BOARD OF GOVERNORS
OF THE
FEDERAL RESERVE SYSTEM
WASHINGTON, D C 20551

STRICTLY CONFIDENTIAL (FR)
CLASS II - FOMC

December 9, 1987

TO: Federal Open Market Committee

FROM: Donald Kohn DK

The attached paper is being distributed as background for the Committee's discussion of the monetary aggregates as long-range policy objectives (Agenda item 6). The focus is on comparisons among the aggregates as indicators or targets of monetary policy, as measured by a number of different tests, including variations in velocity, characteristics of money demand, and standard errors of forecasts of GNP predicated on predetermined growth rates for various M's and derived from simulations of the MPS model and from St. Louis-type reduced-form equations. Particular attention is paid to the characteristics of M1-A, in response to recent work advocating that it receive greater weight in policymaking.

An additional, shorter memorandum will be distributed with the bluebook. It will review monetary aggregates behavior in 1987 and, drawing in part on the material in the attached memo, will discuss further the properties of the aggregates as targets or indicators of policy

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An Evaluation of M1-A as an Indicator and Intermediate Target and Comparisons with M1 and M2[1]

I Summary

This paper presents an analysis of the behavior of the narrow monetary aggregate M1-A, and compares the properties of this aggregate as an indicator of economic activity and as an intermediate monetary target to those of M1 and M2[2] This research was prompted in part by other recent studies of M1-A by government and private analysts. A study by Darby, Mascaro, and Marlow (DMM) concluded that M1-A was a better predictor of real GNP and inflation between 1983 and 1987 Q2 than was M1 or M2[3] Similarly, Paulus argued that other checkable deposits should not be included in a measure of transactions balances and that traditional monetarist relationships are better maintained by using M1-A rather than M1[4]

The conclusions of both of those papers relied to a significant extent on the observation that in the mid-1980s M1-A velocity had not diverged from its trend by as much as had M1 velocity. Section II of

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1 Prepared by Brian Madigan and David Small, Division of Monetary Affairs, Board of Governors of the Federal Reserve System. Donald Kohn, David Lindsey, and Richard Porter commented on this paper Dan Bagatell and Lyle Kumasaka provided research assistance Flint Brayton performed the simulations of the MPS quarterly model and Jong Park and Angelo Mascaro assisted in replicating the DMM model

2 M1-A is the sum of currency in the hands of the public and demand deposits Alternatively, it is M1 less (interest-earning) other checkable deposits

3 Michael R Darby, Angelo R Mascaro, and Michael C Marlow "The Empirical Reliability of Monetary Aggregates as Indicators 1983-1987 " Research Paper No. 8701, U S Treasury Department

4 John Paulus "Monetarism If It Ain't Broke Don't Fix It." Morgan Stanley, 1986

this paper analyzes the behavior of various measures of the velocity of M1-A and the other aggregates during the 1960s and 1970s relative to their trends It then analyzes deviations of these measures during the 1980s from their earlier trends We conclude that if M1-A is not adjusted for the introduction of NOW accounts in 1981--consistent with the velocity charts, although not the econometric techniques, of DMM--that aggregate's velocity experienced extremely large deviations from trend during the 1980s, averaging on the order of 13 to 18 percent The use of M1-A adjusted for those shifts from demand deposits to NOW accounts that were induced by deregulation substantially reduces these deviations, contrary to the position of DMM The velocity of M1, whether shift-adjusted or not, also records sizable deviations from trend during the 1980s, but somewhat smaller on average than those of M1-A Finally, the deviations of M2 velocity from trend levels, when this aggregate is shift-adjusted for the introduction of MMDAs in 1983, are noticeably lower than those of M1-A and M1

Section III uses structural models to compare M1-A with alternative aggregates as intermediate targets and indicators for GNP Based on the specific properties of the money demand equations and the rest of the MPS model, we conclude in part A that a case can be made that M1-A is best-suited of the three aggregates to be an intermediate target. The relative rankings of M1 and M2 depend on the method used These conclusions are entirely dependent on the extent to which the model accurately captures underlying behavior, and in this regard there is considerable uncertainty The various money demand equations have been reestimated frequently following deposit deregulation The M1-A equation in particular should be viewed with considerable suspicion because of recent large misses in the equation's predictions. These misses appear to be associated with interest rate movements, suggesting that the interest elasticity of M1-A is now larger than is captured by the model. If this is the case, the marginal superiority of M1-A in model simulations could be attenuated or even reversed In part B, reduced-form equations relating nominal GNP growth to various monetary aggregates are reported These equations cast doubt on the slight superiority of M1-A by showing that M2 has been a better predictor of nominal GNP during the last few years.

Appendix A presents a critique of the DMM paper. It points out certain anomalies in DMM's position and examines the ability of alternative aggregates to predict future nominal GNP, rather than just real GNP and inflation Our results show that the apparent superiority of M1-A over M2 using the DMM methods disappears in this comparison

Appendix B contains a summary of the structural models used in section II. In general, the aggregates are modeled to have GNP velocities in the long run that depend on the spread of the three month T-bill rate over the aggregates' own rates.

II. OVERVIEW OF GROWTH AND VELOCITY PATTERNS OF M1-A, M1, AND M2

Definitions of the Monetary Aggregates and a Brief History of Deposit Authorization and Deregulation

Before 1980, M-1 was defined to include currency and demand deposits in the hands of the public The concept of money that this definition reflected was that of the medium of exchange, and therefore M-1 included all the instruments that were used to any significant extent to effect transactions Savings and small time deposits were included, along with M-1, only in the broader monetary aggregates M-2 and M-3

Beginning in the mid-1970s, Negotiable Order of Withdrawal (NOW) accounts and credit union share draft accounts--both of which were permitted to earn interest--were offered by depository institutions, primarily in New England These accounts initially were included in the monetary aggregates only at the M2 or M3 level, depending on whether the accounts were liabilities of commercial banks or thrift institutions In the latter part of the 1970s, commercial banks and thrift institutions began to offer Automatic Transfer Service (ATS) accounts These arrangements permit savings balances to be shifted into demand accounts when checks are presented, and effectively allow depositors to earn interest on transactions balances

Because NOW, ATS, and share draft accounts could be used for transactions purposes, in February 1980 the Federal Reserve, as part of a major overhaul of the monetary aggregates, defined a new narrow money stock measure, M1-B, essentially as the sum of old M-1--designated M1-A--and other checkable deposits (OCDs).[5] The redefinition also established M2 as the sum of M1-B, savings and small-denomination time deposits at commercial banks and thrift institutions, general-purpose

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5 Travelers checks issued by nonbank firms were added to M1 in 1981 Travelers checks issued by commercial banks are included in demand deposits.

and broker/dealer money market mutual fund shares, and overnight RP and Eurodollar holdings. Depository institutions nationwide were authorized to offer NOW accounts to households and certain other entities effective December 31, 1980 Initially, these accounts could earn interest at a maximum rate of 5-1/4 percent Businesses, however, continued to be prohibited by law from receiving interest on demand deposits.

In mid-1981, the Federal Reserve dropped M1-A as a published monetary aggregate and changed the designation of M1-B to M1 However, analysts have continued to refer to the sum of currency, travelers checks, and demand deposits as M1-A

The behavior of the aggregates in the 1980s also has been affected by the phased deregulation of interest rates on savings and small time deposits During most of the 1960s and 1970s, rates on these deposits were subject to ceilings under Regulation Q Frequently, these rate ceilings were "binding"--that is, market rates exceeded deposit rates--and depository institutions experienced outflows of funds. In order to stem such disintermediation, in the late 1970s and early 1980s depository institutions were authorized to offer certain types of time deposits that bore market-related interest-rate ceilings The interest-rate limit on savings deposits, however, remained at 5-1/2 percent or less until April 1986

Effective December 1982, banks and thrifts were authorized to offer a savings account with limited transactions features but with no interest rate ceiling--the Money Market Deposit Account (MMDA) The following month, ceiling-free NOW accounts, termed Super-NOW accounts, were permitted. Small time deposit ceilings were removed completely in October 1983 Finally, rate ceilings on ordinary NOW accounts were eliminated at the beginning of 1986, and those on savings deposits were removed on March 31, 1986

Broad Patterns of Growth of The Monetary Aggregates

Levels of M1-A, M1, and M2 since 1959 are shown in Chart 1 [6] M1-A and M1 are represented by the same line until the mid-1970s, when other checkable deposits began to exist in appreciable quantities The two measures diverged sharply beginning in early 1981, when NOW accounts were introduced nationwide M1-A actually declined over 1981, as funds in demand deposits apparently were shifted out of M1-A to interest-earning NOW accounts [7] Since 1981, M1 growth has been more rapid than growth in M1-A, as NOW accounts generally have outpaced currency and demand deposits NOW accounts currently make up about one-third of M1

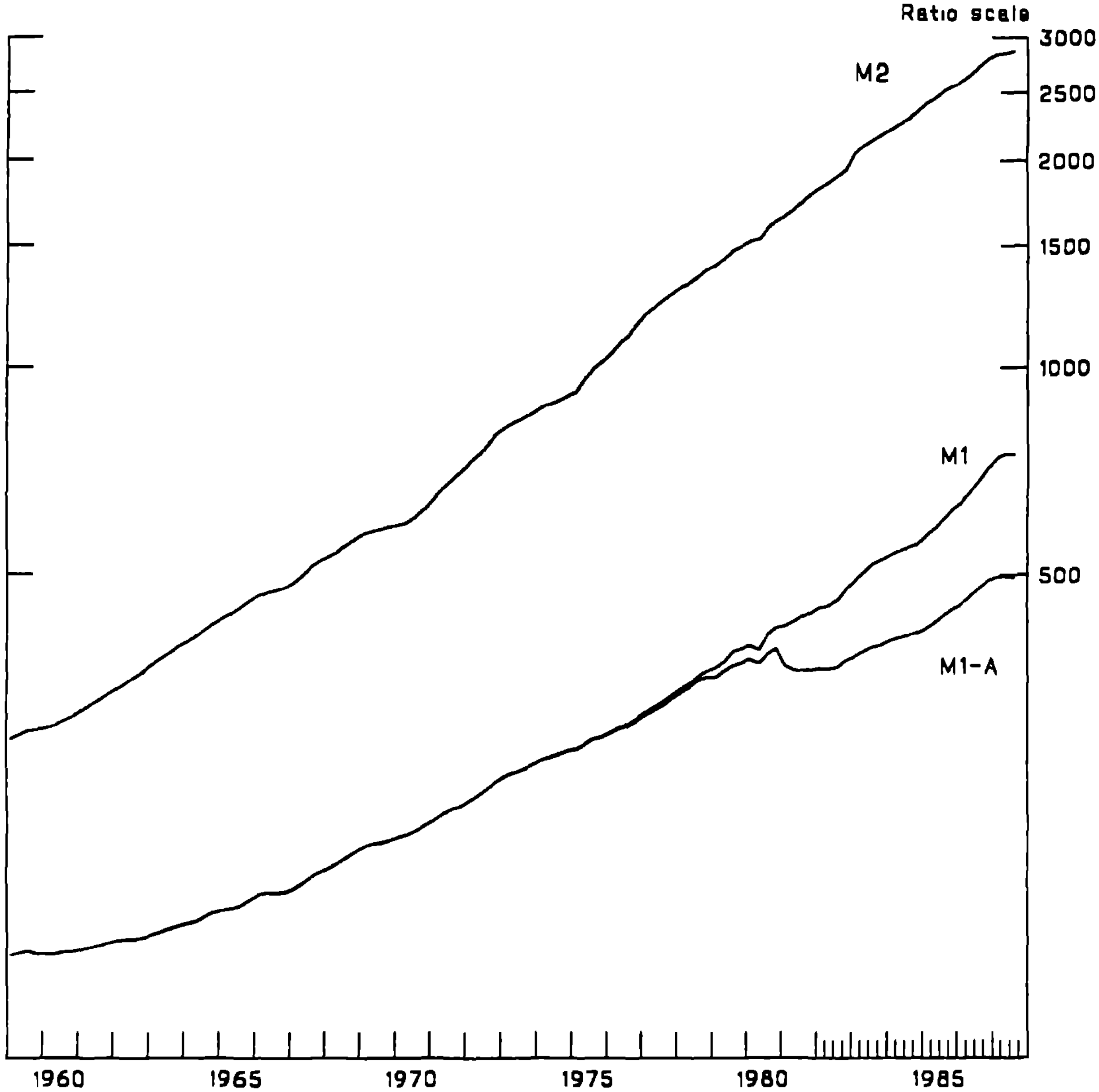
M2 also has grown more rapidly over time than the narrower aggregates, as balances in savings instruments have expanded more quickly than transactions balances The responsiveness of M2, as well as M1-A and M1, during the 1960s and 1970s to interest rates and consequent disintermediation can be observed on the chart by the slower

6 These charts are drawn with ratio scales, which have the useful property that points plotted a given vertical distance from each other anywhere on the chart have the same proportional, rather than additive, relationship. This implies that a series represented on the chart by a straight line has a constant growth rate, a steeper slope implies a higher growth rate

7 As will be discussed below, the nature of this shift--including its effects on the level and stability of M1-A demand--is a central issue in debate concerning the usefulness of M1-A as a monetary target

Chart 1

Levels of the Monetary Aggregates
(billions of dollars)



growth during the periods of high interest rates in 1966, 1969, and 1973-74

Velocities of the Monetary Aggregates

Velocities of the monetary aggregates during the 1960s and 1970s are shown in chart 2 [8] For most of this period, M1-A and M1 velocity were essentially equal and moved fairly closely around a trend line which increased at about 3 percent per year This trend likely reflected a number of factors, including a general rise in the opportunity cost of holding demand deposits and falling costs of investing transactions balances overnight as a result of advances in corporate cash management techniques. M2 velocity, on the other hand, fluctuated nearly trendlessly during the 1960s and 1970s Since most balances in M2 earned interest, over time periods long enough to allow these deposit own rates to adjust to market rates (or new instruments to be authorized), M2 was not affected as much by rising market rates as were M1-A and M1.

Chart 3 shows velocities of the aggregates over the 1960s and 1970s normalized by dividing actual velocity by its trend value each quarter. This scaling facilitates comparison across aggregates having very different levels and trends in velocity On this basis, V1, V1-A,

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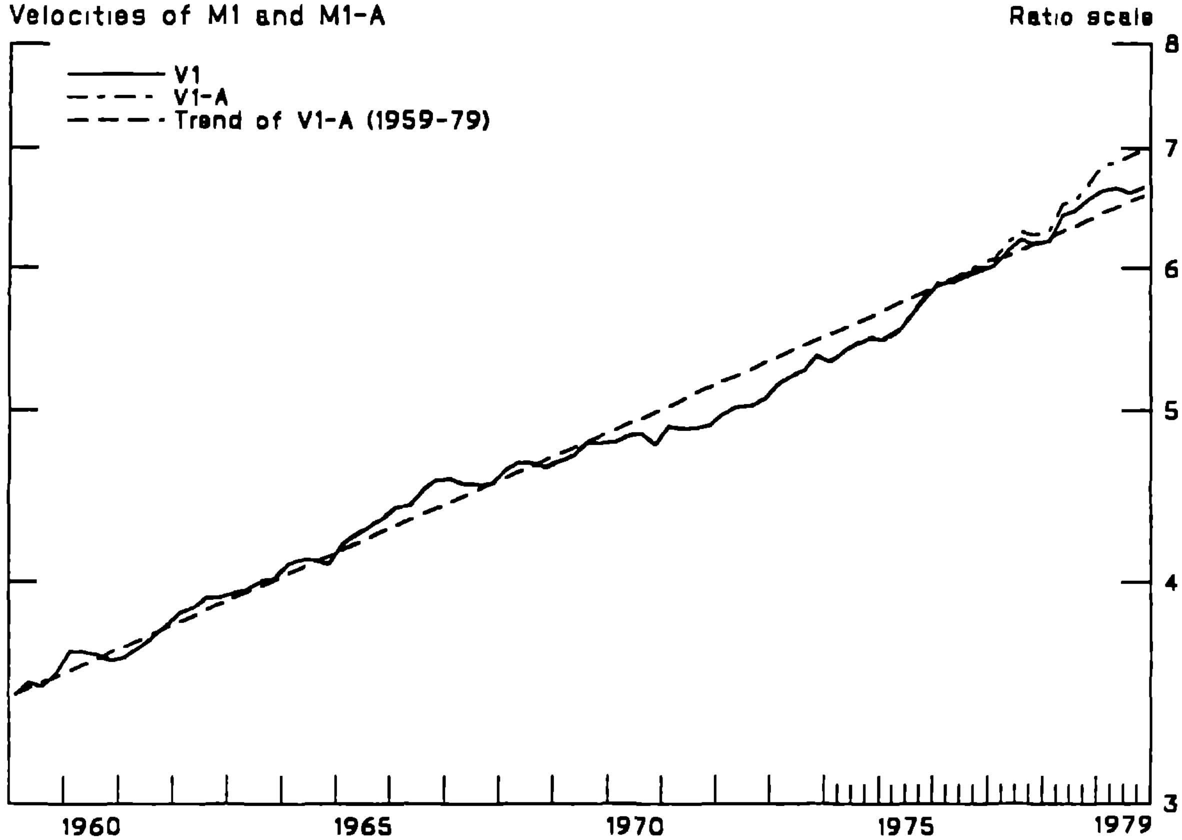
8 Velocity measures used in this paper are defined in the standard fashion as nominal GNP divided by various monetary aggregates A number of analysts have claimed that other "scale" variables--such as consumption or domestic final sales--should be used instead of nominal GNP Indeed, staff research indicates that, for econometric money demand analysis, scale variables other than GNP often are appropriate But the choice of a scale variable, within reasonable limits, does not affect broad patterns of velocity behavior

Chart 2

Velocities of the Monetary Aggregates



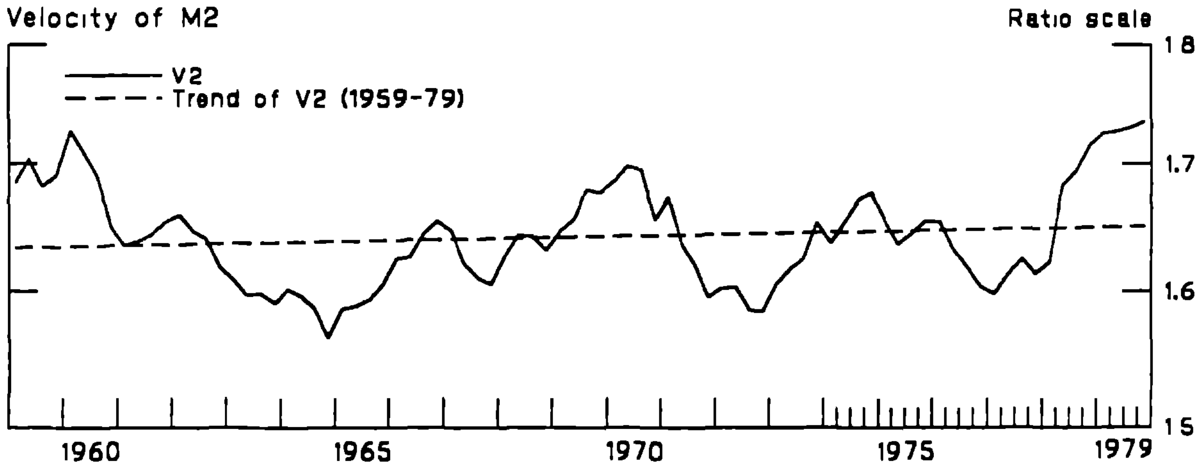
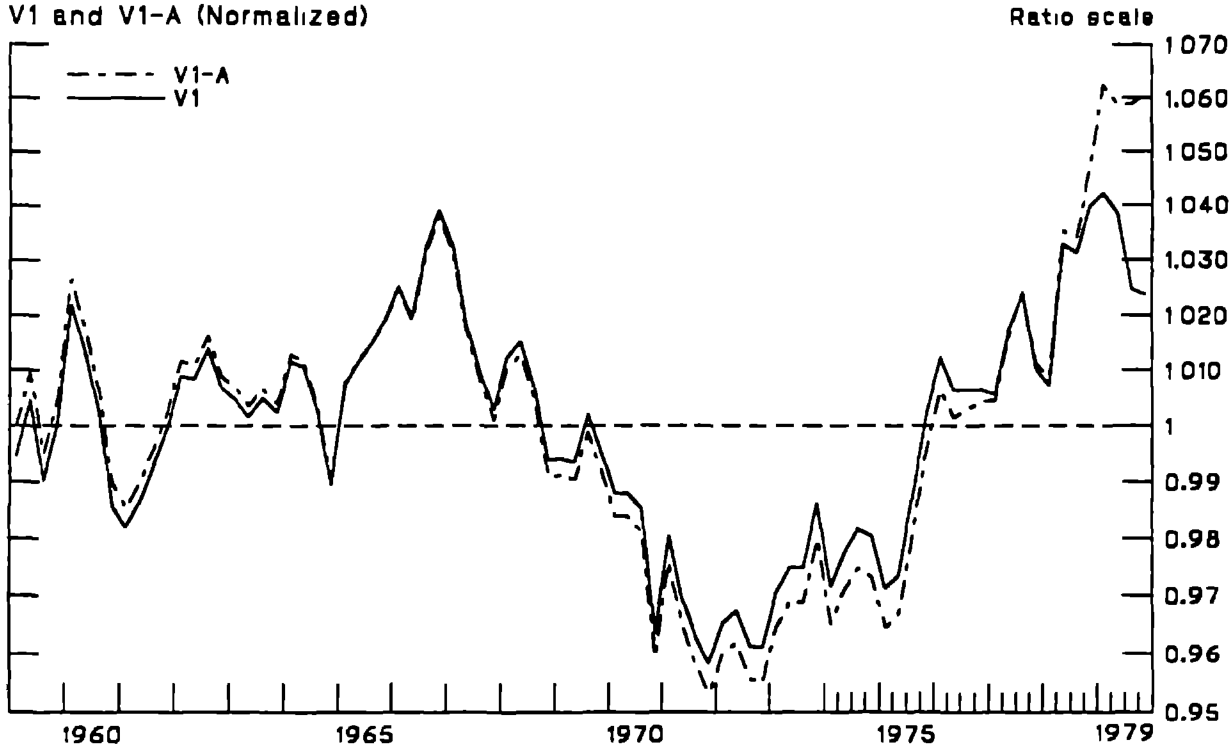
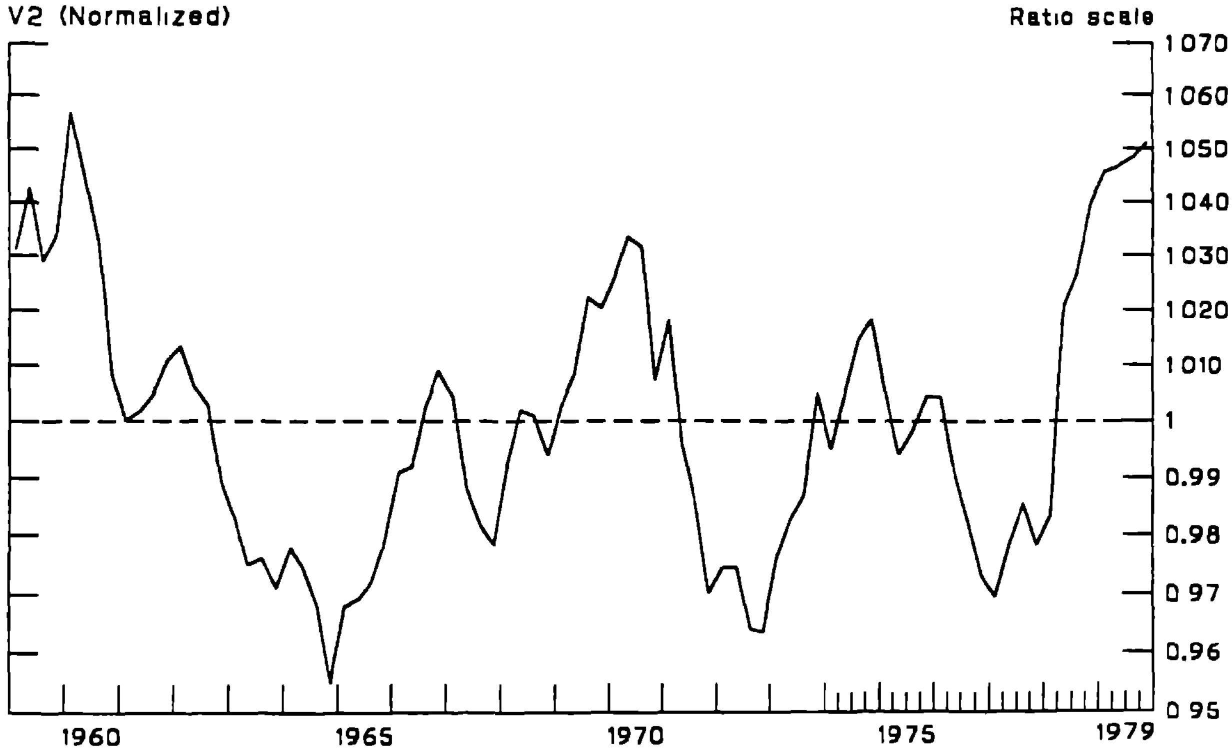


Chart 3

Normalized Velocities of the Monetary Aggregates





and V2 exhibited comparable stability during the 1960s and 1970s.[9] Although the patterns of deviations differed somewhat between V2 and the velocities of the narrower aggregates, each generally remained within five percent of its longer-run trend, and the standard deviation of each from its trend fell between 2 and 2-1/2 percent Moreover, deviations of the series from trend were not completely random, but tended to be correlated across time and, as discussed below, with other variables, these relationships could be exploited to improve the predictability of velocity. The relative stability and predictability of these velocities over these years seemed to lend considerable support at the close of the 1970s to the desirability of using monetary aggregates as intermediate targets for monetary policy.

Chart 4 extends the plots of velocity to include more recent years The chart gives a clear impression that the behavior of the narrow aggregates and their velocities changed in the 1980s. In particular, the velocity of M1-A rose abruptly above its long-run trend in 1981 during the period of the nationwide introduction of NOW accounts. (In comparison, the velocities of M1 and M2 appeared to be affected at that time to a much smaller extent by NOW accounts.)

At the time of the nationwide introduction of NOW accounts, the Federal Reserve staff expected that--without any change in interest rates or income--households would shift funds into NOW accounts from demand deposits, causing a permanently higher level of the trend of

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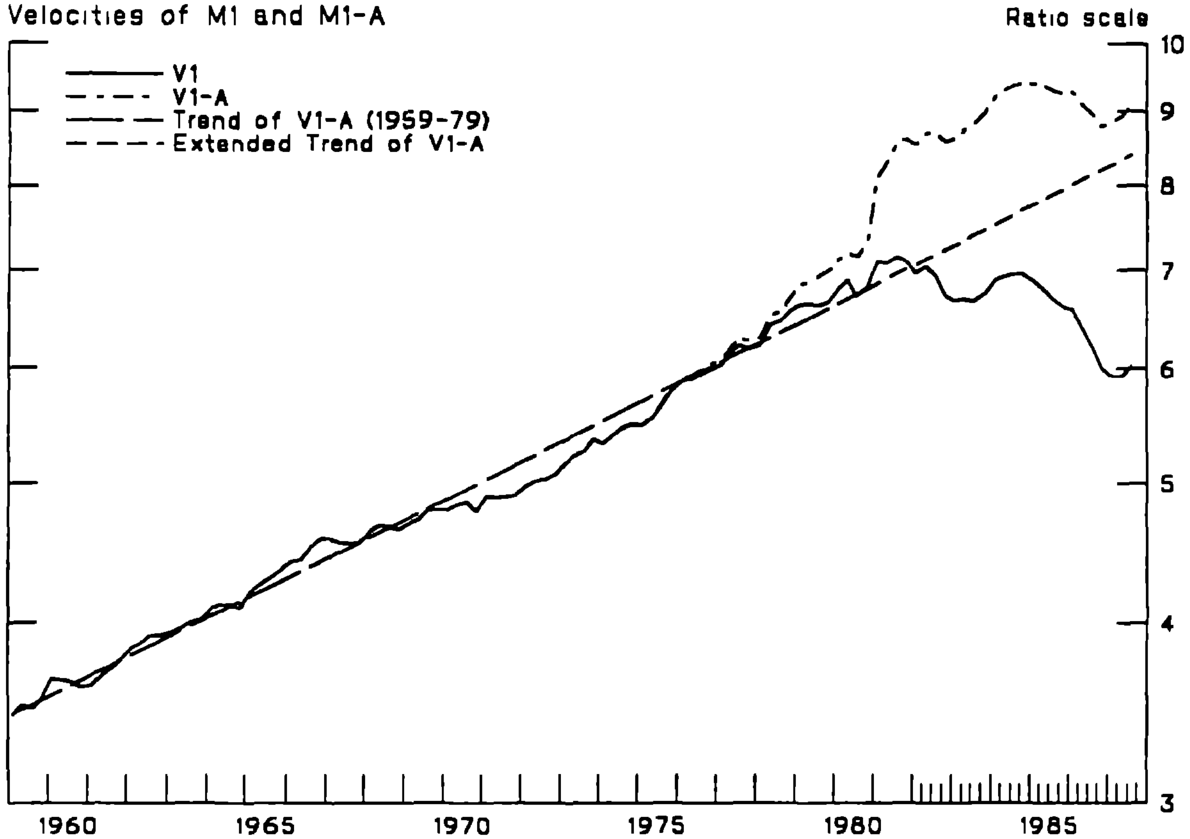
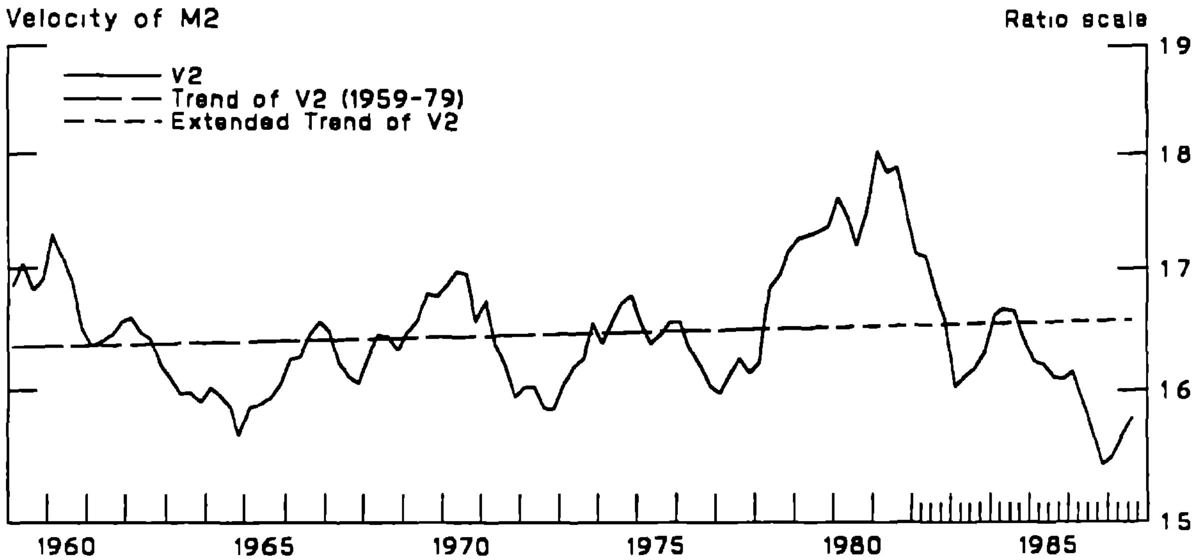
9 The relationship between these deviations from trend and other factors such as interest rates is examined below

Chart 4

Velocities of the Monetary Aggregates
1959 to 1987



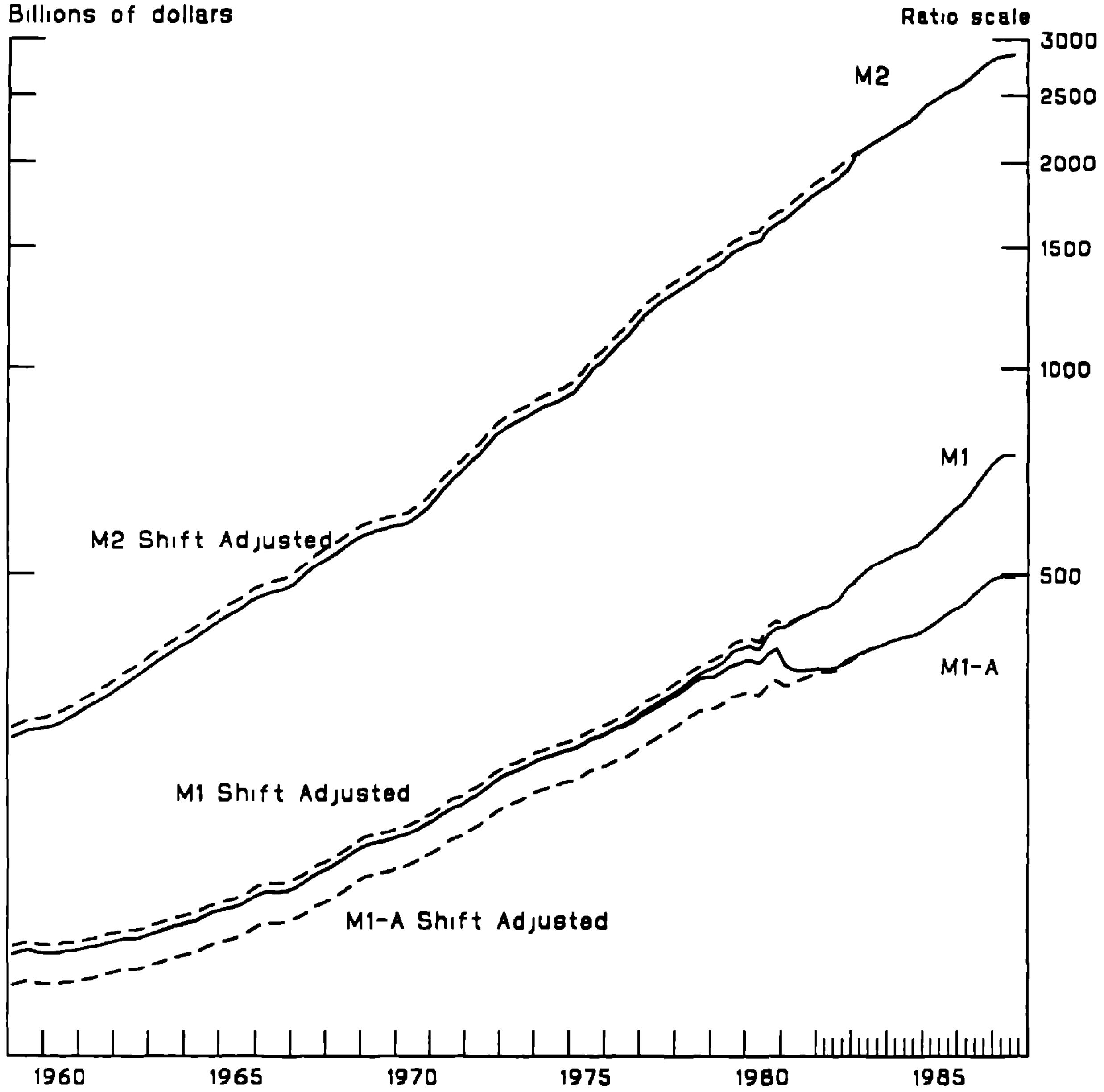


V1-A Also, it was expected that households would shift funds into NOW accounts from savings and small time deposits, leading to a lower level of the trend of V1 (that is, V1-B) and a higher level of the trend in velocity of the nontransactions component of M2. However, it was assumed that once the shifts were allowed for, the velocities of M1-A and M1-B would reflect behavioral patterns roughly consistent with those of the 1960s and 1970s. In order to avoid an inappropriate change in monetary policy during the period of shifting, the Federal Reserve in 1981 announced annual target ranges for shift-adjusted as well as actual M1-A and M1-B The staff developed a method of shift-adjusting both aggregates that relied on special surveys, examination of deposit data patterns, and micro cross-sectional modeling.

Comparable shift-adjusted series, extended to the present and correcting for other shifts, are portrayed along with not-shift-adjusted aggregates in chart 5 The adjustments shown here are retrospective--that is, each series is adjusted to represent an estimate of the aggregate's behavior if current regulations had been in existence over the entire history of the series. M1-A has been adjusted for shifts from demand deposits to OCDs during 1981 and to MMDAs during late 1982 and 1983. Thus, the adjusted series before 1980 lies about 10 percent below the unadjusted series, with the difference representing the estimated amount of funds in M1-A that would have resided in OCDs and MMDAs if these accounts had always been available M1 has been adjusted for shifts into OCDs from outside M1 during 1981 (M1 was not adjusted for the introduction of Super-NOW accounts and MMDAs in late 1982 and

Chart 5

Levels of the Monetary Aggregates
Shift Adjusted and Not Shift Adjusted



early 1983, given staff estimates that funds flowing into Super-NOWs from outside M1 approximately offset funds flowing out of M1 into MMDAs) Finally, M2 is adjusted for the introduction of MMDAs in late 1982.

Chart 6 shows the velocities of the shift-adjusted aggregates It can be seen that shift adjustment greatly reduces the jump in M1-A velocity in early 1981 However, as can be seen using the normalized velocity measures in chart 7, shift adjustment does not eliminate the prolonged excess of V1-A over its 1960-79 trend that has occurred during most of the 1980s Also, the sharp decline in M1-A velocity in the last two years or so is evident in either case, as is the large net drop in M1 velocity since 1981 The charts also show that V-2 shift-adjusted, like its not-shift-adjusted counterpart, has not diverged from its earlier trend to the same extent as has M1-A

Darby, Mascaro, and Marlow argue that the observed instability of these measures of M1-A velocity, shift-adjusted or not-shift-adjusted, is misleading and that underlying velocity growth of M1-A has been relatively stable since the 1960s. DMM claim in particular that the sharp rise in M1-A velocity in 1981 resulted not from deposit flows directly induced by the introduction of nationwide NOW accounts but rather from a monetary policy error They maintain the Federal Reserve underestimated the flow of funds from outside M1-A into NOW accounts during 1981 (and overestimated the effect of nationwide NOW accounts in inducing flows out of M1-A) In other words, they argue that M1-B was boosted to a greater extent by flows into NOW accounts from outside M1

Chart 6

Velocities of the Monetary Aggregates
Shift Adjusted and Not Shift Adjusted

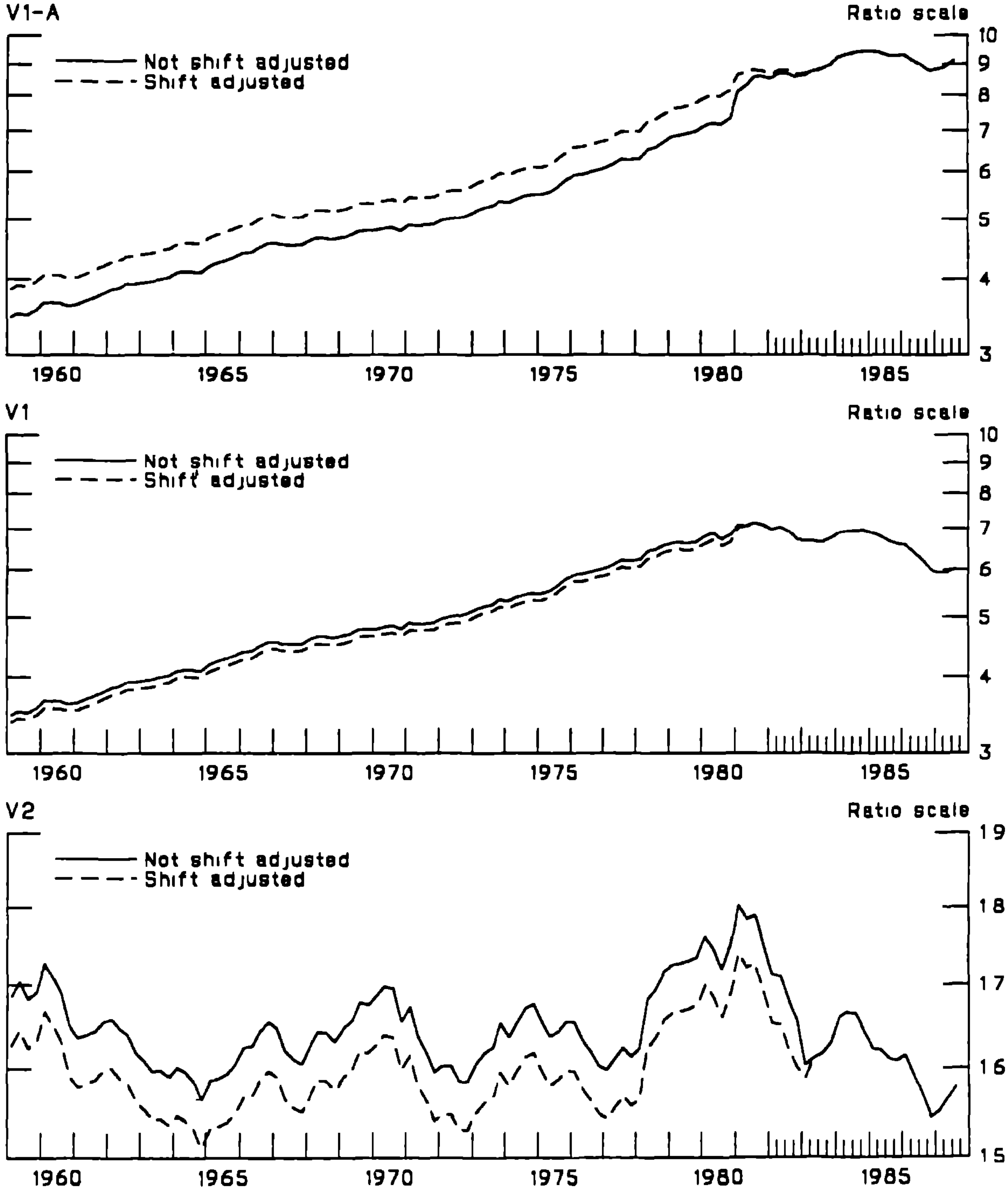
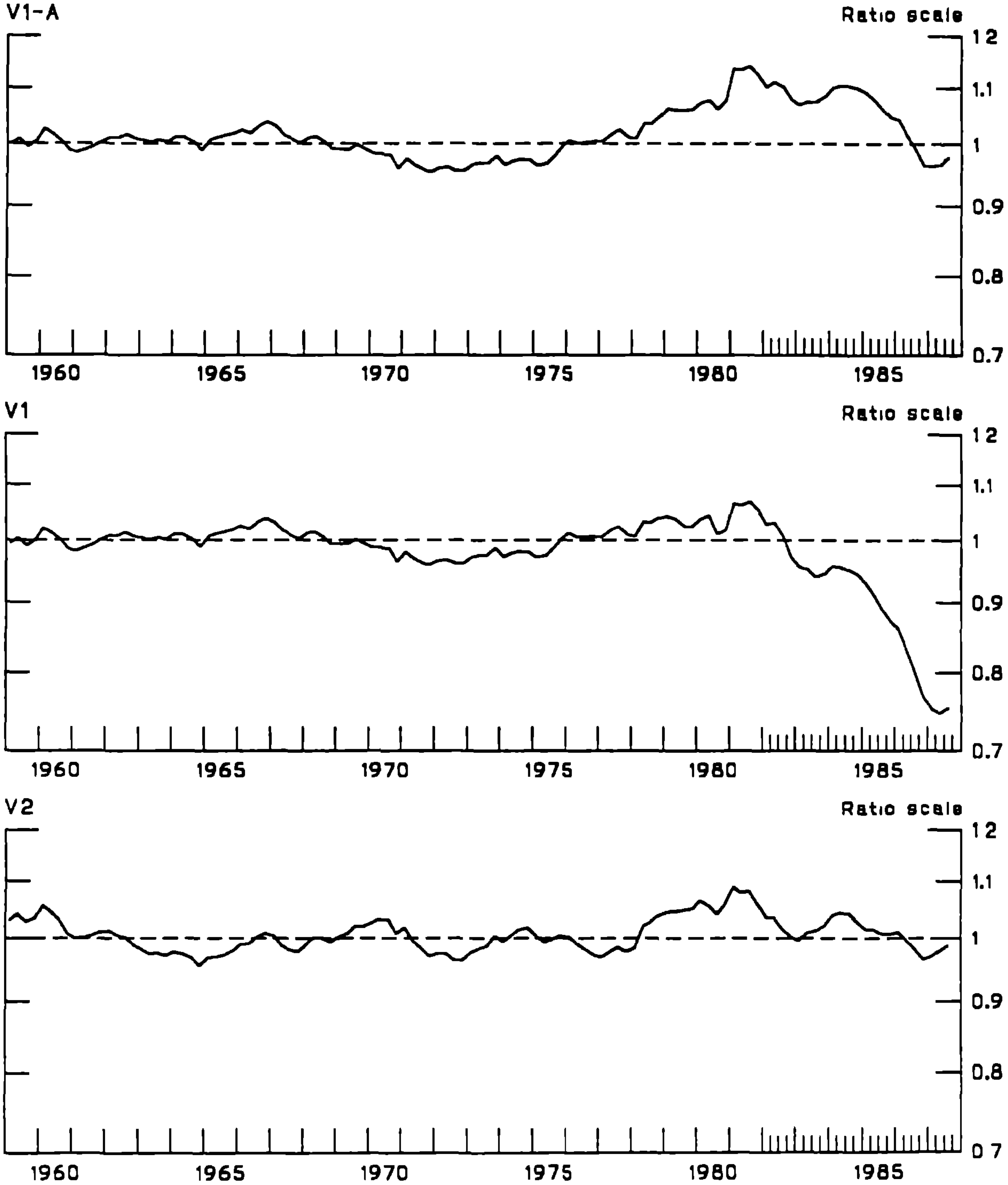


Chart 7

Normalized Shift-Adjusted Velocities

Normalized Around 1959-79 Trend



than the Federal Reserve allowed for, while M1-A was relatively little affected Because M1-B was one of the Federal Reserve's targeted aggregates, interest rates were allowed to rise in order to damp its growth This rise in rates, rather than shifts out of demand deposits and into NOW accounts, argue DMM, caused the observed sharp rise in V1-A in 1981 Thus, on this view, the stability of demand for M1-A and its velocity is maintained, while that of M1-B is seen as having been disrupted. DMM maintain that the "apparent" instability of V1-A is resolved when the lags between changes in money and the resulting changes in income are properly accounted for. To do this, they employ the concept of "leading velocity", that is, nominal GNP divided by money a quarter or more earlier They claim that M1-A's leading velocity is dominated by trend and is relatively unaffected by the nationwide introduction of NOW accounts

Charts 8 through 16 address the issue of whether a case can be made for M1-A simply on the basis of leading velocity Charts 8 through 10 show contemporaneous and leading velocity measures for the various monetary aggregates while charts 11 through 13 show corresponding measures on a normalized basis, that is, scaled by the trend of the respective velocities. Finally, charts 14 through 16 show these measures both shift-adjusted and normalized Table 1 presents statistics on the standard deviation of shift-adjusted and not-shift-adjusted velocity measures around their 1959-1979 trends both in sample and out of sample For M1-A, charts 8 and 11 show that use of leading velocity smooths out the sharp rise in velocity in 1981:Q1

Chart 8

Contemporaneous and Leading Velocity
M1-A

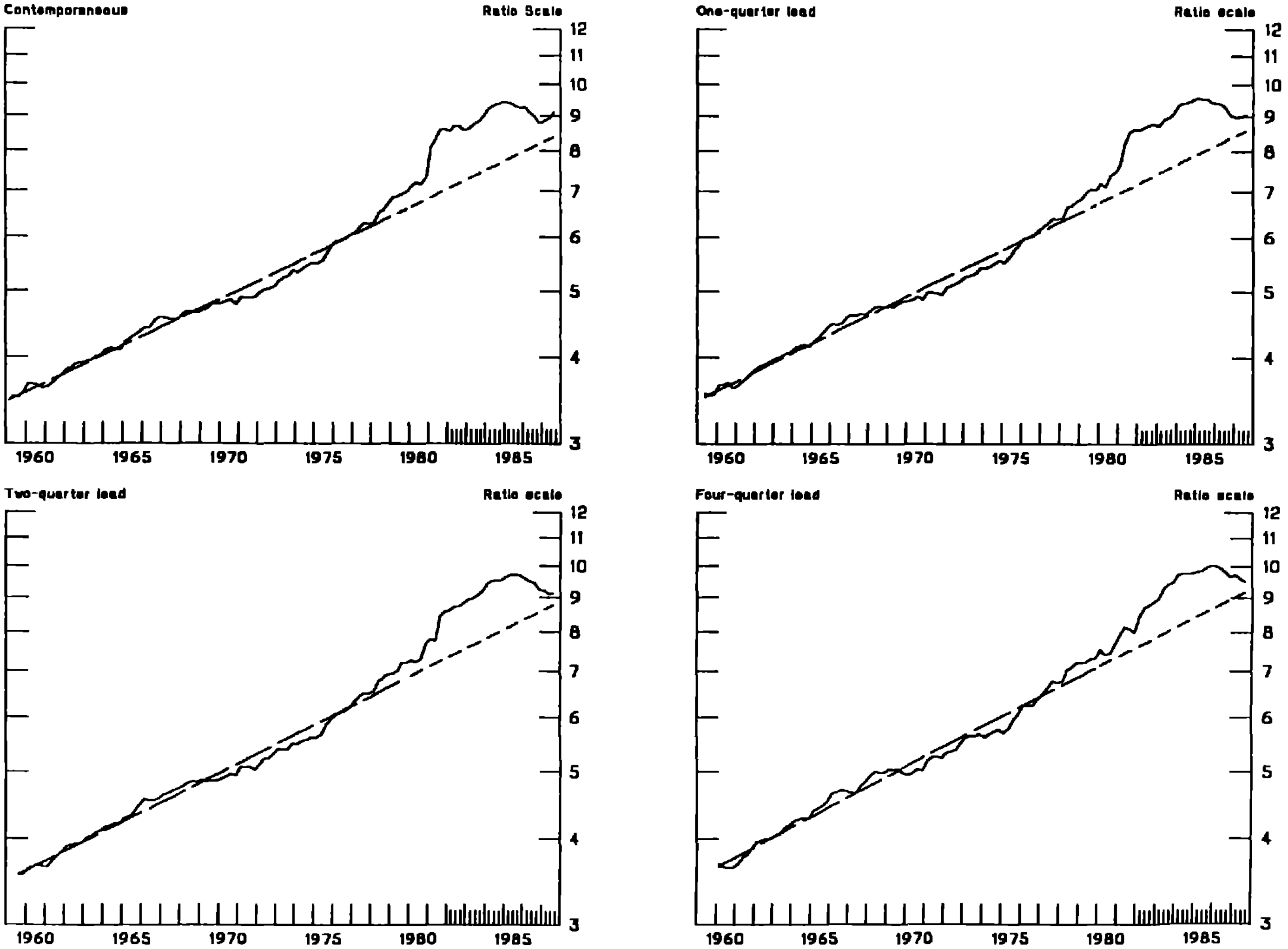


Chart 9

Contemporaneous and Leading Velocity
M1

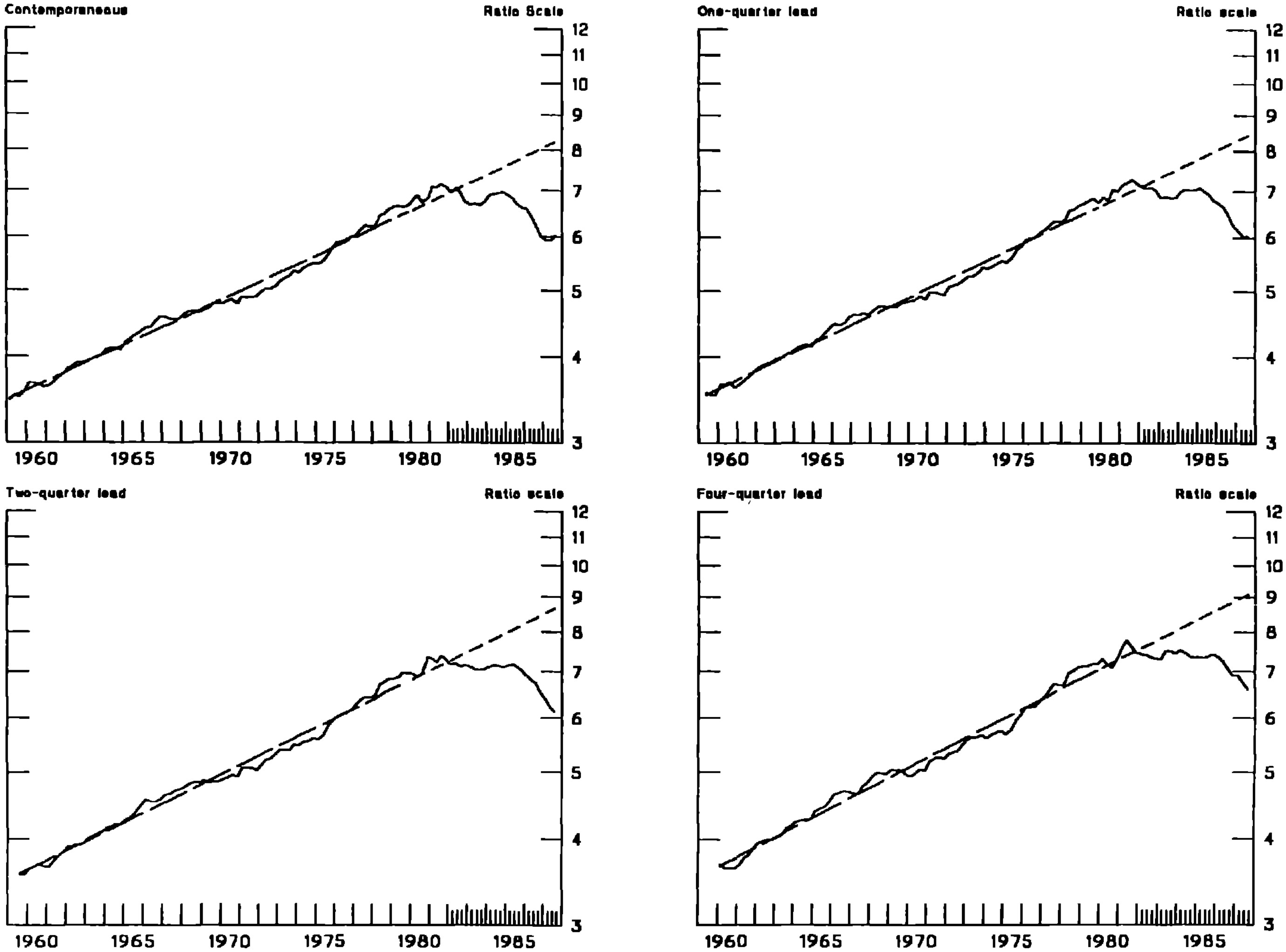


Chart 10

Contemporaneous and Leading Velocity
M2

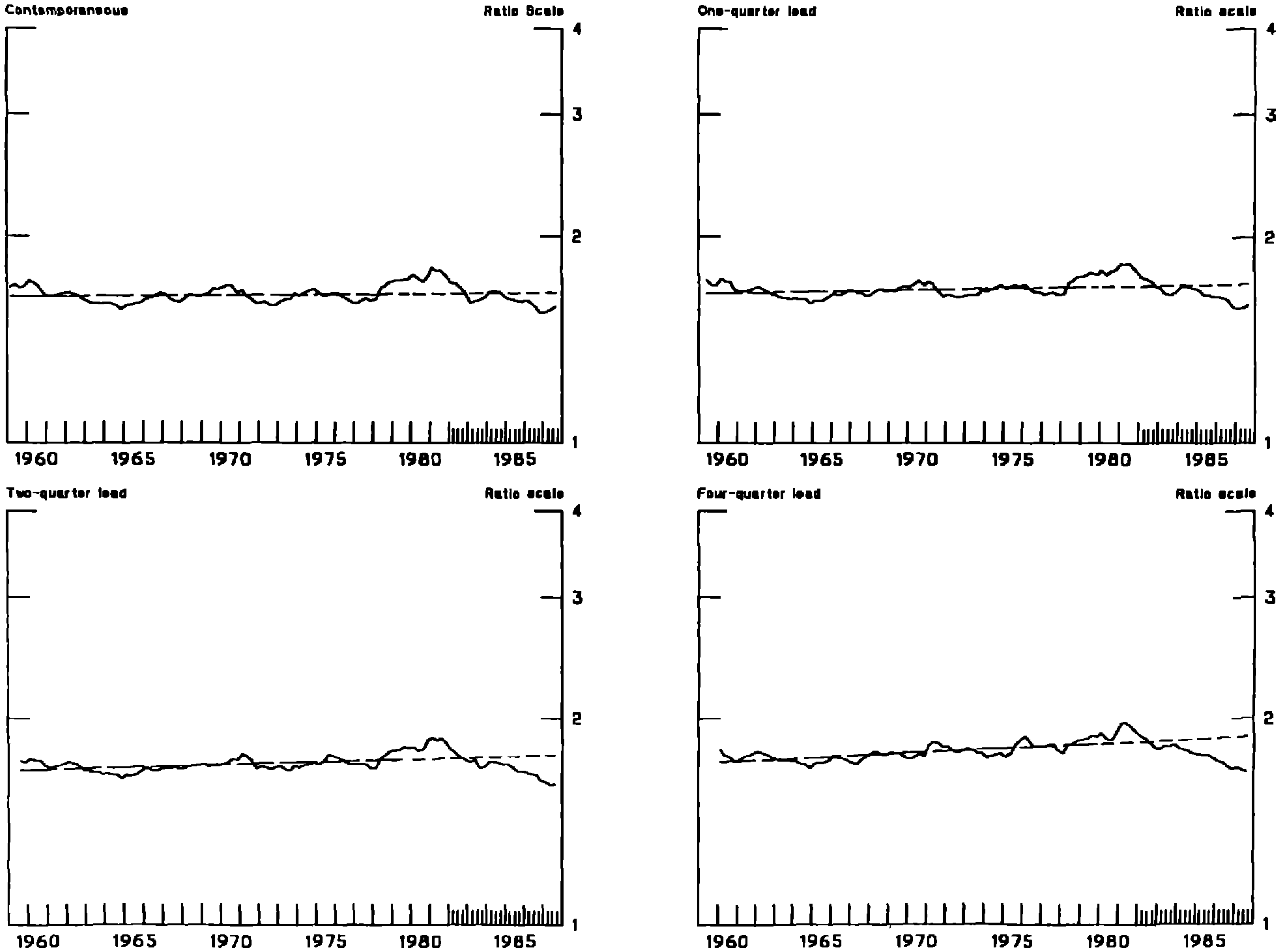


Chart 11

Contemporaneous and Leading Velocity (Normalized)
M1-A

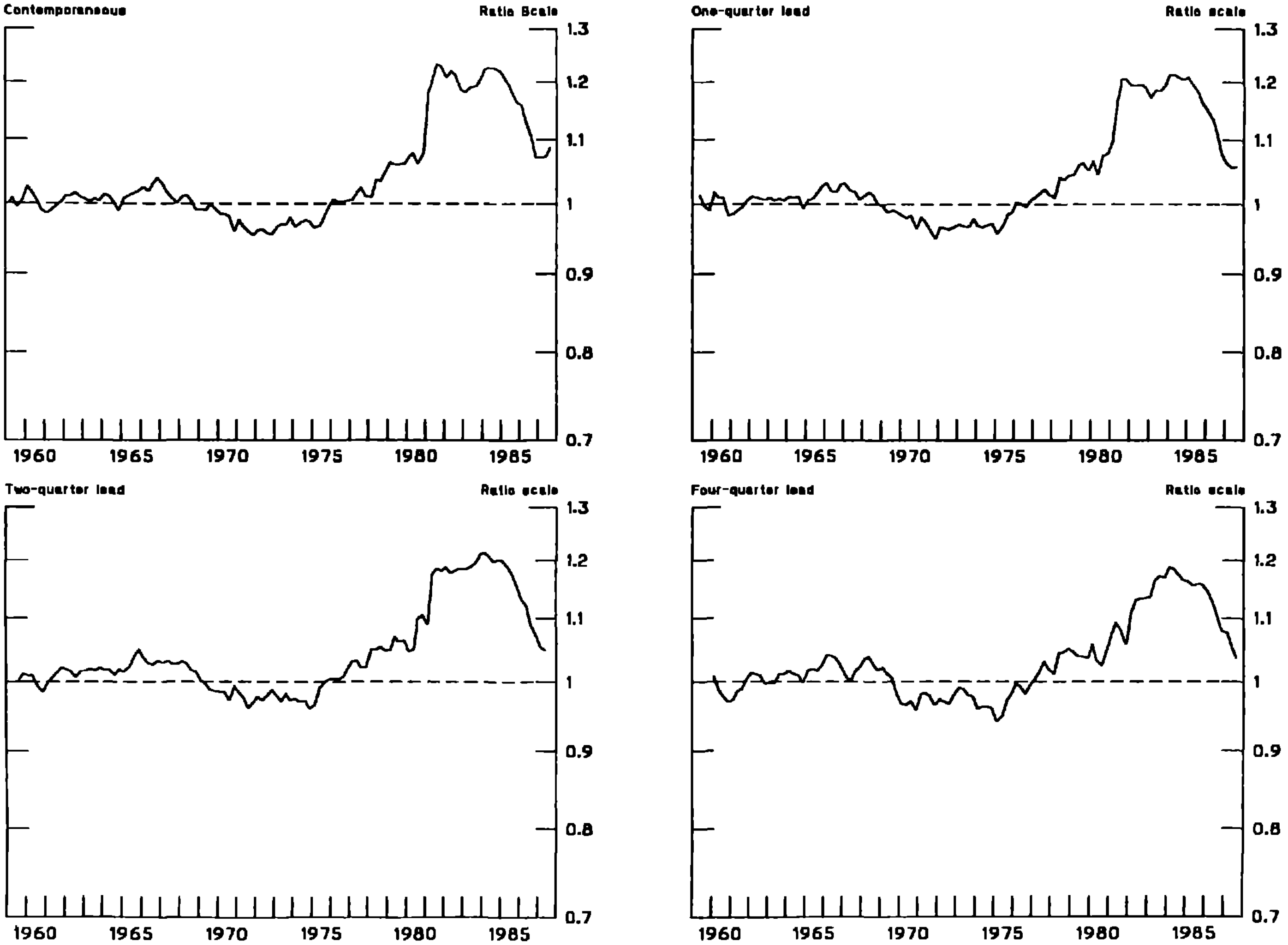
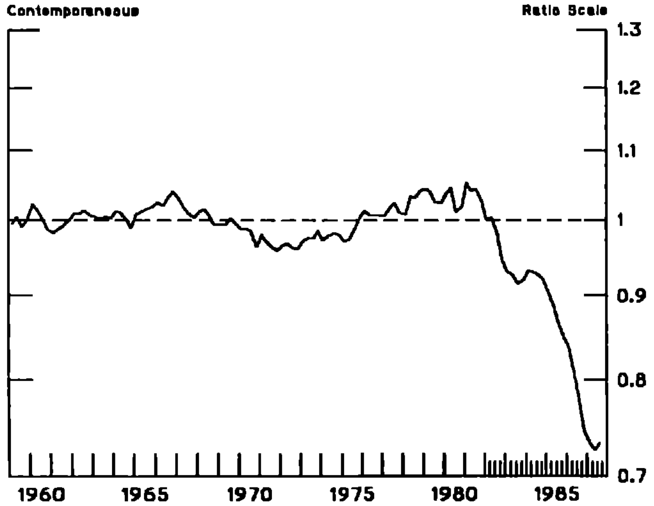
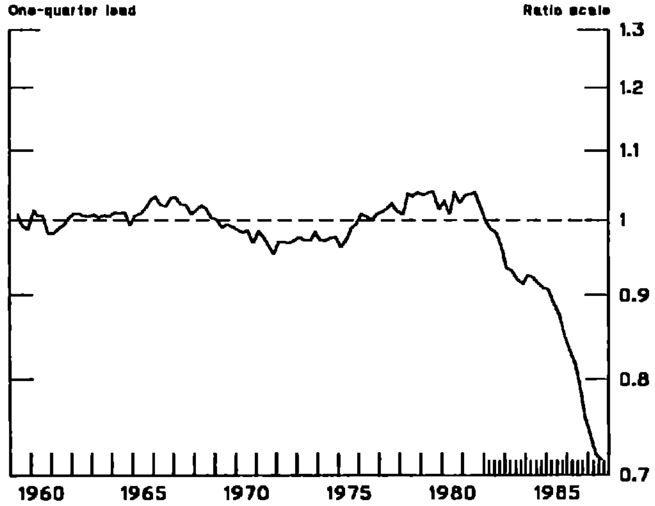


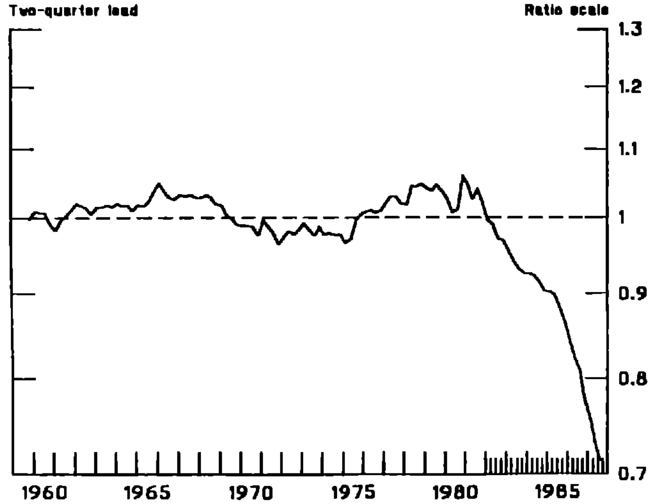
Chart 12

Contemporaneous and Leading Velocity (Normalized)

M1







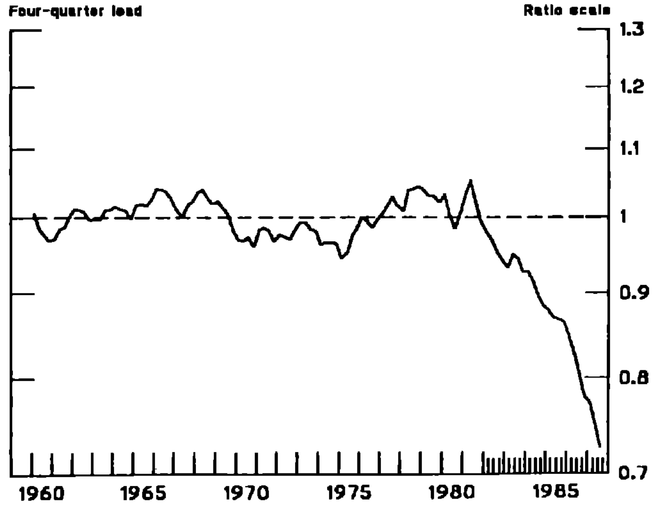


Chart 13

Contemporaneous and Leading Velocity (Normalized)
M2

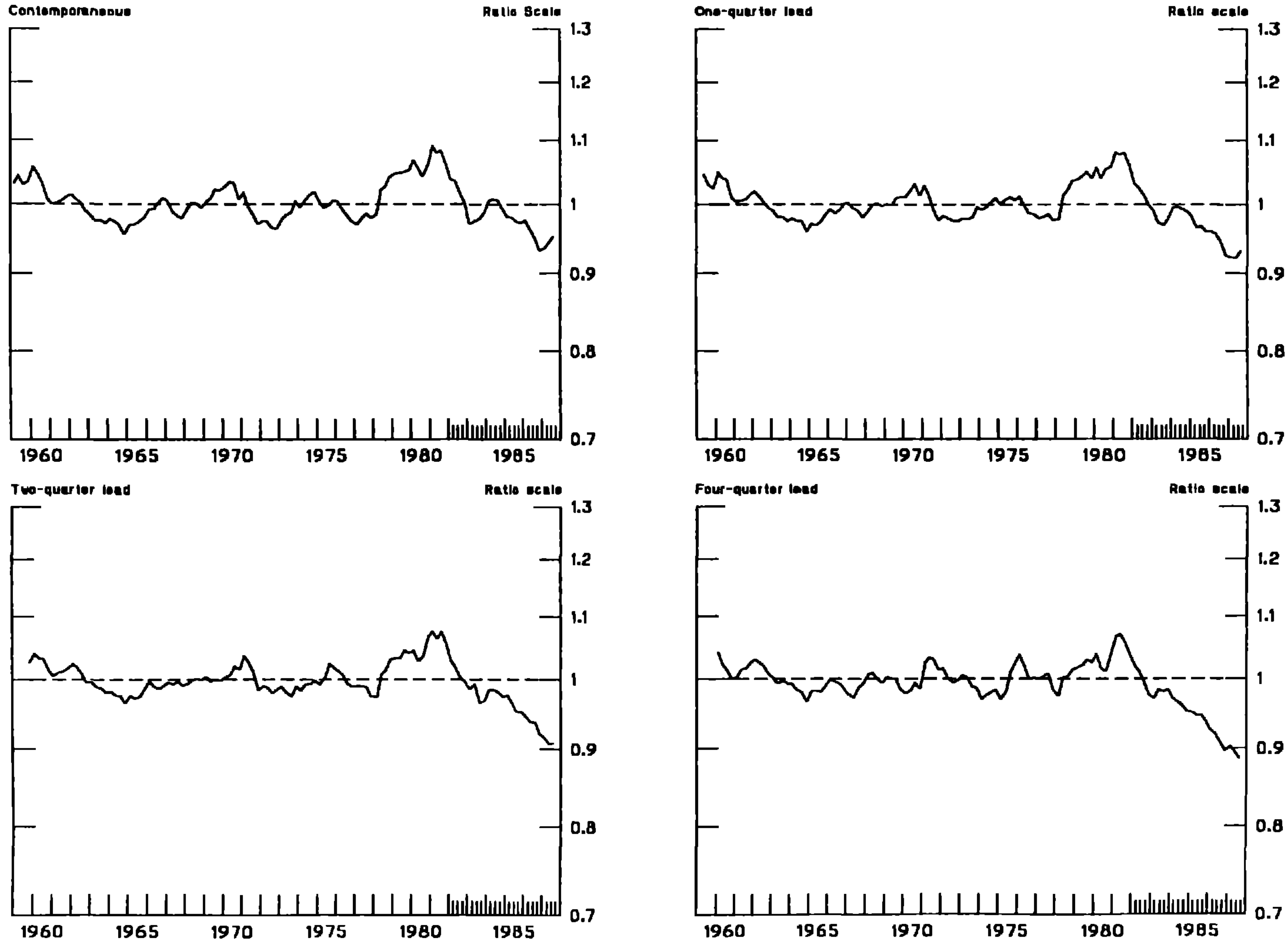


Chart 14

Contemporaneous and Leading Velocity (Normalized)
M1-A Shift-Adjusted

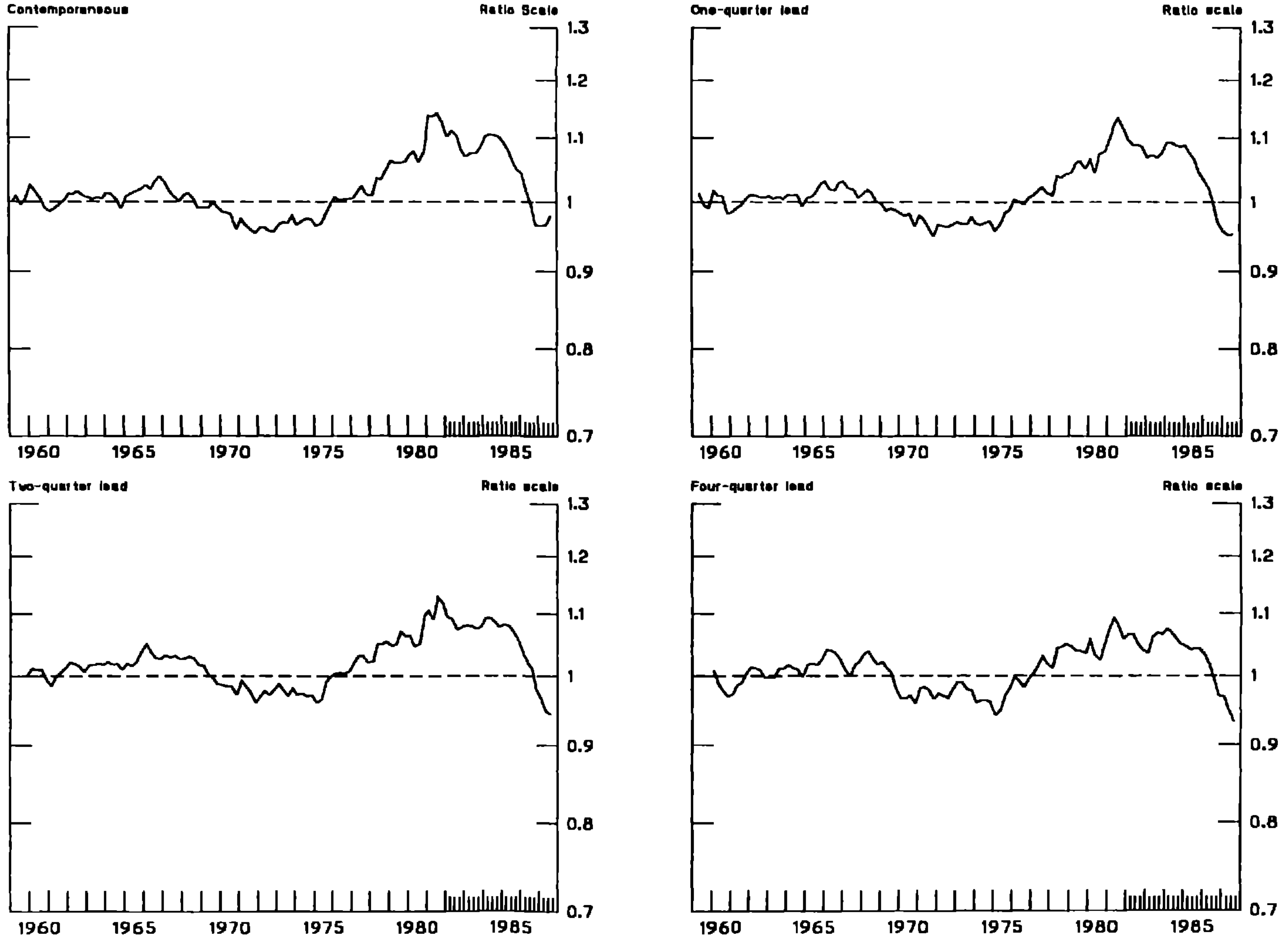


Chart 15

Contemporaneous and Leading Velocity (Normalized)
M1 Shift-Adjusted

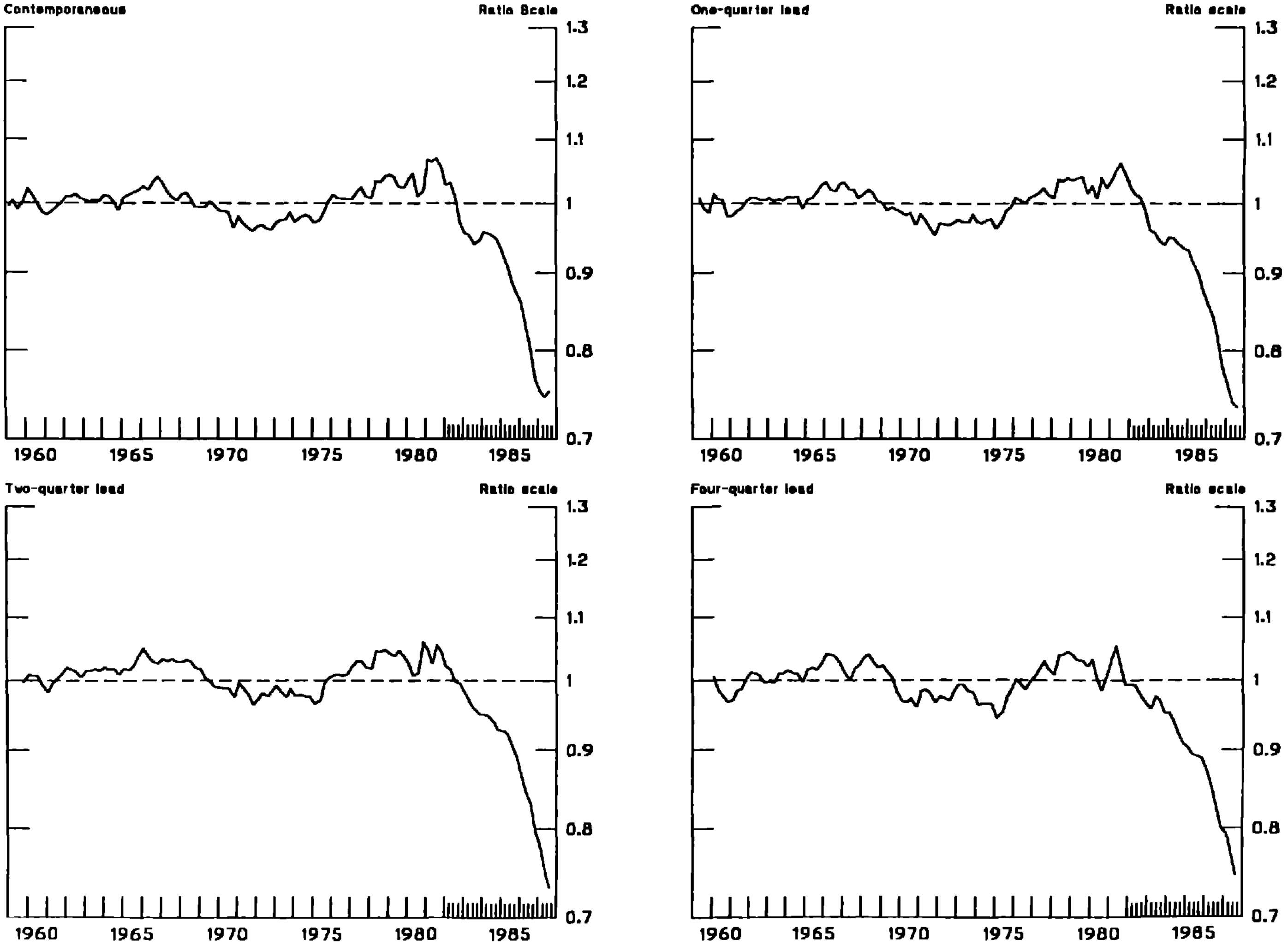


Chart 16

Contemporaneous and Leading Velocity (Normalized)
M2 Shift-adjusted

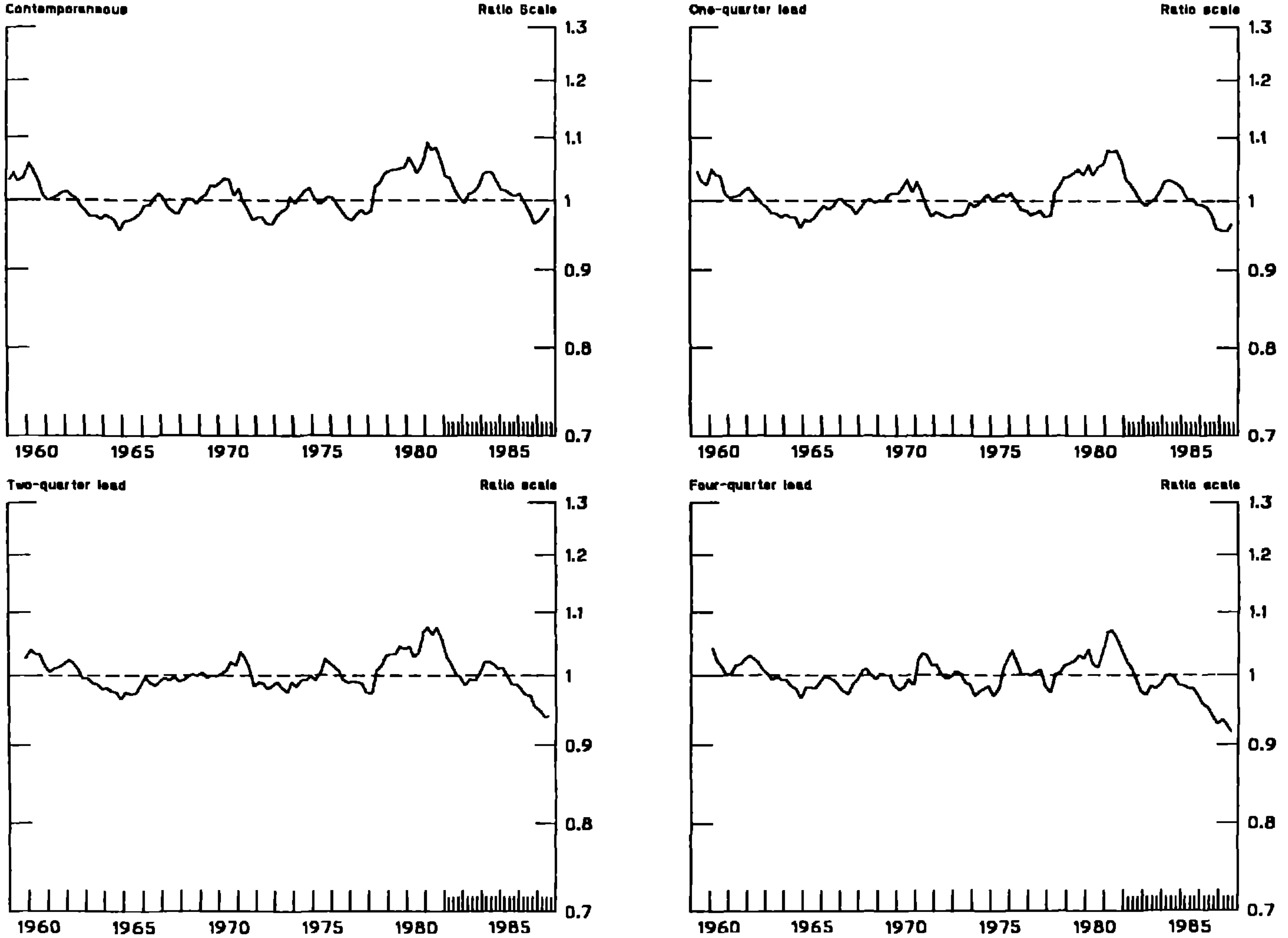


Table 1

STANDARD DEVIATIONS OF VELOCITY MEASURES AROUND TREND
(percent)

	Money Leading GNP by (quarters) 0	1	2	4
Not Shift-Adjusted				
M1-A				
In sample	2.5	2.5	2.5	2.6
Out of sample	17.4	16.1	14.9	12.6
M1				
In sample	2.1	2.1	2.2	2.4
Out of sample	12.9	12.8	12.7	12.2
M2				
In sample	2.4	2.1	1.9	1.7
Out of sample	4.6	4.8	5.1	5.8
Shift-Adjusted				
M1-A				
In sample	2.5	2.5	2.5	2.6
Out of sample	8.5	7.8	7.0	5.4
M1				
In sample	2.1	2.1	2.1	2.4
Out of sample	11.5	11.4	11.2	10.6
M2				
In sample	2.4	2.1	1.9	1.7
Out of sample	4.1	3.8	3.8	4.1

In sample period: 1959:Q1 to 1979:Q4.
Out of sample period: 1980:Q1 to 1987:Q3.

(Arithmetically, this comes about by disassociating that quarter's 22 percent fall in M1-A with its 20 percent increase in nominal GNP) It also moderates somewhat the substantial and sustained deviations during the 1980s of V1-A from its previous trend However, in all cases the velocity of M1-A still clearly diverges from trend In fact, the increase in its velocity above trend over most of the 1980s suggests that M1-A--even when shift-adjusted--was still being affected by shifts from demand deposits to NOW accounts Over the last two years, V1-A has declined appreciably under all lag structures, likely owing to the large net drop in nominal interest rates.

Despite the claims of analysts that leading velocity is more stable than contemporaneous velocity, the evidence of the 1960s and 1970s provided little support for this contention in the case of M1-A For both M1-A and M1, and for leads between zero and four quarters, standard deviations around the 1960-79 trend fall closely around 2-1/2 percent; for longer leads, standard deviations become noticeably larger Thus, available data at the close of the 1970s provided no compelling rationale for leading M1-A in the construction of a velocity measure for M1-A On the other hand, for M2 the goodness of fit between 1960 and 1979 is maximized by leading money by four quarters.

Charts 8, 11, and 14, as well as table 1, suggest that selection of an M1-A target on the basis of the expectation of stable trend growth in any velocity measure--whether shift-adjusted or not, leading or not--would have led to large targeting errors during the 1980s as compared with those for V2 On each of the not-shift-adjusted measures, in 1984 V1-A deviated from its trend by as much as 20 percent or more The errors for V1-A are reduced (to "only" 10 to 15 percent) if the shift-adjusted version is used--casting some doubt on DMM's hypothesis of the stability of V1-A--but in general would have been larger than for V2

A noteworthy characteristic of the velocity of each of the monetary aggregates has been a decline over the last several years that has been unprecedented in the postwar period Chart 17 provides some evidence that recent drops in velocity, as well as movements earlier in the 1980's, were importantly associated with fluctuations in interest rates and opportunity costs [10] Evident in the charts is the general trend increase in the velocity and opportunity cost over the 1960s and 1970s for both M1-A and M1 These trends apparently were broken recently for M1-A and M1, with both velocity and opportunity costs being below trend. As will be discussed below, the usefulness of monetary aggregates as intermediate targets is impaired if velocity is substantially influenced by interest rate movements The first part of the following section analyzes the role of interest rates in money demand and velocity and uses structural models that take interest rates into account to examine the usefulness of alternative aggregates as intermediate policy targets

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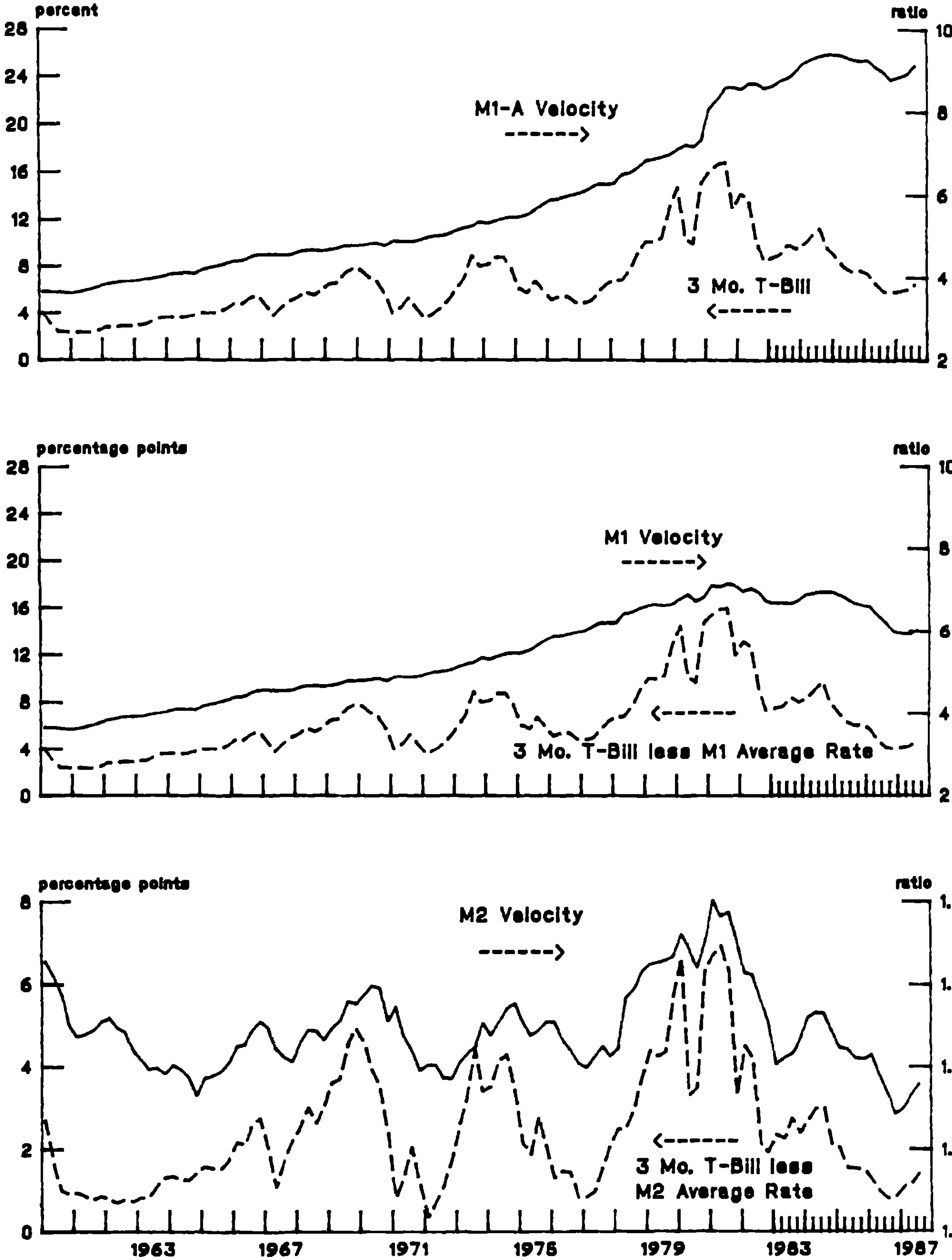
10 The opportunity costs are measured as the three-month Treasury bill rate minus a deposit-weighted average of the own rates paid on deposits in the aggregate The own rates for currency and demand deposits are assumed to be zero

Chart 17

Velocities and Opportunity Costs



III ECONOMETRIC ANALYSIS OF PROPERTIES OF M1-A AND COMPARISONS WITH M1 AND M2

This section compares the properties of M1-A, M1, and M2 as intermediate targets and indicators of nominal GNP Part A presents the results of two econometric analyses of the intermediate target properties of the aggregates and part B compares the ability of the various aggregates to serve as indicators of future GNP in a framework using reduced-form equations

A Intermediate Target Properties

This section assumes that a decision has been made to set monetary growth on a predetermined path, and that this path is not altered in response to evolving financial or economic conditions We assume that the ultimate objectives of policy can be proxied adequately by the level (or growth) of nominal GNP, and that policymakers wish to achieve some optimal level (or growth) of GNP for a particular time period by controlling monetary growth.[11] Achievement of this value for GNP can be thwarted by shifts in behavior either on the real side of the economy or on the financial side or both. For example, GNP might turn out to be weaker than desired if investment spending were autonomously weaker. Alternatively, GNP could be weaker if the demand for money--at given interest rates and GNP--increased, as upward pressure would be placed on interest rates owing to the fixed supply of money at its targeted level, reducing spending by interest-sensitive sectors

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11 Achieving stability of nominal GNP growth requires some degree of interest rate variability In this analysis, we assume that minimizing interest rate variability *per se* is not part of the policymakers' objective

In this framework, it clearly is desirable, other things equal, to target a monetary aggregate whose demand is relatively stable--that is, whose relationship to the economy and other variables is predictable If several aggregates with relatively stable demand functions are available, the best target is the aggregate that would tend to damp real shocks to spending to greatest extent This requires that the demand for that aggregate should be relatively sensitive to spending and relatively insensitive to open market interest rates. When these characteristics are present, a positive shock to spending will strongly increase the quantity of money demanded. That increase will push up interest rates and, if money demand is relatively interest inelastic, the increase in money demand will not be damped much until interest rates are significantly higher Thus, interest rates automatically would rise to restrain the increase in spending. Similarly, an aggregate that possesses relatively stable demand, a high income elasticity, and a low interest elasticity is best able to cushion a shortfall in spending by providing maximum scope for interest rates to fall

Conversely, an aggregate that has a high interest-rate elasticity will not damp shocks to spending very well For example, with such an aggregate an autonomous decline in spending would tend to reduce the quantity of money demanded Maintaining actual money at its targeted level in this case would involve only a relatively small drop in interest rates, because of the high interest elasticity of money demand, and would therefore provide little stimulus to offset the drop in spending.

The relative elasticities can be represented by the ratio of income elasticities to interest rate elasticities as shown in chart 18 A high value of this ratio implies a more attractive monetary target--that is, one that is relatively more sensitive to income and less sensitive to interest rates These estimates are derived from the Board staff's standard quarterly models of M1-A and M1 and a recently-developed aggregate model for M2 (A description of these equations is provided in appendix B.) Because the elasticities of these equations vary with the time horizon, the chart shows a series of ratios for each aggregate over varying time horizons

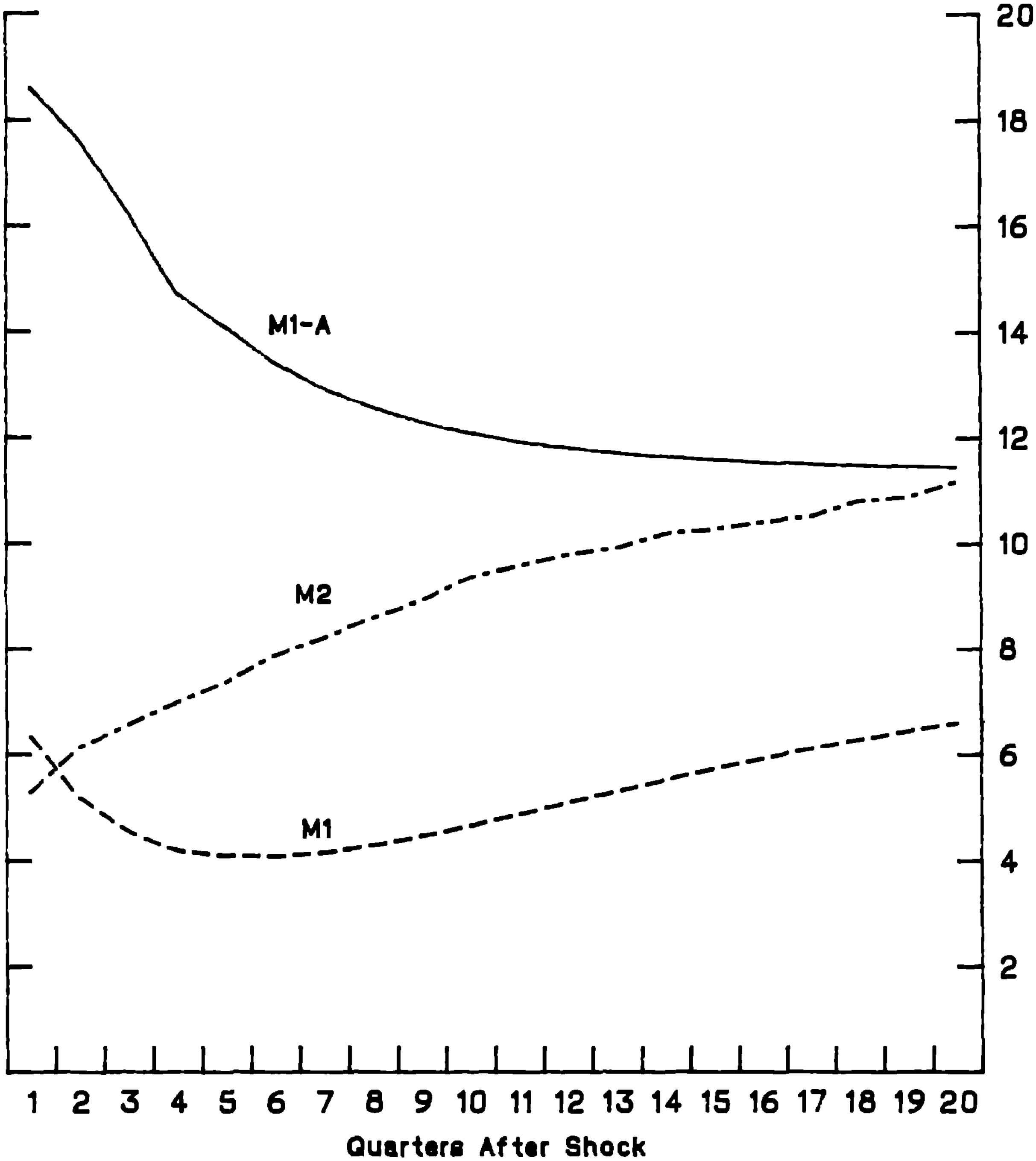
The series for M1 is in general much lower than for M1-A or for M2, reflecting primarily the large interest elasticity of NOW accounts, which stems in part from the slow adjustment of OCD interest rates to changes in market interest rates. The ratio for M2 is lower than that of M1-A The relatively small values for M2 reflect both rate elasticities that are higher and income elasticities that are lower than those for M1-A over the shorter time periods These ratios suggest that, for short- and intermediate-run monetary targeting, M1-A would be the preferred aggregate, followed by M2. Because of the large interest-rate elasticity of M1, its properties as a target are inferior to those of the other aggregates

While this analysis isolates two important characteristics of the demands for the aggregates, it is limited in that it ignores

Chart 18

RATIO OF INCOME ELASTICITY TO INTEREST ELASTICITY

(Absolute Value of Ratio)



differences in the stability of demand for the various aggregates Also missing is any consideration of other sectors of the economy where the dynamic aspects of the response of spending to interest rates and income changes could alter the relative rankings of the aggregates

To incorporate these aspects into the analysis, the staff conducted certain stochastic simulations of the MPS quarterly econometric model The purpose of the simulations was to determine the relative variability of nominal GNP and other measures of economic performance when alternative monetary aggregates are used as targets The simulations begin in the third quarter of 1987, are carried out over five years, and use shocks to each of the equations typical of those measured over the entire sample period. The simulations assume that a given monetary aggregate is held to a predetermined target path [12]

A summary of the simulations is presented in table 2 The table shows standard deviations of the levels of nominal GNP, real GNP, and the GNP deflator at various horizons ranging from 4 to 20 quarters Although the results are somewhat mixed, they tend to mitigate the impression of the superiority of M1-A that is obtained from the simpler exercise reported in chart 18. A surprising result in light of the results of chart 18 is that M1's performance is about the same as M2's and only slightly worse than M1-A at the shorter horizons. Over longer

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12 The target paths for money were established in the following way The MPS model was first simulated with no shocks, to establish a baseline consistent with relatively stable prices and employment behavior Then, using the demand models for M1-A, M1, and M2, target paths for the aggregates consistent with that stable behavior were derived

Table 2

ESTIMATED STANDARD DEVIATIONS OF LEVELS OF NOMINAL GNP,
PRICES, AND REAL GNP
USING ALTERNATIVE INTERMEDIATE MONETARY TARGETS*

	M1-A	M1	M2
Nominal GNP			
4 quarters	1 9	1.9	2 0
8	2.4	2 7	2 9
12	2 9	3 4	3.6
16	3.6	4 2	4 7
20	3.6	4.3	6.1
GNP deflator			
4 quarters	.9	1 0	.9
8	.9	2 0	2 0
12	2.8	3.1	3 2
16	3.3	4.0	4 0
20	3.5	4.8	4.6
Real GNP			
4 quarters	1 9	1.8	1.9
8	2.6	2.4	2.4
12	3.9	3.4	3.8
16	4 7	4 5	5.4
20	4 6	4 8	6 4

*Obtained from stochastic simulations of MPS model periods of four to five years, M2 performs worse than M1-A That these simulations are less favorable to M1-A is to be expected since they take account of the degree of instability of the demand for the aggregates, which is ignored in chart 18 The error history of the aggregates presented in Table 3 suggests that M1-A demand is subject to the greatest uncertainty

While evaluating the relative performance of the aggregates is helpful in judging the weights alternative aggregates should receive as targets for monetary policy, the absolute performance of all of the aggregates in stabilizing prices and income is not especially good For example, the use of an M1-A target will keep the GNP deflator at the two year horizon within 1 percent, but real GNP within only 2-1/2 percent, of an expected path

Conclusions drawn from this and the previous analyses should be qualified in a number of ways First, the money demand equations were treated as if their parameters were known with certainty, but in reality there is substantial uncertainty. Moreover, it seems that parameters of the M1-A equation may be subject to the greatest uncertainty.

In the last year or so, equations representing the demand for demand deposits--the major component of M1-A--have experienced rather large errors, as shown in table 3 The errors for demand deposits and M1-A appear to be related to movements in interest rates, suggesting that the interest elasticity of demand deposits and M1-A may have increased since the period that was used as the sample for econometric estimation In fact, alternative econometric models that the staff has

TABLE 3

MONEY DEMAND FORECAST ERRORS[1]
(percent)

Percent Level Errors[2]	M1-A[3]	M1[4]	M2[5]
Summary Statistics for Quarterly Percent Level Errors· 1985 Q1 - 1987 Q3			
Root Mean Squared Error	1 6	1 1	5
Mean Absolute Error	1 4	9	4
Mean Error	6	6	1
Annual Percent Level Errors			
1981	-.3	- 2	1
1982	7	6	1 8
1983	- 3	-.4	- 3
1984	- 6	-.5	4
1985	- 6	-.2	.3
1986	2 7	1.7	.1
Growth Rate Errors			
Summary Statistics for Quarterly Errors 1985:Q1 - 1987·Q3			
Root Mean Squared Error	2.8	2 2	1.8
Mean Absolute Error	1 9	1.4	1.4
Mean Error	1 2	.8	-.4
Annual Errors			
1981	-.3	- 2	1
1982	1.1	9	1.9
1983	-1.1	-1.1	-2 4
1984	-.3	0	.8
1985	0	.3	-.1
1986	3.7	2 2	- 2

1 Based on long-run simulations starting in 1981:Q1
2. Errors are the actual minus forecasted levels of money expressed as a percent of money stock.
3 Based on the currency and demand deposit equations of the Board quarterly model Both equations are estimated from 1961:Q1 - 1986:Q2
4 Based on the currency, demand deposit and OCD equations of the Board quarterly model. The OCD equation is estimated over 1981:Q3 - 1986:Q3
5 Based on an aggregate M2 equation estimated over 1968:Q1 - 1986:Q2

constructed imply an interest elasticity for M1-A that is about 25 percent larger than that of the standard equation

Several factors could explain an increased interest elasticity of M1-A in the 1980s First, as a result of the authorization of NOW accounts, demand deposits have become much more dominated by businesses than households Businesses are likely to be more interest rate sensitive than households in their basic cash management. Secondly, compensating balance arrangements are quite common for businesses but are not used at all for households These arrangements imply a much higher interest rate elasticity than is the case for ordinary cash management situations These two factors suggest that the changing composition of demand deposits by holder could be boosting the interest rate elasticity of M1-A

In addition, mortgage refinancing activity and prepayments of mortgage-backed securities can have a significant effect on demand deposit levels, owing to regulations relating to the form in which new loan proceeds and security prepayments must be held Refinancing activity is inversely correlated with interest rates, and it might be expected that such effects would be captured in estimated interest rate elasticities. However, this is actually unlikely to be the case because mortgage backed securities have existed in substantial volume only during the 1980s--after the sample period used for econometric investigation

If the elasticity of demand deposits is indeed substantially larger than currently estimated, the relative attractiveness of M1-A as measured in chart 18 could be significantly reduced, because demand deposits are a large fraction of that aggregate The ratio of the income elasticity to the interest rate elasticity for M2 would be little affected, because demand deposits are a small fraction of M2 However, it seems somewhat unlikely that proper measurement of the interest elasticity of M1-A would lead to a conclusion that M1-A is clearly worse than M2 as a policy target, because the margin between the interest-income elasticities of the two aggregates is fairly large The simulations of the MPS model presented in Table 2 presumably would be less affected by a higher interest elasticity of M1-A--the direct effects of the higher elasticity would be offset at least partially by smaller forecast errors and greater demand stability

Another qualification is that the results depend to an extent on other properties of the money demand equations as well as the rest of the MPS model. For example, each of the money demand relationships assumes a stable long-run velocity trend Although the data do not clearly reject such an assumption, neither do they clearly support it The existence of such a stable trend may be more questionable for M1-A than for the other aggregates, especially M2. This is because the payment of interest on demand deposits is prohibited by law Because demand deposits dominate M1-A's behavior, but not M2's, M1-A is relatively sensitive to financial innovations to evade that restriction, and to the possibility of legislative elimination of that restriction Elimination of the prohibition of interest on demand deposits could dramatically change the properties of M1-A, depending on the behavior of the own rate of interest on demand deposits.

The properties of the MPS model as a whole could in principle be an important determinant of the conclusion concerning the slight overall superiority of M1-A in the simulations At one level, that appears not to be the case, as the results tend to confirm the simpler analysis that relied only on the money demand equations. However, the properties of the model were estimated over a period of time when these aggregates generally were not being actively used as targets, and therefore may not accurately represent the behavior of the economy under such circumstances.

Finally, it should be noted that the preceding discussion compared only monetary aggregates as intermediate targets and did not examine the potential benefits of other approaches to conducting monetary policy Although M1-A appears in simulations to be a little more attractive than M1 and M2 as a monetary target, the standard errors in Table 2 and the deviations of M1-A's velocity during the 1980s from its 1960-1979 trend indicate a monetary policy narrowly focused on M1-A would entail significant risks.

B St Louis-Type Reduced-Form Equations

This section reports the properties of econometric equations that relate changes in nominal GNP directly to changes in a monetary aggregate and to changes in a measure of federal spending In contrast to the method used in part A, this approach attempts to collapse the equations of a structural model into a single equation. Thus, the equation is supposed to be a "reduced-form", reducing all the important information in a structural model into a single equation This general technique is the basic method used by Darby, Mascaro, and Marlow [13]

Dynamic simulations of such equations are shown in table 4 Results for shift-adjusted aggregates as well as for not-shift-adjusted measures are reported. These equations were estimated using quarterly data over the period from 1971:Q1 to 1984:Q4 and then simulated from 1985:Q1 to 1987:Q3. The explanatory power of all the equations within the sample is very low, as indicated by the R^2, varying from essentially zero to at most 11 percent Likewise, the in-sample standard errors of the equations are large--between 4-3/4 percent and 5 percent for one-quarter-ahead forecasts

As clearly seen in the top panel, during 1985 and 1986 when interest rates were falling, nominal GNP growth was substantially over-predicted by all aggregates. As indicated by the mean errors in the lower panel, this tendency to over-predict is largest for M1 and M1 shift-adjusted The high interest elasticity of OCD balances, as captured by the structural money demand models, contributed significantly to high M1 growth over this period, and this growth apparently contributed to leading astray the reduced form equations using M1. The mean errors for M1-A also are very large, larger in fact than the mean growth rate of nominal GNP The mean errors for M2 were only about one-half or less of those of the other aggregates

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13 Economists have recognized for some time that the reduced form approach is fraught with econometric problems, such as simultaneous equations bias.

Table 4

ST LOUIS-TYPE REDUCED-FORM RESULTS FOR NOMINAL GNP GROWTH
(percent)

	Actual GNP Growth	Simulated GNP Growth Rates					
		M1-A	M1	M2	M1ASH	M1SH	M2SH
1985:Q1	7.4	11 4	9.2	11 6	10.3	9 6	13 4
1985 Q2	5 5	10 6	10 8	10 6	10 1	10 4	13 7
1985·Q3	7.1	10.4	10.5	6 9	10.5	12.0	6 1
1985.Q4	6.3	11 1	11.8	5.8	10.7	11 9	4 2
1986 Q1	7.0	14 5	16 7	11.2	13.8	16 8	12 5
1986·Q2	3 6	13 0	12.2	7.7	11 7	12 6	9 7
1986 Q3	5 3	16 2	18.1	10.5	15 9	18 2	10 4
1986·Q4	2 1	16 3	21 5	13.3	16 7	20 9	16 2
1987 Q1	8 6	16.2	22 0	10 8	16.4	22 0	11 9
1987·Q2	6 3	12 2	19 5	8 4	12 2	20.0	6 0
1987.Q3	7 0	10 5	13.6	3.7	8 8	14 9	1 0
Mean	5 9	12 9	15 3	9 1	12 5	15 4	9 6

	M1-A	M1	M2	M1ASH	M1SH	M2SH
Regression Summary Statistics						
Long-Run Fiscal Contribution[1]	- 83 (- 74)	.42 (.38)	02 (02)	- 44 (- 40)	54 (.48)	- 58 (- 53)
R^2	11	01	-.03	.10	05	10
Standard Error	4.71	4 96	5.06	4.73	4 87	4 73
Simulation Summary Statistics[2]						
Mean Error	-6.9	-9.3	-3.1	-6 5	-9.4	-3 5
Mean Absolute Error	6 9	9.3	3 8	6 5	9 4	5 3
Root Mean Squared Error	7 7	10 4	4 8	7.4	10 5	6 4

SH indicates the aggregate is shift adjusted
Estimation Period· 1971 Q1-1984 Q4
Simulation Period· 1985 Q1-1987 Q3
1 t-statistics for sum of fiscal variables in parentheses
2 Summary statistics are for quarterly growth rate errors from 1985 Q1 to 1987·Q3
Note The sum of the coefficients of the various monetary aggregates are constrained to equal unity in the simulations reported

Statistics for mean absolute errors and root mean squared errors show a similar pattern These results--in contrast with those of the previous section--suggest some superiority of M2 over M1-A, but all of the aggregates perform very poorly in this framework

Appendix A

A CRITIQUE OF DARBY, MASCARO, AND MARLOW'S PAPER ON M1-A

In a recent working paper, Darby, Mascaro, and Marlow (DMM) claim " that the traditional definition of money (M1 less other checkable deposits, or M1-A) shows no evidence of structural change, and yields <u>lower</u> prediction errors for <u>both</u> real GNP growth and inflation over 1983-1987·Q2 than the errors obtained using M1 or M2."[1] As noted in the text of the current paper, there is little dispute that M1-A's performance has been superior to that of M1 during the 1980s However, we disagree that DMM have presented a strong case that M1-A unambiguously has been a better predictor than M2

DMM's conclusions are based on single-equation reduced-form models of real GNP growth and inflation. For each equation, two versions are presented--one with the price of oil as a key explanatory variable and one without the price of oil [2] The estimation period is 1961 Q1 to 1982·Q4, with out-of-sample forecasts from 1983 Q1 to 1987 Q2 being used to evaluate the alternative aggregates. M1-A, M1 and M2 were used as alternative explanatory variables in the real GNP growth and inflation equations. Based on the accuracy of these out-of-sample forecasts for real GNP growth and inflation, DMM conclude that M1-A is a superior indicator relative to M1 and M2

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1 Michael R. Darby, Angelo R Mascaro, and Michael C Marlow "The Empirical Reliability of Monetary Aggregates as Indicators 1983-1987 " Research Paper No 8701, U S Treasury Department

2 In the real GNP equation, the oil shock variable attempts to capture shortrun disruptions to output from relative oil price changes This shock variable is the square of the percentage change in the price of oil relative to the GNP deflator In the inflation equation, the percentage change in the relative price of oil is used

Table A-1 presents the general form of the DMM equations for real growth and inflation [3] Tables A-2 through A-5 contain the parameter estimates for these equations when M1-A, M1, and M2 and their shift-adjusted versions are used. Tables A-2 and A-3 follow DMM's procedure of adjusting the growth of the aggregates in 1981·Q1 to correct for flows induced by the nationwide introduction of NOW accounts Tables A-4 and A-5 are based on the shift-adjusted monetary aggregates that have been constructed by the Board staff

DMM's statistical results are open to various interpretations, but to view them as clearly indicating that M1-A is superior to M2 as a monetary target overstates the evidence. Rather, M1-A and M2 turn out to be fairly fairly close competitors, with each outdistancing M1 by a sizable margin Nonetheless, both M1-A and M2 have exhibited substantial noise in their relation to the underlying condition of the economy, which implies that targeting either aggregate would pose considerable risks.

Traditional monetarist thought postulates that money growth is a major determinant of nominal GNP growth Conditions on the supply side of the economy--such as wage setting behavior and productivity growth--separate nominal GNP growth into real growth and inflation Thus, it is somewhat surprising that DMM did not cast their models along these lines, but rather specified separate real GNP and inflation equations. Allowances for aggregate supply shocks in these equations were made, but these raise additional complications, and separate DMM

3. Tables A-1 through A-8 are at the end of this appendix

from the traditional approaches.[4] If the supply shock terms are not specified correctly in the econometric representations, ranking the aggregates as targets for monetary policy on the basis of their forecasting performance of real GNP growth and inflation can easily yield incorrect results. For example, no account is taken of the position of the economy relative to full utilization of resources, in the DMM formulation an acceleration of M1-A growth yields the same results for real GNP and inflation no matter what the initial economic conditions are Thus, at different levels of GNP relative to capacity, or in the presence of supply shocks, an aggregate could possibly predict nominal GNP accurately but still fail to predict its division into real GNP and inflation. As shown in Tables A-6 and A-7, even though M1-A yields better real GNP and inflation forecasts, M2 yields better nominal GNP forecasts, as measured by the root-mean-squared error (RMSE) of the growth rate forecasts.

The strongest case made by DMM for choosing M1-A over M2 is based on the real GNP forecast using quarterly data. In addition, though, M1-A yielded better forecasts than M2 on an annual basis from 1983 to 1986. The respective actual growth rates over these years were steadily slowing real GNP growth of 6.5, 5.1, 3 3 and 2 2 percent DMM's M1-A equation with the oil variable included generally predicted such a slowdown with forecasts of 6.0, 4.9, 4 0 and 4 3 percent,

4. For example, see "Polynomial Distributed Lags and the Estimation of the St Louis Equation" by Dallas S. Batten and Daniel L Thorton, Review Federal Reserve Bank of St. Louis, April 1983.

respectively [5] The M2 equation with the oil variable yielded a time profile of 2.5, 3 0, 4 1 and 1 6 percent per year, with increasing real growth between 1983 and 1985 Thus, over the last four years, M1-A has served as a better indicator of the longer-run behavior of real GNP

With respect to the inflation forecasts, DMM again choose M1-A over M2 as the preferred aggregate This "horse race" likewise is conducted on the basis of summary statistics for the out-of-sample forecasts, these statistics from the DMM paper are given in Table A-8 For the set of forecasts that yields the lowest RMSEs, which come from the equations using oil prices as explanatory variables, M1-A clearly dominates M2 with respect to mean error but is only marginally better with respect to the RMSE. Basing a preference for M1-A as the monetary target largely on the basis of the mean error for inflation ignores important information regarding the signals given by the aggregate concerning the likely future course of inflation. In particular, the rate of growth of the GNP deflator has generally been slowing since 1981 DMM's in-sample predictions of inflation for 1982 and their out-of-sample predictions for 1983 also generally fell over this period, but the inflation forecast was too low through 1984:Q3 and too high thereafter. DMM's equations based on M1-A--both with and without the oil variable--signalled continually increasing inflation from late 1983 through 1986, ending at about seven percent in 1987:Q2 But from late

5 These annual growth rate forecasts are based on our version of DMM's model which is nearly identical for the real GNP growth equation. Our inflation equation differs slightly from DMM's in that we estimate slightly higher autocorrelation of the residuals--and get Durbin-Watson statistics slightly closer to two

1983 through late 1985 actual inflation was subsiding Although this pattern of under-forecasting and then over-forecasting inflation yields a low mean error for the forecast, M1-A missed badly by forecasting an upturn in inflation that, aside from quarterly fluctuations, did not occur for at least three years

Finally, we have altered DMM's model by using the Board's shift-adjusted versions of M1-A, M1 and M2 in their model. The out-of-sample forecasts for inflation and growth of real and nominal GNP are given in Tables A-6 and A-7 As shown, the performance of M1-A is weakened when its shift-adjusted version is used While this may argue for not using the shift-adjustment, an alternative explanation for the better performance of not-shift-adjusted M1-A takes into account offsetting effects on that aggregate. Interest rates in general fell over the 1983-1986 forecast period, tending to raise M1-A, M1 and M2 relative to GNP. But the continuing shifts of household balances from demand deposits into newly authorized accounts such as NOW accounts over this period tended to depress M1-A relative to GNP. Thus, the interest rate effects on M1-A balances tended to be offset by shifts brought about by new accounts, inducing an apparent stability in the relation between M1-A and GNP The forecasts based on M2 growth are little changed by using the Board staff's shift-adjustments The net effect is that M2 continues to dominate M1-A in forecasting nominal GNP growth and does as well as M1-A in forecasting inflation when the price of oil is included as an explanatory variable

Table A-1

General Form of DMM Real GNP Growth and Inflation Equations[1/][2/]

$$\Delta\ GNP = constant + DUM1*PCONTROL + DUM1*CCONTROL + \sum_{i=1}^{12} f_i*EXP_{-i}$$

$$+ \sum_{i=0}^{12} M_i*Money_{-i} + \sum_{i=1}^{12} sh_i*Oilshock_{-i}$$

$$\Delta\ DEFL = constant + DUM3*PCONTROL + DUM4*CCONTROL$$

$$+ \sum_{i=1}^{16} g_i*EXP_{-i} + \sum_{i=1}^{16} N_i*Money_{-i} + \sum_{i=1}^{16} pi*oilprice_{-i}$$

Definitions

Δ GNP = real GNP growth

Δ DEFL = rate of growth of GNP deflator

PCONTROL = Dummy variable for price controls. It equals + .143 in 1971:Q3 to 1973:Q3, -.143 in 1973:Q2 to 1974:Q4, and zero elsewhere.

CCONTROL = Dummy variable for credit controls. It equals one in 1980:Q2 and zero elsewhere.

Money = rate of growth of the relevant measure of money--M1A, M1 or M2. Each has some adjustment for financial deregulation. These adjustments reflect Board staff estimates.

Oilshock = the oil shock variable is calculated as $100*[\log (VENOIL/DEFL - \log (VENOIL/DEFL)_{-1}]^2$ where VENOIL = nominal price of Venezualan oil and DEFL = GNP deflator.

Oilprice = $100*[\log(VENOIL/DEFL) - \log(VENOIL/DEFL)_{-1}]$

EXP = rate of growth of cyclically-adjusted Federal expenditures.

Estimation Restrictions
The coefficients on money and expenditures are forced to lie on a second degree polynominal distributed lag (PDL) with a far end restriction in both the real growth and the inflation equations. The coefficients on the oil variable are forced to lie on a third degree PDL in the real growth equation with both near and far end restrictions and on a second degree PDL in the inflation equation with the far end constrained. In both cases the inflation equation is estimated with a first-order autocorrelation correction of the residual.

Estimation Period   1961:Q1 - 1982:Q4 for the real growth equations
1961:Q2 - 1982:Q4 for the inflation equation.

1/ * denotes multiplication.
2/ The subscript i denotes the ith period prior to the current period.

Table A-2

Real GNP Growth Equations with Partial Shift-Adjustment of the Monetary Aggregates [1]

(t-statistics in parentheses)

	Without Oil Shock			With Oil Shock		
	M1A	M1	M2	M1A	M1	M2
Constant	5.22 (3.71)	6.11 (4.49)	3.65 (1.83)	5.50 (3.80)	6.41 (4.63)	3.93 (1.92)
Price Controls	11.67 (1.74)	11.58 (1.65)	7.37 (.86)	7.99 (1.16)	8.10 (1.14)	5.51 (.63)
Credit Controls	-11.24 (-3.26)	-10.65 (-3.01)	-11.63 (-3.20)	-11.01 (-3.23)	-10.51 (-2.99)	-11.63 (-3.22)
Sums of Coefficients						
Expenditures	-.13 (-.98)	-.16 (-1.08)	-.42 (-3.04)	-.23 (-1.54)	-.28 (-1.68)	-.41 (-2.68)
Money	-.21 (-.92)	-.37 (-1.47)	.38 (1.62)	-.09 (-.40)	-.23 (-.89)	.36 (1.51)
Oil Shock	n.a.	n.a.	n.a.	.06 (.28)	.10 (.45)	-.14 (-.59)
$\bar{R}$-squared	.35	.32	.27	.37	.34	.29
Durbin Watson	2.06	1.97	1.85	2.18	2.07	1.94
Standard Error of the Regression	3.38	3.45	3.57	3.32	3.41	3.54

n.a.--not applicable.

1. Partial shift-adjustment indicates the growth of the relevant aggregate in 1981:Q1 has been set equal to that of the corresponding shift-adjusted aggregate.

Table A-3

Inflation Equations with Partial Shift-Adjustment of the Monetary Aggregates [1]

(t-statistics in parentheses)

	Without Oil Shock			With Oil Shock		
	M1A	M1	M2	M1A	M1	M2
Constant	-1.71 (-2.01)	-1.22 (-1.63)	-3.75 (-2.02)	-1.57 (-1.82)	-.87 (-1.14)	-3.39 (-2.03)
Price Controls	-8.60 (-2.48)	-11.00 (-3.35)	-5.49 (-1.02)	-6.13 (-1.74)	-8.28 (-2.48)	-2.09 (-.42)
Credit Controls	1.13 (.72)	.53 (.34)	1.17 (.72)	.68 (.42)	.29 (.19)	.58 (.34)
Sums of Coefficients						
Expenditures	.18 (1.83)	-.00 (-.02)	.30 (2.13)	.23 (2.06)	.005 (.045)	.38 (2.77)
Money	1.21 (8.03)	1.34 (8.82)	.81 (3.31)	1.06 (6.59)	1.21 (7.36)	.65 (3.17)
Oil Shock	n.a.	n.a.	n.a.	.08 (1.16)	.13 (1.94)	.11 (1.13)
rho for first-order autocorrelation of the residual	.17 (1.58)	.13 (1.11)	.44 (4.32)	.11 (.98)	.06 (.50)	.30 (2.68)
$\bar{R}$-squared	.69	.71	.61	.70	.72	.62
Durbin Watson	1.99	1.93	2.10	1.97	1.92	2.00
Standard Error of the Regression	1.58	1.54	1.78	1.56	1.52	1.75

n.a.--not applicable.

1. Partial shift-adjustment indicates that the growth of the relevant monetary aggregate in 1981:Q1 has been set equal to that of the corresponding shift-adjusted aggregate.

Table A-4

Real GNP Growth Equations with Complete Shift-Adjustment of the Monetary Aggregates

(t-statistics in parentheses)

	Without Oil Shock			With Oil Shock		
	M1A	M1	M2	M1A	M1	M2
Constant	5.66 (3.83)	5.90 (4.33)	3.65 (1.84)	5.92 (3.93)	6.20 (4.48)	3.93 (1.92)
Price Controls	11.98 (1.71)	11.42 (1.67)	7.36 (.86)	8.15 (1.13)	7.94 (1.13)	5.50 (.63)
Credit Controls	-11.17 (-3.13)	-10.73 (-3.05)	-11.63 (-3.20)	-10.91 (-3.09)	-10.60 (-3.04)	-11.63 (-3.22)
Sums of Coefficients						
Expenditures	-.20 (-1.49)	-.15 (-1.06)	-.42 (-3.05)	-.31 (-2.04)	-.27 (-1.67)	-.41 (-2.68)
Money	-.18 (-.72)	-.33 (-1.34)	.38 (1.62)	-.54 (-.21)	-.20 (-.77)	.36 (1.51)
Oil Shock	n.a.	n.a.	n.a.	.08 (.36)	.10 (.45)	-.14 (-.59)
$\bar{R}$-squared	.30	.33	.27	.33	.35	.29
Durbin Watson	1.91	2.00	1.85	2.04	2.11	1.94
Standard Error of the Regression	3.50	3.43	3.57	3.44	3.38	3.54

n.a.--not applicable.

Table A-5

Inflation Equations with Complete Shift-Adjustment of the Monetary Aggregates

(t-statistics in parentheses)

	Without Oil Shock			With Oil Shock		
	M1A	M1	M2	M1A	M1	M2
Constant	-1.87 (-2.19)	-1.34 (-1.84)	-3.75 (-2.02)	-1.68 (-1.94)	-.98 (-1.33)	-3.39 (-2.03)
Price Controls	-8.98 (-2.59)	-10.82 (-3.42)	-5.48 (-1.02)	-6.48 (-1.84)	-8.16 (-2.53)	-2.09 (-.41)
Credit Controls	1.10 (.70)	.49 (.32)	1.17 (.72)	.70 (.44)	.27 (.17)	.58 (.34)
Sums of Coefficients						
Expenditures	.16 (1.64)	.01 (.13)	.30 (2.13)	.20 (1.80)	.02 (.14)	.38 (2.77)
Money	1.27 (7.98)	1.34 (9.30)	.81 (3.31)	1.12 (6.60)	1.22 (7.76)	.65 (3.18)
Oil Shock	n.a.	n.a.	n.a.	.09 (1.24)	.13 (1.99)	.11 (1.13)
rho for first-order autocorrelation of the residual	.17 (1.55)	.10 (.88)	.44 (4.31)	.11 (.97)	.03 (.27)	.30 (2.68)
$\bar{R}$-squared	.69	.71	.61	.70	.72	.62
Durbin Watson	1.98	1.94	2.10	1.97	1.93	2.00
Standard Error of the Regression	1.57	1.52	1.78	1.56	1.50	1.75

n.a.--not applicable.

Table A-6

Simulation Errors--Actual Minus Predicted Growth Rates
(Q4 to Q4 growth rate errors; Not-Shift-Adjusted Monetary Aggregates)[1]

Oil Variables Not Included

	Real GNP			Inflation			Nominal GNP		
	M1-A	M1	M2	M1-A	M1	M2	M1-A	M1	M2
1983	-.5	1.4	4.0	1.1	-4.4	-2.7	.6	-3.2	1.3
1984	-.2	3.6	2.1	.8	-6.0	-3.0	.6	-2.4	-.9
1985	-.5	2.3	-.5	-1.3	-6.8	-2.7	-1.8	-4.5	-3.4
1986	-3.5	-2.6	-1.0	-3.9	-9.2	-3.3	-7.7	-12.4	-4.4
RMSE	1.8	2.6	2.3	2.2	6.8	2.9	4.0	6.9	2.9
MAE	1.2	2.5	1.9	1.8	6.6	2.9	2.7	5.6	2.5
ME	-1.2	1.2	1.1	-.8	-6.6	-2.9	-2.1	-5.6	-1.8

Oil Variables Included

	Real GNP			Inflation			Nominal GNP		
	M1-A	M1	M2	M1-A	M1	M2	M1-A	M1	M2
1983	.5	1.6	4.0	.8	-4.3	-2.5	1.4	-2.8	1.6
1984	.2	3.2	2.1	.6	-5.2	-2.4	.8	-2.0	-.3
1985	-.7	1.5	-.8	-1.1	-5.7	-2.2	-1.9	-4.2	-3.1
1986	-2.1	-1.8	.6	-2.5	-7.3	-.9	-4.7	-9.4	-.4
RMSE	1.1	2.1	2.3	1.4	5.7	2.1	2.7	5.4	1.8
MAE	.9	2.0	1.9	1.2	5.6	2.0	2.2	4.6	1.4
ME	-.5	1.1	1.5	-.6	-5.6	-2.0	-1.1	-4.6	-.5

Definitions: RMSE = root mean squared error
MAE = mean absolute error
ME = mean error

1. Growth rates are computed on a compound annual rate basis. As a result, nominal GNP growth need not equal the sum of real growth and inflation. Likewise, the forecast error of nominal GNP growth need not equal the sum of the real GNP growth error and the inflation forecast error.

Table A-7

Simulation Errors--Actual Minus Predicted Growth Rates
(Q4 to Q4 growth rate errors; Shift-Adjusted Monetary Aggregates)[1]

Oil Variables Not Included

	Real GNP			Inflation			Nominal GNP		
	M1ASH	M1SH	M2SH	M1ASH	M1SH	M2SH	M1ASH	M1SH	M2SH
1983	1.6	.4	4.3	-.9	-3.9	-2.7	.8	-3.7	1.7
1984	1.6	3.1	2.3	-1.7	-5.6	-2.8	-.1	-2.4	-.5
1985	.2	2.2	-.6	-2.8	-6.7	-2.4	-2.7	-4.5	-3.2
1986	-3.1	-2.9	-1.0	-4.6	-9.3	-3.0	-8.0	-12.7	-4.2
RMSE	1.9	2.4	2.5	2.9	6.6	2.8	4.2	7.1	2.8
MAE	1.6	2.1	2.0	2.5	6.3	2.8	2.9	5.8	2.4
ME	.1	.7	1.2	-2.5	-6.3	-2.8	-2.5	-5.8	-1.6

Oil Variables Included

	Real GNP			Inflation			Nominal GNP		
	M1ASH	M1SH	M2SH	M1ASH	M1SH	M2SH	M1ASH	M1SH	M2SH
1983	2.3	.8	4.3	-.9	-3.9	-2.4	1.4	-3.2	1.9
1984	1.7	2.8	2.2	-1.5	-5.0	-2.2	.2	-2.2	-.0
1985	-.1	1.4	-.9	-2.4	-5.7	-2.0	-2.6	-4.3	-2.9
1986	-1.7	-2.1	.5	-3.1	-7.4	-.8	-4.9	-9.8	-.2
RMSE	1.6	1.9	2.5	2.1	5.6	2.0	2.9	5.7	1.8
MAE	1.5	1.8	2.0	2.0	5.5	1.9	2.3	4.9	1.3
ME	.5	.7	1.5	-2.0	-5.5	-1.9	-1.5	-4.9	-.3

Definitions: RMSE = root mean squared error
MAE = mean absolute error
ME = mean error

1. Growth rates are computed on a compound annual rate basis. As a result, nominal GNP growth need not equal the sum of real growth and inflation. Likewise, the forecast error of nominal GNP growth need not equal the sum of the real GNP growth error and the inflation forecast error.

Table A-8

Inflation Forecast Errors[1]
(percent)

	Without Oil Variable			With Oil Variable		
	M1-A	M1	M2	M1-A	M1	M2
RMSE	2.35	6.75	2.73	1.79	5.75	1.71
MAE	1.85	6.45	2.59	1.36	5.56	1.91
ME	-1.03	-6.45	-2.59	-.73	-5.36	-1.72

1. See Darby et. al., Table 3.
Based on dynamic simulations of reduced-form equations for the GNP deflator.
RMSE--root mean square error.
MAE--mean absolute error.
ME--mean error.

APPENDIX B

BOARD QUARTERLY MODEL   MONEY DEMAND SECTOR

The standard money demand sector of the Board staff's quarterly econometric model consists of four money demand equations, several definitional identities, and six equations for own rates on deposits The money demand equations are for currency, demand deposits, other checkable deposits, and household transactions deposits (MHH) which is the sum of savings deposits, money market demand accounts (MMDAs), small time deposits, and money market mutual funds. Thus, the M1-A model consists of the sum of the currency and demand deposit equations The M1 model adds the OCD equation to the M1-A model. The M2 model adds the MHH equation to the M1 model, and also adds the quantities of overnight RPs and Eurodollars, which are not modeled and are taken to be exogenous The MHH equation was not used in this paper because it explicitly depends heavily on wealth rather than income. An alternative M2 model, which was used in this paper, uses a single equation to estimate the demand for aggregate M2 and relies primarily on income rather than wealth as the scale variable for M2

In general, the money demand equations specify that the demand for each component depends on a measure of income, spending, or wealth (termed the "scale variable") and on a measure of the opportunity cost of holding that instrument. In addition, some of the equations include a time trend, and others include dummy variables to account for shifts of funds resulting from deregulatory actions. The equations can all be viewed as generalizations of velocity relationships, in that their coefficients imply a unitary long-run elasticity of money demand with respect to changes in the scale variable for given opportunity costs.

Money demand depends in part on the opportunity cost of holding deposits--the market interest rate minus the own interest rate paid on the deposit. Therefore forecasting money demand and estimating the elasticity of money demand with respect to market rates requires modeling of the relationships between market interest rates and deposit rates The six own-rate equations are estimates of these relationships. In some cases, sufficient data exist to estimate these relationships directly. However, the equations for the OCD rate and the savings deposit rate are judgmental adjustments of other estimated equations; this approach is necessary because NOW accounts and savings accounts have been deregulated for only about 1-1/2 years. All of the equations apply some lag in adjustment of own rates to changes in market rates. The estimates imply that adjustment of small time deposit and money market fund rates is fairly prompt--being completed within several months--and essentially complete. However, the equations for OCD, savings, and MMDA rates imply sluggish and incomplete adjustment. Thus, the interest rate elasticity of these components is boosted by the behavior of their own rates.

The aggregate M2 equation uses a weighted average of the opportunity cost of its components as the aggregate opportunity cost. The components' opportunity costs are modeled as described above.
The demand deposit equation assumes that the own rate on demand deposits is zero and measures the opportunity cost of demand deposits simply as

the Treasury bill rate However, the existence of compensating balance arrangements, which involve the implicit payment of interest on balances though earnings credits toward services, calls into question this assumption.

Most of the equations employ specifications that allow for lags in adjustment towards ultimate or optimal values. All the estimated equations are estimated using ordinary least squares The demand equations for currency and demand deposits are estimated for the period from 1961:Q1 to 1986:Q2 The OCD equation is estimated from 1981:Q3 to 1986:Q3, beginning a little after the nationwide authorization of NOW accounts The MHH equation (not used in the current paper) is estimated from 1971:Q1 to 1986:Q2 The own-rate equations are estimated for various periods in the 1980s. The aggregate M2 equation is estimated from 1968:Q1 to 1986:Q2.

The quarterly model equations and parameter estimates are shown on pages 4 to 9

Board Quarterly Model Money Demand Sector1/
(all are single-stage error-correction specifications except Currency)

[t-statistics in brackets]

(1) Currency

$$\log(CURR) = \underset{[-4.4]}{-1.5188} + \sum_{i=0}^{4} r_i \, RTBE_{-i} + \sum_{i=0}^{5} yc_i \log(EPCE)_{-i}$$

$$+ \sum_{i=0}^{3} p_i \log(PEPCE)_{-i} - \underset{[-3.2]}{.0015} \, TYME + \underset{[15.3]}{1.3215} \, U_{-1} - \underset{[-5.9]}{.4989} \, U_{-2}$$

$\Sigma r_i = -.0054$ [-6.8]	$\Sigma yc_i = .8838$ [16.5]	$\Sigma p_i = 1$ [constrained]
$r_0 = -.0003$	$yc_0 = .0935$	$p_0 = .1630$
$r_1 = -.0018$	$yc_1 = .1399$	$p_1 = .1560$
$r_2 = -.0017$	$yc_2 = .2908$	$p_2 = .4284$
$r_3 = -.0008$	$yc_3 = .1297$	$p_3 = .2526$
$r_4 = -.0008$	$yc_4 = .1113$	
	$yc_5 = .1187$	

$\bar{R}^2 = .99998$
Durbin-Watson Statistic = 2.1553
Standard Error of Regression = .0026
Sample Period: 1961:Q1-1986:Q2
Estimated: 8/87

1/ See page B-7 for definitions of the variables.

(2) Demand Deposits

$$\Delta\log(DD) = \underset{[-2.5]}{-.1222} \; \underset{[-3.2]}{-\; .0183} \log(RTBE)_{-1}$$

$$\underset{[-2.5]}{-\; .1749} \, [\log(DD) - \log(EPCEN)]_{-1}$$

$$\underset{[-2.2]}{-\; .0010} \, TYME_{-1} \; \underset{[-2.7]}{-\; .0030} \, SHIFT_{-1}$$

$$\underset{[2.2]}{+\; .1649} \log(1 - JNOWT)_{-1} + \sum_{i=0}^{1} dr_i \, \Delta\log(RTBE)_{-i}$$

$$+ \sum_{i=0}^{2} dy_i \, \Delta\log(EPCEN)_{-i} \; \underset{[-3.3]}{-\; .0089} \, \Delta SHIFT$$

$$\underset{[11.3]}{+\; .8834} \, \Delta\log(1 - JNOWT) \; \underset{[2.5]}{+\; .1535} \, \Delta\log(DD)_{-1}$$

$\Sigma dr_i = \underset{[-3.4]}{-.0305}$	$\Sigma dy_i = \underset{[13.6]}{.8465}$
$dr_0 = -.0081$	$dy_0 = .4868$
$dr_1 = -.0224$	$dy_1 = .1936$
	$dy_2 = .1661$

One convergence restriction is imposed on the estimates:

$$\sum_{i=0}^{1} dy_i + \text{coefficient on } \Delta\log(DD)_{-1} = 1$$

$\overline{R^2} = .7671$
Durbin H Statistic = -.6331
Standard Error of Regression = .0068
Sample Period: 1961:Q1-1986:Q2
Estimated: 8/87

(3) OCDs

$$\Delta\log(OCD) = \underset{[-4.1]}{-.5083} - \underset{[-4.0]}{.0514}\ TAYLOG1_{-1}$$

$$- \underset{[-4.2]}{.2047}\ [\log(OCD) - \log(EPCEN)]_{-1}$$

$$- \underset{[-2.3]}{.0250}\ \Delta TAYLOG1 + \underset{[7.9]}{.8580}\ \Delta\log(EPCEN)$$

$$+ \underset{[1.3]}{.1420}\ \Delta\log(OCD)_{-1}$$

One convergence restriction is imposed on the estimates:

sum of coefficients on $\Delta\log(EPCEN)_{-1}$ and $\Delta\log(OCD)_{-1} = 1$

$\bar{R}^2 = .7835$
Durbin H Statistic = -.9373
Standard Error of Regression = .1293
Sample Period: 1981:Q3-1986:Q3
Estimated: 8/87

Definitions (all variables on a quarterly average basis)

CURR = currency + travelers' checks

DD = demand deposits (business and consumer)

EPCE = personal consumption expenditures in 1982 dollars

EPCEN = personal consumption expenditures in current dollars

JNOWT = NOW account availability index (held constant from 1985 onward)

OCD = other checkable deposits = M1 - currency and travelers' checks - demand deposits

PEPCE = deflator for personal consumption expenditures

ROCDE = own rate on OCDs (effective yield)

(ROCDQ is a weighted average of regular NOW and SuperNOW rates at banks and thrifts through 1986:Q2, with the weights being quantities of deposits lagged one quarter. Survey SuperNOW rates for 1986:Q1 and :Q2 were judgmentally adjusted upward by 22 and 12 basis points, respectively, to reflect blending/tainting with regular NOW rates. Starting in 1986:Q3, ROCDQ is a lagged-deposit weighted average of rates on all OCDs at banks and thrifts. ROCDE is simply ROCDQ converted to an effective yield basis.)

RTBE = rate on 3-month T-bills (effective yield)

RTBOCDE = RTBE - ROCDE (opportunity cost of OCDs)

SHIFT = 0 through 1974:Q2, 1 in 1974:Q3, increments by ones until reaching 10 in 1976:Q4, and remains at ten thereafter (a dummy variable for the "missing money")

TAYLOG1 = log(RTBOCDE) if RTBOCDE > .75
= 1/.75 * RTBOCDE - 1 + log(.75) if RTBOCDE < .75
(becomes the first-order expansion of log for spreads less than .75)

TYME = time variable: 1947:Q1 = 1, increments by 1 each quarter

U = uncorrelated error term (coefficients are autoregressive parameters)

Quarterly Aggregate M2 Equation
(t-statistics in parentheses)

$$\Delta\log(M2) = \underset{(-4\ 88)}{-.0728} - \underset{(-2.52)}{.00012}\ TIME + \underset{(2.35)}{.0062}\ MMDADUM$$

$$- \underset{(-6.62)}{0119}\ TAYLOG_{-1}$$

$$- \underset{(-5.18)}{.1899}\ [\log(M2) - \log(GNP)]$$

$$\underset{(1\ 22)}{.0776}\ \Delta\log(GNP)$$

$$- \underset{(-5.06)}{0090}\ \Delta TAYLOG$$

$$- \sum_{i=0}^{2} w_i\ \Delta\log(WEALTH)_{-i}$$

$$- \underset{(-4\ 034)}{.0156}\ \Delta DUMMCON$$

$$+ \underset{(4.97)}{.0314}\ \Delta MMDADUM$$

$$+ \underset{(6.47)}{.493}\ \Delta\log\ (M2)_{-1}$$

$\Sigma_i w_i = \underset{(5.64)}{.4292}$, $w_o = \underset{(1.90)}{123}$ $w_i = \underset{(1.13)}{.075}$ $w_2 = \underset{(3.64)}{231}$

Restrictions. $\Sigma y_i + \Sigma w_i + dm = 1$

where dm = .429--the coefficient on lagged $\Delta\log(M2)$

Sample Period: 1968:1 - 1986·2
$\bar{R}$-squared: .669
Durbin-H statistic: .126
Standard Error of the Regression: 00478

Definitions

TAYLOG = RM2SP, if RM2SP $\geq$ SPLICE

$= \frac{1}{SPLICE} * RM2SP - 1 + \log(SPLICE)$, if RM2SP < SPLICE

splice = 0.5

RM2SP = RTBE - RM2E

RTBE = 3 month T-bill rate: effective rate

RM2E = deposit weighted average of deposit own-rates, with weights being stocks lagged one quarter. Deposit own-rates are as defined in quarterly model (ROCDE, RSTDE, RMMDAE, RMMFE, RSAVE) plus rates on overnight Euro and RPs, all on an effective basis

GNP = nominal GNP

DUMMCON = credit control dummy: equals 0 except for 1980:Q2 when it equals 1.

MMDADUM = MMDA dummy: equals 0 during 1982:Q3 and earlier. In 1982:Q4 it equals .1667; in 1983:Q1 and thereafter it equals 1.

WEALTH : Excludes land and the stock market.