniques. The motivation for such a new approach is, of course, the rather poor out-of-sample behavior of the standard money demand specification for most narrow money measures over much of the period since 1974.

We begin with two elementary exercises that are designed to convince the skeptic that in the last six years something new has happened to the money demand relationship. Table 1 displays for the last 30 years the annualized growth in income velocity of M-1A and M-1B, a crude estimate of the trend in these velocities, and the average rate of change of the bill rate. The

[26] See Jared Enzler, Lewis Johnson, and John Paulus, "Some Problems of Money Demand," *Brookings Papers on Economic Activity*, 1:1976, pp. 261–80; and Perry D. Quick and John Paulus, "Financial Innovations and the Transactions Demand for Money," (Board of Governors of the Federal Reserve System, Division of Research and Statistics, Banking Section, February, 1977; processed).

[27] See William A. Barnett, "Economic Monetary Aggregation: An Application of Index Numbers and Aggregation Theory," *Journal of Econometrics*, (September 1980).

Table 1
Growth in Velocity and Short-Term Interest Rates

Six-year period	Velocity of M-1A	Velocity of M-1B	Bill Rate	Trend estimate velocity for M-1A*	Trend estimate velocity for M-1B*
	(Average Annualized Rate of Change)				
1950:3-56:2	3.93	3.93	17.9	2.98 (2.54)	2.98 (2.54)
1956:3-62:2	3.33	3.33	13.6	3.02 (3.41)	3.02 (3.41)
1962:3-68:2	2.99	2.98	13.2	2.60 (4.30)	2.59 (4.28)
1968:3-74:2	2.25	2.24	10.2	2.28 (3.42)	2.27 (3.41)
1974:3-80:2	4.60	3.77	5.9	4.48 (6.63)	3.66 (5.37)

* M-1A and M-1B are identical prior to 1963. The series were extended backwards in time using the 1959 average ratio of the new demand deposit series to the old series. The trend estimates are based on a linear regression of annualized rates of growth of the velocity on an intercept and the annualized rates of growth of the bill rate. The trend estimate is the intercept in this regression; the numbers in parenthesis beneath the trend estimates are the t-ratios from this regression.

estimates are presented by six-year segments, which were chosen so that the last one coincided with the significant deterioration in standard demand equations. This table shows that, except for the last period, velocity growth has been directly related to the size of interest rate increases, as implied by standard theory. In the last period, however, velocity accelerated while the advance in the Treasury bill rate slowed. The trend estimates presented in the last two columns show that trend growth in velocity was steady or declined somewhat until the 1974:3–80:2 period when it increased rather sharply. As discussed below, equations for the two principal components of M-1A indicate that the demand deposit component is producing the M-1 prediction errors during this latter period and not currency.

It can also be demonstrated rather convincingly that the prediction errors in the standard demand deposit equation are not, fundamentally, a matter of faulty elasticity estimates for income and short-term interest rates. Table 2 presents demand deposit equation errors that are associated with alternative assumptions of interest rate and income elasticities. The errors presented in the table for the 1974:2–80:2 period remain substantial for all combinations of long-run interest rate and income elasticities shown. For example, in a "monetarist" equation with an interest elasticity of nearly zero and an income elasticity of unity, the implied error is about 35 percent. By

Table 2
Demand Deposit Errors for Alternative Long-Run Income and Interest Rate Elasticities (Percentage (logarithmic) errors)

		β_2 income elasticity							
		.5	.6	.7	.8	.9	1.0	1.5	1.8
β_1 interest rate elasticity	0	-28.4	-29.8	-31.3	-32.7	-34.1	-35.5	-42.6	-46.8
	-.1	-26.8	-28.2	-29.6	-31.0	-32.4	-33.9	-40.9	-45.2
	-.2	-25.1	-26.5	-28.0	-29.4	-30.8	-32.2	-39.3	-43.5
	-.3	-23.5	-24.9	-26.3	-27.7	-29.1	-30.6	-37.6	-41.9
	-.4	-21.8	-23.2	-24.6	-26.1	-27.5	-28.9	-36.0	-40.2
	-.5	-20.2	-21.6	-23.0	-24.4	-25.8	-27.2	-34.3	-38.6

NOTE: This table is based on the long-run demand for money equation

(1) $\ln(M_t) = \ln(p_t) + \beta_o + \beta_1\ln(r_t) + \beta_2\ln(y_t) + e_t$

and,

β_1 = long-run interest elasticity of money demand
β_2 = long-run income elasticity of money demand
M_t = nominal demand deposit balances
p_t = the GNP deflator
r_t = 90-day bill rate
y_t = real GNP
e_t = error term

Differencing (1) for τ periods yields

$$\ln(M_t) - \ln(M_{t-\tau}) = \ln(p_t) - \ln(p_{t-\tau}) + \beta_1[\ln(r_t) - \ln(r_{t-\tau})] + \beta_2[\ln(y_t) - \ln(y_{t-\tau})] + e_t - e_{t-\tau}$$

or

(2) $\Delta\ln(M_t) = \Delta\ln(p_t) + \beta_1\Delta\ln(r_t) + \beta_2\Delta\ln(y_t) + \Delta e_t$, where $\Delta = 1 - B^\tau$, $B^\tau x_t = x_{t-\tau}$

and B the lag operator, $Bx_t = x_{t-1}$.

The errors Δe_t in the table are computed by rewriting (2) as $\Delta e_t = \Delta\ln(M_t) - \Delta\ln(p_t)$

$- \beta_1\Delta\ln(r_t) - \beta_2\Delta\ln(y_\tau)$

The reported errors are denominated in percent, i.e., they equal $100\Delta e_t$. The (logarithmic) differences are measured from 1974:2 to 80:2.

comparison, assuming an income and interest rate elasticity of one-half implies an error of about 20 percent. Relaxing the requirement that the long-run money demand function be homogenous of degree one in prices and setting it below unity would clearly help to reduce the error over this period of substantial inflation. However, when all other things are assumed to be unchanged, no other assumption seems to make sense.[28]

Results for Standard Specifications

Assessments of the money demand shift have typically been made using the dynamic out-of-sample error performance for an equation estimated through 1974:2 (or 1973:4) and simulated outside this period. We first examine these errors for three standard specifications:

$$(1)\quad \ln(M/p)_t = \beta_0 + \beta_1 \ln(M/p)_{t-1} + \beta_2 \ln(r_{1t}) + \beta_3 \ln(r_{2t}) + \beta_4 \ln(y_t) + u_{1t} = f_t + u_{1t}$$

$$(2)\quad \ln(M/p)_t = f_t + \beta_5 t + u_{2t}$$

$$(3)\quad \Delta \ln(M/p)_t = \Delta f_t + u_{3t},\ u_{3t} = \Delta u_{2t}$$

where M = the monetary aggregate being considered
p = GNP deflator
r_1 = Treasury bill rate
r_2 = commercial bank passbook savings rate
y = real GNP
t = linear time trend variable
u_{it} = random error for $i = 1,2,3$
f_t = the deterministic portion of equation (1)
Δ = the first-difference operator

Equation (1) is, perhaps, the most common specification of M-1 demand. Equation (2) represents a simple way of modifying this specifica-

[28] The price elasticity has the interpretation, of course, of a partial elasticity, measuring the responsiveness of nominal money holdings to changes in prices with all other variables held fixed. Suppose the following occurs: prices double *but* interest rates remain fixed and everyone engages in the same set of real transactions. Clearly, it takes twice as much nominal money balances in the new situation because the same goods in nominal terms are twice as expensive. However, if the increase in prices is accompanied by higher nominal interest rates, and all other things are not the same, an increase in prices may not be associated with an equal percentage increase in nominal money balances. Such an increase in the nominal rate of interest will not only encourage the usual reaction of economization of money balances for a given set of money management techniques, which is captured in the equation by the β_2 term shown in equation (1), below, but may also encourage an investment in new money management techniques, which is not captured in the standard equation.

tion by adding a time trend to (1), to capture changes in cash management techniques and other financial innovations.[29] As with time trends in productivity equations, there is no fundamental reason to believe that this kind of technological progress will bear a simple functional relationship to time. Indeed, the endogenous aspect of investment in money management techniques is central to our analysis and the evidence suggests that the impact of these developments is irregular and occurs in spurts. Nevertheless, the money demand equations with a time trend provide a useful contrast to the more complex specifications discussed below. Finally, the last specification, equation (3), is obtained simply by taking first differences of equation (2). It was included to evaluate whether the first difference specification restores stability to the standard equation.[30]

In Table 3 out-of-sample error statistics for these three demand specifications are presented for the principal component of the narrow measures (demand deposits), M-1B, and an augmented measure (M-1B plus overnight RPs and overnight Eurodollars). The table also displays F-statistics to test the hypothesis that the coefficients are equal in the two subperiods, 1959:4–74:2 and 1974:3–80:2. Appendix Tables B-1 to B-3 provide more complete information on the regression estimates over various periods and the period-by-period percentage errors, as well as information for several other narrow or augmented aggregates.[31] The summary statistics shown for growth rate errors are of two kinds — annualized quarterly errors and yearly errors, the latter being defined for the six one-year periods beginning in 1974:2–75:2 and ending in 1979:2–80:2.

None of the three measures shown appears to be stable in the sense that cumulative percentage errors (the last column) for all of the aggregates tend to be large and the F-statistics indicate rejection of the null hypothesis of coefficient stability in most cases.[32] As may be seen in Table 3, each of the aggregates generates very large errors in the first year, 1974:2–75:2, averaging about 5.4 percentage points for demand deposits, 4.4 percentage points for M-1B and 4.7 percentage points for augmented M-1B. The pattern of errors thereafter diverges with demand deposits and M-1B continuing to make large negative errors in the next two periods, 1975–76 and 1976–77, before stabilizing in 1977–78; by contrast, errors from the equation for the augmented measure tended to stabilize over the period from 1975:2 to 1978:2.

[29] The Board's MPS equation for demand deposits has had a comparatively weak time trend in it — currently 1.5 percent per year of the level of demand deposits — for some time. See also, Charles Lieberman, "The Transaction Demand for Money and Technological Change," *Review of Economics and Statistics*, Vol. 59, No. 3 (August, 1977), pp. 307–17.

[30] R. W. Hafer and Scott E. Hein, "The Dynamics and Estimation of Short-Run Money Demand," *Federal Reserve Bank of St. Louis Review*, Vol. 62, (March 1980), pp. 25–35.

[31] The other measures considered in these Appendix Tables using specification (1) are currency, M-1A, demand deposits plus other checkable deposits (i.e., M-1B less currency), demand deposits plus .6 times other checkable deposits, demand deposits plus overnight RPs and Eurodollars, and M-1B plus overnight RPs and Eurodollars.

[32] At the 10 percent significance level, all F-statistics indicate rejection. At the 1 percent level, two out of the three specifications for each aggregate are rejected.

Table 3
Post-Sample Errors and Stability Tests of Alternative Standard Money Demand Specifications for Demand Deposits, M-1B, and Augmented M-1B

Aggregate	Specification	F-test	Quarterly errors Mean	Quarterly errors RMSE	Annual errors by 4-quarter periods 74–75	75–76	76–77	77–78	78–79	79–80	Annual errors Mean	Annual errors RMSE	Cumulative percentage error in 80:2
Demand deposits	log-level (1) no time trend	2.36	–4.58	6.31	–8.0	–5.6	–4.2	–1.0	–4.0	–5.9	–4.80	5.25	–31.1
	log-level (2) time trend	3.70	–3.56	5.20	–4.8	–4.4	–4.1	–1.1	–3.6	–4.2	–3.72	3.91	–23.5
	first difference (3)	3.50	–3.13	5.01	–3.3	–3.3	–2.3	–.5	–4.4	–5.8	–3.26	3.65	–20.5
M-1B	log-level (1) no time trend	4.47	–2.56	4.27	–6.6	–3.3	–2.2	.1	–.7	–3.5	–2.70	3.45	–16.3
	log-level (2) time trend	3.62	–1.87	3.48	–4.0	–2.7	–2.6	–.1	–.3	–2.1	–1.97	2.41	–11.7
	first difference (3)	1.86	–1.45	3.15	–2.5	–1.6	–1.2	.2	–.9	–3.1	–1.53	1.88	–9.0
Augmented M-1B	log-level (1) no time trend	7.80	–1.99	4.73	–6.1	–2.0	–.8	.7	.8	–5.2	–2.09	3.41	–12.5
	log-level (2) time trend	4.17	–1.55	4.23	–4.4	–1.7	–1.3	.6	1.3	–4.2	–1.63	2.68	–9.7
	first difference (3)	2.06	–1.29	4.15	–3.5	–1.0	–.1	.9	.7	–5.1	–1.35	2.61	–8.0

NOTE: M-1B augmented equals M-1B + overnight RPs and overnight Eurodollars. Error statistics are based on a dynamic simulation of the demand equation starting in 1974:3. Errors are defined as actual minus predicted; predicted growth rates are defined in terms of the predicted level of the aggregate in the dynamic simulation. Annual growth rate errors are defined for six four-quarter periods starting with 1974:2–75:2 and ending with 1979:2–80:2. The F-test is based on regressions for two subperiods, 1959:4–74:2, 1974:3–80:2, and the entire period, 1959:2–80:2; see Henri Theil, *Principles of Econometrics*, (New York: John Wiley and Sons, 1971), p. 147. The cumulative percentage error equals the level error as a percent of the actual level of deposits.

Finally, in the most recent two-year period, the demand deposit equation continued to overpredict by sizable amounts. The overprediction of the M-1B equation was relatively small in 1978–79, but much larger in 1979–80, while the augmented M-1B equation produced a large positive error in 1978–79, but a very large negative error in 1979–80. Overall, although the cumulative percentage error (or mean error) for the augmented M-1B measure is smaller than that of M-1B itself, its out-of-sample root mean square errors are higher; the best annual root mean square for M-1B is 1.9 percentage points compared with 2.6 percentage points for the augmented M-1B measure.[33]

In the second quarter of 1980 all of the equations for these three aggregates — and indeed for six other combinations presented in Appendix B — registered the largest quarterly increase in the cumulative percentage error of the entire six-year period (Appendix Table B-2), ranging from 4 to 5 percentage points (16 to 20 points at an annual rate). For example, the error for augmented M-1B cumulates from –8.2 percent of the level in 1980:1 to –12.5 percent of the level in 1980:2, an error of 17 percent at an annual rate.[34] Thus the argument that the addition of RPs to M-1B will generally internalize errors produced by demand deposits is not confirmed by the econometric evidence.

Moreover, it is not obvious on *a priori* gounds why an M-1 measure that includes instruments such as RPs would be an improvement. While overnight RPs are potentially good substitutes for demand deposits in terms of liquidity, they are also close substitutes for other market instruments, such as Treasury bills and commercial paper, in terms of yield and maturity. Thus, a definition that includes RPs — and perhaps money market fund shares — would have some built-in stability for shifts out of demand deposits into these very liquid alternatives. However, while such liquid assets may have absorbed much of the funds shifted from demand deposits, the public may not regard them as being very suitable for transactions purposes and thus may not view them as transactions balances. Stated differently, some statistical comparisons may favor an augmented measure of transactions balances — since what was released from demand deposits may have been applied largely to assets such as RPs and money market mutual fund shares — although the public may not view such an augmented combination of assets as its transactions balances. Moreover, such an augmented aggregate is likely to be strongly affected by a different set of forces, the attractiveness of its liquid asset com-

[33] As shown in Appendix B, the inclusion of money market mutual funds shares — added both to M-1B and augmented M-1B — increases the root mean square error but lowers the mean error. However, such equations tend to underpredict growth in these measures in the last two years.

[34] A part of the explanation for this unprecedented shortfall may have been the marginal reserve requirement on managed liabilities (including RPs) established in October 1979 and by further increases in that requirement in March 1980. During the period when the reserve requirement was binding, the offering rate on RPs declined relative to other market rates, reflecting this reserve requirement. Thus part of the explanation for the sharp drop in RPs in the first half of 1980 — down by $8 billion from the fourth quarter 1979 level of $47.6 billion — may be the behavior of the own rate on RPs. Since we have not included an own rate on RPs in the equation, the fall-off is partly expected.

ponents relative to other liquid assets. For example, an increase in investors' aversion to interest rate risk may cause shifts out of Treasury bills and notes into overnight RPs that do not have interest rate risk or a decision by corporations to borrow more heavily in the commercial paper market — causing an increase in the commercial paper rate — may result in a reduction in the amount of RPs demanded. To fully internalize all kinds of shifts — those from demand deposits to liquid assets and those among different liquid assets — one could go to a very broad liquid assets aggregate, such as L. While L has shown no evidence of having undergone a shift like that of M-1, it is for all practical purposes uncontrollable using the conventional instruments of monetary policy.

A Specification Containing Money Management Effects

An alternative approach to an augmented M-1, one that is more consistent with the discussion of the previous section, is to respecify the M-1 equation. For example, if, as we have argued, a determinant of money demand is the profitability of investments in money management techniques, then f in equation (1) is incompletely specified. The discussion suggests that the equation should contain a variable representing the perceived profitability of investments in these techniques.

By including a time trend, we have, of course, already taken a step in this direction by considering a slight departure from the standard specification. We believe, however, that there are more attractive alternatives to specifying changes in money management techniques than through the use of a time trend. As noted above, a time trend assumes that the impact of new money management techniques is distributed uniformly over time and the evidence discussed above demonstrates that sustained shortfalls in money demand still occurred during the mid- and late-1970s, even with the inclusion of a time trend variable. One alternative approach that is more closely related to the perceived opportunity cost of holding demand deposits is the past peak in interest rates or "ratchet" approach.[35]

One justification for using the previous peak in interest rates is that there might be an awareness threshold that is related to interest rate peaks and once the previous peak has been surpassed more attention is drawn to the opportunity cost of holding money balances and to the profitability of investing in new techniques. Or, alternatively, if interest rate peaks imply a higher level of rates in the future than prevailed in the past — as would be the case, for example, if rates followed a random walk — then firms might be willing to undertake investments in new money management techniques that were previously judged unprofitable. In essence, this approach suggests that once a past peak has been surpassed, investments are made in new money management techniques that lead to a more permanent effect on money demand,

[35] See Enzler et al., "Some Problems in Money Demand," and Quick and Paulus, "Financial Innovation."

even after market rates have dropped below the previous peak. That is, once the fixed costs of an investment are borne, it remains in place and is not discarded even though rates have declined.

The relationship between peaks in interest rates and the subsequent impact on cash management, and thereby money demand, may be lengthy and somewhat variable for a number of reasons. If the threshold effects are large, the new investments to be undertaken may be more sizable than otherwise and take a longer time to implement. Such episodes may also spur the development of new technologies, new research and development efforts and the promotion of new practices by the suppliers of cash management services. Bringing the new technology in line — learning by doing — takes time as does recruiting the skilled labor force to operate it. Finally, it takes time before the new technology is diffused throughout the industry. To represent these effects we have used a ratchet variable, s_t, that is somewhat more flexible than the past peak representation.[36]

Let v_t be the relevant opportunity cost for evaluating cash management investments. We define s_t by

$$s_t = \sum_{j=1}^{t} \left(v_j - \frac{1}{n} \sum_{i=j-n+1}^{i=j} v_i\right)^+$$

where $(\ )^+$ denotes the nonnegative values of $(\ )$.[37] That is, s_t is the cumulative sum of t nonnegative terms where each term in the sum is the difference between the current value of v and the n-period moving average of current and past values. If v_i is larger than this average, the positive difference is added to the sum; otherwise it contributes nothing.

Chart 1 plots the time series for the ratchet variable, s_t, and v_t, where v_t is defined as the five-year Treasury bond rate. The chart shows that this ratchet variable moves somewhat closely with the past peak in the federal funds rate and, to a lesser extent, the actual five-year bond rate. In the empirical work, this rate performed somewhat better than a similar flexible ratchet variable using shorter term rates, perhaps reflecting the tendency for cash management investments to be evaluated over a longer horizon than cash flows.[38] Observe from the figure that s_t will ordinarily rise after a peak in the five-year rate is reached.

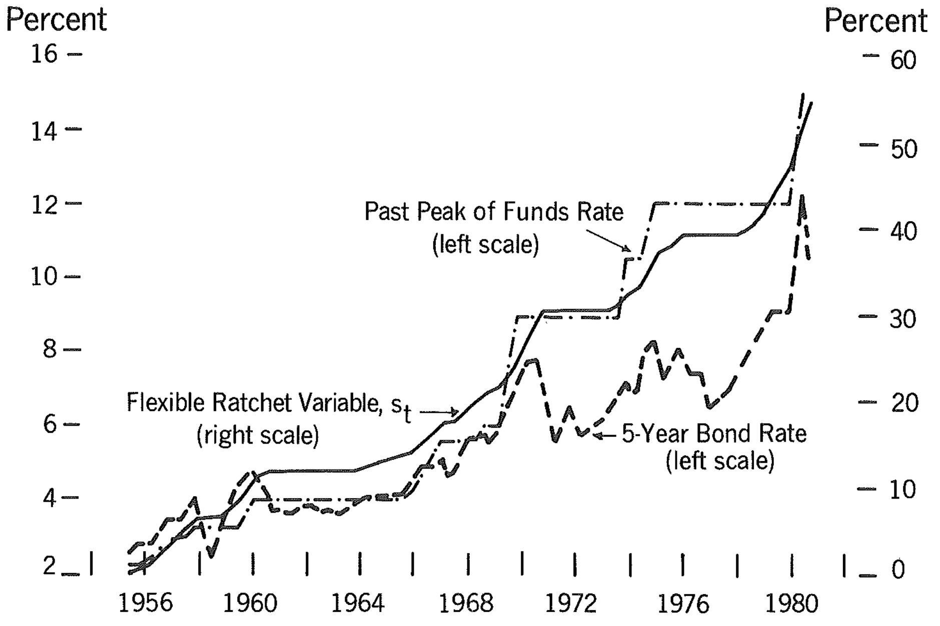
As shown in Appendix A, the long-run interest rate elasticity with cash

[36] A ratchet variable satisfies the property that $s_t \geq s_{t-1}$ for all t.

[37] This nonnegative aspect is, of course, what makes s_t a ratchet variable.

[38] See Milton Friedman, "Time Perspective in the Demand for Money," *Scandinavian Journal of Economics*, 1977, pp. 397–416, for a discussion of the effect of the spectrum of interest rates on cash holdings; and Richard Porter and Eileen Mauskopf, "Cash Management and the Recent Shift in the Demand for Demand Deposits," (Board of Governors of the Federal Reserve System, Division of Research and Statistics, Econometric and Computer Applications Section, November, 1978; processed), pp. 12–15, for a critical assessment of the practical implications of Friedman's results for the demand for money by firms.

Chart 1 **Behavior of Bond Rate, Past Peak of Federal Funds Rate and Flexible Ratchet Variable**



management is greater in absolute value than the short-run elasticity where cash management techniques are held fixed. Moreover, as interest rates rise, more firms find it profitable to begin adopting new money management techniques. Thus in the aggregate the long-run interest rate elasticity should rise (in absolute value) as rates rise.[39] To account for these variable elasticity effects, three simple functional forms for s_t were estimated. Table 4 displays these forms and terms for the corresponding elasticities.[40] In general, we would expect that the elasticity would increase only gradually as rates go up since increases in the elasticity only take place when new firms cross a cash management threshold. If cash management costs fell abruptly or the rates rose sharply, however, the process might be more discrete and less gradual.

One other modification to the ratchet variable, s_t, was also considered which sets s_t at a positive level in the first period. In the calculations reported, we set s_t equal to zero in 1953:1 and cumulate from there. However, in a sense, s_t represents an index of cash management investments and this index of cash management investments may have been positive in 1953:1, so that we should start with an initial endowment, s_e. Thus in some estimates we use $(s_t + s_e)$ instead of s_t, where s_e is a parameter to be determined by the data.

Appendix B presents further details on the regression specifications that include these cash management variables. Essentially, we employed a Shiller distributed lag estimation technique, using a four-quarter lag for the short-term Treasury bill rate, a three-quarter lag for real GNP and a six-quarter lag for the money management ratchet variable; the passbook rate entered the regression contemporaneously.[41] Except for the ratchet variable, a double logarithmic functional form was used with the dependent variable being measured as real balances. Equation (4) lists the equation used:

$$(4) \qquad \ln(M/p) = \beta_o + \sum_{j=o}^{3} \beta_{1j}^{s} r_{1t-j} + \beta_2 r_{2t} + \sum_{j=o}^{2} \beta_{3j} y_{t-j} + \sum_{j=o}^{5} \beta_{4j} g(s_{t-j})$$

where g is one of the functions in Table 4.

[39] See Appendix A for a further discussion of the analytics behind these points.

[40] Without specifying the distribution of the fixed costs of cash management for various-sized firms, the theoretical specification of the aggregate form of this elasticity cannot be determined. The functions estimated were chosen to cover various simple possibilities.

[41] See Appendix B for additional discussion of the interpretation of the passbook rate in these regressions. The discussion, in essence, suggests that the passbook rate may have acted as a proxy for the money management variable.

Table 4
Alternative Specification of the Variable Elasticity of Money Holdings with Respect to the Ratchet Variable

Form	Function	Elasticity*
1. linear	s_t	$c\ s_t$
2. linear times log	$s_t \times \ln(s_t)$	$cs_t(l + \ln(s_t))$
3. power transformation	s_t^λ	$c\lambda s_t^\lambda, \lambda > 0$

* c is the coefficient of the function in the regression. This coefficient will vary substantially in magnitude from one functional form to another.

A comparison of the in-sample properties of the money management money demand specification (Appendix Table B-4) with the standard specification (Appendix Tables B-1 and B-3) for demand deposits, M-1B, and augmented M-1B (M-1B plus overnight RPs and Eurodollars) reveals several differences. First, the standard errors in the two specifications are about the same in the early period (1955:1–74:2), but over the entire period (1955:1–80:2) the money management specification has a considerably smaller standard error than the standard equation. Second, the long-run elasticities for the three-month bill rate and real GNP tend to be much more stable in the money management specification than the standard specification. Although estimates of the money management ratchet parameters tend to vary somewhat more over the two sample periods than the income and bill rate elasticities, Appendix B indicates one sense in which the money management parameter impacts can be viewed as being about the same in the two sample periods.[42] On the other hand, the ratchet variable does increase in significance as the sample period is extended so that it cannot be concluded that the estimated impact of money management on money demand has been pinned down precisely or that the specifications reported here are capable of restoring the properties of M-1 equations to pre-1974 magnitudes.

The overall improvement of the money management specification over the standard specification can also be seen in the post-sample growth rate statistics — mean errors and root mean square errors — that are displayed in Table 5 for the various specifications of the money management variable. For example, the mean error for the best money management specification for demand deposits is about zero, as compared to a mean error of –3.3 percentage points for the best results of standard specifications; the root mean square errors in these two specification are equal. For M-1B, the best money management specification has a lower mean error (–.8 percentage points) com-

[42] See the discussion in the first full paragraph following Appendix Table B-4. The constant elasticity specification is not, however, satisfactory as the sample period is extended over the period of difficulty. Indeed, this variable is always insignificant when added to the linear or log-product specifications.

Table 5
Post-Sample Errors and Stability Tests of Alternative Cash Management — Money Demand Specifications for Demand Deposits, M-1B, and M-1B Augmented

Aggregate	Specification of functional form of the ratchet variable	F-test	Quarterly errors Mean	Quarterly errors RMSE	Annual errors by 4-quarter periods 74–75	75–76	76–77	77–78	78–79	79–80	Annual errors Mean	Annual errors RMSE	Cumulative percentage error in 80:2
Demand Deposits	linear	6.73	−2.73	5.91	−4.4	−5.9	−3.4	.1	−1.4	−2.1	−2.84	3.46	−17.5
	logarithmic (constant elasticity)	13.9	−3.98	6.32	−7.1	−6.2	−3.2	.2	−3.2	−5.4	−4.16	4.81	−26.6
	linear times log (s_e)	5.60	−2.40	5.69	−4.3	−5.6	−3.3	.2	−1.0	−1.0	−2.49	3.22	−15.2
	power transformation (s_e)	3.94	−.05	6.46	−3.6	−3.8	−2.6	1.1	1.7	6.6	−.11	3.68	−.1
M-1B	linear	4.58	−.95	4.44	−2.8	−3.9	−2.1	.9	1.8	.2	−1.00	2.30	−5.7
	logarithmic (constant elasticity)	7.74	−1.78	4.75	−4.9	−4.3	−2.1	1.2	.9	−2.0	−1.86	2.97	−11.0
	linear times log (s_e)	3.86	−.73	4.33	−2.9	−3.6	−2.1	1.0	2.1	1.0	−.76	2.31	−4.3
	power transformation (s_e)	2.58	−.95	4.45	−2.8	−3.9	−2.1	.9	1.8	.2	−1.00	2.31	−5.7
M-1B augmented	linear	4.27	−.61	4.77	−2.9	−3.0	−1.0	1.6	3.4	−1.8	−.63	2.45	−3.7
	logarithmic (constant elasticity)	7.81	−1.06	5.64	−4.0	−3.3	−.9	2.1	2.9	−3.4	−1.09	2.95	−6.4
	linear times log (s_e)	3.36	−.44	4.51	−2.9	−2.8	−1.0	1.6	3.6	−1.2	−.45	2.40	−2.6
	power transformation (s_e)	6.06	−.93	4.96	−3.2	−3.0	−1.0	1.6	2.7	−3.0	−.97	2.55	−5.7

pared to a mean error of −1.9 percentage points for the best of the standard specifications. Furthermore, the best results for M-1B employing the cash management specification are better in terms of mean error and root mean square error than the results for augmented M-1B employing the standard specification.[43,44]

The results discussed above are encouraging, especially in light of the unprecedented departures of the M-1 equation in the mid- and late-1970s. They suggest that longer term considerations involving a higher perceived opportunity cost of holding demand deposit balances lead to downward adjustments in the amount of demand balances held for a given short-term rate of interest and a given amount of aggregate spending. At a minimum, such a cash management variable can provide the observer with a better indication of those periods during which standard specifications are most likely to undergo downward shifts. Moreover, it is possible that further refinements in this variable — perhaps involving the inclusion of the costs of cash management systems, another determinant of the profitability of money management investments — will enhance the predictability of the narrow monetary aggregates. Nevertheless, it is also possible that even with further improvements there will continue to be a greater amount of uncertainty involved in forecasting the public's money demand behavior; this is because departures from standard equations tend to be associated with the investment process — the timing of which is inherently difficult to project — and involves the adoption of some new systems — such as the concentration account — that tend to have lumpy effects on money demand.

III. Implications

A. M-1

The evidence presented in the previous section indicates that certain improvements can be made to the standard specification of the demand for narrow money balances by including a variable representing the profitability of investing in new cash management systems. Nevertheless, there currently is no satisfactory procedure for lowering the presently large amount of uncertainty about the demand for the narrow transactions measure of money or its velocity to levels of the early 1970s. An augmented transactions measure —

[43] The results for the augmented M-1B measure — as well as augmented M-1B plus money market mutual fund shares — also show some improvement. A three-asset model that describes the joint demand for RPs and deposits as an inventory process is set out in Porter and Mauskopf, "Cash Management and the Recent Shift," pp. 45 to 51. In general, the cash management effects would influence both demand deposits and RPs in somewhat similar ways. The equations reported in Appendix Table B-4, however, do not incorporate an own rate for RPs and cannot be used to test the money management hypothesis in a three-asset model.

[44] The novelty of the approach we have adopted to represent cash management effects has three distinct elements: a variable elasticity, a ratchet property, and a long-term rate. We have seen that the assumption of a variable elasticity appears to be an important ingredient in modeling the cash management process. Appendix Table B-7 shows that neither the inclusion of a simple past peak rate in constant elasticity form nor the inclusion of longer term rates in constant elasticity form restores stability to the function.

that adds highly liquid substitutes such as RPs and money market mutual fund shares — may lower drift but this likely would come at the expense of heightened uncertainty about quarter-to-quarter growth, since the behavior of demand deposit substitutes is at times strongly affected by portfolio considerations that can be very difficult to quantify with any precision. Somewhat more promising is the alternative approach of respecifying the money demand relationship to include a variable that reflects the perceived profitability of investing in new cash management techniques, ones that enable the depositor to conduct a given volume of transactions with smaller amounts of narrow money balances. Nevertheless, the results show that the errors based on this improved specification since the mid-1970s tend to be considerably larger than those based on the standard specification before that time.

Consequently, it appears to the authors that a given rate of projected GNP growth will be associated with a wider range of potential rates of growth in M-1. In other words, for a given nominal GNP growth rate objective, historical relationships embodied in an econometric model can be used to provide a point projection for the monetary growth rate and level of interest rates — and thus velocity — that is consistent with this objective. However, surrounding this point projection of monetary growth is a confidence interval, the size of which depends on uncertainty about the public's money demand or velocity behavior.[45] In view of the shifts that have occurred in the velocity of narrow money since the mid-1970s — ones that have not been adequately captured even with modifications to the money demand specification or with augmented measures of money — it seems clear that the confidence interval for M-1 velocity is now much wider than it has been historically. The out-of-sample root mean square error for the annualized rate of change of M-1 velocity, based on standard equations, appears to have roughly doubled from the early 1970s to more recently.

One method of dealing with this added uncertainty is to establish ranges for M-1 growth that are wider than would be the case if there were less uncertainty.[46] A possible control procedure would be to adjust actual money

[45] More precisely, since the shifts in M-1 demand discussed earlier have all been in the downward direction and the analysis suggests that further downward shifts are likely to occur, the widening of the confidence interval stems from a drop in its lower end. In other words, it is now more likely that a given rate of GNP growth will be associated with M-1 growth that is below the point projection given by standard models.

[46] It is assumed here that the wider range reflects the greater likelihood that a given rate of growth of GNP will be associated with slower growth in M-1 than was the case in earlier times, before pronounced downward shifts occurred in money demand. Consequently, the wider range results mainly from a decline in the lower end of a confidence interval having equal probability tails. Since the probability distribution of outcomes for M-1 growth is likely to be more asymmetric because of potential downward shifts in money demand, the mid-point of the range — between the upper and lower end — will tend to differ from the mean of the probability distribution by more; the mean of the probability distribution represents the rate of growth that can be expected to minimize losses with a quadratic loss function. While there is a case for focusing more on the mean of the probability distribution, under most circumstances the mean and the mid-point will tend to be near each other and we choose, for simplicity, to conduct the discussion in terms of the mid-point of the range. Alternatively, even with an asymmetric probability distribution one could construct a confidence interval having a midpoint that equals the mean of the probability distribution if one is willing to accept unequal tail probabilities.

growth within this wider range during the policy period — say, fourth quarter to fourth quarter — in response to incoming information. For example, if incoming information suggested that economic activity and interest rates were behaving as expected but money growth was weak, it might be inferred that some upward drift in velocity—or downward drift in money demand—was occurring and thus that monetary growth in the lower portion of the target range is most consistent with the GNP objective. In other words, it might be inferred that "effective" money growth — after adjusting for estimated downward drift in money demand — was outpacing actual or measured growth and that no adjustment was necessary, even though actual money growth was near the lower end of the range. Indeed, simulations of money demand based on a generally accepted money demand model and the best available information on the "right-hand side" variables — output, prices, and interest rates — could be used to make estimations of effective monetary growth and determine the extent to which actual monetary growth could fall short of the mid-point of the range. The extent to which desired actual money growth might fall short of the mid-point of the range would thus depend on the estimated shortfall of actual from effective money growth. In the event that complete confidence were attached to the model-based estimate of effective money growth, the adjusted target for money growth could equal the mid-point of the range less the difference between effective and actual monetary growth. However, in practice the usefulness of such a procedure of adjusting monetary growth targets is limited by uncertainty about the specification of the money demand equation and the reliability of early estimates and projections of the right-hand side variables. Nevertheless, with more uncertainty about money demand behavior, the potential shortfall of actual from effective money growth would tend to be greater, suggesting a wider range.

If monetary growth ranges are not sufficiently wide to reflect the enhanced uncertainty of M-1 velocity, then target ranges may require occasional adjustments. For example, if it becomes highly certain that a sizable downward shift in money demand is occurring — one much larger than allowed for by the lower end of the range — the entire range could be adjusted downward by an appropriate amount. Frequent adjustments to the range, however, may cause confusion and could erode the credibility of the monetary authority.

Instead of following such a flexible approach, one could argue that it is inappropriate to establish wider ranges or to adjust monetary growth targets to reflect evidence that a shift in money demand is occurring and that efforts should be directed to hitting the mid-point of a fairly narrow range, regardless of what incoming information suggests. One might justify such a position on grounds that missing the mid-point of the announced range damages credibility, or that preliminary data and standard money demand models can give highly misleading signals, or that any acceleration in effective monetary growth can be absorbed by the private sector with only minimal difficulty. However, if one accepts the proposition that further downward shifts in M-1 demand can be expected to occur, ones that are largely unpredictable, then monetary policy would tend to be more expansionary and GNP growth more variable than suggested by historical experience, if targeted ranges were not adjusted accordingly. If a rigid policy of hitting the mid-point were pursued during those periods when shifts occur, effective monetary growth would tend to exceed the mid-point of the range and GNP growth would tend to exceed expectations. If the private sector is capable of quickly identifying and adjusting to such enlarged variability of effective money growth during these periods, then output would be little affected and the greater variability of GNP growth would be reflected in a more variable inflation rate. However, if the private sector is slow to recognize the increase in effective money growth and is not able to make necessary adjustments readily, then output growth would tend to be more variable than if actual monetary growth were more flexibly adjusted to reflect shifts.

B. M-2 and M-3

In view of the difficulties associated with the narrow measures of money, more attention could be focused on the broader measures — M-2 and M-3. M-2 contains very liquid alternatives to transactions balances — money market mutual fund shares and overnight RPs and Eurodollars — along with savings and small-denomination time deposits. The M-3 measure also contains term RPs and large-denomination time deposits.

It was noted earlier that M-2 behavior in recent years seems to have been closer to that forecast on the basis of historical experience than for the narrower measures — both in terms of registering very little drift and smaller quarter-to-quarter forecast errors — although the sources of its satisfactory performance are not completely evident. The discussion of previous sections demonstrates that the addition of RPs and money market mutual fund shares to an M-1 measure seems to offset some of the downward drift in the demand deposit component. Consequently, some of this drift in the demand deposit component was mirrored in growth of these components of M-2. However, lowered drift in the demand deposit plus money market mutual fund shares and overnight RPs and Eurodollars component of M-2 comes at the expense of larger quarter-to-quarter forecast errors. Thus, on balance, it appears that the relatively favorable performance of M-2 in recent years is attributable more to the savings and small-denomination time deposit component of this aggregate than to the money market mutual fund share and overnight RP and Eurodollar components.[47]

The changing character of the interest-earning component of M-2, however, has added to uncertainty about the response of this aggregate to changes in market rates. A growing proportion of this aggregate has yields

[47] See David J. Bennett et al., "Econometric Properties of the Redefined Monetary Aggregates," pp. 26 to 28.

that vary with market rates — especially money market mutual fund shares and time deposits in the form of money market certificates and small saver certificates. Moreover, interest rate ceilings on all savings and small time accounts are scheduled to be phased out by 1986. Consequently, the relationship between this measure and market interest rates is changing, as a given change in market rates can be expected to have somewhat less effect now on growth in this measure than in earlier times. Ultimately, the nontransactions component of M-2 might be highly insensitive to changes in market rates because own and competing rates likely will move closely together, leaving the differential largely unchanged. Meanwhile, though, reliable elasticity estimates may be difficult to establish. Experience thus far in 1980 would tend to confirm this point. Growth in the non-M-1B portion of the M-2 measure has been about in line with that suggested by historical evidence, even though the fraction of this aggregate accounted for by money market mutual fund shares, money market and small saver certificates, and overnight RPs and Eurodollars had grown to nearly one-third of total M-2 by mid-year. One could conclude from this episode that the interest elasticity of M-2 has not declined by as much as one might have expected or that the behavior of M-2 can at times be influenced by unpredictable shifts in portfolio composition among M-2 and non-M-2 assets.

Nevertheless, the M-2 aggregate has a relatively close relationship with income and is likely to internalize much of the deposit shifts that are expected to accompany nationwide NOW accounts scheduled for the end of 1980. Based on NOW account experience in the Northeast, it is apparent that the public will open new NOW accounts by transferring funds not only from demand deposit accounts but also from savings deposits and other liquid assets. Thus M-1A growth can be expected to fall below the underlying rate of growth of transactions balances while growth in M-1B will tend to overstate such growth. Moreover, in this environment there is likely to be a great deal of uncertainty for a while about the rate at which households will shift to NOW accounts and the corresponding effects on the growth rates of M-1A and M-1B. By contrast, growth in M-2 is likely to be virtually unaffected by the introduction of nationwide NOW accounts, as the accompanying portfolio shifts are likely to affect only its composition.

M-3 might also have some advantages over the narrower measures, especially in an environment of uncertainty regarding shifts in transactions balance demands. However, because its term RP and large-denomination time deposit components play a prominent role in the managed liabilities strategies of commercial banks and thirft institutions, this measure is likely to be more heavily influenced than M-2 by credit demands and the costs of other managed liabilities, such as Eurodollar borrowing. Perhaps reflecting these complications, the demand for the M-3 measure has generally been more difficult to predict than the demands for the narrow measures and M-2.[48]

[48] Ibid., pp. 28 to 30.

C. Control Procedures

With heightened uncertainty about the behavior of the narrow transactions measures of money, there are certain advantages to control procedures that allow more flexibility to adjust monetary growth rates to reflect money demand shifts as they emerge. A set of operating procedures that places primary emphasis on stabilizing short-term interest rates over short periods of time — with adjustments occurring in response to cumulative departures of actual from targeted money growth — would, in comparison with one that produces more steady month-to-month growth in money, tend to provide more opportunity to evaluate incoming information to determine whether departures represent money demand shifts. In other words, in those instances when shifts in money demand occur, effective money growth rises above actual money growth and, if control procedures produce steady month-to-month growth in actual M-1 balances, money market rates would tend to drop, imparting unanticipated stimulus to the economy. Once it is recognized that effective money growth has advanced above target, there may be a desire to return effective growth to the target range by adjusting policy instruments to lower actual growth by the appropriate amount, which might require that money market rates rise above their initial levels, at least for a while. By contrast, with a control procedure that involves relatively slow adjustment of the federal funds rate — and implicitly other money market rates — more opportunity would exist to observe incoming information to determine whether it is desirable for actual money growth to slow. Thus by steadying interest rates when shifts do occur, effective monetary growth would tend to be stabilized and interest rate variability, of course, would be damped. However, when shifts do not occur, this control procedure would tend to add to month-to-month variability in both effective and actual monetary growth and perhaps output and prices.

Consequently, a control procedure that produces relatively steady growth in money in the short run has important advantages when there are disturbances in markets for goods and services, while one that tends to produce more stability in interest rates in the short run has important advantages when there are disturbances to the monetary sector, especially money demand.[49] For example, if economic activity were to weaken unexpectedly at a time when money demand behaved as expected, there would be a tendency for monetary growth rates — both actual and effective — to slow and market rates to soften. A reserve targeting procedure would essentially enable interest rates to fall as efforts were undertaken to return money growth to target. The decline in rates, in turn, would tend to stimulate spending and return GNP growth toward the GNP objective. If, by contrast, the federal

[49] The discussion here parallels the analysis of the choice of an intermediate target of monetary policy. See William Poole, "Optimal Choice of Monetary Policy in a Simple Stochastic Macro Model," *Quarterly Journal of Economics*, Vol. 84 (May 1970), pp. 197–216, and Stephen F. LeRoy and David E. Lindsey, "Determining the Monetary Instrument: A Diagrammatic Exposition," *American Economic Review*, Vol. 68 (December 1978), pp. 929–34.

funds rate were stabilized, this partially corrective decline in rates would be postponed and, if postponed long enough, GNP growth might fall below the objective. Conversely, if, as noted above, the decline in money market rates were the result of a downward shift in money demand, a control procedure that quickly returned actual growth in money to the target range would tend to add to effective monetary growth and could lead to more monetary stimulus than desired, especially if it took a long time to recognize this development and make the appropriate adjustment in actual money growth. However, actual monetary growth would immediately slacken with a control procedure that stabilized money market rates. Indeed, actual money growth would tend to slow by roughly enough to keep effective money growth about unchanged.

The relative merits of alternative control procedures depend importantly on whether there is more near-term uncertainty about the behavior of money demand or about aggregate demands for and supplies of goods. The above discussion suggests that, all else the same, a control procedure that tends in the short run to stabilize money market rates could be preferable to one that yields close short-run control over actual monetary growth during times when there is heightened uncertainty about money demand behavior. However, such a procedure would tend to add to the variability of actual and effective monetary growth during those periods when money demand behaves as expected. Moreover, some of the conditions that have been associated with unpredictable shifts in money demand — particularly high and variable interest and inflation rates — have also been associated with heightened uncertainty about economic activity and inflation expectations. Consequently, in such an environment the precision of any control procedure is weakened.

APPENDIX A
Cash Management and the Demand for Money by Firms

This appendix has three parts. Part I presents an analysis of the demand for money with endogenous cash management under the assumption that all cash management costs are variable. Part II considers two variations of the model presented in Part I. The first allows for some fixed costs of cash management; the second also treats the case where the benefit from cash mangement is based on both current period expenditures and the stock of accumulated cash management "capital." The last section, Part III, examines actual cash management practices in the United States with reference to the analytical discussion in sections I and II.

I. Demand for Money with Endogenous Cash Management: Variable Costs of Cash Management

The classical inventory model of the demand for money by firms posits that firms minimize the sum of opportunity costs (foregone interest) and transaction costs when the day-to-day cash flow (cash inflows less outflows) is uncertain.[50] Transactions costs arise through the exchange of deposits for interest-bearing liquid assets that are alternatives to deposits. The firm is assumed to follow a simple inventory rule of adjusting its cash position by exchanging deposits for the liquid asset when the deposit balance reaches a predetermined ceiling or by selling the liquid asset when the deposit balance hits a predetermined floor. Following the exchange, deposits are always restored to the same level under this rule. If transactions costs are independent of the size of the transaction and daily net cash flows are independent over time with mean zero, the Miller-Orr cube root expresion for average demand deposits is [51]:

$$(A-1)\ M = k(\sigma^2 b/r)^{1/3}$$

where M = nominal demand deposits balances
σ^2 = the variance of daily cash (stochastic) flows
b = the nominal transaction cost
r = the opportunity cost of holding cash
$k = (4/3)(3/4)^{1/3} = 1.21$

The equation can be expressed in real terms by dividing both sides of (A−1) by the price level p,

$$(A-2)\ M/p = k(\bar{\sigma}^2\bar{b}/\bar{r})^{1/3}$$

where bars over variables denote real variables. The equation predicts that as the scale of a firm's operation increases as, say, indexed by the real standard deviation ($\bar{\sigma}$) of net cash flows, the firm will be able to avail itself of scale economies; optimal money balances increase by 2/3 of the percentage increases in σ. The interest elasticity of the demand for real cash balances is −1/3 and the elasticity with respect to the real brokerage fee ($\bar{b}$) is 1/3.

In the Miller-Orr model, daily fluctuations in the firm's cash position are assumed to be exogenous. However, many of the developments in the cash management field suggest that firms are able to adopt new techniques that enable them to lower the perceived or actual variance of their cash flow.

Increased certainty about net cash flow is achieved through purchasing information about actual cash flow or through the use of various procedures to restructure receipts and payments.

[50] While part of the variability in the net cash flow may be predictable, we can treat the entire variability as being stochastic and assume that the firm has already made the proper response to the predictable portion. Essentially, funds needed to cover predictable outflows can be invested to mature when such outflows are scheduled to occur, provided that the returns exceed transaction costs; also, on the receipts side, predictable inflows can be placed in advance by making a forward commitment.

[51] Merton Miller and Daniel Orr, " A Model of the Demand for Money by Firms," *Quarterly Journal of Economics*, Vol. 80, 1966, pp. 413–435, and Daniel Orr, *Cash Management and the Demand for Money*, New York: Praeger, 1969.

To incorporate this possibility into the Miller-Orr model we assume that by buying λ units of cash management services, the firm reduces the variance of its net cash flows from σ^2 to $g(\lambda)\,\sigma^2$.[52] Chart 1 provides a particular illustration of the assumed shape of the function g (λ).[53,54]

If we impose a specific form on $g(\lambda)$ such as

$$(A-3)\quad g(\lambda) = \frac{1}{1+\lambda}$$

and assume that the cost of purchasing λ units of cash management services is λe, then optimal cash holdings follow a fourth-root rule

$$(A-4)\quad M = K(\sigma^2 be/r^2)^{1/4}$$

where

$$k = (4/3)(9/8)^{1/4} = 1.373.$$

Thus with endogenous cash management, the transaction elasticity becomes 1/2 rather than 2/3, and the interest elasticity is $-1/2$ rather than $-1/3$. Changes in the cost of cash management will also affect demand for deposits under this more general formulation. Advances in computer technology, in cash management software, in cash management research, in telecommunications and wire transfers, will lower the cost (e) of reducing uncertainty, thereby lowering optimal money balances.

The decline in scale and brokerage fee elasticity and the increase in the interest rate elasticity — as compared with the classical Miller-Orr model — are independent of the specific form of $g(\lambda)$. We show this below.

With endogenous cash management, the expected cost function is given by

$$(A-5)\qquad C = \frac{\theta g(\lambda)}{z(h-z)} + \frac{r(h+z)}{3} + \lambda e = c_1 + c_2 + c_3$$

where

$\theta = \sigma^2 b$
h = ceiling on cash balances
z = return point for the cash balance; that is, once the ceiling (h) or floor of zero balances is encountered, the cash balance is restored to z (by selling or purchasing the interest-bearing asset).

[52] More generally, g may be indexed on σ and b. To simplify notation we ignore such complications, but they may be important in aggregating the model.

[53] The function g is assumed to have the following properties:

$$(a-1)\quad g(0) = 1$$
$$(a-2)\quad g'(\lambda) < 0$$
$$(a-3)\quad g''(\lambda) > 0$$

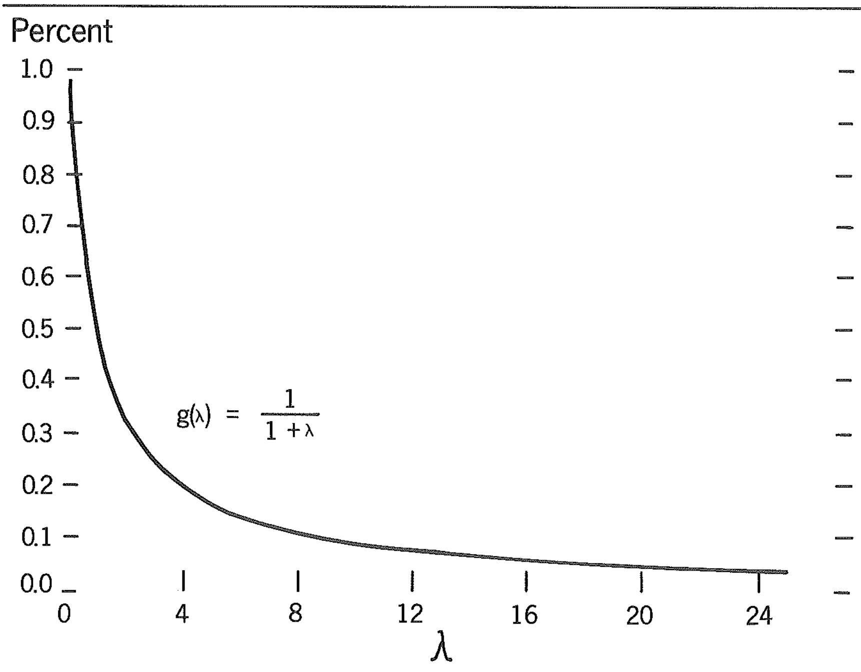
Thus g is a convex function. The second-order conditions for a minimum require, in addition, that

$$(a-4)\quad 3g(\lambda)g''(\lambda) > 2(g'(\lambda))^2$$

at the optimum level for λ. This last condition puts a super convexity condition on g. For example, if $\ln g(\lambda)$ is convex, (a-4) is satisfied.

[54] Cash management purchases which reduce the effective brokerage fee have the same effect analytically and can be considered as part of the same process.

Chart 2 An Illustration of the Function g(λ)



c_1 represents the product of the brokerage fee, b, with the probability of having to incur a transaction,

$$\frac{\sigma^2 g(\lambda).}{z(h-z)}$$

The second term, c_2, is the product of the opportunity cost of holding cash, r, with the expected average cash balances,

$$\frac{h+z.}{3}$$

The last term, c_3, represents the cash management costs which equal the number of units, cash management services purchased, λ, times the price per unit, e.

The inventory problem is to minimize expected costs; that is, to minimize $C = C(z,h,\lambda)$ with respect to the three arguments z, h, and λ. If we let $Z = z-h$, or $h = z+Z$, an equivalent statement of the problem is to minimize $C = C(z,Z,\lambda)$. The first-order conditions for a minimum are:

$$\text{(A-6)} \quad \frac{\partial C}{\partial z} = 0 => \frac{\theta g(\lambda)}{z^2 Z} = \frac{2r}{3}$$

$$\text{(A-7)} \quad \frac{\partial C}{\partial Z} = 0 => \frac{\theta g(\lambda)}{z Z^2} = \frac{1r}{3}$$

$$\text{(A-8)} \quad \frac{\partial C}{\partial \lambda} = 0 => \frac{-\theta g'(\lambda)}{zZ} = e$$

From the ratio of (A–6) and (A–7),

$$\text{(A-9)} \quad Z = 2z$$

Substituting (A–9) into (A–8) and taking the ratio of the resulting equation to (A–6) gives

$$\text{(A-10)} \quad -z\frac{g'(\lambda)}{g(\lambda)} = \frac{3}{2}\frac{e}{r} .$$

Substituting (A–9) into (A–6) gives

$$\text{(A-11)} \quad z^3 = \frac{3\theta g(\lambda)}{4r} .$$

The properties of the model can be determined from (A–10) and (A–11).

At the optimum, $h = 3z$ so that money balances are

$$\text{(A-12)} \quad M = \frac{h+z}{3} = \frac{4}{3} z.$$

Thus the elasticites of M with respect to r, σ, e, or b are the same as the elasticities of z with respect to these arguments.The earlier assertion that the interest elasticity of money demand with endogenous cash management is greater in absolute value than its value without cash management requires our showing that

$$\text{(A-13)} \quad \frac{\partial \ln(z)}{\partial \ln(r)} < -\frac{1}{3} .$$

From (A-11)

$$\text{(A-14)} \quad \frac{\partial \ln(z)}{\partial \ln(r)} = -\frac{1}{3} + \frac{1}{3}\frac{\partial \ln(g(\lambda))}{\partial \ln(r)}$$

$$= -\frac{1}{3} + \frac{1}{3}\frac{\partial \ln(g)\lambda))}{\partial \lambda}\frac{\partial \lambda}{\partial \ln(r)}$$

$$= -\frac{1}{3} + \frac{1}{3}\frac{g'(\lambda)}{g(\lambda)}\frac{\partial \lambda}{\partial \ln(r)} .$$

Since $g'(\lambda)<0$ and $g(\lambda)>0$ the sign of the second term on the right-hand side of (A-14) will be less than 0 if

$$\frac{\partial \lambda}{\partial \ln(r)} > 0 .$$

Substituting for z from (A-10) into (A-11), and taking logs of the resulting equation, confirms that the latter term is greater than zero.

The elasticity results referred to in the text for σ and b also follow immediately.

II. Fixed Costs of Cash Management

To include fixed costs of cash management in the model we may assume that the purchase of λ units of cash management services costs $e\lambda + \bar{e}$, where $\bar{e}$ represents the fixed costs prorated over the appropriate period of time. If it is optimal to purchase some cash management service, then

$$\text{(A-17)} \quad C(z^{cm}, h^{cm},\lambda^{cm}) \leq C(z^n,h^n,o),$$

where the superscript cm denotes the optimal value of the variable when λ is free to vary, and the superscript n denotes the optimal value when no cash management services are purchased, that is, when $\lambda = 0$. Apart from this additional constraint qualification, everything in part I goes through.

The interesting results, of course, concern the relationship of $\bar{e}$ to r, θ and e. It is intuitively clear than an increase in the interest rate, r, will provide incentives for the firm to buy cash management services at higher fixed costs, $\bar{e}$. For example, if $g(\lambda) = 1/(1+\lambda)$, the break-even point is the value of $\bar{e}$ that makes (A-18) an exact equality:[55]

$$\text{(A-18)} \quad \bar{e} \leq 1.817(\theta r^2)^{1/3} - 2.746(\theta e r^2)^{1/4} + e$$

Appendix Chart 2 plots the breakeven point as a function of r for various values of θ under the assumption that $e = 1$.

We can also generalize the model by viewing the firm as purchasing both variable cash management services, λ, and adding to its stock of cash management capital, k:

$$\text{(A-19)} \quad k = k_0 + i,$$

where i denotes the investment and k_0 denotes the initial stock. In general, k is an abstract con-

[55] If this inequality is satisfied, it will pay to purchase cash management services. Equation (A-18) is derived from (A-17). The constants in this expression are approximate, not exact.

cept involving both human and nonhuman elements. Cash management output is then

$$g = g(\lambda,k),$$

where

$$g(o,o) = 1$$
$$g_1 = \frac{\partial g}{\partial \lambda} < 0$$

$$g_2 = \frac{\partial \lambda}{\partial k} < 0$$

and g is a convex function of λ and k. The previous analysis in part I can be viewed as a special case of this model in which k was fixed. The cost function in this more general case is then

$$C(h,z,\lambda,i) = \frac{\theta g(\lambda i+k_0)}{z(h-z)} + \frac{r(h+z)}{3} + \lambda e_1 + ie_2 + \bar{e}$$

where e_1 denotes the unit price of cash management services and $e_2 i + \bar{e}$ denotes the total cost of i, that is, fixed plus variable costs. The analysis for this somewhat more general case proceeds much the same way as before.

III. A Brief Interpretation of Actual Cash Management Practices

A number of popular cash management techniques can be interpreted readily in the context of the model developed above. Included among these techniques are lock boxes, controlled disbursement, information retrieval systems, and improved forecasting techniques. Most of these techniques have both fixed and variable costs. Fixed costs include changes in business operations, the recruitment of specialized personnel, the retraining of existing personnel, the allocation of office space, and the acquisition of specialized electronic equipment such as computers and telecommunications equipment. Correspondingly, variable costs include wages and salaries, per item charges levied by banks (for lock box items or wire transfers), equipment maintenance, and so forth.

Most of the techniques that have been adopted by firms appear to have been directed at lowering uncertainty about day-to-day cash flows. In the context of the formal model, they are aimed at lowering σ^2. Lock boxes can be used to lower uncertainty about the schedule under which items are collected, in addition to generally speeding up collection. For example, the precision of projections of daily collected demand deposit balances can be improved by sorting lock box items on the basis of the location of the bank on which they are drawn and the size of the check, with special handling given to large checks for speedier presentment and collection. Consequently, the firm can more reliably predict the interday pattern of its collections over the next several business days. Controlled disbursement reduces intraday uncertainty about collected balances—in addition to slowing down disbursements—by enabling the firm to know early each day the volume of checks presented against its account. This certainty gain is achieved because the bank used for disbursements typically receives one cash letter each day, usually early in the day. By contrast, when a firm uses a money center bank for disbursements, there is more intraday uncertainty about clearings, as money center banks ordinarily obtain cash letters throughout the day.[56] Information retrieval systems—using electronic telecommunications equipment—permit firms to regularly monitor deposit balances at the firm's many banks throughout the country. This information can be used within the day to modify projections of end-of-day balances. All of these techniques, along with advanced model-based forecasting procedures, greatly assist in

[56] The use of payable-through drafts has many similarities to controlled disbursement. In particular, the firm need not keep balances in its demand deposit account with its payable-through bank; instead, each day it usually funds those items being presented against its account, following notification.

determining the amount of deposit balances that are going to be available for investment each day and the appropriate maturity of such investments. In this way, the cash manager can enter the market early in the day, when more short-term investment opportunities are available and terms tend to be most favorable.

Reductions in certain transactions costs ($\bar{b}$) also appear to have influenced cash management practices, as suggested by the above theory. Some qualitative evidence based on interviews suggests that the cost of investing in large RP lots has tended to decline, in real terms, as a fixed charge per transaction has generally supplanted an *ad valorem* fee. Also, the true cost of making wire transfers apparently has declined—as accessibility has improved and the use of wire transfers has become more widespread—and this has enhanced the ability of cash managers to move funds among accounts and make investments in immediately available funds.

Another important cash management practice, one that embodies many of the techniques discussed above, is the cash concentration account. With a cash concentration account, a firm is able to pool the variability of its many local and regional accounts by transferring funds—using the wire or depository transfer checks—into or out of these accounts to its concentration bank in response to inflows to or outflows from individual accounts. By such pooling, the firm is able to take advantage of disturbances to individual accounts that tend to be offsetting in the aggregate and to make a single (larger) investment from its concentration account. Optimal demand deposit balances under a cash concentration account arrangement can often be substantially below those that would be maintained by managing each individual account separately.[57] Consequently, adoption of a cash concentration system tends to be associated with a substantial reduction in the firm's aggregate demand deposit balances, and the widespread application of cash concentration accounts by firms likely has led to lumpy effects on the money stock.

[57] To illustrate the possibilities, suppose that the consolidation costs are zero. Then, even when net cash flows into individual accounts are perfectly correlated, consolidating the accounts into one cash concentration account reduces the optimal cash balance; see Mauskopf and Porter, "Cash Management and the Mid-Seventies Shift in the Demand for Demand Deposits in the U.S.," forthcoming in *Proceedings of Rome Conference on Monetary and Financial Models*, (Editions ECONOMICA, Paris).

APPENDIX B
Additional Empirical Results and Discussion

List of Tables

Appendix Table Number	Title	Page
B-1	Estimates of Equation (1) for M-1B, Its Components and Various Augmented Measures.	44–45
B-2	Cumulative Error and Other Summary Statistics from a Dynamic Simulation of Equation (1) for M–1B, Its Components and Various Augmented Measures	46–47
B-3	Estimates of Equations (2) and (3) and Selected Variants for Demand Deposits, M–1A, M–1B and Augmented M–1B	48–56
B-4	Estimates of Equation (4) for Demand Deposits, M–1B and Augmented M–1B: the Linear, Logarithmic and Linear Times Logarithmic Specifications	57–58
B-5	Estimates of Equation (4) for Demand Deposits, M–1B and Augmented M–1B: the Power Transformation Specification	59–61
B-6	Estimates of Alternatives to Equation (4) Containing the Past Peak in the Federal Funds Rate of Long-Term Rates	62–63
B-7	Post-Sample Errors and Stability Tests for Equations Containing the Past Peak in the Federal Funds Rate of Long-Term Rates	64
B-8	Estimates for Augmented Measures Containing Money Market Mutual Fund Shares (MMMFs)	65–66
B-9	Post-Sample Errors and Stability Tests for Augmented Measures Containing Money Market Mutual Funds Shares (MMMFs)	67

This appendix presents estimates of various equations that were referred to in the text. All simulation results described in the text are based on *dynamic out-of-sample* simulations of these equations. Before examining the results, a few brief comments on the econometric procedure are in order. The regressions containing a lagged dependent variable were all estimated with a first-order Cochran-Orcutt autocorrelation correction.[58] The F-tests reported in the text used to test the equality of coefficients across various periods should be regarded as asymptotic tests because of the presence of the lagged dependent variable. Since the standard errors in the two subperiods appear to be quite different — with the second period standard error much larger than that of the first — this test should, in principle, also be corrected for heteroskedasticity.[59] However, attempts of others to make such corrections have generally not reversed any conclusions and, thus, we have not made any here. Finally, the degrees of freedom correction used in all of the Shiller distributed lag estimates and associated F-tests developed are based on the formula by Paulus.[60,61]

[58] Some comparisons were made using an alternative Hildreth-Lu procedure and the results, in all cases, were very close in terms of post-sample simulations. While the Hildreth-Lu technique has some decided asymptotic advantages to Cochran-Orcutt for the lagged dependent variable specifications, it was decided to use the faster Cochran-Orcutt technique to update results for standard money demand equations. For the money management specification discussed in the text, there is no lagged dependent variable so this problem does not occur.

[59] See Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," *Journal of the American Statistical Association*, Vol. 57, 1962, pp. 348-68.

[60] Robert J. Shiller, "A Distributed Lag Estimator Derived from Smoothness Priors," *Econometrica*, Vol. 41, July 1973, pp. 78-88.

[61] See John D. Paulus, "Demand Analysis and Stochastic Prior Information," Board of Governors of the Federal Reserve System Division of Research and Statistics, Special Studies Paper No. 32, February, 1973; processed; pp. 36-8.

Table B-1

Appendix Table B-1 displays estimates of equation (1) for M-1B and four of its components — M-1A, currency, demand deposits, and demand deposits plus other checkable deposits, the last measure being the difference between M-1B and currency. Also shown are estimates for four augmented aggregates: (1) demand deposits plus .6 times other checkable deposits,[62] (2) demand deposits plus overnight RPs plus overnight Eurodollars, (3) augmented M-1B consisting of M-1B plus overnight RPs and overnight Eurodollars and (4) augmented M-1B plus term RPs. Over the early period, 1959:4–74:2, the estimates generally are in agreement with the theoretical predictions of the transactions model. For example, the long-run elasticity of demand deposits with respect to overall short-term interest rates, the sum of the passbook and bill rate elasticities, is –.19. The long-run transaction elasticity of demand deposits is .51, indicating substantial scale economies in transactions. These attractive properties, however, disappear when the estimates are extended through 1980:2 as the lagged dependent variable rises to the vicinity of unity for all measures except currency and augmented M-1B. Thus the estimated equation for these measures suggests no simple interpretation over the long-sample period other than that there has been a shift in the equation.

Table B-3

Table B-3 shows estimates of equations (2) and (3) over three periods, 1959:4–74:2, 1974:3–80:2 and 1959:4–80:2, for four measures, demand deposits, M-1A, M-1B, and augmented M-1B. In addition to these equations, three other variants are shown: a first difference equation without a time trend, that is, the equation obtained by taking the first difference of equation (1); a log-level equation which contains a split time trend, one trend for the early period, 1959:4–74:2, and another trend for the later period; and the first difference equation with "split time trends," that is, dummy variables for each subperiod.[63] The columns headed by T_1 and T_2 contain the estimates of the split time trend for both the log-level and first difference specification.

Comparing the estimates in Table B-3 with those in Table B-1 for the same aggregate, we see that the addition of the time trend terms eliminates the most undesirable feature of the estimates in Table B-1, namely the tendency for the lagged dependent variable to rise to unity or greater when the sample is extended to 1980:2. Nonetheless, there is clear cut evidence that neither the addition of the time trend variables nor the introduction of the first-difference procedures resolves very much of the recent problem with the standard specifications.

At first glance the estimates from the first-difference specification seem to be more robust than the log-level specification. There is less tendency for the lagged dependent variable to rise sharply when the sample period is extended to 1980:2. For example, the lagged dependent variable rises from .76 to .97 in the log-level specification for demand deposits, but stays in the .5 to .6 range for the first-difference estimates. However, the F-tests reported in the lowest panel of the table indicate the first difference estimates are all unstable, except for the one equation without an intercept ("no time trend") for all four measures and the one with an intercept for M-1B.

However, inspection of these "stable" estimates and their $\bar{R}^2$'s for 1959:4–74:2 versus 1974:3–80:2 is at odds with impressions given by other statistics. For example, the $\bar{R}^2$ for M-1A in the first-difference equation without an intercept drops significantly and the bill rate takes on the wrong sign in the latter period. Although the F-test for the significance of the overall regression is large enough to indicate that the coefficients are nonzero, the hypothesis that the interest rate and income coefficients have doubled (or halved) is easily accepted. Thus the recorded stability in the equation appears to be associated solely with the stability of the lagged dependent variable, not income and interest rates.

The evidence from the regressions with the split time trends — one for 1959:4–74:2 and a different trend for 1974:3–80:2 — indicates that the time trend has increased sharply (in absolute value) in the post–74:2 period. For demand deposits, the first difference specification indi-

[62] This measure represents the approximate proportion of NOW and ATS accounts which have been estimated to have come initially from demand deposits.

[63] For simplicity, we refer to the dummy variable terms in the first-difference equation as the split time trend. Implicitly, we are thinking of the trend in the integrated (or levels) transformation of this equation.

cates that the annual rate of reduction in demand deposit holdings is 3.32 percentage points per year in the latter period, compared with 1.12 percent in the early period. The comparable figures for M-1A are 2.24 percentage points and .68 percentage points, respectively, and for M-1B 1.60 percentage points and .64 percentage points.

Digression on the Passbook Rate

Before discussing the estimates of the money management specifications, it is helpful to examine more closely one variable that likely has been a proxy for investments in money management techniques in the standard specification, the passbook rate on regular savings accounts at commercial banks. A previous Board staff study using the Demand Deposit Ownership Survey (DDOS) concluded that the passbook elasticity estimates derived from equations for aggregate demand deposits were much higher than might be justified by the disaggregated equations.[64] In this regard, it is noteworthy that the passbook rate appears to be highly correlated with the ratchet variable, s_t, with a simple correlation over .9 in each of the periods 1959:4–74:3 and 1974:3–80:2. Since large increases in the passbook rate (changes in ceiling) have generally come at times when there were large increases in market rates and therefore in the ratchet variable, the passbook rate may have acted as a proxy for cash management activities in the standard equation. This correlation would explain the anomaly of the size of the passbook elasticity between the disaggregated and aggregated estimates.

More recently, the use of the passbook rate in the standard equation can be criticized on the grounds that many households have now substituted money market funds for passbook accounts as their primary buffer for demand deposits.[65] To address both these passbook-rate issues, we have run estimated equations using the money management specification in three different ways:

(1) with a passbook rate
(2) with no passbook rate
(3) with the rate being defined as the maximum of the passbook rate and the average rate paid on money market mutual fund shares.

Table B-4

Table B-4 displays summary regression estimates of the money management specification for two variable elasticity functional forms — the linear and the linear times log — and one constant elasticity specification. As indicated in the text, a Shiller distributed lag estimation scheme of three quarters, four quarters and six quarters, was employed to estimate the impact on real money balances of real GNP, the three-month bill rate and the ratchet variable, respectively. In each Shiller estimate, a first-degree polynomial lag was chosen. The prior distribution on the degree was set to unity (k = 1) for all distributed lags except that on the cash management variable where the prior was set to four (k = 4). The results reported here use the specification in which the "passbook rate" represents the maximum of the rate paid on money market fund shares and the passbook rate.[66]

The regressions reported in Table B-4 provide reasonable support for the notion that the ratchet variable enters significantly if a variable elasticity specification is used, that is, the results for the linear and the linear times log functional forms for s_t agree with the theory. The ratchet variable for these regressions rose in significance as the period of estimation was extended beyond 1974:2 but its long-run coefficient tended to stabilize rather quickly.[67] The specification using the constant elasticity was definitely inferior to either of the variable elasticity specifications; it generally had the wrong sign as the estimates were extended beyond 1974:2. Indeed, an

[64] Helen T. Farr, Richard D. Porter and Eleanor M. Pruitt, "Demand Deposit Ownership Survey," in *Improving the Monetary Aggregates: Staff Papers*, (Federal Reserve Board, 1979), p. 99. The implied aggregate elasticity was obtained by multiplying the share of deposits of the sector which held savings balances in the period of the study — households — by the disaggregated passbook elasticity.

[65] See, for example, Richard D. Porter et al, "Financial Innovation," pp. 219-24.

[66] Results for the other two specifications — no passbook rate or the actual passbook rate — are not terribly different. In general, the cash management terms are more significant, as might be expected, when the passbook rate is excluded from the equation.

[67] The results for these intermediate sample periods — beginning in 1955:1 and ending after 1974:2 but before 1980:2 — are not shown.

F-test (or t-test) of the hypothesis that the constant elasticity ratchet term should enter as an additional variable in either specification (linear or linear times log) indicates that it should not.

Of the two variable elasticity estimates shown in Table B-4, those for the linear times log specification appear to be more stable over the two sample periods shown. For example, the long-run elasticity of M-1B with respect to the bill rate and real output changes only from –.027 to –.026, and from .53 to .51, respectively, as the sample period is extended. The passbook elasticity, on the other hand, falls sharply from –.039 to –.008. If, as we have suggested, the passbook rate is, in part, a proxy for the cash management effects, this effect may be offset by the estimated increase in the ratchet term. In absolute value, this coefficient increases from .0007 in the early period to .0011 in the later period — corresponding to an average elasticity of –.020 for such cash management effects in the early period compared to –.058 for the entire period. The combined ratchet and passbook elasticity in the early period is thus –.059 compared to –.066 in the later period. Consequently, if we average across these two terms, the equation has remarkably stable elasticities for the bill rate, real GNP and the "cash management impacts" for both the early period and the entire period.

Table B-5

Appendix Table B-5 presents the individual regression coefficients for the remaining money management specification which uses the power transformation. The optimum values of λ reported in this table for 1955:1–74:2 were obtained by searching over a grid of values of λ to find the minimum of the standard error of the regression. Oddly enough, slightly different estimates are obtained if the minimum of the error sum of squares is chosen as the criterion. The mystery is cleared up when it is recognized that the degrees of freedom in the Shiller regression depend on λ.[68] However, as may be seen in Chart 3 for demand deposits these different estimating procedures tend to be very similar estimates of λ. The likelihood function, though, is essentially flat so that λ is very poorly determined by the data.

This raises difficult problems for this model because the value of λ has a direct bearing on the mean error and the root mean square error of the post-sample growth rates. Chart 4 plots the mean growth rate errors for demand deposits against λ. Except for the little dip in the function between 4 and 5, the chart shows that the mean error tends to go from a large negative value to large positive values as λ increases from 0 to 6, with a zero error appearing at about $\lambda = 3$. The quarterly and annual root mean squares, plotted in Chart 5, show that the minimum root mean square errors for both measures reach a minimum at about $\lambda = 2$.

Tables B-6 and B-7

These tables show the summary estimation and post-sample properties, respectively, of modified demand equations for demand deposits, M-1B and augmented M-1B. The modification to equation 4 is accomplished by replacing the ratchet term g(s), with either a past peak rate (the federal funds rate) or a long-term rate (a 5-year or 10-year government bond rate). All rates enter the equation in logarithmic form. The results indicate that all of these variations are inferior to the specifications containing a variable elasticity ratchet term.[69]

Tables B-8 and B-9

These tables display the summary estimation of post-sample simulation properties of equations (1), (2), and (3) for augmented measures containing money market mutual fund shares

[68] The minimum error sum of squares corresponds to the maximum likelihood estimation while the minimum standard error corresponds to the method-of-moments estimator.

[69] Several detailed comments by William White of the International Monetary Fund have prompted us to consider a much wider set of regression and simulation results as a basis for comparing and contrasting the standard specification with our money management alternative. These additional results involve: (1) the use of Koyck (geometric) distributed lags in the money management specification and a Shiller distributed lag distribution in the standard specification; (2) the use of a nonconstant elasticity five-year bond rate without a ratchet transformation and with a past peak ratchet transformation. The results of these further comparisons, which are reported in a forthcoming Board staff study, do not change the basic character of the results discussed in this paper. The additional results do suggest, however, that the flexible ratchet only modestly improves upon the past peak ratchet.

(MMMFs). Like the standard equations used to evaluate augmented M-1B, these equations make no attempt to incorporate appropriate own-rate effects for MMMFs (or RPs) into the equation. The results indicate that the addition of MMMFs to M-1B or to augmented M-1B do not resolve the M-1 problem. Although the mean errors are somewhat smaller than the standard specification, the root mean square errors are worse. Moreover, the pattern of the annual errors (reported in the middle of Table B-9) strongly suggests that the improved mean errors of this aggregate compared to the standard specification for M-1B is coincidental. Other evidence concerning the volume of turnover on MMMF accounts indicates that these accounts resemble passbook savings accounts not demand deposit accounts.[70]

[70] For a discussion of this point, see Richard D. Porter and others, "Financial Innovation," p. 223. Recent evidence on account turnover is consistent with the evidence discussed in this reference.

Chart 3 **Standard Error and Sum of Squares for Demand Deposits as a Function of λ**

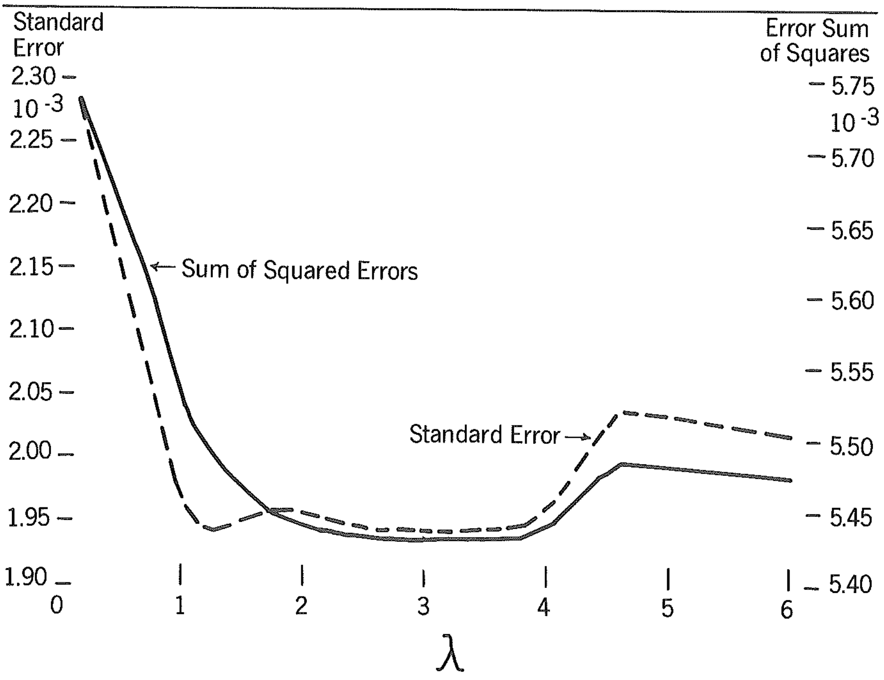


Chart 4 Mean Errors for Demand Deposits as a Function of λ

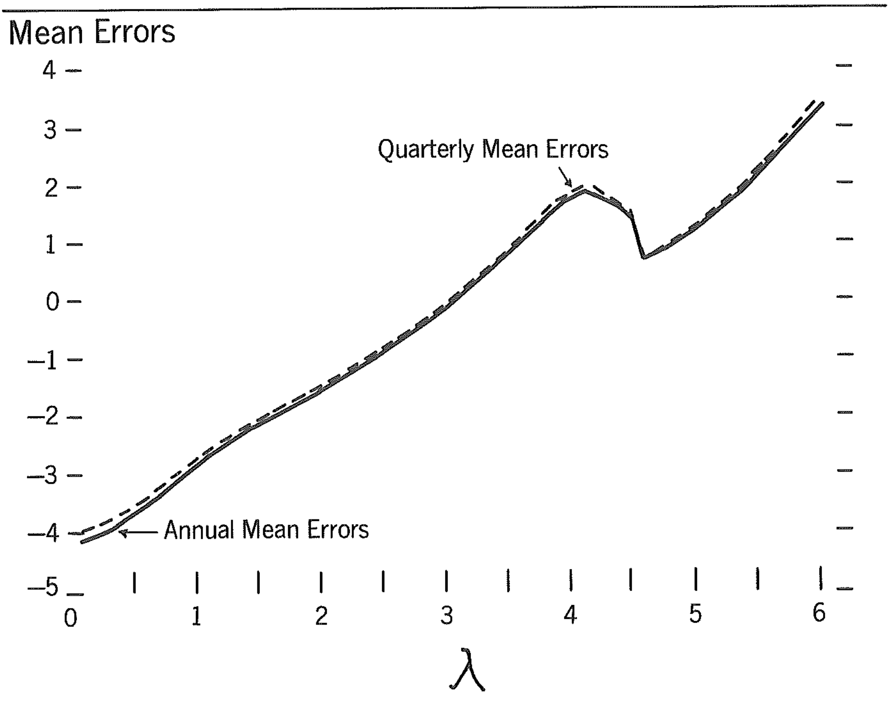
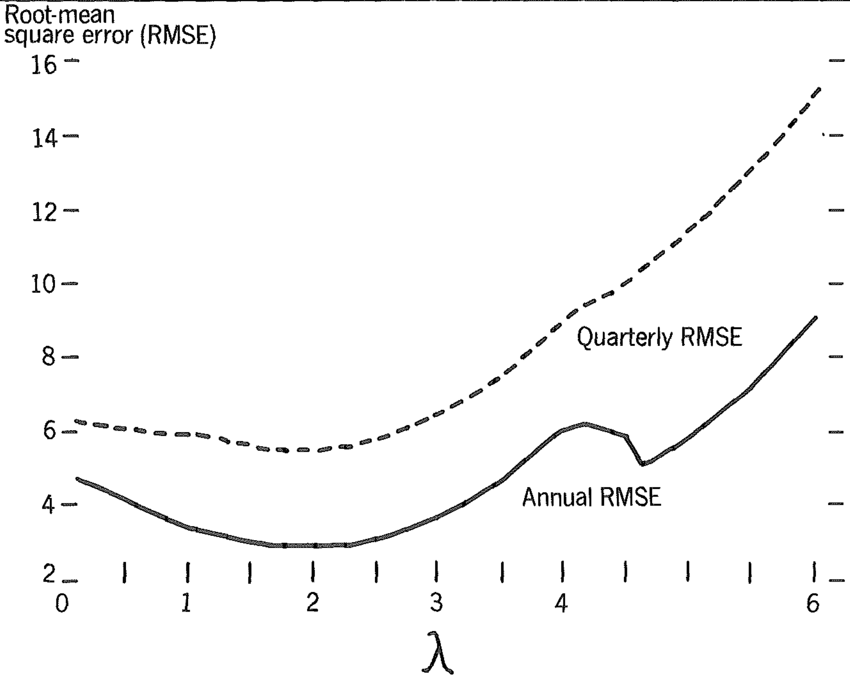


Chart 5 RMSE's for Demand Deposits as a Function of λ



Appendix Table B-1
Estimates of Equation (1) for M-1B, Its Components and Various Augmented Measures

	Constant	Real GNP	Treasury Bill Rate	Commercial Bank Pass-book Rate	Lagged Dependent Variable	$\bar{R}^2$	Standard Error of Regression	RHO	DW
M-1A									
1959:4 to 74:2	.788	.161	-.020	-.018	.660	.992	.0049	.52	1.58
	(1.93)	(3.31)	(-3.59)	(-1.05)	(5.15)				
1959:4 to 80:2	-.383	.020	-.023	-.003	1.05	.982	.0064	.36	1.71
	(-2.28)	(1.18)	(-4.93)	(-.18)	(36.45)				
M-1B									
1959:4 to 74:2	.795	.162	-.020	-.018	.657	.992	.0049	.52	1.58
	(1.95)	(3.34)	(-3.58)	(-1.06)	(5.13)				
1959:4 to 80:2	-.314	.028	-.022	-.007	1.03	.983	.0062	.42	1.72
	(-1.63)	(1.59)	(-4.52)	(-.46)	(28.27)				
Currency									
1959:4 to 74:2	-.101	.180	-.004	.001	.709	.999	.0037	.37	2.01
	(-1.31)	(4.00)	(-1.02)	(.13)	(10.50)				
1959:4 to 80:2	-.177	.217	(-.007)	-.001	.666	.999	.0038	.43	1.99
	(-2.53)	(5.44)	(-2.41)	(-.14)	(11.42)				
Demand Deposits									
1959:4 to 74:2	.441	.116	-.026	-.017	.772	.982	.0058	.51	1.66
	(1.05)	(2.92)	(-4.12)	(-.86)	(6.43)				
1959:4 to 80:2	-.500	.037	-.027	-.011	1.06	.981	.0076	.32	1.70
	(-2.85)	(1.88)	(-5.13)	(-.60)	(44.47)				
Demand Deposits plus Other Checkable									
1959:4 to 74:2	.449	.117	-.026	-.017	.769	.982	.0058	.50	1.65

1959:4 to 80:2	-.451	.043	-.026	-.015	1.04	.974	.0073	.39	1.71
	(-2.28)	(2.15)	(-4.78)	(-.85)	(34.91)				
Demand Deposits plus 0.6* (Other Checkable)									
1959:4 to 74:2	.446	.117	-.026	-.017	.770	.982	.0058	.50	1.65
	(1.06)	(2.94)	(-4.12)	(-.87)	(6.41)				
1959:4 to 80:2	-.475	.040	-.027	-.013	1.05	.977	.0074	.36	1.71
	(-2.54)	(2.06)	(-4.98)	(-.75)	(38.88)				
Demand deposits + Overnight RPs + Overnight Eurodollars									
1959:4 to 74:2	.577	.155	-.022	-.025	.695	.988	.0055	.41	1.71
	(1.70)	(3.92)	(-3.93)	(-1.51)	(6.48)				
1959:4 to 80:2	-.635	.041	-.031	-.015	1.08	.963	.0088	.26	1.66
	(-3.09)	(1.97)	(-5.31)	(-.80)	(30.34)				
Augmented M-1B: M-1B + Overnight RPs + Overnight Eurodollars									
1959:4 to 74:2	.852	.201	-.016	-.026	.599	.995	.0046	.42	1.66
	(2.66)	(4.35)	(-3.42)	(-1.76)	(5.42)				
1959:4 to 80:2	-.203	.043	-.021	-.015	.992	.985	.0071	.45	1.65
	(-.77)	(1.72)	(-3.61)	(-.75)	(16.00)				
Augmented M-1B + Term RPs									
1959:4 to 74:2	.491	.181	-.016	-.025	.691	.995	.0046	.34	1.85
	(2.16)	(4.59)	(-3.59)	(-1.88)	(8.22)				
1959:4 to 80:2	1.03	.200	-.003	-.059	.572	.990	.0073	.81	1.51
	(2.47)	(3.96)	(-.416)	(-1.83)	(4.97)				

Appendix Table B-2
Cumulative Error and Other Summary Statistics from a Dynamic Simulation of Equation (1) for M-1B, Its Components and Various Augmented Measures* (Percent)

	M-1A	M-1B	Currency	Demand Deposits	Demand Deposits plus Other Checkable	Demand Deposits plus 0.6*×(Other Checkable)	Demand Deposits plus Overnight RPs plus Net Eurodollars	Augmented M-1B: M-1B plus Overnight RPs plus Net Eurodollars	Augmented M-1B plus Term RPs
1974:3	-1.5	-1.5	-.72	-1.5	-1.5	-1.5	-1.5	-1.4	-.9
4	-3.4	-3.4	-.81	-3.7	-3.7	-3.7	-4.2	-3.4	-2.9
1975:1	-5.7	-5.6	-.70	-6.7	-6.6	-6.7	-7.4	-5.6	-5.3
2	-6.4	-6.3	-.22	-7.8	-7.7	-7.7	-7.9	-5.9	-5.1
3	-7.1	-6.9	.01	-8.7	-8.5	-8.6	-8.5	-6.2	-5.2
4	-8.8	-8.5	.04	-11.0	-10.7	-10.8	-10.6	-7.7	-6.4
1976:1	-9.6	-9.2	.60	-12.4	-11.9	-12.1	-11.7	-8.3	-6.8
2	-10.1	-9.6	1.5	-13.6	-13.0	-13.2	-11.7	-7.8	-5.8
3	-11.2	-10.5	1.8	-15.5	-14.6	-15.0	-12.7	-8.2	-5.8
4	-11.7	-10.9	1.7	-16.5	-15.3	-15.8	-13.2	-8.4	-6.0
1977:1	-11.9	-11.0	1.4	-16.8	-15.5	-16.0	-13.3	-8.4	-6.0
2	-12.9	-11.8	.88	-18.2	-16.7	-17.3	-13.6	-8.6	-5.8
3	-13.0	-11.9	1.3	-18.8	-17.2	-17.9	-13.6	-8.3	-5.2
4	-12.7	-11.4	1.7	-18.7	-16.9	-17.6	-12.9	-7.6	-4.3

1978:1	-12.4	-11.1	2.0	-18.5	-16.6	-17.4	-12.6	-7.2	-3.8
2	-13.2	-11.8	1.0	-19.3	-17.2	-18.1	-13.3	-7.9	-4.3
3	-13.4	-11.9	.93	-19.5	-17.3	-18.2	-13.4	-7.9	-4.2
4	-14.2	-12.1	.92	-20.6	-17.6	-18.8	-13.8	-7.8	-3.7
1979:1	-16.5	-13.1	.41	-23.8	-18.8	-20.7	-16.0	-8.4	-4.0
2	-16.8	-12.5	.04	-24.0	-17.7	-20.1	-15.1	-7.1	-2.2
3	-16.8	-12.0	.37	-24.0	-17.1	-19.7	-15.1	-6.6	-1.5
4	-17.3	-12.4	.23	-24.6	-17.5	-20.2	-16.5	-7.5	-2.8
1980:1	-18.0	-12.8	-.13	-25.3	-17.7	-20.6	-17.6	-8.2	-4.1
2	-22.2	-16.3	-.68	-31.2	-22.3	-25.7	-24.7	-12.5	-8.5
F-statistics	3.09	4.47	1.38	2.36	3.35	2.83	4.49	7.80	6.28
RMSE	4.86	4.27	1.86	6.31	5.49	5.75	6.71	4.73	5.09
Mean error	-3.39	-2.56	-.12	-4.58	-3.41	-3.87	-3.72	-1.99	-1.36

* The simulated equation for each aggregate was the one estimated over the period 1959:4 to 74:2. The cumulative error in the predicted level is expressed as a percent of the actual level. The RMSE and mean errors are based on the difference between the actual and predicted annualized growth rate of the series; the predicted growth rate is defined from the predicted level path from the equation.

Appendix Table B-3
Estimates of Equation (2) and (3) and Selected Variants for Demand Deposits, M-1A, M-1B, and Augmented M-1B

Aggregate	Period of Fit	Specification	Constant or Time Trend	T_1	T_2	Intercept for Levels Regressions	Treasury Bill Rate	Commercial Bank Passbook Rate	Real GNP	Lagged Dependent Variable	$\bar{R}^2$	Standard Error	RHO	DW
Demand Deposits														
	1959:4–74:2	levels	–.0013			–.438	–.029	–.014	.256	.764	.984	.0055	.36	1.73
			(–2.99)			(–1.02)	(–5.49)	(–.89)	(4.00)	(7.04)				
	1974:3–80:3	levels	–.0100			–.944	–.008	–.125	.739	.330	.958	.0083	.37	1.59
			(–3.96)			(–.71)	(–.68)	(–.54)	(4.26)	(1.46)				
	1959:4–80:2	levels	–.0016			–1.27	–.031	–.001	.219	.973	.984	.0069	.19	1.72
			(–4.34)			(–5.65)	(–7.22)	(–.10)	(4.89)	(36.35)				
	1959:4–74:2	first diff.	–.0011				–.019	–.044	.236	.588	.394	.0064		1.83
			(–.87)				(–2.45)	(–1.49)	(2.13)	(4.50)				

1974:3–80:2	first diff.	–.0125				.003	–.010	.695	.056	.491	.0090		1.69
		(–3.92)				(.14)	(–.05)	(3.66)	(.25)				
1959:4–80:2	first diff.	–.0041				–.013	–.034	.428	.527	.474	.0077		1.72
		(–3.31)				(–1.68)	(–.99)	(4.28)	(4.90)				
1959:4–74:2	first diff.					–.019	–.050	.169	.603	.396	.0064		1.79
						(–2.44)	(–1.76)	(2.13)	(4.66)				
1974:3–80:2	first diff.					.002	–.204	.257	.705	.126	.0118		1.54
						(.10)	(–.72)	(1.27)	(3.44)				
1959:4–80:2	first diff.					–.012	–.062	.205	.667	.408	.0082		1.64
						(–1.50)	(–1.75)	(2.61)	(6.36)				
1959:4–80:2	levels		–.0014	–.0015	–1.03	–.031	–.002	.209	.940	.984	.0069	.16	1.71
			(–3.54)	(–4.12)	(–3.51)	(–7.43)	(–.17)	(4.74)	(23.87)				
1959:4–80:2	first diff.		–.0028	–.0083		–.010	–.050	.450	.378	.512	.0075		1.69
			(–2.12)	(–4.17)		(–1.28)	(–1.47)	(4.66)	(3.19)				

Appendix Table B-3 (cont'd)
Estimates of Equation (2) and (3) and Selected Variants for Demand Deposits
M-1A, M-1B and Augmented M-1B

Aggregate	Period of Fit	Specification	Constant or Time Trend	T_1	T_2	Intercept for Levels Regressions	Treasury Bill Rate	Commercial Bank Passbook Rate	Real GNP	Lagged Dependent Variable	$\bar{R}^2$	Standard Error	RHO	DW
M-1A														
	1959:4–74:2	levels	–.0010			–.060	–.023	–.013	.252	.707	.993	.0047	.37	1.71
			(–2.74)			(–.14)	(–4.83)	(–.90)	(4.12)	(6.00)				
	1974:3–80:3	levels	–.0067			–.365	–.011	–.072	.604	.380	.918	.0065	.31	1.63
			(–3.97)			(–.32)	(–1.16)	(–.39)	(4.43)	(1.85)				
	1959:4–80:2	levels	–.0014			–1.03	–.026	.004	.199	.953	.986	.0057	.22	1.73
			(–4.74)			(–5.56)	(–7.17)	(.34)	(4.96)	(31.33)				
	1959:4–74:2	first diff.	–.0006				–.014	–.042	.209	.575	.395	.0055		1.78
			(–.53)				(–2.07)	(–1.64)	(2.18)	(4.38)				

1974:3-80:2	first diff.	-.0082				.001	.008	.559	.139	.524	.0072		1.76
		(-3.63)				(.04)	(-.05)	(3.69)	(.65)				
1959:4-80:2	first diff.	-.0029				-.010	-.033	.363	.509	.487	.0063		1.72
		(-2.93)				(-1.49)	(-1.18)	(4.43)	(4.81)				
1959:4-74:2	first diff.					-.014	-.045	.175	.578	.403	.0055		1.75
						(-2.06)	(-1.85)	(2.46)	(4.44)				
1974:3-80:2	first diff.					.002	-.134	.242	.621	.234	.0092		1.52
						(.12)	(-.62)	(1.54)	(2.95)				
1959:4-80:2	first diff.					-.009	-.054	.207	.598	.437	.0066		1.60
						(-1.27)	(-1.89)	(3.18)	(5.63)				
1959:4-80:2	levels		-.0012	-.0013	-.760	-.026	.002	.193	.909	.986	.0057	.19	1.72
			(-3.65)	(-4.37)	(-2.87)	(-7.35)	(.18)	(4.98)	(20.34)				
1959:4-80:2	first diff.		-.0017	-.0056		-.007	-.045	.374	.399	.513	.0061		1.70
			(-1.62)	(-3.67)		(-1.15)	(-1.60)	(4.69)	(3.51)				

Appendix Table B-3 (cont'd)
Estimates of Equation (2) and (3) and Selected Variants for Demand Deposits
M-1A, M-1B and Augmented M-1B

Aggregate	Period of Fit	Specification	Constant or Time Trend	T_1	T_2	Intercept for Levels Regressions	Treasury Bill Rate	Commercial Bank Passbook Rate	Real GNP	Lagged Dependent Variable	$\bar{R}^2$	Standard Error	RHO	DW
M-1B														
	1959:4–74:2	levels	–.0010			–.052	–.023	–.013	.252	.705	.993	.0047	.37	1.71
			(–2.73)			(–.12)	(–4.81)	(–.91)	(4.13)	(5.98)				
	1974:3–80:2	levels	–.0047			.436	.001	–.059	.499	.339	.824	.0057	.27	1.55
			(–3.63)			(.41)	(.08)	(–.40)	(4.62)	(1.86)				
	1959:4–80:2	levels	–.0016			–.954	–.024	–.001	.229	.902	.987	.0054	.29	1.72
			(–5.02)			(–5.06)	(–6.39)	(–.05)	(5.37)	(23.77)				
	1959:4–74:2	first diff.	–.0006				–.014	–.042	.210	.575	.395	.0055		1.78
			(–.53)				(–2.06)	(–1.65)	(2.20)	(4.38)				

1974:3–80:2	first diff.	−.0058				.004	.028	.482	.209	.549	.0066		1.76
		(−3.10)				(.31)	(.18)	(3.62)	(1.05)				
1959:4–80:2	first diff.	−.0024				−.008	−.037	.350	.487	.480	.0060		1.72
		(−2.65)				(−1.36)	(−1.40)	(4.58)	(4.61)				
1959:4–74:2	first diff.					−.014	−.046	.176	.577	.403	.0055		1.75
						(−2.05)	(−1.86)	(2.48)	(4.43)				
1974:3–80:2	first diff.					.005	−.140	.262	.527	.354	.0079		1.52
						(.33)	(−.77)	(1.93)	(2.57)				
1959:4–80:2	first diff.					−.007	−.055	.223	.546	.411	.0062		1.59
						(−1.14)	(−2.07)	(3.62)	(5.09)				
1959:4–80:2	levels		−.0012	−.0014	−.415	−.022	−.005	.231	.798	.987	.0053	.24	1.71
			(−3.77)	(−4.78)	(−1.40)	(−6.23)	(−.462)	(5.80)	(13.26)				
1959:4–80:2	first diff.		−.0016	−.0040		−.007	−.045	.350	.432	.490	.0059		1.70
			(−1.55)	(−2.95)		(−1.16)	(−1.66)	(4.63)	(3.92)				

Appendix Table B-3 (cont'd)
Estimates of Equation (2) and (3) and Selected Variants for Demand Deposits
M-1A, M-1B and Augmented M-1B

Augmented Measure	Period of Fit	Specification	Constant or Time Trend	T_1	T_2	Intercept for Levels Regressions	Treasury Bill Rate	Commercial Bank Passbook Rate	Real GNP	Lagged Dependent Variable	$\bar{R}^2$	Standard Error	RHO	DW
Augmented M-1B														
	1959:4–74:2	levels	-.0006			.107	-.020	-.019	.233	.699	.995	.0045	.31	1.79
			(-1.91)			(.24)	(-4.35)	(-1.42)	(4.70)	(6.50)				
	1974:3–80:3	levels	-.0043			-.648	.0046	-.144	.599	.429	.900	.0076	.31	1.54
			(-2.67)			(-.52)	(.35)	(-.74)	(4.24)	(2.25)				
	1959:4–80:2	levels	-.0016			-.982	-.024	-.012	.279	.847	.989	.0061	.25	1.66
			(-5.47)			(-4.68)	(-5.66)	(-.94)	(6.01)	(16.25)				
	1959:4–74:2	first diff.	-.0002				-.011	-.043	.206	.540	.365	.0055		1.84
			(-.22)				(-1.58)	(-1.69)	(2.19)	(4.03)				

1974:3–80:2 first diff.	-.0049				.012	-.073	.538	.297	.532	.0087		1.69
	(-2.18)				(.71)	(-.34)	(3.13)	(1.34)				
1959:4–80:2 first diff.	-.0024				-.003	-.043	.395	.457	.463	.0067		1.69
	(-2.42)				(-.42)	(-1.44)	(4.69)	(4.07)				
1959:4–74:2 first diff.					-.011	-.044	.193	.539	.376	.0054		1.82
					(-1.58)	(-1.83)	(2.68)	(4.06)				
1974:3–80:2 first diff.					.015	-.246	.356	.456	.445	.0094		1.47
					(.81)	(-1.13)	(2.18)	(2.01)				
1959:4–80:2 first diff.					-.0012	-.062	.274	.484	.430	.0069		1.53
					(-.17)	(-2.08)	(3.92)	(4.14)				
1959:4–80:2 levels		-.0012	-.0014	-.341	-.020	-.022	.284	.722	.989	.0060	.24	1.62
		(-3.36)	(-4.45)	(-.90)	(-4.54)	(-1.63)	(6.27)	(8.91)				
1959:4–80:2 first diff.		-.0016	-.0038		-.002	-.049	.390	.425	.468	.0066		1.68
		(-1.41)	(-2.60)		(-.28)	(-1.63)	(4.64)	(3.66)				

Appendix Table B-3 (cont'd)
F-Tests and Post-Sample Errors from a Dynamic Simulation (All errors are *quarterly* errors at percentage annual rates)

	Equation (2)			Equation (3)			First difference equation without constant		
Aggregate	F-test	mean error	RMSE	F-test	mean error	RMSE	F-test	mean error	RMSE
Demand Deposits	3.70	-3.56	5.20	3.50	-3.13	5.01	1.04	-3.73	5.54
M-1A	3.59	-2.70	4.03	2.67	-2.27	3.82	.72	-2.59	4.10
M-1B	3.62	-1.87	3.48	1.86	-1.45	3.15	.89	-1.77	3.38
Augmented M-1B	4.17	-1.55	4.23	2.06	-1.29	4.15	1.84	-1.42	4.24

Appendix Table B-4
Estimates of Equation (4) for Demand Deposits, M-1B and Augmented M-1B:
The Linear, Logarithmic and Linear Times Logarithmic Specifications

Aggregate	Period of Fit	Specification of Ratchet Variable	Constant	Real GNP	Passbook rate	Treasury Bill rate	Ratchet Variable	$\bar{R}^2$	Standard Error	RHO	D-W
Demand Deposits	1955:1-74:2	linear	1.96 (4.78)	.493 (7.65)	-.046 (-2.30)	-.028 (-1.96)	.0038 (-3.31)	.985	.0055	.90	1.32
	1955:1-80:2	linear	2.50 (2.59)	.409 (3.45)	-.007 (-.95)	-.013 (-.89)	-.0078 (-4.47)	.982	.0068	.99	1.30
	1955:1-74:2	logarithmic (constant elasticity)	2.51 (10.54)	.413 (10.75)	-.038 (-1.74)	-.050 (-3.86)	-.0226 (-1.92)	.984	.0058	.85	1.21
	1955:1-80:2	logarithmic (constant elasticity)	-1.19 (-.93)	.784 (5.20)	-.014 (-1.78)	-.042 (-2.58)	.0133 (.03)	.975	.0081	.99	1.03
	1955:1-74:2	linear times log	1.85 -(4.45)	.506 (7.82)	(-.044 (-2.15)	-.030 (-2.40)	-.0010 (-3.30)	.985	.0054	.91	1.32
	1955:1-80:2	linear times log	2.20 (3.09)	.448 (4.55)	-.0010 (-1.27)	-.027 (-2.03)	-.0018 (-5.67)	.983	.0067	.99	1.31
M-1B	1955:1-74:2	linear	2.01 (5.66)	.517 (9.29)	-.041 (-2.37)	-.026 (-2.13)	-.0028 (-2.87)	.993	.0046	.92	1.37
	1955:1-80:2	linear	2.12 (5.18)	.494 (8.04)	-.006 (-1.14)	-.018 (1.49)	-.0047 (-5.16)	.989	.0053	.96	1.32
	1955:1-74:2	logarithmic (constant elasticity)	2.40 (14.00)	.464 (16.81)	-.043 (-2.48)	-.044 (-4.28)	-.0182 (-2.17)	.993	.0047	.80	1.26

Appendix Table B-4 (cont'd)
Estimates of Equation (4) for Demand Deposits, M-1B and Augmented M-1B:
The Linear, Logarithmic and Linear Times Logarithmic Specifications

Aggregate	Period of Fit	Specification of Ratchet Variable	Constant	Real GNP	Passbook rate	Treasury Bill rate	Ratchet Variable	$\bar{R}^2$	Standard Error	RHO	D-W
	1955:1–80:2	logarithmic (constant elasticity)	.97	.611	–.012	–.030	–.0095	.986	.0059	.99	1.20
			(1.11)	(5.63)	(–2.00)	(–2.55)	(–.57)				
	1955:1–74:2	linear times log	1.93	.527	–.039	–.027	–.0007	.993	.0046	.92	1.37
			(5.35)	(9.44)	(–2.23)	(–2.59)	(–2.83)				
	1955:1–80:2	linear times log	1.99	.512	–.008	–.026	–.0011	.989	.0052	.96	1.33
			(5.13)	(8.78)	(–1.43)	(–2.47)	(–5.47)				
Augmented M-1B	1955:1–74:2	linear	1.81	.544	–.036	–.024	–.0023	.995	.0045	.93	1.51
			(5.07)	(9.75)	(–2.14)	(–2.06)	(–2.32)				
	1955:1–80:2	linear	1.63	.569	–.004	–.014	–.0048	.992	.0055	.94	1.42
			(4.31)	(9.77)	(–.61)	(–1.07)	(–5.50)				
	1955:1–74:2	logarithmic (constant elasticity)	2.15	.502	–.049	–.041	–.019	.995	.0046	.81	1.37
			(12.53)	(18.11)	(–2.91)	(–4.05)	(–2.25)				
	1955:1–80:2	logarithmic (constant elasticity)	.428	.695	–.009	–.027	–.011	.989	.0064	.99	1.24
			(.46)	(5.95)	(–1.41)	(–2.10)	(–.61)				
	1955:1–74:2	linear times log	1.77	.549	–.036	–.026	–.0006	.995	.0045	.93	1.50
			(4.90)	(9.85)	(–2.10)	(–2.57)	(–2.24)				
	1955:1–80:2	linear times log	1.49	.587	–.006	–.024	–.0011	.993	.0053	.94	1.46
			(4.13)	(10.69)	(–1.00)	(–2.21)	(–5.67)				

Appendix Table B-5
Estimates of Equation (4) for Demand Deposits, M-1B and Augmented M-1B: The Power Transformation Specification

Variable	1955:4–74:2	1955:4–80:2
Demand Deposits		
β_0	1.77	2.03
β_{10}	–.009	–.012
β_{11}	–.011	–.012
β_{12}	–.010	–.010
β_{13}	–.009	–.007
β_2	–.039	–.022
β_{30}	.210	.234
β_{31}	.171	.155
β_{32}	.132	.076
β_{40}	-1.40×10^{-6}	4.53×10^{-7}
β_{41}	-1.68×10^{-7}	-1.05×10^{-6}
β_{42}	4.80×10^{-7}	5.82×10^{-7}
β_{43}	-1.04×10^{-6}	-2.03×10^{-6}
β_{44}	3.17×10^{-6}	2.08×10^{-6}
β_{45}	-2.52×10^{-6}	-1.66×10^{-6}
Sums of Lagged Coefficients		
β_1	–.039	–.041
	(–4.22)	(–3.99)
β_3	.513	.466
	(8.15)	(5.61)
β_4	-1.47×10^{-6}	-1.62×10^{-6}
	(-3.05)	(–5.89)
λ	3.1	3.1
s_e	1.0	1.0
$\bar{R}^2$	.986	.984
Standard Error	.0054	.0066
RHO	.94	.98
DW	1.40	1.34

Appendix Table B-5 (cont'd)
Estimates of Equation (4) for Demand Deposits, M-1B and Augmented M-1B: the Power Transformation Specification

Variable	1955:4–74:2	1955:4–80:2
M-1B		
β_0	1.95	2.03
β_{10}	-.006	-.007
β_{11}	-.007	-.007
β_{12}	-.007	-.006
β_{13}	-.006	-.004
β_2	-.039	-.008
β_{30}	.203	.212
β_{31}	.175	.169
β_{32}	.146	.126
β_{40}	-.0016	-.0003
β_{41}	-.0007	-.0017
β_{42}	.0003	-.0007
β_{43}	.0009	.0010
β_{44}	.0006	.0009
β_{45}	-.0007	-.0012
Sums of Lagged Coefficients		
β_1	-.026	-.024
	(-2.45)	(-2.24)
β_3	.525	.507
	(9.42)	(8.68)
β_4	-.0013	-.0020
	(-2.84)	(-5.44)
λ	1.2	1.2
s_e	1	1
$\bar{R}^2$	.993	.989
Standard Error	.0046	.0052
RHO	.92	.96
DW	1.37	1.33

Appendix Table B-5 (cont'd)
Estimates of Equation (4) for Demand Deposits, M-1B and Augumented M-1B: the Power Transformation Specification

Variable	1955:4–74:2	1955:4–80:2
Augmented M-1B		
β_0	1.81	1.63
β_{10}	-.006	-.003
β_{11}	-.008	-.006
β_{12}	-.007	-.004
β_{13}	-.004	-.001
β_2	-.036	-.004
β_{30}	.202	.242
β_{31}	.181	.189
β_{32}	.161	.137
β_{40}	-.0024	-.0019
β_{41}	-.0015	-.0037
β_{42}	-.0002	-.0015
β_{43}	.0008	.0019
β_{44}	.0008	.0017
β_{45}	.0002	-.0014
Sums of Lagged Coefficients		
β_1	-.024	-.014
	(-2.06)	(-1.07)
β_3	.544	.569
	(9.75)	(9.78)
β_4	-.0023	-.0048
	(-2.32)	(-5.50)
λ	1	1
s_e	1	1
$\bar{R}^2$	.995	.992
Standard Error	.0045	.0055
RHO	.93	.94
DW	1.51	1.42

Appendix Table B-6
Estimates of Constant Elasticity Money Demand Equations Containing Long Rate or Past Peak Variables

						Long-Run Elasticity					
Aggregate	Period of Fit	Variable Added to Standard Equation	Constant	Real GNP	Passbook Rate*	Treasury Bill Rate	Long Rate or Past Peak	$\bar{R}^2$	Standard Error	RHO	DW
Demand Deposits	1955:4–74:2	Past peak of Federal funds rate	1.96	.505	–.052	–.034	–.085	.987	.0051	.91	1.48
			(6.55)	(10.52)	(–2.68)	(–3.95)	(–4.34)				
	1955:4–80:2	Past peak of Federal funds rate	.20	.637	–.012	–.029	–.076	.978	.0077	.99	1.11
			(.15)	(4.23)	(–1.65)	(–2.56)	(–1.64)				
	1955:4–74:2	5-year government bond rate	2.62	.400	–.058	–.031	–.051	.984	.0058	.84	1.19
			(11.78)	(10.70)	(–3.05)	(–2.08)	(–1.67)				
	1955:4–80:4	5-year government bond rate	–1.14	.694	–.011	–.012	–.087	.978	.0077	1.00	1.13
			(–.77)	(4.71)	(–1.45)	(–.57)	(–1.79)				
	1955:4–74:2	10-year government bond rate	2.57	.409	–.058	–.038	–.050	.984	.0058	.83	1.19
			(11.14)	(10.44)	(–3.15)	(–3.10)	(–1.62)				
	1955:4–80:2	10-year government bond rate	–1.13	.690	–.012	–.020	–.104	.978	.0076	1.00	1.18
			(–.73)	(4.70)	(–1.55)	(–1.12)	(–1.91)				
M-1B	1955:4–74:2	Past peak of Federal funds rate	2.01	.526	–.046	–.028	–.064	.994	.0042	.92	1.56
			(7.84)	(12.87)	(–2.87)	(–3.98)	(–3.84)				
	1955:4–80:2	Past peak of Federal funds rate	1.09	.589	–.009	–.025	–.074	.989	.0054	.99	1.36
			(1.15)	(5.60)	(–1.74)	(–3.16)	(–2.26)				

	1955:4–74:2	5-year government bond rate	2.55	.442	–.050	–.026	–.044	.993	.0048	.90	1.28
			(11.93)	(12.65)	(–2.87)	(–1.97)	(–1.56)				
	1955:4–80:2	5-year government bond rate	1.44	.558	–.009	–.004	–.085	.987	.0057	.99	1.28
			(1.82)	(5.57)	(–1.70)	(–.28)	(–2.44)				
	1955:4–74:2	10-year government bond rate	2.51	.449	–.050	–.032	–.044	.993	.0048	.89	1.28
			(11.22)	(12.11)	(–2.88)	(–2.96)	(–1.50)				
	1955:4–80:2	10-year government bond rate	2.02	.503	–.011	–.008	–.11	.987	.0057	.99	1.27
			(3.02)	(5.74)	(–1.91)	(–.70)	(–3.10)				
Augmented M-1B	1955:4–74:2	Past peak of Federal funds rate	1.78	.559	–.043	–.028	–.055	.995	.0042	.93	1.67
			(6.69)	(13.35)	(–2.63)	(–4.08)	(–3.26)				
	1955:4–80:2	Past peak of Federal funds rate	1.87	.545	–.007	–.022	–.111	.991	.0060	.97	1.34
			(4.22)	(8.54)	(–1.25)	(–2.47)	(–4.60)				
	1955:4–74:2	5-year government bond rate	2.25	.485	–.045	–.024	–.046	.995	.0046	.91	1.43
			(10.21)	(13.75)	(–2.65)	(–1.86)	(–1.66)				
	1955:4–80:2	5-year government bond rate	2.20	.490	–.008	.018	–.134	.990	.0062	.97	1.33
			(4.51)	(7.17)	(–1.23)	(1.16)	(–4.02)				
	1955:4–74:2	10-year government bond rate	2.20	.494	–.044	–.029	–.046	.994	.0046	.91	1.58
			(9.51)	(13.12)	(–2.61)	(–2.87)	(–1.58)				
	1955:4–80:2	10-year government bond rate	2.24	.495	–.009	.006	–.152	.990	.0062	.96	1.35
			(5.75)	(8.68)	(–1.43)	(.49)	(–4.63)				

* The passbook rate is the maximum of the rate on passbook savings accounts at commercial banks and the rate on money market mutual fund shares.

Appendix Table B-7
Post-Sample Errors and Stability Tests for Equations Containing the Past Peak in the Federal Funds Rate or Long-Term Rates

	Specification	F-test	Quarterly Errors Mean	Quarterly Errors RMSE	Annual Errors Mean	Annual Errors RMSE
Demand Deposits	Past peak in federal funds rate	11.29	-3.62	6.51	-3.76	4.20
	5-year government bond rate	6.68	-3.59	6.86	-3.73	4.42
	10-year government bond rate	7.45	-3.59	6.85	-3.73	4.41
M-1B	Past peak in federal funds rate	8.82	-1.61	4.72	-1.68	2.43
	5-year government bond rate	4.75	-1.54	4.99	-1.60	2.64
	10-year government bond rate	5.73	-1.53	4.96	-1.59	2.62
Augmented M-1B	Past peak in federal funds rate	12.36	-1.15	5.12	-1.19	2.48
	5-year government bond rate	5.63	-1.04	5.37	-1.07	2.76
	10-year government bond rate	9.01	-1.03	5.32	-1.07	2.74

Appendix Table B-8
Estimate for Augmented Measures Containing Money Market Mutual Fund Shares (MMMFs)

Augmented Measure	Period of Fit	Specification	Constant or Time Trend	T_1	T_2	Intercept for Levels Regressions	Treasury Bill Rate	Commercial Bank Passbook Rate	Real GNP	Lagged Dependent Variable	$\bar{R}^2$	Standard Error	RHO	DW
M-1B plus MMMFs	1959:4–74:2	levels				.820	–.019	–.018	.165	.649	.992	.0049	.51	1.58
						(2.03)	(–3.57)	(–1.08)	(3.41)	(5.10)				
	1959:4–80:2	levels				1.08	–.004	–.041	.151	.618	.986	.0064	.88	1.77
						(2.66)	(–.67)	(–1.39)	(3.82)	(7.14)				
	1959:4–74:2	levels	–.0010			–.011	–.022	–.013	.252	.698	.993	.0047	.37	1.71
			(–2.68)			(–.03)	(–4.77)	(–.94)	(4.17)	(5.95)				
	1959:4–80:2	levels	–.0009			.050	–.007	–.024	.205	.744	.986	.0063	.74	1.80
			(–1.77)			(.11)	(–1.08)	(–.89)	(3.11)	(10.06)				
	1959:4–74:2	first diff.	–.0005				–.014	–.042	.208	.569	.392	.0055		1.78
			(–.49)				(–2.05)	(–1.66)	(2.19)	(4.34)				
	1959:4–80:2	first diff.	–.0003				–.005	–.041	.221	.540	.377	.0065		1.76
			(–.35)				(–.72)	(–1.41)	(2.87)	(5.79)				
	1959:4–80:2	levels		–.0005	–.0006	.416	–.006	–.027	.188	.695	.986	.0063		1.81
				(–.84)	(–1.12)	(.71)	(–.84)	(–.98)	(2.71)	(8.30)				
	1959:4–80:2	first diff.		–.0009	.0006		–.005	–.037	.230	.537	.375	.0065		1.77
				(–.75)	(.39)		(–.73)	(–1.25)	(2.96)	(5.74)				

Augmented M-1B plus MMMFs	1959:4–74:2	levels				.852	−.016	−.026	.201	.599	.995	.0045	.41	1.67
						(2.68)	(−3.42)	(1.77)	(4.39)	(5.47)				
	1959:4–80:2	levels				1.19	.001	−.046	.199	.538	.990	.0067	.83	1.78
						(3.28)	(.17)	(−1.52)	(4.83)	(6.05)				
	1959:4–74:2	levels	−.0006			.131	−.020	−.019	.230	.698	.995	.0045	.31	1.79
			(−1.84)			(.30)	(−4.31)	(−1.43)	(4.69)	(6.51)				
	1959:4–80:2	levels	−.0008			.191	−.003	−.034	.245	.668	.990	.0067	.71	1.85
			(−1.70)			(.38)	(−.37)	(−1.26)	(3.78)	(8.45)				
	1959:4–74:2	first diff.	−.0002				−.011	−.043	.205	.536	.362	.0055		1.84
			(−.18)				(−1.56)	(−1.71)	(2.18)	(4.01)				
	1959:4–80:2	first diff.	−.0003				.001	−.047	.276	.434	.341	.0069		1.79
			(−.28)				(.20)	(−1.52)	(3.38)	(4.33)				
	1959:4–80:2	levels		−.0004	−.0005	.616	−.001	−.038	.228	.609	.990	.0067	.74	1.85
				(−.61)	(−.85)	(.99)	(−.08)	(−1.35)	(3.21)	(6.92)				
	1959:4–80:2	first diff.		−.0008	.0006		.001	−.043	.286	.426	.338	.0069		1.79
				(−.66)	(.41)		(.20)	(−1.37)	(3.46)	(4.23)				

Appendix Table B-9
Post-Sample Error and Stability Tests for Augmented Measures Containing Money Market Mutual Fund Shares (MMFs)

Aggregate	Specification	F-test	Quarterly errors Mean	Quarterly errors RMSE	Annual errors by 4-quarter periods 74–75	75–76	76–77	77–78	78–79	79–80	Annual errors Mean	Annual errors RMSE	Cumulative percentage error in 80:2
M-1B plus MMMFs	levels, no trend variable	9.17	.15	5.09	-5.3	-3.4	-2.2	.8	3.5	7.8	.20	4.42	.8
	first difference with intercept	1.64	1.20	4.51	-1.4	-1.9	-1.3	1.0	3.4	8.1	1.31	3.77	6.7
Augmented M-1B plus MMMFs	levels, no trend variable	9.61	.47	4.90	-4.8	-2.1	-.8	1.4	4.7	4.8	.52	3.56	2.6
	first difference with intercept	1.78	1.11	4.49	-2.5	-1.2	-.2	1.5	4.6	4.9	1.21	3.03	6.2

APPENDIX C:
The Behavior of Inventories in the Last Half of the 1970s

Equation (C-1) presents the equation used to explain and predict inventory holdings.

(C-1) $\ln(I/C) = a_0 + a_1 \ln(I_{-1}/C) +$

$a_2\,RTB + a_3\,(PIN) + a_4 \ln(\sigma/C) + a_5$ trend where

I = real quarterly inventories of all businesses, including farms (in 1972 dollars)

C = real personal consumption expenditure (in 1972 dollars)

σ = an uncertainty term represented by the absolute value of the change in the percentage change in real final sales (included as a measure of the volatility of sales movements) multiplied by the level of real final sales.[71]

RTB = the six-month Treasury bill rate.

PIN = a three-year moving average of the annualized rate of change of the price deflator for inventories

trend = time trend

The variables representing real quantities have been scaled by real consumption expenditures, C. The equation was chosen because of its similarities to a standard money demand equation. Nominal inventory holdings depend on a transaction measure (consumption), an uncertainty measure for aggregate output, $\ln(\sigma/C)$, and the opportunity cost of holding inventories—the gain on investments in financial assets (the six-month bill rate) less a measure of the expected own rate on physical inventories (that is, the "real" rate). Since this opportunity cost measure takes on both positive and negative values, the components representing the real rate were entered separately. Also, owing to the existence of positive and negative values for the rate of inflation on inventories, both variables were entered into the equation in linear, not logarithmic, form.[72]

Table C-1 lists estimates of the equation for 1962:1–74:2 and 1962:1–80:2. In the early period, all variables have the correct sign except for the bill rate. Table C-2 displays out-of-sample simulation results for the 1974:3–80:2 period. While the equation has shown a very mild tendency to overpredict—it has basically been on track.[73]

[71] We are indebted to our colleague Laura Rubin for suggesting this measure. See Laura S. Rubin, "Aggregate Inventory Behavior: Response to Uncertainty and Interest Rates," *Journal of Post Keynesian Economics*, Vol. 2, No. 2, Winter 1979–80, pp. 201–11.

[72] Of course, since the bill rate and inflation rate enter linearly, the opportunity cost measure (the real rate) could be entered directly. Results for this specification were somewhat worse and are not shown.

[73] However, the F-statistic to test whether the coefficients are equal in the two subperiods, 1962:1–74:2 and 1974:3–80:2 is large enough ($F_{6,61} = 5.69$) to reject the hypothesis of coefficient stability in the inventory equation.

Table C-1
Regression Estimates for Real Inventories

Period	a_0	a_1	a_2	a_3	a_4	a_5	Standard Error	$\bar{R}^2$	RHO	D-W
1962:1–74:2	−.076	.908	.0013	.00045	.00092	−.00017	.0035	.975	.26	2.01
	(−2.27)	(28.3)	(1.89)	(.761)	(2.137)	(−1.69)				
1962:1–80:2	−.055	.932	.0007	−.0009	.00006	−.00006	.0046	.978	.45	2.01
	(−1.73)	(28.2)	(1.25)	(−1.72)	(.146)	(−.59)				

Table C-2
Out-of-Sample Simulation Results for Inventories

Period	Actual	Predicted	Percentage Error
	billions of real dollars		
1974:3	300.1	301.7	.54
4	300.8	301.8	.01
1975:1	297.0	303.9	-2.32
2	292.8	289.8	-2.40
3	293.4	296.7	-1.11
4	292.1	296.8	-1.60
1976:1	294.3	295.6	-.43
2	296:7	297.6	-.32
3	298.4	300.4	-.68
4	298.7	301.8	-1.04
1977:1	301.5	302.3	-.26
2	304.8	304.2	.18
3	309.0	308.2	.27
4	311.8	313.0	-.38
1978:1	315.9	315.9	.01
2	319.8	320.3	-.15
3	322.9	324.7	-.55
4	325.9	328.5	-.80
1979:1	328.9	331.2	-.70
2	333.5	334.1	-.18
3	335.3	338.9	-1.09
4	335.6	342.2	-1.95
1980:1	335.7	342.7	-2.08
2	336.5	340.5	-1.18

REFERENCES

Barnett, William A. "Economic Monetary Aggregation: An Application of Index Numbers and Aggregation Theory," *Journal of Econometrics,* September, 1980, pp. 11-48.

Bennett, David J., Flint Brayton, Eileen Mauskopf, Edward K. Offenbacher and Richard D. Porter. "Econometric Properties of the Redefined Monetary Aggregates." Board of Governors of the Federal Reserve System, Division of Research and Statistics, Econometric and Computer Applications Section, February, 1980; processed).

Enzler, Jared, Lewis Johnson, and John Paulus. "Some Problems of Money Demand," *Brookings Papers on Economic Activity,* 1:1976, pp. 261-80.

Farr, Helen T., Richard D. Porter and Eleanor M. Pruitt. "Demand Deposit Ownership Survey," in *Improving the Monetary Aggregates: Staff Papers,* Board of Governors of the Federal Reserve System, 1979, pp. 91-116.

Friedman, Milton. "Time Perspective in the Demand for Money," *Scandinavian Journal of Economics,* 1977, pp. 397-416.

Garcia, Gillian and Simon Pak. "Some Clues in the Case of the Missing Money," *American Economic Review,* vol. 69, May 1979, pp. 330-40.

Goldfeld, Stephen. "The Case of the Missing Money," *Brookings Papers on Economic Activity,* 3:1976, pp. 683-730.

Hafer, R.W. and Scott E. Hein. "The Dynamics and Estimation of Short-Run Money Demand," *Federal Reserve Bank of St. Louis Review,* Vol. 62, March 1980, pp. 25-35.

LeRoy, Stephen F. and David E. Lindsey. "Determining the Monetary Instrument: A Diagrammatic Exposition," *American Economic Review,* Vol. 68, December 1978, pp. 929-34.

Lieberman, Charles. "The Transaction Demand for Money and Technological Change," *Review of Economics and Statistics,* Vol. 59, No. 3, August 1977, pp. 307-17.

Mauskopf, Eileen, and Richard D. Porter. "Cash Management and the Mid-Seventies Shift in the Demand for Demand Deposits in the U.S.," forthcoming in *Proceedings of Rome Conference on Monetary and Financial Models,* (Editions ECONOMICA, Paris).

Miller, Merton and Daniel Orr. "A Model of the Demand for Money by Firms," *Quarterly Journal of Economics,* Vol. 80, 1966, pp. 413-435.

Orr, Daniel. *Cash Management and the Demand for Money,* New York: Praeger, 1969.

Paulus, John D. "Demand Analysis and Stochastic Prior Information," Board of Governors of the Federal Reserve System, Division of Research and Statistics, Special Studies Paper No. 32, February, 1973; processed.

Poole, William. "Optimal Choice of Monetary Policy in a Simple Stochastic Macro Model," *Quarterly Journal of Economics,* Vol. 84, May 1970, pp. 197-216.

Porter, Richard and Eileen Mauskopf. "Cash Management and the Recent Shift in the Demand for Demand Deposits," Board of Governors of the Federal Reserve System, Division of Research and Statistics, Econometric and Computer Application Section, November 1978; processed.

Porter, Richard D., Thomas D. Simpson, and Eileen Mauskopf. "Financial Innovation and the Monetary Aggregates," *Brookings Papers on Economic Activity,* 1:1979, pp. 213-29.

Quick, Perry D. and John Paulus. "Financial Innovations and the Transactions Demand for Money," Board of Governors of the Federal Reserve System, Division of Research and Statistics, Banking Section, February, 1979; processed.

Rubin, Laura. "Aggregate Inventory Behavior: Response to Uncertainty and Interest Rates," *Journal of Post Keynesian Economics,* Vol. 2, No. 2, Winter, 1979-80, pp. 201-11.

Shiller, Robert J. "A Distributed Lag Estimator Derived from Smoothness Priors," *Econometrica,* Vol. 41, July 1973, p. 78-88.

Simpson, Thomas D., "The Market for Federal Funds and Repurchase Agreements," Staff Studies 106 (Board of Governors of the Federal Reserve System, July, 1979).

Theil, Henri. *Principles of Econometrics,* New York: John Wiley and Sons, 1971.

Tinsley, Peter A., Bonnie Garrett, and Monica Friar. "The Measurement of Money Demand," Board of Governors of the Federal Reserve System, Division of Research and Statistics, Special Studies Section, November 1978; processed.

United States House of Representatives. Subcommittee on Domestic Monetary Policy of the Committee on Banking, Finance and Urban Affairs. 96th Congress, Second session. *Measuring the Monetary Aggregates: Compendium of Views*. Washington, D.C.: U.S. Government Printing Office, 1980.

Wenninger, John and Charles Sivesind. "Changing the M-1 Definition: An Empirical Investigation," Federal Reserve Bank of New York, April, 1979; processed.

Zellner, Arnold. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," *Journal of the American Statistical Association*, Vol. 57, 1962, pp. 348–68.

Discussion

Benjamin M. Friedman*

It is difficult to read the papers prepared for this conference without remarking at the great contrast between the views that they represent and those that typified the father and the grandfather of this conference, held eight years ago and eleven years ago, respectively. The sharp turnaround in opinion on the appropriate policy role of the monetary aggregates, which has been the subject of all three conferences, has occurred no doubt in large part as a response to the events of the 1970s. In any case, it is striking.

Within a year after the first of the Federal Reserve Bank of Boston's conferences met in 1969 to assess the question of the use of monetary aggregates in formulating monetary policy, the Open Market Committee of the Federal Reserve System initially adopted a policy approach that amounted to targeting monetary aggregates. By 1972, the common assumption reflected by most of the papers presented at the Bank's second "Controlling Monetary Aggregates" conference was that the primary policy issue confronting policy-makers was how best to implement the monetary targets approach which the then-prevailing dominant opinion assumed constituted the best overall policy strategy. Three years later the Congress passed its Resolution 133, further formalizing this "intermediate target strategy" with the monetary aggregates — and, for all practical purposes, the narrowly defined money stock — as the particular intermediate target variable for monetary policy. Indeed, the cutting edge of monetary policy debate by the mid–1970s appeared to be whether, within this overall policy approach, there should be any latitude at all for policy-makers to seek different targeted monetary growth rates as economic circumstances varied.

What has happened within the past few years that has rendered the tone of the papers at today's conference so different? Two separate developments have been primarily responsible. The first, which is not the direct focus of this conference but which bears importantly on its subject nonetheless, was the emergence of what have come to be recognized as important shocks on the supply side of the economy. The view shared by most of the participants at the two earlier conferences was that the economy's aggregate supply of goods and services exhibited a highly stable behavior against which there arose fluctuations in the corresponding aggregate demand. Moreover, some people argued that major historical episodes of aggregate demand instability had been due at least in part to variations in monetary and fiscal policies. Hence in the absence of aggregate demand fluctuations, which to some extent could be eliminated merely by rendering policy less volatile, the economy would experience relatively little instability. The events of the 1970s, however,

* Benjamin M. Friedman is Professor of Economics at Harvard University.

including in particular the two major oil price shocks, have represented a wholly different phenomenon which the theory of monetary policy under monetary aggregate targets was never designed to encompass in the first place. It would always be possible, of course, for policy-makers to allow an identifiable supply shock to occur without seeking to induce any offsetting variation at all on the demand side; but no theory exists showing that that would be the optimal policy, or even a very good one.

The second, and more ironic, aspect of the events of the 1970s that has accounted for this collective change of heart constitutes the central motivation for many of the papers at this conference, and especially the paper by Thomas Simpson and Richard Porter. As the work of numerous researchers has made clear, the adoption of the intermediate target strategy for monetary policy, with a monetary aggregate as the intermediate target variable, rested fundamentally on the presumption of stable financial behavior in general and a stable demand for some readily definable and measurable "money" in particular. As is well documented, however, both in the Simpson-Porter paper and elsewhere, the 1970s saw the emergence of sudden and almost wholly unanticipated shifts in precisely this element of economic behavior. Moreover, as Simpson and Porter emphasize, there is no reason to be confident that these shifts are now in the past; indeed, according to their analysis the worst quarter thus far for money demand behavior was the second quarter of 1980. If anything, monetary policy-makers are just in the midst of, rather than looking back on, what has gone wrong.

As a result of this combination of developments that have gone so deeply against the grain of the presumptions that typified the 1969 and 1972 predecessors of this conference, many policy issues of major importance are once again open for debate. As the papers for today's conference indicate, the set of open questions now includes the reliability of money (however defined) as an "indicator" of future economic activity, the relative usefulness of broad versus narrow monetary aggregates, the inside monetary aggregates versus the monetary base, and so on. These are all centrally important issues for monetary policy, and any policy-maker or researcher who thought that they were settled now needs to think again. In addition, another newly open question less directly confronted in these papers is that of monetary versus credit aggregates. The chief issues here are which side of the balance sheet — the assets or the liabilities — is a better indicator of future economic activity, and which side is more controllable. The consensus in previous years was that, because substitutions were easier and cheaper to make on the credit side of the balance sheet than within the monetary subset on the asset side, money was more useful than credit from both perspectives; but changes in the payments process as well as other financial innovations have now rendered even that traditional presumption open for debate once again.

Finally, as policy-makers and researchers rethink these questions, they will inevitably want also to reconsider whether the intermediate target strategy based on a single target of any kind is indeed the best approach to monetary policy. One reason for questioning this strategy is the controllability issue. Under the intermediate target strategy it is essential that policy be able to control its intermediate target variable relatively closely. Under an alternative conception of the monetary policy process advanced by some researchers — sometimes called the "information variable" approach — whether or not policy can directly control the aggregate or aggregates on which it focuses is of much less consequence. Under this alternative approach policy-makers would monitor such variables for the information that they provide about economic activity both currently and in the future, and policy would respond to the observed movements of these variables, but there would be no presumption of controlling them as if they were the proximate targets of policy. The second reason for questioning the intermediate target strategy is simply the by-now well-understood logical flaw inherent in any two-stage procedure that substitutes a proximate target in place of the more basic economic objectives that policy really seeks to achieve. As James Pierce so aptly puts the point in his paper for this conference, it is unfortunate to waste what few tools policy-makers have by devoting them to the pursuit of intermediate targets at all.

The principal focus of the Simpson-Porter paper is the importance of financial innovation in what has gone wrong in the 1970s under the intermediate target approach based on monetary aggregate targets. Consideration of a few basics readily suggests that financial innovation can occur with relative ease. The financial markets typically have a very different technology from that in other areas of economic activity. In most financial businesses there is a small amount of fixed physical capital, and the labor force is both highly educated and highly mobile, in comparison to other industries. Consequently, the technology in financial markets is extremely well adapted to rapid innovation.

Although it may be tempting to suppose that the rapid and widespread occurrence of financial innovation in the United States in the 1970s has been a unique phenomenon, closer inspection of the historical record suggests otherwise. Even a quick look back to the 1960s immediately recalls that that decade began without a market for negotiable certificates of deposit, without a Eurodollar market, and without a freely functioning market in federal funds. Those innovations that came about in the 1960s were just as important for how the U.S. financial markets function as the NOW accounts, money market certificates, money market mutual funds and repurchase agreements that emerged in the 1970s with well-known consequences for monetary policy that have provided the primary motivation for the papers at today's conference. Furthermore, a look ahead to the 1980s does not require prescience to suspect that some potentially important innovations which have already occurred have not yet had their full effect on how the financial markets function. The increasing prevalence of floating-rate loan agreements in the banking system and pass-through securities in the bond market, and the new markets for traded options and financial futures, are but a few examples. The relationships among financial asset demands and supplies that will evolve as a result of these and other innovations could differ sharply from prior experience.

As a result of the increasing evidence of the importance of financial innovation, views are changing about the stability of money demand relationships in both the short and the long run. A crude dichotomy, oversimplified almost to the point of caricature, nonetheless expresses the general direction of this change in thinking. Until several years ago the almost universally held opinion was that, although money demand might be subject to severe instability in the short run, whatever short-run bounces occurred would average out so that in the long run money demand would be stable. That belief in turn gave rise to a policy prescription, at least for achieving long-run objectives, of simply selecting some monetary aggregate and stabilizing its rate of growth; which specific aggregate to choose was at most a second-order matter in comparison to the main idea of picking one and stabilizing it.

By contrast, a new view which is only just emerging recognizes the possibility that the demand for any specific monetary aggregate may be even more unstable in the long run than in the short run. The reason, very simply, is that in the long run the structural forces of financial innovation have the opportunity to change the whole meaning of that aggregate by changing the roles that the assets it encompasses play within the economic system. An all-encompassing measure like total financial assets, of course, is much less subject to such evolutionary forces. For any more narrowly defined aggregate, however, policy-makers must now face the possibility that the long run is not very sympathetic to the fixed monetary aggregate target approach either. The long run allows short-run random disturbances to balance out, but it also gives the markets the opportunity to innovate out from under the restrictions implied by the control of any specific aggregate. A particular feature of this process that receives great emphasis in the Simpson-Porter paper — and appropriately so — is the erosion by recent financial innovations of the traditional distinction between transactions balances and liquid investments. One fairly direct implication of these innovations, therefore, is that whatever "specialness" money may have had is becoming progressively less significant.

The paper by Simpson and Porter represents a continuation of the work done in recent years on this and related problems by them and their colleagues on the Federal Reserve Board staff. This work has been of high quality throughout, and it has made substantial contributions to the understanding of these subjects, especially at the empirical level. The results it has generated are highly valuable, and other researchers as well as policy-makers are in their debt.

The paper first documents the breakdown of the past relationships between money and economic activity. Much of this material is familiar, and the evidence introduced is fairly straightforward.

The paper then goes on to discuss the motivations for financial innovation. In an especially interesting part of this section of the paper, Simpson and Porter present an argument showing that the zero-interest constraint on demand deposits and reserve balances is not the sole reason for financial innovations of the kind that have recently occurred. Because financial innovation is a big and complex subject, however, the analysis offered here stops well short of developing the kind of full-scale theory of financial innovation attempted elsewhere by William Silber and others. Instead, the object is to point out that, because financial innovation itself is an inherently unpredictable process, the effect of innovation on shifting monetary aggregate relationships is also therefore unpredictable.

The operational part of the paper exploits the concept of financial innovation to offer a new specification of money demand. The novelty that Simpson and Porter introduce here is an "innovation proxy" variable constructed from an interest rate lag structure that is more flexible in some degree than the usual ratchet variable. The reasoning behind this proxy variable is plausible, and the estimated money demand functions incorporating it perform well enough to consider the new variable potentially important. These functions are still subject to a variety of criticisms, but, because most of them concern the usual problems common to standard money demand functions found elsewhere in the literature, there is little need to dwell on them here — with one exception. Surely this paper's emphasis on the recent financial innovations, and especially on the consequent blurring of transactions balances and liquid investments, leads naturally to a portfolio approach to the demand for money. In that case, the money demand function should include either a wealth variable or, alternatively, the lagged holdings of nonmoney assets as a way of representing the nature of the portfolio diversification problem faced by investors. This omission is hardly unique to the Simpson-Porter specification, but in this case it does seem inconsistent with the underlying motivation that they provide for seeking a new specification in the first place.

The one important subject on which Simpson and Porter are less than adequately forthcoming in this paper, in my judgment, is this work's implications for monetary policy. I think it is possible to read this paper in either of two ways. One is that the new money demand specification has satisfactorily proxied financial innovation effects, so that policy-makers may now proceed as if they again have a stable money demand function. Under this reading the intermediate target strategy, with some monetary aggregate as the intermediate target variable, remains the best way to go about designing and implementing monetary policy. By contrast, the second interpretation of the paper — and from their oral remarks I suspect this is the one Simpson and Porter prefer — is that, although their empirical work has documented the importance of financial innovation *ex post*, financial innovation nonetheless remains fundamentally unpredictable *ex ante*. Despite this new empirical work, therefore, policy-makers still do not have a stable money demand function such as is needed to go about the monetary targets approach as before. What should policy-makers do under this reading? Here the limited suggestions made by Simpson and Porter, involving principally the widening of target ranges so to recognize uncertainties, and a vaguely specified injunction to stabilize interest rates within those ranges, are not very satisfactory.

What, then, should policy-makers do? I will conclude with a few remarks about what approach to monetary policy might be consistent with this second interpretation of the Simpson-Porter paper, There is now an accumulating amount of evidence that the credit market plays a role in the determination of economic activity which is not simply the mirror of that played by the money market. This result is not surprising in light of the available economic theory. Karl Brunner, James Tobin and others at this conference — not to mention researchers who are not here — have developed models explicitly representing the credit market separately from the money market. There is no reason at the theoretical level to presume that the credit market is unimportant; that is basically an empirical question. Moreover, two recent sets of empirical findings both suggest an important role for the credit market. Christopher Sims has examined a four-variable system consisting of real output, prices, money and an interest rate, and has found in that system a major causal role associated with the interest rate. In work parallel to Sims', I have examined a similar four-variable system consisting again of real output, prices and money, and in this case a quantity measure of credit liabilities in place of Sims' interest rate. In this system I have found a major role associated with the credit quantity variable. Under the standard interpretation that the interest rate variable and the credit aggregate variable are in effect simply the price and the quantity in the same market, therefore, these two separate strands of research apparently deliver the same conclusion about the importance of the credit market. In addition, further tests show that the information about future economic activity measured in Sims's work by the interest rate and the analogous information measured in my work by the credit aggregate are systematically related, although not with a perfect correlation.

The conclusion that follows from this work is that, in the presence of financial innovations which continually shift the demand and supply relationships for specific assets and liabilities, policy-makers may have to expand to a three-variable, or three-target, approach to monetary policy. The three relevant variables here reflect the independent importance of two markets and the relative price connecting them: in particular, a quantity variable for the money market, a quantity variable for the credit market, and an interest rate representing the relative rate of exchange between the two. It would be convenient, of course, if the world were structured so that all the information needed to conduct monetary policy were embedded in any one of these variables — or, if not any one, then any two. But the evidence warrants increasing skepticism that anything less than a full three-variable approach, based on money, credit and the interest rate, will enable monetary policy to achieve the results for which participants at the two predecessors of this conference had hoped.