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# The Link Between M1 and the Monetary Base in the 1980s

**S**INCE 1980, there have been several changes in the Federal Reserve System's reserve requirements that have altered the relationship between the money stock, M1, and the monetary base. The Monetary Control Act of 1980 (henceforth, MCA) brought all depository institutions—member and nonmember commercial banks, saving and loan associations, mutual savings banks and credit unions—under a uniform set of reserve requirements and removed reserve requirements on a broad category of savings time deposits that are close substitutes for checkable deposits. In February 1984, the Federal Reserve switched from lagged reserve accounting to contemporaneous reserve accounting.<sup>1</sup>

This article shows how these changes affected the relationship between the money stock and the monetary base, arguing that, under fairly general conditions, the relationship should have become less variable since 1980. Evidence consistent with this argument is then presented.

## CHANGES IN THE MONEY SUPPLY PROCESS SINCE 1980

A simple model of the money supply process provides a useful framework to illustrate how the link between M1 and the monetary base has changed in the 1980s. This model is summarized by the following equation:

$$(1) M1 = m \cdot MB,$$

where M1 denotes the stock of money consisting of checkable deposits and currency held by the non-bank public; MB denotes the stock of the monetary base consisting of total reserves and currency; and  $m$  represents the money multiplier.

The money multiplier, which translates fluctuations in the monetary base into fluctuations in M1, depends on the reserve requirements that the Federal Reserve imposes on depository institutions and a number of ratios that reflect portfolio decisions of both depository institu-

<sup>1</sup>The Fed moved from contemporaneous to lagged reserve accounting in 1968.

tions and the public (see the appendix for details and verification of the claims made in the text). For a given set of portfolio preferences and reserve requirements, equation 1 shows what level of M1 will result from any given level of the monetary base.

The ratios that reflect portfolio preferences of depository institutions and the public generally are not constant. As a result, even if reserve requirements were unchanged, variation in these ratios would produce variability in the money multiplier. The MCA was intended to strengthen the link between Federal Reserve actions and changes in the money stock by reducing or eliminating specific sources of variability in the multiplier.

### ***Uniform Reserve Requirements for Member and State-Chartered Nonmember Banks***

The MCA imposed uniform reserve requirements on all depository institutions. Before 1980, reserve requirements on deposits of state-chartered nonmember banks were established by the state in which they were domiciled. These requirements were generally lower than those imposed by the Federal Reserve. More importantly, while only vault cash held by these institutions was part of the monetary base, checkable deposits held by these institutions were included in M1.<sup>2</sup>

Without uniform reserve requirements on checkable deposits, the multiplier would change as deposits shifted between member and nonmember banks. For example, as checkable deposits flowed from member to nonmember banks, reserves would be released so that a larger money stock could be supported by the same level of the monetary base. That is, the multiplier would increase. The opposite would

occur when deposits flowed from nonmember to member banks. With uniform reserve requirements, such shifts in checkable deposits are no longer a source of variation in the multiplier.

The same reasoning applies to shifts of time and savings deposits between nonmember and member banks. Before the MCA, as these deposits flowed from member to nonmember banks, reserves were released that could support a larger volume of checkable deposits. Other things the same, the multiplier would fluctuate as time and savings deposits shifted between member and nonmember banks. Again, uniform reserve requirements established by the MCA removed this source of variation.

### ***Extending Reserve Requirements to Thrifts***

The MCA also extended the same set of reserve requirements to deposits at thrift institutions, thereby removing another source of variation from the multiplier. Before 1980, these institutions were not subject to the Fed's reserve requirements and checkable deposits held at these institutions, called NOW accounts, were not included in M1. In February 1980, however, M1 statistics were revised to include interest-bearing checking accounts held at thrifts and the historical data were revised to reflect this change.<sup>3</sup> Consequently, shifts of checkable deposits between thrifts and banks influenced the money multiplier prior to the adoption of the MCA. Now, deposit shifts between thrifts and banks can no longer be a source of variation in the money multiplier.

Before the nationwide introduction of interest-bearing checking accounts on January 1, 1981, however, thrifts did not hold a large amount of NOW accounts.<sup>4</sup> Accordingly, deposit shifts be-

<sup>2</sup>For a discussion of state reserve requirements, see Gilbert and Lovati (1978) and Gilbert (1978).

<sup>3</sup>See Hafer (1980) for a detailed discussion of the redefinition of the monetary aggregates. While the redefinition did not change the aggregate level of the monetary base, vault cash holdings of thrifts were moved from currency to total reserves.

There were two other important definitional changes in the aggregates in the 1980s. Starting in February 1980, demand deposits of foreign commercial banks and official institutions were excluded from M1. In July 1981, non-bank traveler's checks were included in M1. In both cases, the M1 series was revised historically. The latter revision introduces an additional source of variability in the M1-base relationship because non-bank traveler's checks

are not reservable. Further, since foreign deposits are still subject to reserve requirements, they absorb the base even though they are no longer included in M1.

<sup>4</sup>For example, as of December 31, 1979, the non-bank depository institutions held only \$4.2 billion in NOW accounts.

tween thrifts and banks may not have been an important source of variation in the multiplier prior to 1981.<sup>5</sup>

### *Elimination of Reserve Requirements on Savings and Time Deposits*

Before the MCA, the Federal Reserve imposed reserve requirements of 3 percent on commercial bank savings and time deposits.<sup>6</sup> The MCA eliminated reserve requirements on a broad class of savings and time deposits (hereafter, S&Ts).<sup>7</sup> As a consequence, shifts between formerly reservable deposits and non-reservable time deposits no longer affect the multiplier. Of course, shifts between currently reservable time deposits and checkable deposits or non-reservable time deposits remain a source of variability in the multiplier. Hence, the elimination of reserve requirements on a broad class of S&Ts does not guarantee that the variability of the multiplier will be reduced.

### *The Gradual Implementation of the MCA*

Reserve requirement changes under the MCA were phased in over several years. The adjustments for most nonmember banks and

thrifts occurred gradually over an eight-year period. Beginning November 1980, these institutions had to maintain only one-eighth of the required reserves they would eventually hold when the act was fully implemented. Each successive September until 1987 (when the phase-in was completed), these institutions had to hold an additional one-eighth of the target level of required reserves.

Member bank reserve requirements generally were reduced by the MCA.<sup>8</sup> Starting November 1980, a seven-step phase-down began, with one-fourth of the new reserve requirements being implemented in November 1980 and one-sixth of the remainder being implemented in six steps. The full phase-down was completed on March 1, 1984. For member banks whose reserve requirements were raised, the phase-in was implemented in four steps, with one-fourth of the increase being required in November 1980 and one-fourth being met in each of the next three Septembers.

Although member banks had completely adjusted to the new reserve requirements by March 1, 1984, the full impact of the MCA on the multiplier could not have emerged until the phase-in was completed for all depository institutions—unless the effect of extending reserve

<sup>5</sup>Conversations with Board staff suggest that thrifts may have held vault cash in excess of what would have been required on NOW accounts. If, in effect, thrifts were holding vault cash in the form of reserves against these accounts as if they were member banks, a shift from demand deposits in a member bank to a NOW account at a thrift would have no effect on the multiplier using current data. Prior to the revision of the monetary aggregates, however, such a shift would have caused the money supply to decline with no corresponding change in the monetary base. Consequently, it would have affected the multiplier. Furthermore, prior to January 1, 1981, member banks in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont also issued interest-bearing NOW accounts that were not included in the money stock at that time. Member banks, however, were required to hold reserves against these deposits. Nevertheless, a shift from a member bank NOW account to a thrift NOW account would have left both the money stock and the monetary base unchanged if thrifts were holding vault cash as reserves against these deposits.

It should be noted, however, that in both cases above, the measured ratio of currency to either M1 or checkable deposits would have changed before the redefinition of money and the adoption of MCA. Nonetheless, the variation in the currency ratio would have been reflected in the measured multiplier only in the first case.

<sup>6</sup>The actual system of reserve requirements was slightly more complicated, as there were different marginal reserve requirements on time deposits by total size of outstanding deposits and by term to maturity.

<sup>7</sup>Specifically, the MCA imposed reserve requirements on time deposits except some of those that have an original maturity shorter than 3½ years; shorter-maturity time deposits that are transferable, or that are non-transferable and owned by anybody excluding an individual person or a sole proprietorship, are still subject to a 3 percent reserve requirement.

<sup>8</sup>Prior to the MCA, a system of marginal reserve requirements on transaction deposits varied with the deposit size of the institution. For example, just before the implementation of the MCA, the marginal reserve requirement on demand deposits more than \$400 million was 16¼ percent, while that on deposits less than \$2 million was 7 percent. Hence, the money supply could change relative to the base as transaction deposits shifted between institutions of different size. By reducing the number of tiers in the marginal system from five to two,—that is, by partially removing the marginal reserve requirement system—the MCA reduced the importance of this source of variability in the multiplier. Moreover, the new system generally lowered reserve requirements to be maintained against transaction accounts. Starting in November 1980, the marginal reserve requirement was only 3 percent for accounts less than \$25 million and was 12 percent for accounts in excess of \$25 million. With the exception of member banks holding balances of checkable deposits between \$25 million and \$100 million, member banks were subject to lower marginal reserve requirements on checkable deposits.

requirements to thrifts is quantitatively unimportant. Because of the nature of the phase-in, the variability of the multiplier might not have dropped sharply at any particular time during the 1980s. Instead, MCA's impact on the variability of the multiplier could have occurred gradually throughout the transition period.

### *The Impact of the MCA on the Level of the Multiplier*

In addition to reducing the variability of the multiplier, the MCA's changes in reserve requirements had divergent effects on the level of the multiplier.<sup>9</sup> While higher reserve requirements for nonmember banks, thrifts and some member banks reduced the multiplier, the elimination of reserve requirements on a broad class of S&Ts for member banks and lower reserve requirements for most member banks increased it. The net effect of the MCA on the size of the multiplier depends on the relative magnitude of these effects.<sup>10</sup>

### *The Change to Contemporaneous Reserve Requirements*

In February 1984, the Fed changed its reserve accounting procedures from lagged reserve accounting (LRA) to contemporaneous reserve accounting (CRA). Under LRA, depository institutions were required to hold reserves during the current reserve-maintenance period based on the average of reservable deposits (both checkable and time deposits) held during the prior two weeks. Under CRA, required reserves for the current reserve-maintenance period are based more heavily on the amount of reservable deposits in that period.<sup>11</sup>

The major reason for adopting CRA was to increase the Federal Reserve's control over the money stock.<sup>12</sup> It could have increased or had no effect on the variability of the multiplier.<sup>13</sup> If it affected the multiplier's variability, the level of the multiplier also would have declined;

<sup>9</sup>For a given level of the monetary base, an expected increase (decrease) in the money multiplier would imply an increase (decrease) in the money supply. If the Fed removes reserves from (injects reserves into) the system, however, the money supply need not be affected by the expected increase in the multiplier. Typically, changes in the money supply produced by changes in the multiplier as a result of reserve-requirement changes are largely offset through open market operations. See Burger (1979).

<sup>10</sup>See footnote 8. As of September 30, 1978, large banks held more than 48 percent of the total demand deposits outstanding. The net effect of the MCA on reserve requirements for all depository institutions on the phase-in dates is shown in table 2 which lists all reserve-requirement changes from 1973 to 1988.

<sup>11</sup>Strictly speaking, reserve requirements under CRA are not completely contemporaneous. There is a two-day lag on reserve requirements on transaction accounts and a 14-day lag on liabilities other than transaction deposits. See Gilbert and Trebing (1982) for details.

<sup>12</sup>One of the main concerns about the effect of LRA on monetary control was that LRA encouraged the Fed to validate deposit creation of depository institutions. Specifically, some observers argued that under LRA depository institutions were free to create any desired amount of the checkable deposits. The Fed would be forced to supply the necessary reserves two weeks later; otherwise, there would be a sharp increase in the federal funds rate.

At one level, this argument reflects a view that the Fed might be more concerned with movements in the federal funds rate than with its money supply objective. At another level, however, it was frequently suggested,—e.g., Laufenberg (1976)—that LRA severed the contemporaneous link between the money stock and the monetary base. Thornton (1983), however, has shown that the link need not be affected by the accounting procedure for reserve requirements; a contemporaneous link between the money stock and the monetary base could be maintained either through depository institutions' holdings of excess reserves

or through the currency-deposit ratio under LRA. von Hagen (1987) arrives at a similar conclusion, but emphasizes the role of interest rate expectations under LRA. Thornton (1984) provides some early evidence on the effect of the move to CRA on the variability of money and interest rates. Also, see Thornton (1982) for an analysis of money stock control under LRA and CRA.

<sup>13</sup>While the contribution of the variance of the currency-deposit ratio and the ratio of excess reserves to checkable deposits to the variability of the multiplier both decline with the adoption of CRA, the contribution of the variance of the other ratios could get larger. The net effect on the variance of the multiplier depends on the relative magnitude of these effects. Given the importance of the currency-deposit ratio, in particular, the variance of the multiplier should decline with the adoption of CRA. This conjecture depends on modeling depository institutions' holdings of excess reserves as a proportion of their checkable and time deposits. If this specification is inappropriate, the only link between M1 and the base would be through the currency-deposit ratio. In this instance, the variance of the multiplier would increase with the move to CRA.

Also, if depository institutions hold excess reserves as a buffer stock under CRA, there might be no change in the variability of the multiplier. See Thornton (1983) for details. Although it is not immediately obvious why depository institutions would behave that way, Tarhan and Spindt (1983) provide some evidence that banks maintain excess reserves as a buffer stock.

otherwise, it would have no effect on the level of the multiplier.

## EMPIRICAL EVIDENCE

The multiplier is measured as the ratio of M1 to the monetary base. The effects of reserve requirement changes are reflected in the adjusted monetary base, so that they are not reflected in its multiplier. The effect of such changes are not reflected in the source base, so they are reflected in the multiplier obtained using it. Because the above analysis abstracts from reserve requirement changes, normally it would be preferable to use the adjusted monetary base to construct the multiplier. The adjusted monetary base can also yield misleading results, however, because the ratio of reservable time deposits to total checkable deposits appears in the adjusted monetary base and not its multiplier after November 1980.<sup>14</sup> Removing this component from the multiplier only after November 1980 biases the results toward finding a reduction in the multiplier's variance.<sup>15</sup>

Although the multiplier derived from the source base does not suffer from this limitation, it reflects reserve-requirement changes. The effect of such changes on the variability of the multiplier before and after the MCA depends on the frequency and magnitude of reserve-requirement changes during the two periods. If reserve-requirement changes were more frequent or larger before the MCA, failure to abstract from such changes produces results that are biased in favor of seeing a reduction in variability after the MCA. If they are less frequent or smaller, the bias would be in the opposite direction.

The analysis presented here is carried out for multipliers based on the adjusted monetary base ( $m_A$ ) and the source base ( $m_S$ ) to see if the results are affected by these factors. The data are monthly and cover the period from January 1973 through December 1988.

## *The Level of the Multiplier*

As noted previously, the net effect of the MCA on the level of the multiplier is analytically indeterminate. On one hand, extending reserve requirements to nonmember banks and non-bank depository institutions and increasing reserve requirements for some member banks cause the multiplier to fall. On the other hand, the elimination of reserve requirements on a broad class of S&Ts and the reduction in reserve requirements for most member banks cause the multiplier to rise. The effect of the move to CRA is somewhat less indeterminate analytically. If it had any affect at all, the multiplier would decline.

Figure 1 shows the levels of the two multipliers over the period. The vertical lines correspond to the initiation of the MCA and the adoption of CRA. Both multipliers generally decline from January 1973 through early 1980. Following a sharp decline in early 1980 and a sharp rise in mid-1980, the multipliers generally rose until mid-1986 and declined thereafter. Although both multipliers declined slightly during 1984, the beginning of the decline, especially for the adjusted monetary base multiplier, predates the adoption of CRA by several months. Relating the behavior of the level of the multipliers to the adoption of the MCA and CRA by direct inspection is complicated by the fact that the multipliers are influenced greatly by the "k-ratio," the ratio of currency to checkable deposits, which changed markedly during this period.<sup>16</sup>

## *The Effect of the MCA and the Adoption of CRA on the Non-Currency Ratio Components of the Multiplier*

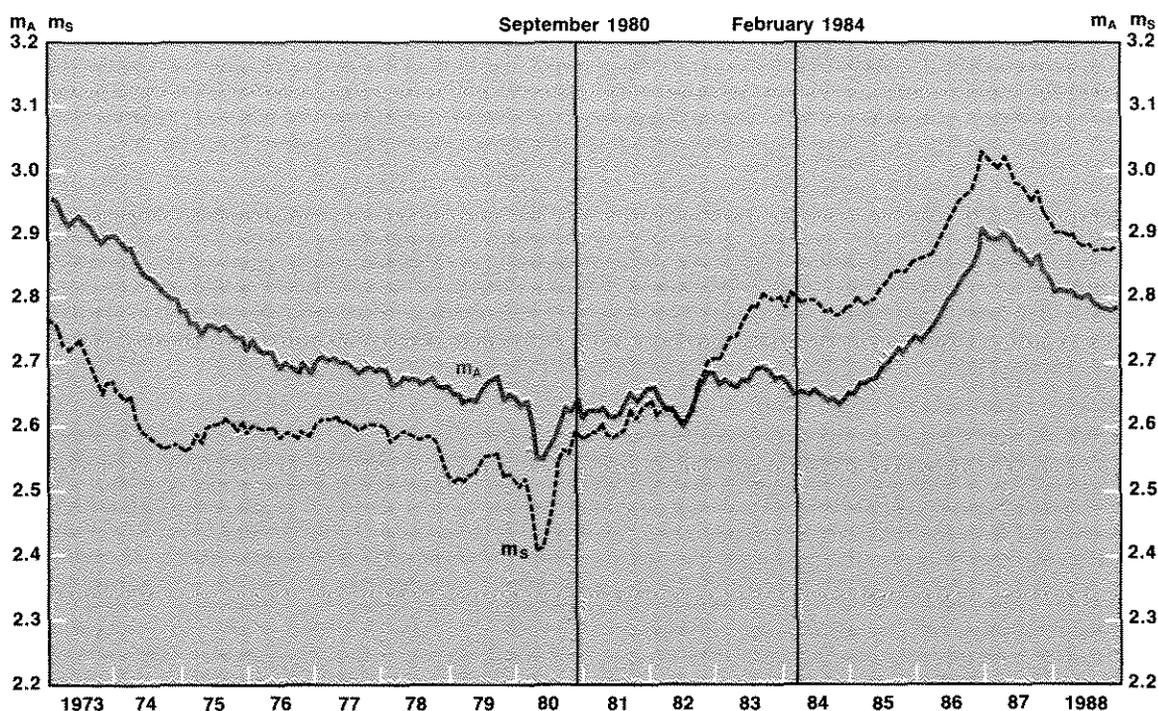
One can abstract from movements in the k-ratio by obtaining a joint representation for the other components. Each multiplier can be written in the general form,

<sup>14</sup>See Gilbert (1987), especially the appendix, for a discussion of the revised adjusted monetary base.

<sup>15</sup>The strength of this conclusion is based on an implicit assumption that the covariance between this and other multiplier components is zero. If the covariance is nonzero, the direction of the bias could be the opposite of that stated in the text.

<sup>16</sup>For a discussion of the importance of the k-ratio and its behavior during the 1980s, see Burger (1988).

**Figure 1**  
**Adjusted Monetary Base and Source Base Multipliers**



$$(2) m = (1 + k)/(z + k),$$

where  $k$  is the  $k$ -ratio and  $z$  is a composite of the required reserve ratios and the other ratios that reflect the portfolio preferences of depository institutions and the public. Equation 2 can be solved for  $z$  to yield

$$(3) z = (1 + k - mk)/m.$$

This calculation of  $z$  is done for both  $m_A$  and  $m_S$ ; the results are denoted respectively as  $z_A$  and  $z_S$ .

Figures 2 and 3 show the behavior of the multiplier, the  $k$ -ratio and  $z$  for the adjusted monetary base and source base, respectively, over the full sample period. In both cases,  $z$  declines following the adoption of the MCA,

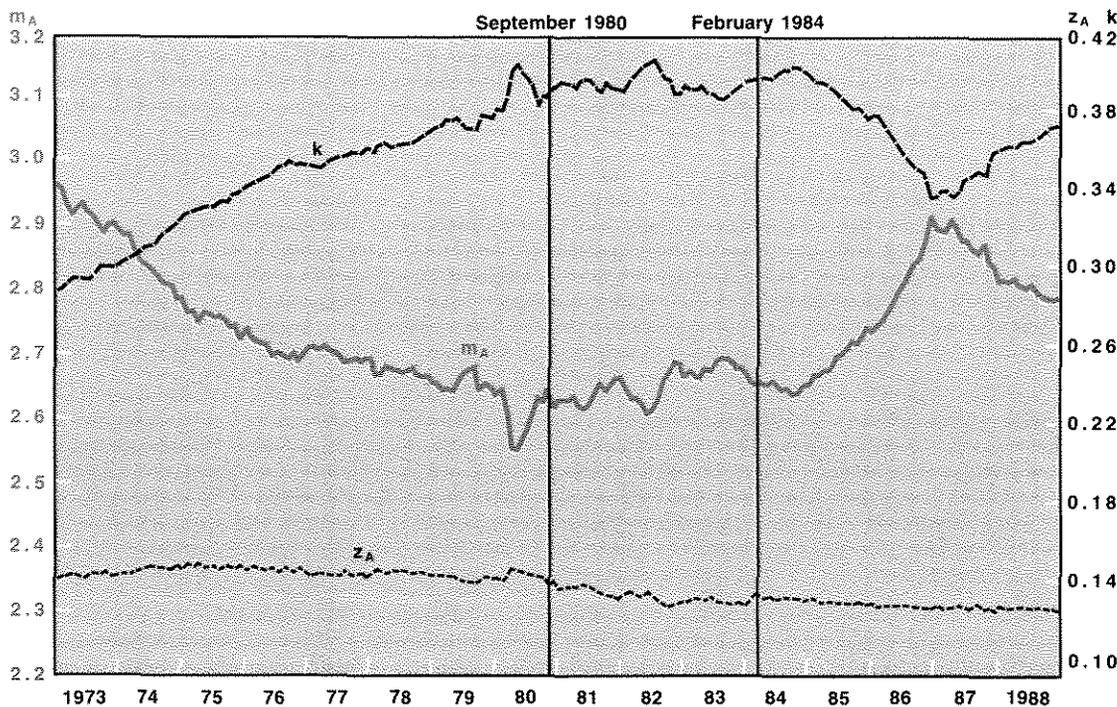
although the timing of this descent does not match precisely the implementation of the MCA. The behavior of  $z_S$  in the early to mid-1980s was influenced greatly by the Federal Reserve's imposition and subsequent elimination of credit controls.<sup>17</sup> Nonetheless, its decline through February 1984 suggests that the elimination of reserve requirements on many savings and time deposits and/or the lowering of reserve requirements for most member banks are the dominant factors influencing the level of the multiplier.<sup>18</sup>  $z_S$  declines markedly through February 1984 and increases slightly thereafter. The increase following the move to CRA is consistent with the hypothesized effect of CRA, but is so small that the move to CRA might not have had an important impact on the level of the multiplier.  $z_A$  behaves similarly, except that

<sup>17</sup>The credit controls imposed new reserve requirements on increases in credit card lending, on large-denomination time deposits and on money market mutual funds. The credit controls were imposed in March 1980 and removed in July 1980.

<sup>18</sup>Actually, this observation is not too surprising. The removal of reserve requirements on a large class of time and savings deposits should have caused the multiplier to increase significantly. Moreover, the Board's estimates in-

dicates that the largest effect of reserve-requirement changes for member and nonmember institutions on reserves was through institutions that had their reserve requirements decreased (see table 2).

**Figure 2**  
**Adjusted Monetary Base Multiplier and Its Components**



it continues to fall following the move to CRA.<sup>19</sup>

Figures 2 and 3 reveal that much of the movement in the multipliers is associated with movements in the k-ratio. The dominant effect of the k-ratio on the multipliers is particularly evident for the source base multiplier after 1984, when  $z_S$  hardly changed. Indeed, the decline in both multipliers since mid-1986 is associated with a rise in the k-ratio; it appears to be unrelated to movements in  $z$ .

The effect of reserve-requirement changes on the level of  $z_S$  is seen more clearly when the

data are differenced. The differences of  $z_A$  and  $z_S$ , denoted  $\Delta z_A$  and  $\Delta z_S$ , respectively, are presented in figure 4. Beginning in 1980, there are several pronounced spikes in  $\Delta z_S$ . The first two are the large positive and negative spikes associated with the introduction and subsequent elimination of the credit controls. The next seven large negative spikes are associated with the important phase-in dates for the MCA for member banks.

The presence of spikes in  $\Delta z_S$  related to reserve-requirement changes and their absence in  $\Delta z_A$  attests both to the importance of the ef-

<sup>19</sup>The divergent behavior of  $z_A$  and  $z_S$ , especially after the move to CRA, is difficult to explain. With the exception of the ratio of reservable time deposits to checkable deposits, changes in all other ratios should be reflected in the same way in both measures of  $z$ . An increase in the ratio of reservable time deposits to checkable deposits would cause  $z_S$  to rise; because of the way that the adjusted monetary base has been calculated since November 1980, however, such an increase would have no effect on  $z_A$ . In any event, the disparate movements in the  $z$ 's had a very small effect on the multipliers; both multipliers have moved together after February 1984.

It should be noted, that because  $z_S$  reflects the actual level of reserve requirements while  $z_A$  reflects the average

level over some base period before November 1980 and the marginal reserve requirement on transaction deposits (12 percent) thereafter,  $z_S$  is larger than  $z_A$  until mid-1982 and is smaller thereafter. The level of  $z_S$  in recent years is somewhat puzzling, however, because it is substantially less than the marginal reserve requirement on transaction deposits. Moreover, both measures suggest that the proportion of the  $z$ 's not accounted for by reserve requirements is very small. Indeed, the excess reserve ratio and the ratios of government and foreign deposits to total checkable deposits averaged .0018, .0397 and .0231, respectively, from February 1984 through December 1988.

Figure 3  
Source Base Multiplier and Its Components

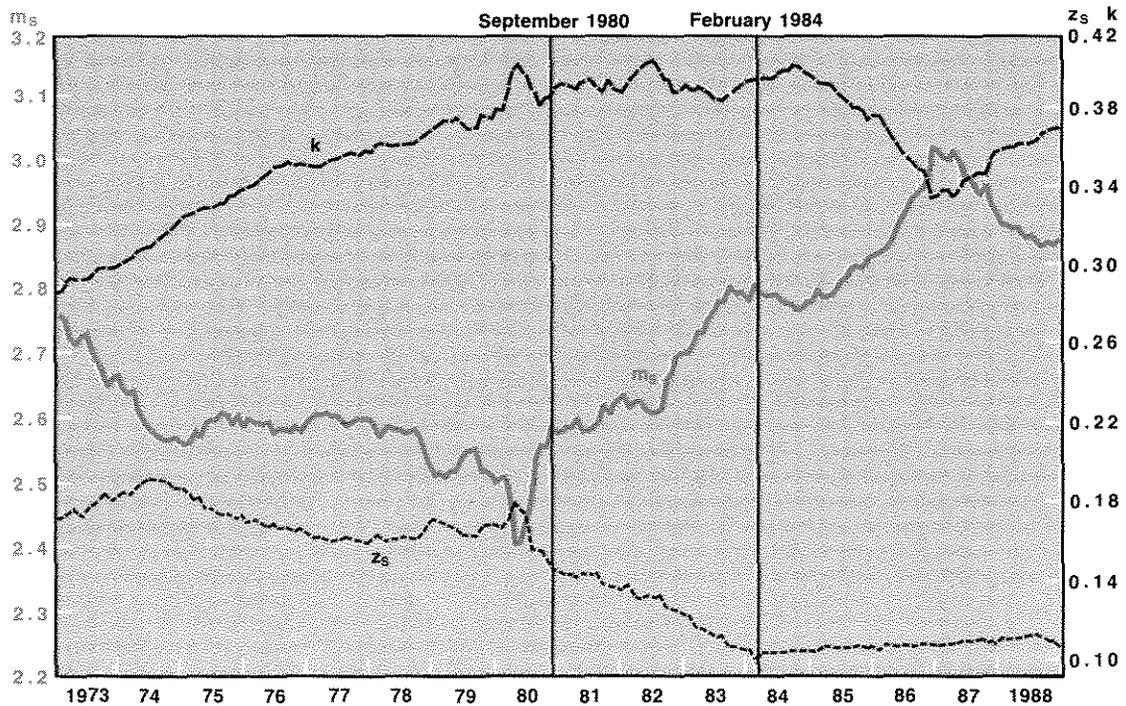


Figure 4  
Changes in the Non-k Components of the Multipliers

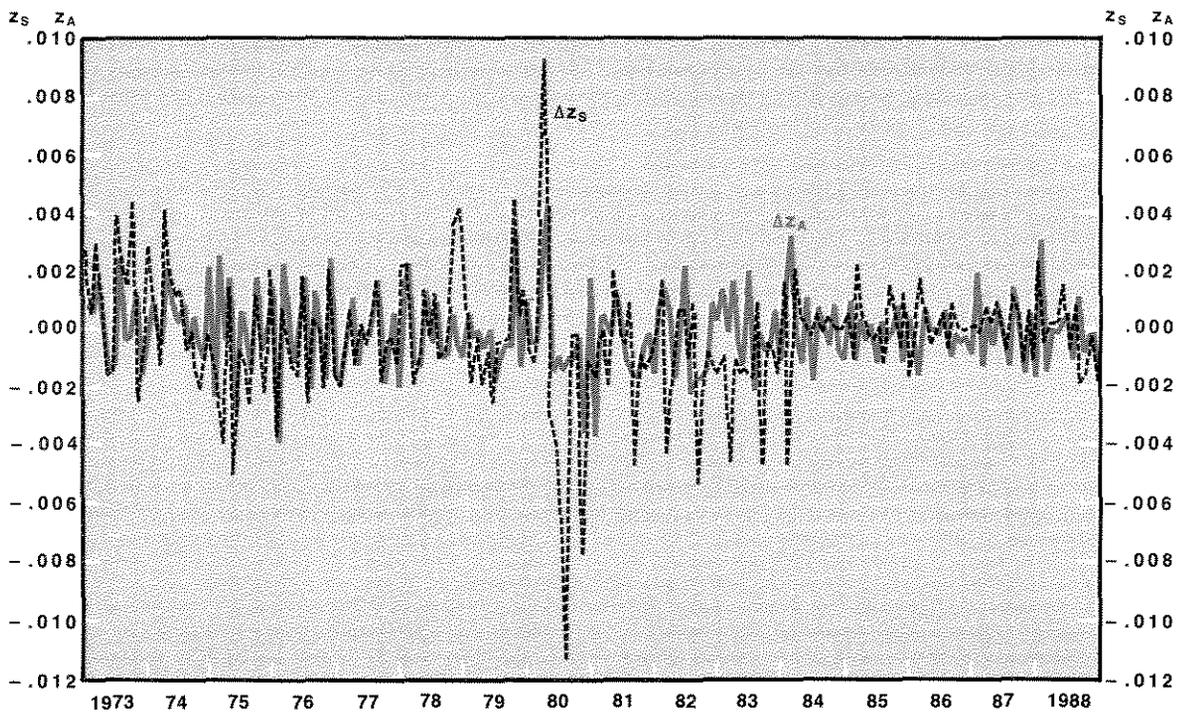


Table 1  
Variances of  $\Delta m$ ,  $\Delta z$  and  $\Delta k$ <sup>1</sup>

Variable	1973.1-1980.11	1980.12-1988.12	1980.12-1984.1	1984.2-1988.12	F <sup>2</sup>
$\Delta m_A$	1.731	1.576	1.641	1.554	1.1
$\Delta m_S$	2.987	1.762	1.945	1.630	1.7*
$\Delta z_A$	.022	.015	.020	.012	1.5
$\Delta z_S$	.072	.023	.031	.013	3.1*
$\Delta k$	.063	.081	.085	.079	.8
<b>Observations Deleted<sup>3</sup></b>					
$\Delta m_S$	2.046	1.414	.866	1.624	1.4
$\Delta z_S$	.047	.010	.006	.008	4.7*
$\Delta k$	.055	.078	.062	.085	.7

<sup>1</sup>Actual variance is  $10^{-4}$  times the reported variance.

<sup>2</sup>An F-statistic with an \* indicates the hypothesis that the variances of the variable are equal across the pre- and post-MCA periods can be rejected at the 5 percent significance level.

<sup>3</sup>Observations were deleted based on the following rule: if the reserve requirement change took place on or before the 15th of the month, that month was deleted; if it took place after the 15th, the next month was deleted. A close examination of deleted observations of  $\Delta m_S$  and  $\Delta z_S$  with the corresponding dates indicates that this rule performs reasonably well.

fect of reserve-requirement changes on  $m_S$  and to the usefulness of the monetary base adjustment in capturing their effect. Furthermore, the fact that these spikes are completely eliminated after the phase-in of member banks confirms the conclusion reached by the analysis of  $z_A$  and  $z_S$  that extending reserve requirements to nonmember banks and thrifts had a relatively unimportant effect on the multiplier. With so little variation in reserve ratios evident in  $z_S$  after February 1984, assessing the effect of the move to CRA is difficult. Furthermore, the final phase-in of the MCA for member banks coincides closely with the adoption of CRA.

### *The Variability of the Multiplier*

Because the levels of the multipliers, the corresponding  $z$ 's and the  $k$ -ratio have definite trends, the variances of the levels are not very useful as measures of variation. More appropri-

ate measures are the variances of the first differences ( $\Delta$ ) of these variables.<sup>20</sup>

The variances of the first differences of the multipliers, the  $z$ 's and the  $k$ -ratio for various periods are presented in the upper part of table 1. This table also presents the F-statistic for a test of the null hypothesis that the variances of each series for the periods 1973.1-1980.11 and 1980.12-1988.12 are equal against the alternative that the variance is larger during the earlier period. These data show that the variance of both  $\Delta m_A$  and  $\Delta m_S$  declined following the adoption of the MCA; however, only the decline for  $\Delta m_S$  is statistically significant at the 5 percent level. There is also a decrease in the variances of  $\Delta z_A$  and  $\Delta z_S$  following the adoption of the MCA. Caution must be exercised in interpreting the decline in the variance of  $\Delta z_A$ ; it is biased downward because of the elimination of the ratio of reservable time deposits to checkable

<sup>20</sup>Diagnostic tests indicate that  $m_A$ ,  $m_S$ ,  $z_A$ ,  $z_S$  and  $k$  are non-stationary in levels but stationary in first differences. Moreover, in most cases, the hypothesis that, in levels,

these series follow a random walk cannot be rejected at the 5 percent level.

**Table 2**  
**Reserve Requirement Changes, 1973-88**

<b>Effective Date</b>	<b>Reserve requirement change</b>
June 21, 1973	The Board amended its Regulation D to establish a marginal reserve requirement of 8 percent against certain time deposits and to subject to the 8 percent reserve requirement certain deposits exempt from the rate limitations of the Board's Regulation Q. In addition, reserves against certain foreign branch deposits were reduced from 10 percent to 8 percent. These changes had little effect on required reserves.
July 12, 1973	Reserve requirements were imposed against finance bills. This action increased required reserves approximately \$90 million.
July 19, 1973	The reserve requirement against all net demand deposits, except the first \$2 million was increased 1/2 percentage point. This action increased required reserves approximately \$760 million.
October 4, 1973	The marginal reserve requirement against certain time deposits was increased from 8 percent to 11 percent. This action increased required reserves approximately \$465 million.
December 27, 1973	The marginal reserve requirement against certain time deposits was reduced from 11 percent to 8 percent. This action reduced required reserves approximately \$360 million.
September 19, 1974	The marginal reserve requirement against time deposits in denomination greater than \$100,000 and more than four-month maturity was eliminated. This action reduced required reserves approximately \$510 million.
December 12, 1974	The reserve requirement against all time deposits with an original maturity of six months or longer was reduced from 5 percent to 3 percent; the reserve requirement against all time deposits with an original maturity of less than six months was increased from 5 percent to 6 percent; and the reserve requirement against net demand deposits more than \$400 million was reduced from 18 percent to 17-1/2 percent. In addition, the 3 percent marginal reserve requirement on large certificates of deposit with an initial maturity of less than four months was removed. These actions reduced required reserves approximately \$710 million.
February 13, 1975	The reserve requirements against all categories of net demand deposits up to \$400 million were reduced by one-half of 1 percentage point, and the reserve requirement against net demand deposits of more than \$400 million was reduced 1 percentage point. This action reduced required reserves approximately \$1,065 million.
May 22, 1975	The reserve requirement against foreign borrowings of member banks, primarily Eurodollars, was reduced from 8 percent to 4 percent. This action reduced required reserves approximately \$80 million.
October 30, 1975	The reserve requirement against member bank time deposits with an original maturity of four years or more was reduced from 3 percent to 1 percent. This action reduced required reserves approximately \$360 million.
January 8, 1976	The reserve requirement on time deposits maturing in 180 days to 4 years was reduced from 3 percent to 2-1/2 percent. This action reduced required reserves by approximately \$500 million.
December 30, 1976	The reserve requirement against net demand deposits up to \$10 million was reduced by 1/2 percentage point, and the reserve requirement against net demand deposits more than \$10 million was reduced by 1/4 percentage point. This action reduced required reserves by approximately \$550 million.
November 2, 1978	A supplementary reserve requirement of 2 percentage points was imposed on time deposits of \$100,000 or more. This action increased required reserves approximately \$3.0 billion.

**Table 2 (Continued)**  
**Reserve Requirement Changes, 1973-88**

Effective Date	Reserve requirement change
October 11, 1979	A marginal reserve requirement of 8 percent was imposed on "managed liabilities" of member banks, Edge Act corporations, and U.S. agencies and branches of foreign banks above a base average for the two weeks ending September 26, 1979. Managed liabilities included large time deposits (\$100,000 and more with maturities of less than one year), repurchase agreements against U.S. government and federal agency securities, Eurodollar borrowings, and federal funds borrowings from a nonmember institution. On October 25, required reserves and reserves held by Edge Act corporations were included in member bank reserves. (Previously reserves held by these institutions were recorded as "other deposits" by Federal Reserve Banks.) These actions raised required reserves approximately \$355 million and \$320 million, respectively.
March 12, 1980	The 8 percentage point marginal reserve requirement was raised to 10 percent. In addition, the base upon which the marginal reserve requirement was calculated was reduced. This action increased required reserves about \$1.7 billion.
May 29, 1980	The marginal reserve requirement was reduced from 10 percentage points to 5 percentage points and the base upon which the marginal reserve requirement was calculated was raised. This action reduced required reserves about \$980 million.
July 24, 1980	The 5 percent marginal reserve requirement on managed liabilities and the 2 percent supplementary reserve requirement against large time deposits were removed. These actions reduced required reserves about \$3.2 billion.
November 13, 1980	Required reserves of member banks and Edge Act corporations were reduced about \$4.3 billion and required reserves of other depository institutions were increased about \$1.4 billion due to the implementation of the Monetary Control Act of 1980.
February 12, 1981	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased by approximately \$245 million.
March 12, 1981	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of small nonmember "quarterly reporters" increased about \$75 million.
May 14, 1981	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased by approximately \$245 million.
August 13, 1981	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased approximately \$230 million.
September 3, 1981	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of member banks were reduced about \$2.0 billion, and required reserves of other depository institutions were increased about \$0.9 billion.
November 12, 1981	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased about \$210 million.
January 14, 1982	The low reserve tranche for transaction accounts at depository institutions was raised from \$25 million to \$26 million. This action reduced required reserves approximately \$60 million.
February 11, 1982	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased about \$170 million.

**Table 2 (Continued)**  
**Reserve Requirement Changes, 1973-88**

<b>Effective Date</b>	<b>Reserve requirement change</b>
March 4, 1982	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of member banks decreased by about \$2.0 billion.
May 13, 1982	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased about \$150 million.
August 12, 1982	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember banks and foreign-related institutions increased about \$140 million.
September 2, 1982	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of member banks were reduced about \$2.1 billion, and required reserves of other depository institutions were increased about \$0.9 billion.
October 28, 1982	In accordance with provisions of the Depository Institutions Act of 1982, required reserves of certain former member banks were reduced by approximately \$100 million.
December 23, 1982	In accordance with provisions of the Depository Institutions Act of 1982 that exempted the first \$2.1 million of reservable liabilities at all depository institutions from reserve requirements, required reserves were reduced by an estimated \$800 million.
March 3, 1983	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of member banks were reduced by approximately \$1.9 billion.
April 14, 1983	Required reserves were reduced an estimated \$80 million as a result of the elimination of reserve requirements on nonpersonal time deposits with maturities of 2-1/2 to 3-1/2 years.
September 1, 1983	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of member banks were reduced about \$2.0 billion, and required reserves of other depository institutions were increased about \$0.9 billion.
October 20, 1983	Required reserves were reduced an estimated \$100 million as a result of the elimination of reserve requirements on nonpersonal time deposits with maturities of 1-1/2 to 2-1/2 years.
January 12, 1984	The low reserve tranche for transaction accounts at depository institutions was raised from \$26.3 million to \$28.9 million. Also, in accordance with the provisions of the Depository Institutions Act of 1982, the reserve requirement exemption applied to total reservable liabilities was raised from \$2.1 million to \$2.2 million. These actions reduced required reserves by about \$350 million.
February 2, 1984	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of member banks were reduced about \$2.0 billion.
September 13, 1984	In conjunction with the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember depository institutions increased about \$1.08 billion.
January 3, 1985	The low-reserve tranche for transaction accounts was raised from \$28.9 million to \$29.8 million. The exemption applied to reservable liabilities was also raised from \$2.2 million to \$2.4 million. These actions reduced required reserves by about \$190 million.
September 12, 1985	According to the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember depository institutions were increased about \$1.23 billion.
January 2, 1986	The low-reserve tranche for transaction accounts was raised from \$29.8 million to \$31.7 million. The exemption applied to reservable liabilities was also raised from \$2.4 million to \$2.6 million. These actions reduced required reserves by about \$340 million.

**Table 2 (Continued)**  
**Reserve Requirement Changes, 1973-88**

Effective Date	Reserve requirement change
April 24, 1986	Money market deposit accounts (MMDA), which had previously been subject to full reserve requirements, were made subject to the transitional phase-in program of the Monetary Control Act. In addition, the order of application of the exemption applied to reservable liabilities was changed. These actions reduced required reserves by about \$260 million.
September 11, 1986	According to the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember depository institutions were increased about \$1.58 billion.
January 1, 1987	The low-reserve tranche for transaction accounts was raised from \$31.7 million to \$36.7 million. The exemption applied to reservable liabilities was also raised from \$2.6 million to \$2.9 million. These actions reduced required reserves by about \$970 million.
September 10, 1987	According to the transitional phase-in program under the Monetary Control Act, required reserves of certain nonmember depository institutions were increased about \$1.70 billion.
December 31, 1987	The low-reserve tranche for transaction accounts was raised from \$36.7 million to \$40.5 million. The exemption applied to reservable liabilities was also raised from \$2.9 million to \$3.2 million. The actions reduced required reserves by about \$740 million.
December 29, 1988	The low-reserve tranche for transaction accounts was raised from \$40.5 million to \$41.5 million. The exemption applied to reservable liabilities was also raised from \$3.2 million to \$3.4 million. The actions reduced required reserves by an estimated \$210 million.

deposits from  $m_A$ . Care must also be taken in interpreting the decline in the variance of  $\Delta z_s$  because reserve-requirement changes affect that variance in an indeterminate way. To remove the effect of reserve-requirement changes, the variances of  $\Delta m_s$ ,  $\Delta z_s$  and  $\Delta k$  were recalculated from smaller samples in which observations for months affected by the reserve-requirement changes were deleted. These variances are presented in the bottom portion of table 1. The list of reserve requirement changes from January 1973 through December 1988 is presented in table 2.<sup>21</sup> The results show a large, though not statistically significant, decline in the variance of  $\Delta m_s$  and a large and statistically significant decline in the variance of  $\Delta z_s$ .<sup>22</sup> Hence, while it is clear that reserve-requirement changes had a substantial effect on the variances of  $\Delta m_s$  and  $\Delta z_s$ , these changes do not seem to qualitatively affect the observed impact of the MCA.

The variance of  $\Delta k$  increased slightly, but not significantly so over these periods. Hence, it would appear that the observed reduction in the variances of  $\Delta m_A$  and  $\Delta m_s$  can be attributed to the predicted reduction in the variances of  $\Delta z_A$  and  $\Delta z_s$ . This is not necessarily the case, however. The variance of  $\Delta m$  is given by an expression like

$$(4) \text{Var}(\Delta m) = a^2 \text{Var}(\Delta k) + b^2 \text{Var}(\Delta z) - 2ab \text{Cov}(\Delta k, \Delta z),$$

where Var and Cov denote the variance and covariance of the variables in parentheses, respectively. Because the coefficients,  $a$  and  $b$ , change with the MCA and the adoption of CRA, it is impossible to say that the observed decline in the variance of  $\Delta m$  is due solely to the decline in the variance of  $\Delta z$ . A clearer picture of the effects of the MCA and the adoption of CRA on the variance of  $\Delta m$  can be obtained by calculating the proportion of the variance of  $\Delta m$  ac-

<sup>21</sup>Reserve-requirement changes from 1960 to 1973 can be found in Burger (1979), pp. 6-7.

<sup>22</sup>As expected, the variance of  $\Delta z_s$  from the sample in which observations affected by reserve-requirement changes

were deleted is substantially smaller than that from the full sample. The same is generally true for the variance of  $\Delta m_s$ .

**Table 3**  
**Relative Contributions of the Components to the Variance of  $\Delta m$**

Variable <sup>1</sup>	1973.1-1980.11	1980.12-1988.12	1980.12-1984.1	1984.2-1988.12
$a^2\text{Var}(\Delta k)/\text{Var}(\Delta m_A)$	.389	.599	.496	.683
$b^2\text{Var}(\Delta z_A)/\text{Var}(\Delta m_A)$	.339	.272	.298	.248
$2ab\text{Cov}(\Delta z_A, \Delta k)/\text{Var}(\Delta m_A)$	.272	.129	.206	.068
$a^2\text{Var}(\Delta k)/\text{Var}(\Delta m_S)$	.170	.591	.431	.797
$b^2\text{Var}(\Delta z_S)/\text{Var}(\Delta m_S)$	.516	.400	.406	.300
$2ab\text{Cov}(\Delta z_S, \Delta k)/\text{Var}(\Delta m_S)$	.315	.009	.162	-.097
<b>Observations Deleted<sup>2</sup></b>				
$a^2\text{Var}(\Delta k)/\text{Var}(\Delta m_S)$	.215	.854	.733	.875
$b^2\text{Var}(\Delta z_S)/\text{Var}(\Delta m_S)$	.490	.249	.187	.192
$2ab\text{Cov}(\Delta z_S, \Delta k)/\text{Var}(\Delta m_S)$	.296	-.094	.080	-.067

<sup>1</sup>The coefficients  $a$  and  $b$  are  $(z-1)/(z+k)^2$  and  $(1+k)/(z+k)^2$ , respectively. These coefficients are evaluated at the means of  $z$  and  $k$  during the periods, and the proportions are based on the  $\text{Var}(\Delta m)$  calculated from the approximations rather than the actual sample variance for  $\Delta m$ .

<sup>2</sup>See footnote 3 from table 1.

counted for by each component on the right-hand side of equation 4.

These proportions for the relevant periods are presented in table 3. For both multipliers, the proportion of the variance of  $\Delta m$  explained by the  $\Delta z$  component declines after November 1980, while the proportion of the variance explained by the  $\Delta k$  component rises. Furthermore, the decline in the proportion of the variance of the change in the multiplier explained by the  $\Delta z$  component continues after the adoption of CRA. This latter observation is not necessarily evidence that the move to CRA reduced the variability of the multiplier; however, the completion of the MCA phase-in for member banks coincides closely with the adoption of CRA.

## CONCLUSION

The changes in reserve requirements specified by the Monetary Control Act of 1980 and the

switch to contemporaneous reserve accounting in February 1984 imply that the link between M1 and the monetary base should have become tighter in the 1980s. The empirical evidence presented in this article suggests that, in fact, the money-base relationship has strengthened in the sense that, for a given  $k$ -ratio, the multiplier has become less variable.

By eliminating or, at least, diminishing the importance of some sources of variability in the multiplier, these changes have potentially enhanced the Federal Reserve's control over M1. The degree to which control over M1 has improved, however, hinges on how these changes, among others, have affected the predictability of the multiplier.<sup>23</sup> The slight reduction in the variance of the change in the multiplier in the 1980s does not necessarily imply that the multiplier itself is easier to predict. The evidence presented in this article suggests that the predictability of the multiplier, especial-

<sup>23</sup>See Johannes and Rasche (1979) and Hafer and Hein (1983) for a discussion of the control problem for M1 and how it is related to the Fed's ability to forecast the money multiplier. Johannes and Rasche (1987) argue that their money stock control model performs well during the 1980s.

ly that for the source base, depends crucially on the predictability of the k-ratio in the 1980s. In any case, further research is necessary to determine whether predicting the multiplier has become more or less difficult.

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## Appendix

The following equations form a simple static model of the money supply process. This model is intended solely to illustrate the main effects of the passage of the Monetary Control Act on the money supply process. It is not intended to represent completely the money supply process.<sup>1</sup>

- (1)  $M1_t = CD_t + C_t$
- (2)  $SB_t = RR_t + ER_t + C_t$
- (3)  $RR_t = r_c [CD_t^M \gamma + CD_t(1-\gamma)] + r_T TR_t^R + r_G GD_t$
- (4)  $ER_t = \alpha [CD_t^M + \delta_1 CD_t + GD_t + \beta CD_t^N + \zeta (TD_t - \delta_1 CD_t)] \gamma + \alpha (CD_t + \delta_2 CD_t + GD_t) (1-\gamma)$
- (5)  $TD_t^R = \delta_1 CD_t \gamma + \delta_2 CD_t (1-\gamma), \delta_1 > \delta_2$
- (6)  $TD_t = TD_t^R + TD_t^{NR}$

$$(7) CD_t = CD_t^M + CD_t^N$$

$$(8) CD_t^M = \theta CD_t$$

$$(9) C_t = k CD_t$$

$$(10) TD_t = \lambda CD_t$$

$$(11) GD_t = g CD_t$$

The superscripts, M and N, distinguish deposits held at member depository institutions from those held at nonmember institutions. (Nonmember institutions include both banks and thrifts). The superscripts R and NR distinguish reservable from nonreservable time and savings deposits. The variable names are:

C = the currency component of the money stock

CD = checkable deposits

TD = time and savings deposits

<sup>1</sup>For example, the model does not account explicitly for the fact that required reserves under both LRA and CRA consist of deposits at the Federal Reserve plus vault cash held during the two weeks prior to the current reserve maintenance period. Since the impact of the variability of changes in vault cash is the same under all regimes, accounting for this fact would merely add another random

component to all of the reduced-form expressions; so it does not qualitatively affect the conclusions. The same conclusion holds for Eurodollar deposits and traveler's checks, which are also not explicitly treated in the model.

GD = government deposits

SB = source base, currency plus total reserves

RR = required reserves

ER = excess reserves

M1 = the M1 definition of the money stock

$r_C$  = reserve requirement ratio on reservable checkable deposits

$r_T$  = reserve requirement ratio on reservable savings and time deposits

$\gamma$  is a shift parameter with the characteristic,

$$\gamma = \begin{cases} 1 & \text{before November 1980} \\ 0 & \text{after November 1980} \end{cases}$$

The reserve requirement ratios,  $r_C$  and  $r_T$ , and the coefficients,  $\beta$  and  $\xi$ , are assumed to be fixed parameters, whereas the ratios,  $\theta$ ,  $k$ ,  $\lambda$ ,  $\delta_1$ ,  $\delta_2$ ,  $g$  and  $\alpha$ , are treated as independent random variables with time-invariant (stationary) distributions.

These equations establish the relationship between the monetary base and M1 and the features of the MCA that have altered that relationship. In the context of this static model, there are two distinct regimes: before the MCA,  $\gamma=1$ ; and, after the MCA,  $\gamma=0$ . Equation 1 is simply the current definition of M1, currency plus checkable deposits, including demand deposits and NOW accounts. Equation 2 defines the uses of source base as the sum of required and excess reserves and currency held by the nonbank public.

Equation 3 specifies required reserves in the pre-MCA period ( $\gamma=1$ ) and under MCA ( $\gamma=0$ ). Before the MCA, reserves were required to be held against checkable deposits and savings and time deposits at member banks, as well as total government deposits. Equation 5 says that, prior to the MCA, reservable time and savings deposits were a fraction,  $\delta_1$ , of checkable deposits. Equation 5 defines that class, under the MCA, to be a smaller fraction of checkable deposits,  $\delta_2$ , where  $\delta_1 > \delta_2$ . Equation 4 describes excess reserve holdings by all depository institutions under both regimes and is general enough to capture the possibility that nonmember banks acted as if they were subject to reserve requirements. Specifically, if

$$\beta = \frac{\alpha + r_C}{\alpha} \text{ and } \xi = \frac{\alpha + r_T}{\alpha},$$

then member and nonmember banks acted identically before and after the MCA.

Equation 6 is an identity for total time and savings deposits. Similarly, equation 7 is an identity for total checkable deposits. Equations 8 through 11 establish proportional links of checkable deposits at member banks, currency, total time and savings deposits and government deposits, respectively, to total checkable deposits.

Equations 1 through 11 are general enough to show the potential impact of the MCA on the multiplier. A dynamic specification, however, is necessary to illustrate the possible effects of the switch from LRA to CRA. Introducing a dynamic element into the model can be accomplished easily by substituting the following equations for equations 3 and 5:

$$(3') \text{RR}_t = r_C \text{CD}_{t-1}^M \gamma + r_C \text{CD}_{t-1} (1-\gamma)(1-\psi) \\ + r_C \text{CD}_t \psi + r_T \text{TD}_t^R \\ + r_C \text{GD}_{t-1} (1-\psi) + r_C \text{GD}_t \psi$$

$$(5') \text{TD}_t^R = \delta_1 \text{CD}_{t-1} \gamma + \delta_2 \text{CD}_{t-1} (1-\gamma)(1-\psi) \\ + \delta_2 \text{CD}_t \psi$$

where  $\psi=0$  under LRA and  $\psi=1$  under CRA.

### *The Effects of the MCA*

The multipliers (denoted by  $m$ ), linking M1 to the source base in the static framework for the pre- and post-MCA regimes, are given respectively by:

$$(12a) m = \frac{1 + k}{A},$$

$$\text{where } A = \alpha(\theta + \delta_1 + g + \beta(1-\theta) + \xi(\lambda - \delta_1)) \\ + r_C(\theta + g) + r_T \delta_1 + k$$

$$(12b) m = \frac{1 + k}{B},$$

$$\text{where } B = \alpha(1 + \delta_2 + g) + r_C(1 + g) \\ + r_T \delta_2 + k$$

The impact of the MCA on the multiplier can be seen partly by comparing the expressions in 12. First, notice that the ratio of checkable deposits at member banks to total checkable deposits,  $\delta_1$ , does not influence the multiplier under the MCA. Second, the parameters that capture the nonmember banks' preferences for holding excess reserves disappear from the

multiplier under the MCA. If, however, non-member banks held reserves as if they were member banks, deposit shifts between member and nonmember banks would not have been a source of variability in the multiplier. Nevertheless, even in this case, the MCA would have affected the multiplier because of the MCA's reclassification of reservable time deposits. This new classification means that  $\delta_2$  replaces  $\delta_1$  and  $\lambda$  in the multiplier under the MCA regime.

To see how the MCA affected the variability of the multiplier, we can compare the variances of  $m$  expressed in equations 12a and 12b. By using a Taylor's series expansion to approximate the variances of  $m$  before the MCA, one can verify the following:

$$(13) \text{Var}(m) = \left(\frac{\partial m}{\partial k}\right)^2 \sigma_k^2 + \left(\frac{\partial m}{\partial \theta}\right)^2 \sigma_\theta^2 + \left(\frac{\partial m}{\partial g}\right)^2 \sigma_g^2 + \left(\frac{\partial m}{\partial \alpha}\right)^2 \sigma_\alpha^2 + \left(\frac{\partial m}{\partial \delta_1}\right)^2 \sigma_{\delta_1}^2 + \left(\frac{\partial m}{\partial \lambda}\right)^2 \sigma_\lambda^2,$$

where

$$\frac{\partial m}{\partial k} = \frac{A - (1+k)}{A^2}$$

$$\frac{\partial m}{\partial \theta} = \frac{\alpha\beta - (r_C + \alpha)(1+k)}{A^2}$$

$$\frac{\partial m}{\partial g} = \frac{r_C + \alpha(1+k)}{A^2}$$

$$\frac{\partial m}{\partial \alpha} = \frac{\theta + g + \delta_1 + \beta(1-\theta) + \xi(\lambda - \delta_1)(1+k)}{A^2}$$

$$\frac{\partial m}{\partial \delta_1} = \frac{\alpha\xi - (r_T + \alpha)(1+k)}{A^2}$$

$$\frac{\partial m}{\partial \lambda} = \frac{\alpha\xi}{A^2}(1+k)$$

and  $\sigma_j^2$  denotes the constant variance of the random variable  $j$ . This approximation assumes that the covariances between the random variables is 0.

Similarly, we can approximate the variance of the multiplier under MCA:

$$(14) \text{Var}(m) = \left(\frac{\partial m}{\partial k}\right)^2 \sigma_k^2 + \left(\frac{\partial m}{\partial g}\right)^2 \sigma_g^2 + \left(\frac{\partial m}{\partial \alpha}\right)^2 \sigma_\alpha^2 + \left(\frac{\partial m}{\partial \delta_2}\right)^2 \sigma_{\delta_2}^2,$$

where

$$\frac{\partial m}{\partial k} = \frac{B - (1+k)}{B^2}$$

$$\frac{\partial m}{\partial g} = \frac{r_C + \alpha(1+k)}{B^2}$$

$$\frac{\partial m}{\partial \alpha} = \frac{1 + g + \delta_2(1+k)}{B^2}$$

$$\frac{\partial m}{\partial \delta_2} = \frac{r_T + \alpha(1+k)}{B^2}$$

Comparing equations 13 and 14 reveals that some sources of variation present before the MCA are no longer relevant—namely,  $\sigma_\theta^2$ ,  $\sigma_{\delta_1}^2$ , and  $\sigma_\lambda^2$ . Variability of the ratios of time deposits at member banks to total checkable deposits and total time deposits to total checkable deposits does not contribute to the variance of the multiplier under the MCA. The MCA, however, does maintain reserve requirements on some time deposits, represented here by  $\delta_2 CD_1$ . Accordingly, variability in the ratio of these deposits to total checkable deposits essentially represents a new source of variation in the multiplier under MCA.

The MCA had another important effect on the variance of the multiplier. In particular, by changing the level of the multiplier, it changed the coefficients on each of the individual variances. The multiplier in the MCA regime will be unambiguously larger than in the pre-MCA regime if, before the adoption of the MCA, non-member banks acted identically to member banks—that is, if  $\beta = \frac{\alpha + r_C}{\alpha}$  and  $\xi = \frac{\alpha + r_T}{\alpha}$ .

As  $\beta$  and  $\xi$  approach 0, the difference in the multipliers for the two regimes gets smaller. But, provided that  $(\delta_1 - \delta_2)(r_T + \alpha) > (1 - \theta)(r_C + \alpha)$ ,  $B < A$  and the multiplier is larger under MCA. That is, if the impact of eliminating reserve requirements on a large class of time and savings deposits is greater than the effect of extending reserve requirements to all depository institutions, then the multiplier is

larger in the current regime than in the pre-MCA regime.<sup>2</sup>

That the multiplier can be larger under MCA implies that the sources of variability remaining under MCA can make a greater contribution to the variability of the multiplier. Even under the simplifying assumption that the magnitudes of the remaining sources of variability do not change across regimes, the variance of the multiplier could be larger under the current regime. Although it is highly unlikely that the variance would increase, the variability in  $k$  is likely to have a greater impact on the variance of the multiplier under MCA than in the pre-MCA regime.

### *The Effects of the Move to CRA from LRA*

To investigate the possible effects of the switch to CRA from LRA, we employ the dynamic version of the model. In the dynamic model, there are three regimes of interest: pre-MCA, LRA ( $\gamma=1, \psi=0$ ); MCA, LRA ( $\gamma=0, \psi=0$ ); and, MCA, CRA ( $\gamma=0, \psi=1$ ). The contemporaneous multipliers in the dynamic model for these three regimes are given, respectively, by:

$$(15a) \quad m = \frac{1+k}{A'}$$

$$\text{where } A' = \alpha[\theta + \delta_1 + g + \beta(1-\theta) + \xi(\lambda - \delta_1)] + k$$

$$(15b) \quad m = \frac{1+k}{B'}$$

$$\text{where } B' = \alpha(1 + \delta_2 + g) + k$$

$$(15c) \quad m = \frac{1+k}{C'}$$

$$\text{where } C' = \alpha(1 + \delta_2 + g) + r_c(1+g) + r_T\delta_2 + k$$

Before discussing the effects of the move to CRA, we can see how the MCA influenced the multiplier under LRA by comparing 15a with 15b. As in the static model, the random ratio of checkable deposits at member banks to total checkable deposits and the fixed parameters, describing the behavior of nonmember banks' holdings of excess reserves prior to MCA, are no longer relevant for the multiplier in the MCA/LRA regime. Also, the MCA influences the level of the multiplier in an analytically indeterminate way.

The move to CRA unambiguously decreased the average level of the multiplier, however, as can be seen by inspecting equations 15b and 15c. Nevertheless, the net effect from the first to the third regimes predicted by the dynamic model is identical to that predicted by the static model. That is, holding all else constant, the level of the multiplier is most likely higher now than before the MCA if the net effect of the MCA was to decrease average reserve requirements.

In fact, the dynamic version of the model of the money supply process has similar predictions about the impact of the MCA on the variability of the multiplier to those from the static model. The similarities of the predictions of both models can be verified by approximating the variance of the multipliers expressed in 15 with a Taylor's series expansion. Since the multiplier declines from the second to the third regimes, variation in  $k$  and  $\alpha$  provide smaller contributions to the variability of the multiplier upon the move to CRA. The change in the importance of the variability of  $\delta_2$  and  $g$  for the variability of the multiplier could be smaller, but is likely to be larger. Nonetheless, the predicted effect of the MCA on the variability of the multipliers and its components from the first to the third regimes in the dynamic model is qualitatively identical to the effect predicted by the static model.<sup>3</sup> Specifically, the variance of the multiplier should fall with the implementation of the MCA and the switch to CRA.

<sup>2</sup>As discussed in the main text but not captured in this simple model, if the effect of reducing reserve requirements on checkable deposits held at many member banks is large, the adoption of the MCA would tend to increase the multiplier.

<sup>3</sup>As Thornton (1983) shows, the isolated impact of the move to CRA on the multiplier is diminished if depository institutions hold excess reserves as a buffer stock to absorb changes in required reserves under CRA, a possibility not

captured by the dynamic model. To the extent that these institutions hold excess reserves as a buffer stock, the switch from LRA to CRA has a smaller effect on the dynamic structure of the money supply process. Further, one can verify, by setting  $\alpha=0$ , that the move to CRA could have increased the variability of the multiplier if, under LRA, the only contemporaneous link between the monetary base and M1 were through currency holdings.