# Measuring the Policy Effects of Changes in Reserve Requirement Ratios

**Joseph H. Haslag**
Senior Economist
Federal Reserve Bank of Dallas

**Scott E. Hein**
Norwest Bank Distinguished Scholar
Texas Tech University

*This measurement issue is potentially important for students of monetary policy. If movements in the adjustment factor are an amalgam of policy and nonpolicy actions, it is a mistake to interpret movements in the St. Louis adjustment factor as a direct measure of reserve requirement ratio changes.*

Karl Brunner (1961) argues that movements in a monetary policy measure should solely reflect those actions undertaken through all three of the Federal Reserve's policy tools: open market operations, discount window loans, and changes in reserve requirements. In Brunner's view, high-powered money—the sum of bank reserves and currency held by the nonbank public (also known as *source base*)—is too narrow a measure for policy analysis. His main criticism is that changes in reserve requirement ratios would not cause movements in high-powered money. As a result, he suggests constructing an adjustment factor—which he terms *liberated reserves*—to measure policy actions undertaken via changes in reserve requirements. Brunner defines the monetary base as the sum of high-powered money and the adjustment factor. This combination provides a monetary policy measure that possesses Brunner's desired property of representing all Federal Reserve tools.[1]

Following Brunner's lead, both the Federal Reserve Bank of St. Louis (hereafter "St. Louis") and the Board of Governors of the Federal Reserve System (hereafter "Board") currently calculate monetary base series that add an adjustment factor to high-powered money. The purpose of the adjustment factor ostensibly is to measure, in dollar terms, monetary policy actions implemented through changes in reserve requirements. In both the St. Louis and Board measures, the adjustment factor is an index value constructed as the difference between what required reserves would have been under the base-period reserve requirement structure and actual required reserves. Movements in the index value, therefore, are interpreted as changes in the amount of required reserves freed (absorbed) relative to the base period.

Peter Frost (1977) and Manfred Neumann (1983), however, have argued that the St. Louis index value is a poor proxy for measuring changes in reserve requirements.[2] In essence, these critics argue that movements in the adjustment factor, over time, can occur for nonpolicy reasons. Critics claim, as such, that the adjustment factor is not a pure measure of policy changes conducted through the Federal Reserve's tools but includes other considerations.

This measurement issue is potentially important for students of monetary policy. If movements in the adjustment factor are an amalgam of policy and nonpolicy actions, it is a mistake to interpret movements in the St. Louis adjustment factor as a direct measure of reserve requirement ratio changes. To illustrate this point, suppose that a nonpolicy action causes a movement in the adjustment factor. A researcher looking at such an episode in monetary policy history would, using the adjustment factor, erroneously identify this movement as reflective of a policy action. This identification problem also arises when researchers estimate correlations between the adjustment factor and economic variables, claiming the adjustment factor measures reserve requirement ratio changes. If the adjustment factor does not properly distinguish between policy and nonpolicy actions, it is not clear whether either episodic differences or the estimated correlations are due to movements in policy actions, nonpolicy actions, or both. Examples of potential inference problems arise in several articles examining the relationship between reserve requirements and economic activity, including Prakesh Lougani and Mark Rush (forthcoming), Joseph Haslag and Scott Hein (1992), Charles Plosser (1990), and Mark Toma (1988).

We have two main objectives in this article. First, we describe and construct a measure of changes in required reserves caused by changes in reserve requirement ratios for the United States from 1929 through 1993. Unlike the current reserve adjustment measures, this alternative measure distinguishes between movements resulting from changes in reserve requirement ratios and those resulting from changes in deposits. Our alternative measure is constructed by modifying Brunner's liberated reserves notion. More specifically, we constrain changes in the reserve index measure to equal zero during periods in which no changes in reserve requirement structures were implemented. Our objective is to generate a cleaner measure of changes in reserve requirements, especially for analysts explicitly interested in monetary policy research.

The second, and more important, objective is to empirically assess the importance of this measurement issue. While the criticism of the existing procedure has been around since the late 1970s, the significance of the distortion has been generally ignored. After providing a descriptive (episodic) overview of the measurement differences, we use formal statistical techniques to quantify the differences between the existing adjustment factor and our measure.

## The history of adjustment factors

Before we describe the alternative method used to construct the reserve requirement change, it is useful to provide a brief overview of the adjustment factor. With such an overview, one can better understand how the definition of adjustment factor has evolved over time and the criticisms of this measure.

Brunner (1961) first suggested the idea of a comprehensive measure of monetary policy actions. He proposed the notion of liberated reserves, defined as reserves freed or impounded by changes in reserve requirements. Leonall Anderson and Jerry Jordan (1968, 8) describe the process of constructing the reserve adjustment measure for a particular month as follows:

> First, the weighted average reserve requirement on demand deposits for the month (using for weights the distribution of these deposits by class of member bank) is computed. Then, the difference in average reserve requirements from the previous month is multiplied by net demand deposits for the previous month.

The reserve adjustment measure is then the algebraic sum of the monthly estimations. Thus, the change in the reserve adjustment measure is simply

$$(1) \qquad \Delta L = D_t \Delta wr,$$

where $L$ denotes liberated reserves, $D_t$ is the period-$t$ level of deposits against which reserves are required to be held, and $\Delta wr = wr_t - wr_{t-1}$ is the change in the weighted average of reserve requirement ratios.[3] (The $\Delta$ is the first-difference operator.) The weighted average takes into account that reserve requirements are different for different-sized banks. For example, in 1994 the first \$51.9 million of checkable deposits at a particular bank are subject to a 3-percent reserve requirement. (This \$51.9 million level is called the *low-reserve tranche*.) For deposit levels above the low-reserve tranche, the reserve requirement ratio is 10 percent. The weighted average is then the sum of the following products: the fraction of period-$t$ deposits that are subject to the low-tranche reserve requirement times 0.03 (the 3-percent reserve requirement) and the fraction of period-$t$ deposit levels that are above the low-reserve tranche level times 0.10 (the 10-percent reserve requirement). Note that if there were only one reserve requirement ratio, this approach would yield changes in liberated reserves only when reserve requirements were changed.

A problem with constructing liberated reserves in this way is that nonpolicy actions can affect the change in liberated reserves over time. For example, suppose that depositors shift their accounts from banks with deposit levels below the low-reserve tranche to large banks. Because the reserve requirement ratio is higher at the large bank than at the small bank, the weighted average reserve requirement ratio will change. Consequently, there is a change in the reserve adjustment measure. Frost (1977) identifies this problem, as well as another concern, in measuring monetary policy using the monetary base measure. (See the box entitled "Frost's Logarithmic Adjustment Factor" for details on his methodology.)

At about the same time as Frost's work, two researchers at the St. Louis Fed, Albert Burger and Robert Rasche (1977), were calculating the Reserve Adjustment Magnitude, or RAM. St. Louis' RAM was designed to measure the impact of changes in reserve requirement ratios. The Federal Reserve Bank of St. Louis' adjustment measure is calculated as

$$RAM_t = (r_b - r_t)D_t, \quad (2)$$

where $r_t$ is the vector of the reserve requirement ratios that apply in period $t$, $r_b$ is the vector of the reserve requirement ratios in a selected base period, and $D_t$ is the vector of period-$t$ quantity of deposits against which reserves must be held. The St. Louis monetary base adds RAM to high-powered money. RAM can be interpreted as the level of required reserves in period $t$ less what required reserves would have been were the base-period reserve requirement still in effect. A positive value of RAM indicates that reserves have been freed relative to the base-period reserve requirements. Conversely, a negative value indicates that reserves have been impounded relative to the base-period reserve requirements.

Consider how RAM changes over time. The changes in RAM from one period to the next (discrete time) can be represented as

$$\Delta RAM_t = -\Delta r_t D_t + (r_b - r_t)\Delta D_t. \quad (3)$$

Equation 3 indicates that RAM changes over time in response to two factors. The first term on the right-hand side of equation 3 captures changes in reserve requirement ratios. The second term, which we refer to as the *deposit-flow effect*, indicates that RAM can change over time even if reserve requirements are constant.[4] Specifically, changes in deposits indirectly reflect both the households' and banks' behavior. Because these changes affect both RAM and the monetary base, the adjustment factor presents a basic identification problem: movements in RAM can be due to changes in reserve requirements, due to changes in deposits against which reserves must be held, or some combination of both. The implication is that RAM is a potentially poor proxy of changes in reserve requirement ratios.[5]

In the remainder of this article, we turn our attention to measuring changes in required reserve ratios. We construct our measurement by constraining the change in measure of required reserves to equal zero for those periods in which no change is made in reserve requirements.

## Constructing the reserve step index

We offer an alternative measure of effective reserve requirement ratios that is not affected by such deposit flows. To create our measure, which we term the *reserve step index* (RSI), we use data on weekly levels of required reserves. We modify the St. Louis base-period selection process; that is, our RSI measure is constructed using the reserve requirement ratio structure for August 1978. St. Louis, however, uses the average reserve requirement structure for 1976–80 as its base period.[6] We choose August 1978 for our RSI base period for two reasons. First, August 1978 is the month in which RAM is closest to zero (there are no monthly values of RAM in which it is identically zero). Second, our base-period selection permits a fairly direct comparison with the St. Louis RAM measure insofar as the average reserve requirement ratio in 1976–80 is evidently close to the August 1978 reserve requirement structure.

The various dates for changes in reserve requirement ratios are obtained from the annual report of the Board of Governors for every year from 1929 to the present.[7] With the dates of the changes in reserve requirement ratios, the difference between required reserves in the week(s) in which the change in structure took place and the week prior to change is used as our estimate of the value of reserves freed (absorbed) by the policy action.[8] This measure is added to the previous level of RSI, resulting in a cumulative measure of dollar changes in required reserves resulting from changes in reserve requirement ratios.

We consider separately the dates after August 1978 and the dates before August 1978. For dates after August 1978, we look for the first period that reserve requirement ratios were altered. For each date after August 1978, we calculate the change in RSI as

$$RSI_t - RSI_{t-1} = \begin{cases} RR_{t-1} - RR_t \text{ if reserve requirement changes,} \\ \text{or} \\ 0, \text{ otherwise.} \end{cases} \quad (4)$$

Similarly, from the August 1978 benchmark, we move backward in time, looking sequentially for dates on which changes in the reserve requirement ratio structure were implemented. Again, equation 4 is used to determine the path of RSI.

## Frost's Logarithmic Adjustment Factor

Peter Frost (1977) identifies a problem with a monetary base measure. Specifically, Frost argues that the measure "distorts the effect of Federal Reserve policy actions on the growth in the money supply" (1977, 168). Frost's point is that the growth rate of the monetary base should be equal to the growth rate of high-powered money in periods in which reserve requirements are constant. Yet, Frost shows that differentiating the log of liberated reserves with respect to time yields

$$\text{(A.1)} \qquad \frac{\Delta B}{B+L} \neq \frac{\Delta B}{B} \text{ for } L \neq 0.$$

Frost proposes a solution to this problem: a logarithmic adjustment factor. The bottom line is that Frost's series ensures that the monetary base and high-powered money *grow* at identical rates in those periods in which reserve requirement ratios do not change. However, in levels, the logarithmic adjustment factor moves over time, even in those periods in which reserve requirements do not change. As such, Frost's measure is suspect as a measure of monetary policy actions implemented through changes in reserve requirement ratios.

Frost's adjustment factor is defined as

$$\text{(A.2)} \qquad \Gamma_t = \sum_{j=1}^{t} G_{jr} \Delta r_t,$$

where $G_r$ is the arithmetic mean of $1/(r + k)$ for period $t$ and period $t$–1, $r$ is the reserve-to-deposit ratio, $k$ is the currency-to-deposit ratio, and $\Delta r$ is the change in reserve requirements. Obviously, with $\Delta r = 0$ (a case in which reserve requirements are constant over time), $\Gamma$ is constant. The logarithmic reserve adjustment measure uses $\Gamma$ so that the percentage change in the logarithmic reserve adjustment is equal to the change in high-powered money. Formally,

$$\text{(A.3)} \qquad \ln(B + L^*)_t = \ln B_t + \Gamma_t.$$

Differentiate equation A.3 with respect to time and solve for the growth rate of the logarithmic adjustment factor ($L^*$) to yield

$$\text{(A.4)} \qquad \frac{dL^*}{dt} = \frac{L^* dB}{Bdt} + (B + L^*)\frac{d\Gamma}{dt}.$$

From equation A.2, the term $d\Gamma/dt = 0$ during periods in which reserve requirements do not change. Thus, the percentage change in $L^*$ is equal to the percentage change in $B$, implying that $B$ and $B + L^*$ grow at the same rate.

For our purposes, equation A.4 indicates that the value of $L^*$ does change over time, even when reserve requirements do not. So, Frost's approach satisfies the criterion that growth rates for high-powered money and monetary base are identical in those periods in which reserve requirements do not change. However, $L^*$ is not a good indicator of changes in reserve requirements, in our sense, because it moves over time even though reserve requirements do not change.

It is important to note that Frost's $\Gamma$ term is quite similar to our notion of what makes a good measure. Both *RSI* and $\Gamma$ do not change during periods in which reserve requirement ratios are constant. In constructing *RSI*, we use the level of required reserves as the basis for calculating changes in required reserves caused by changes in reserve requirement ratios. Implicitly, we are multiplying changes in reserve requirement ratios by deposits. However, Frost calculates $\Gamma$ as the product of the change in reserve requirement ratios and $1/(r + k)$.

In periods in which there is no change in reserve requirements, equation 4 dictates that the step index be held constant.

When the change in RSI is not zero, equation 4 indicates the change in the dollar amount of reserves freed (absorbed) by changes in reserve requirements in the particular week in which the reserve requirement change was enacted. While the input data we use is weekly, our aim is to construct a monthly series. We simply sum across all the weekly changes in RSI that take place within a month to get a monthly value. With the estimates of monthly changes, we start with *RSI* = 0 in August 1978, adding the monthly value of the change in *RSI* to the previous month's level, both forward and backward in time, to create our time series. The result is an index time series documenting the cumulative measure of changes in required reserves, relative to August 1978, that are due to changes in reserve requirement ratios.

The relationship between changes in RSI and changes in RAM is straightforward. First, note that $RR_t = r_t D_t$ (where $RR$ is required reserves). For periods in which changes in reserve requirement ratios occur, substituting this expression into equation 3, one can write

$$\text{(5)} \qquad \Delta RAM_t = r_b' \Delta D_t + \Delta RSI_t \qquad \text{for } r_t \neq r_{t-1},$$

where $\Delta$ is the difference operator. In periods in which no changes in reserve requirements take place, $r_t = r_{t-1}$,

$$\text{(6)} \qquad \Delta RAM_t = r_b' \Delta D_t - r_t' \Delta D_t = (r_b - r_t)\Delta D_t, \text{ and } \Delta RSI_t = 0.$$

Taken together, equations 5 and 6 describe the movements in RAM, differentiating between periods in which changes in reserve requirement ratios occur and periods in which only changes in deposit levels occur. Equations 5 and 6 share a common term, $r_b'\Delta D_t$. This term represents the change in required reserves due to deposit flows ($\Delta D_t$).

The deposit-flow effect, $(r_b - r_t)'\Delta D_t$, makes it difficult to use the St. Louis measure as proxy for measuring changes in reserve requirement ratios. Using the RAM methodology, required reserves are treated as freed (or absorbed) as deposits change over time, even when reserve requirement ratios are fixed and $r_b \neq r_t$. In contrast, for periods in which no changes to reserve requirements occur, $\Delta RSI = 0$ by construction.[9] Our next objective is to empirically assess the costs, if any, of including the deposit-flow variable in a measure of changes in reserve requirement ratios.

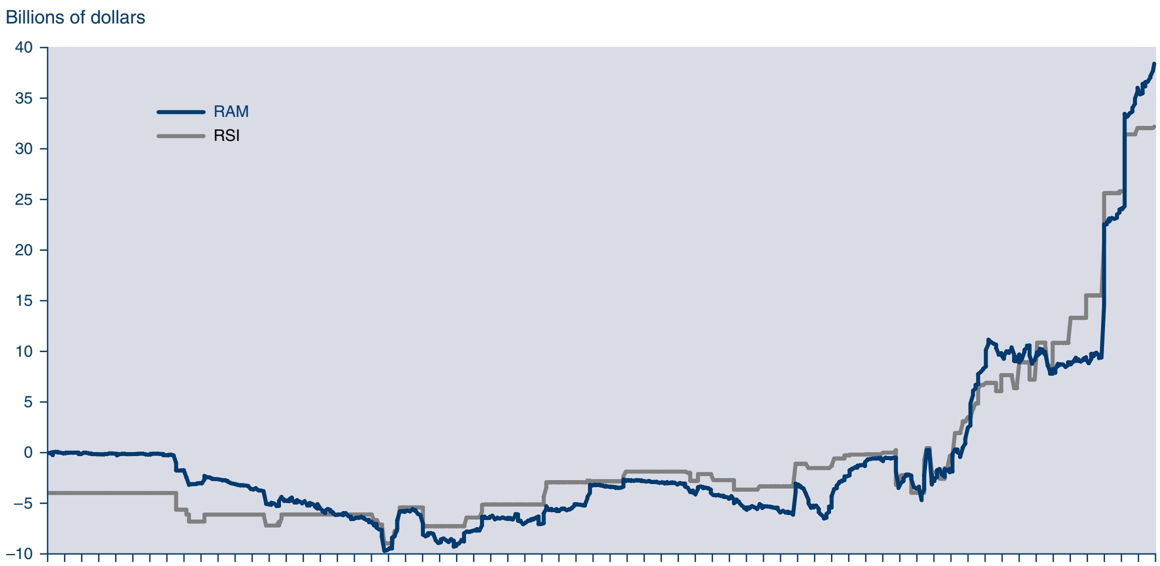
## Comparing RSI and RAM over time

Figure 1 plots the original RAM series and RSI, the step index, from January 1929 through December 1993. (The actual monthly series for RSI is included in the appendix.) By construction, RSI does not move in periods between changes in reserve requirement structures. As such, the reserve step index is constructed as a sequence of infrequent, permanent shocks. This time series behavior is quite different from that of RAM, which shows much more drift; that is, RAM experiences more frequent changes in its level.

Because both series are index numbers, a comparison of the two series is implicitly a comparison relative to the base period. Because we use essentially the same base period to construct RSI as RAM, however, absolute comparisons of the two series, and the implied reserve requirement ratio structures, are a justifiable approximation.

The two reserve index series (RAM and RSI) exhibit qualitatively similar time series behavior. Some important differences, however, emerge during particular episodes. For example, consider the period 1929–36. This period represents an interval in which there is a sizable difference between the levels of the two measures. RSI hovers around –$4 billion for most of this period, indicating that reserve requirements were higher during this interval than those in place during the 1978 base period. In contrast, in the 1929–36 period, RAM is near zero for the entire period. A researcher using RAM (and interpreting it as changes in reserve requirement ratios) would infer that reserve requirements in the 1929 through 1936 period were really not that different from those of the 1976–80 period. The interpretation provided by RAM is that reserve requirements were not very restrictive during the first half of the 1930s relative to the August 1978 base period. RSI, however, suggests a much more restrictive policy stance was in place in the 1929–36 period relative to the August 1978 base period. Specifically, the 1929–36 reserve requirement structure absorbed about $4 billion

Figure 1
**RAM and RSI Series, January 1929–December 1993**




SOURCES: Federal Reserve Bank of St. Louis and authors' calculations.

in reserves relative to the August 1978 reserve requirement structure. After 1936, both RSI and RAM decline, and by 1945, the two series obtain about the same level. In highlighting the 1929–36 period, it is easy to see inference problems created by the presence of the deposit-flow effect during the Great Depression. The fact that RAM is close to zero during the 1929–36 period has more to do with the outflow of deposits from banks during this period than with monetary policy actions. As such, one could wrongly infer that reserve requirements were about the same in the 1929–36 period as they were during the 1976–80 period.[10]

Another discrepancy between the time series behavior of RAM and RSI occurs beginning in 1973 and ending about 1975. In early 1973, RSI falls slightly, while RAM begins a steady decline that ends in early 1975. Both RAM and RSI are below zero, indicating that the reserve requirement structure during the 1973–75 period was high relative to the appropriate base periods. Deposit inflows, with basically high reserve requirements relative to the base period, drive RAM down sharply from 1973 through 1975. RSI, however, indicates that very few required reserves were absorbed by reserve requirement ratio changes during this period. As measured by RAM, the rapid deposit growth in this period would have exaggerated the policy constraining effects of reserve requirements. As the public moved deposits into reservable deposit accounts in 1973, RAM suggests that the level of required reserves was becoming more and more restrictive during the 1973–75 period. RSI suggests, however, that the average level of required reserves was raised only slightly between 1973 and 1975.[11]

Similarly, again in 1987–90, deposit outflows drive RAM sharply lower than RSI. Between 1987 and 1990, RAM increases only slightly. One could infer that reserve requirement ratios had been lowered slightly, freeing a small amount of reserves. In contrast, RSI rises rather sharply during the 1987–90 period, indicating that monetary policy was actually freeing a larger amount of reserves.[12] Based on RAM, the late 1980s looks like a period in which reserve requirements were lowered slightly, then held fairly steady. In contrast, RSI indicates that a series of policy actions was implemented in which reserve requirements were lowered. The data in Figure 1 can be reconciled by treating the small increase in RAM as resulting from deposit outflows. Reserves freed by lower reserve requirements were being offset by smaller quantities of deposits. Consequently, RAM—the product of these two separate effects—shows only slight increases, while RSI accurately captures the falling reserve requirements.

## A time series analysis of the differences between RSI and RAM

By displaying the levels of the RAM and the RSI series, Figure 1 depicts episodic differences between the two measures. However, the evidence does little to shed light on the importance of such differences. It may be the case that the two series only randomly deviate from (a linear combination of) one another. One way to shed light on this issue is to examine the statistical long-run relationships between *RSI* and *RAM*. In particular, we ask whether *RAM* and *RSI* are similar time series. Our belief is that there is no permanent long-run association between these two measures in the sense that if one wanted to forecast movements in RSI using RAM over an infinite horizon, the variance around that forecast would be infinity. Based on the time series behavior presented in Figure 1, we suspect that deposit-flow effects can, and do, cause the two variables to permanently diverge from one another.

Robert Engle and Clive Granger (1987) have suggested the use of cointegration techniques to explore long-run relationships in time series. If deposit-flow effects are a short-run phenomenon that results only in temporary deviations between the two measures, then deviations between the two series should disappear in the long run. Hence, such deviations can be characterized as simply "noise." On the other hand, if deposit flows are significant and not self-reversing, there is likely to be no long-run relationship in the two series.

Evidence indicates that both *RAM* and *RSI* are integrated of order one—I(1).[13] As such, the two series may be cointegrated. The following is the output from an ordinary least squares regression using levels of *RAM* and *RSI* (standard errors in parentheses):

$$RAM_t = -.323 + .862\ RSI_t + e_t. \tag{7}$$
$$(.125)\quad(.17)$$
$$D\text{–}W = .03;\ R^2 = .82.$$

As the two measures, *RSI* and *RAM*, each has unit roots, a test for cointegration seeks to determine whether there is a unit root in the residual, $e_t$, from equation 7. Under the null hypothesis that there is a unit root in $e_t$, the test statistic is –2.25, which is larger than the 5-percent critical value of –3.17. Hence, one fails to reject the null hypothesis that there is a unit root in the error term. Thus, one cannot reject the null hypothesis that *RAM* and *RSI* are not cointegrated.[14] Similarly, the small value of the Durbin–Watson statistic also suggests that RAM and RSI are not cointegrated. The evidence, therefore, suggests there is no long-run relationship between RAM and RSI. As such, there is no evidence to support the notion that RSI and RAM are driven by a common factor. Nor should one conclude that deviations in the two measures simply reflect self-reversing noise.

Our interpretation of these tests is that RAM gives weight to a deposit-flow effect that may permanently bias the estimate of changes in required reserves resulting from true changes in reserve requirement ratios over an infinite horizon. Moreover, the evidence suggests that the deposit-flow effect is itself integrated of order one; that is, the deposits against which reserves must be held have a unit root, resulting in *RAM* and *RSI* not being cointegrated. Indeed, an auxiliary test is to look for unit roots in the differences in the time series—$RAM_t - RSI_t$—which, by construction, is the deposit-flow effect, measured as the vector product of deposits against which reserves must be held times the difference in reserve requirements in the current period and in the base period. Unit root tests on this variable indicate that this deposit-flow measure is indeed integrated of order one—I(1). In light of these findings, the discrepancy in the two alternative measures of changes in required reserves is not a trivial issue. The differences between the two series do not gravitate toward zero in the long run. The evidence presented formalizes what "ocular econometrics" suggests—the two series are different. This evidence further suggests that the two measures would provide very different signals about changes in reserve requirement ratios over time.

## Relationships to economic activity

In this section, we examine two specific questions in a reduced-form macroeconomic setting. First, does the deposit-flow measure help to predict movements in macroeconomic variables differently from the current reserve requirement measure?[15] Since RSI ignores the deposit-flow effect, testing for marginal predictive power of deposit-flow effects is an indirect test of what measure is contributing to the predictive power of *RAM*. Second, are the coefficients on deposit-flow measure equal to the coefficients on RSI? Because RAM essentially constrains these two effects to be equal, empirical work using RAM supposes that the effects of changes in reserve requirements and changes in deposits are identical. The question, however, is whether this constraint is empirically supported.

To examine the first question, we begin by separating the deposit-flow effect and the reserve-requirement effect. We define $\Delta DEPFLOW_t = \Delta RAM_t - \Delta RSI_t$. $\Delta DEPFLOW$ generally will not equal zero for periods in which changes in reserve requirement ratios occur.[16]

The strategy here is to estimate reduced-form macroeconomic models in which the explanatory variable, the percentage change in *RAM*, is decomposed into the percentage change in the deposit-flow variable and the percentage change in *RSI* (each as a proportion of the adjusted monetary base).[17] The reduced-form setting is useful for purposes of identifying differences in predictive content. In these simple regressions, we are focusing on the indicator properties of the separate components of the monetary base. (Of course, this question does not answer whether the monetary base is a better or worse indicator compared with other variables.)

We estimate separately reduced-form models of the inflation rate (using the implicit price deflator), the percentage change in real GNP, and the percentage change in nominal GNP. The right-hand-side variables in these regressions are lagged values of the percentage change in high-powered money ($\Delta SB$), $\Delta RSI$, and the deposit-flow variable ($\Delta DEPFLOW$). In the inflation and output growth equations, we include both lagged values of the inflation rate and real GNP growth. In the nominal GNP growth equation, lagged values of nominal GNP growth are also included. We use the Akaike Information Criterion to select the appropriate lag length for all explanatory variables in the regressions. The general representation of the reduced-form regressions is as follows:

$$(8)\quad \Delta Y_t = a_0 + \sum_{j=1}^{n_1} \Delta Y_{t-j} + \sum_{j=1}^{n_2} \Delta SB_{t-j} + \sum_{j=1}^{n_3} \Delta RSI_{t-j} + \sum_{j=1}^{n_4} \Delta DEPFLOW_{t-j},$$

$$(9)\quad \Delta P_t = a_0 + \sum_{j=1}^{n_1} \Delta P_{t-j} + \sum_{j=1}^{n_2} \Delta y_{t-j} + \sum_{j=1}^{n_3} \Delta SB_{t-j} + \sum_{j=1}^{n_4} \Delta RSI_{t-j} + \sum_{j=1}^{n_5} \Delta DEPFLOW_{t-j},$$

and

$$(10)\quad \Delta y_t = a_0 + \sum_{j=1}^{n_1} \Delta P_{t-j} + \sum_{j=1}^{n_2} \Delta y_{t-j} + \sum_{j=1}^{n_3} \Delta SB_{t-j} + \sum_{j=1}^{n_4} \Delta RSI_{t-j} + \sum_{j=1}^{n_5} \Delta DEPFLOW_{t-j},$$

where $\Delta Y$ is nominal GNP growth, $\Delta P$ is the inflation rate, and $\Delta y$ is output growth. The $n_i$'s denote the appropriate lag length for each variable in the model.

Unfortunately, national income and product accounts data are not constructed in a consistent manner back to 1929. Hence, we use two different data sources. For the period 1929–83, we use quarterly data from Nathan Balke and Robert Gordon (1986) on real GNP and the fixed-weight deflator. Since these data end in 1983, we also consider a postwar period that includes more recent history, namely, 1951–93. For this period, we use real GNP, the implicit price deflator, and nominal GNP data from the Bureau of Economic Analysis. In all, we estimate the three reduced-form regressions over two periods: 1929–83 and 1951–93.

The key reason for separating the reserve-requirement effect and the deposit-flow effect in a reduced-form specification is that the deposit-flow effect signals changes affecting both the demand for deposits by households and businesses and the supply of deposits by banks. As such, the deposit-flow effect in this reduced-form equation is not a pure policy measure but is an amalgam of these different shocks.[18]

The reduced-form setting used in this analysis does little to shed light on the transmission mechanism differentiating the reserve-requirement effect from the deposit-flow effect because we do not have structural equations. However, the reserve-requirement effect represents a tax on the banking system and, hence, is a particular type of shock. Thus, while these tests do not provide direct evidence on the structural effects, they do provide evidence on whether separating reserve-requirement effects from other effects helps to predict economic activity. Moreover, the $\Delta RAM$ measure implicitly assumes that the effects of changes in $\Delta DEPFLOW$ and $\Delta RSI$ are equal. By separately including the deposit-flow measure and $\Delta RSI$ in the regression, we can test whether this restriction is supported by the data. This test is important in analyzing the response of macroeconomic variables to policy changes, as given in impulse response functions. Specifically, if the coefficients on lagged values of $\Delta RSI$ are different from the coefficients on lagged values of the deposit-flow measure, one cost of using $\Delta RAM$ is that impulse response functions—or, for that matter, any parameter estimate—will be biased.

Table 1 reports the sum of the estimated coefficients for each of the three regression equations, using data for the period 1929–83.[19] The table also summarizes evidence on the null hypothesis that the sum of the coefficients equals zero. Insofar as the sum of the coefficients indicates some long-run relationship present in the reduced-form equation, the test determines whether there are significant long-run predictive effects.[20] Table 1 documents that $\Delta RSI$ is significantly related to changes in inflation, output growth, and nominal GNP growth in the sense that the sum of coefficients is different from zero. Increases in $\Delta RSI$, occurring because of a lowering of reserve requirements, predict subsequent increases in inflation, output growth, and nominal GNP growth. In contrast, $\Delta DEPFLOW$ is not related to the inflation rate or nominal GNP growth. Moreover, while $\Delta DEPFLOW$ is weakly related (at the 10-percent significance level) to output growth, as indicated by the tests on the sum of the coefficients, increases in deposit flows predict subsequent *decreases* in output growth.[21]

Table 2 reports the sum of the coefficients and test statistics, estimating the same relationships with data after World War II: 1951–93.[22]

Table 1
**Regression Results for Inflation, Output Growth, And Nominal GNP Growth Equations, 1929–83**

| | Sum of the Estimated Coefficients | | |
|---|---|---|---|
| | Dependent Variable | | |
| **Independent Variable** | ***Inflation*** | ***Real GNP*** | ***Nominal GNP*** |
| *Inflation* | .720(1)** | .005(1) | NA |
| *Output growth* | –.051(2) | .515(3) | NA |
| $\Delta$*SB* | .091(6) | .005(3) | .172(6) |
| $\Delta$*RSI* | .176(7)** | .560(2)** | .568(7)** |
| $\Delta$*DEPFLOW* | .062(1) | –.409(1)* | .160(2) |
| *Nominal GNP growth* | NA | NA | .627(4)** |

Table 2
**Regression Results for Inflation, Output Growth, And Nominal GNP Growth Equations, 1951–93**

| | Sum of the Estimated Coefficients | | |
|---|---|---|---|
| | Dependent Variable | | |
| **Independent Variable** | ***Inflation*** | ***Real GNP*** | ***Nominal GNP*** |
| *Inflation* | .867(3)** | –.135(1) | NA |
| *Output growth* | .064(1) | .310(1) | NA |
| $\Delta$*SB* | –.001(1) | .007(1) | .005(1) |
| $\Delta$*RSI* | .008(7) | –.010(7) | –.030(7) |
| $\Delta$*DEPFLOW* | –.037(7) | .002(1) | –.006(1) |
| *Nominal GNP growth* | NA | NA | .366(1) |

* Significant at the 10-percent level.
** Significant at the 5-percent level.
NA denotes *not applicable*.
NOTE: Numbers in parentheses represent the number of lagged values included in the regression.

Table 3
**Tests of Exclusion Restrictions**

**Panel A: Sample Period 1929–83**

| | Dependent Variable | | |
|---|---|---|---|
| **Independent Variable** | ***Inflation*** | ***Real GNP*** | ***Nominal GNP*** |
| $\Delta RSI$ | 3.54** | 6.96** | 4.86** |
| $\Delta DEPFLOW$ | .62 | 2.76* | 3.06** |

**Panel B: Sample Period 1951–93**

| Independent Variable | Inflation | Real GNP | Nominal GNP |
|---|---|---|---|
| $\Delta RSI$ | 4.26** | 2.29** | 2.63** |
| $\Delta DEPFLOW$ | 6.84** | .49 | .66 |

* Significant at the 10-percent level.
** Significant at the 5-percent level.

NOTE: F-statistics calculated under the null hypothesis that coefficients on lagged values of independent variable equal zero. Tests are conducted on the same regressions that are reported in Table 1 and Table 2.

The results differ from the 1929–83 period in two particular ways. First, the sum of the coefficients on $\Delta RSI$ and $\Delta DEPFLOW$ is uniformly smaller in the 1951–93 sample than in the 1929–83 sample. Second, neither $\Delta RSI$ nor $\Delta DEPFLOW$ exhibits a statistically significant long-run relationship to economic activity in the 1951–93 sample.

Another way to distinguish between reserve-requirement effects and deposit-flow effects is to determine whether they differ in terms of their short-run predictive content. Specifically, the question is whether movements in one or both of the components of RAM help to predict changes in economic activity. The test statistic, sometimes referred to as a Granger causality test, is calculated under the null hypothesis that the coefficients on lagged values of the variable are jointly equal to zero. The test indicates whether reserve requirements or deposit flow, or both, can help predict short-run changes in economic activity. Table 3 reports the test statistics for both our samples. In Panel A, the tests are reported using the 1929–83 sample, whereas Panel B reports the tests calculated using the 1951–93 sample. In both sample periods, the results indicate that $\Delta RSI$ always helps to predict changes in inflation, output growth, and nominal GNP growth. The ability of changes in $\Delta DEPFLOW$ to predict changes in economic activity is uneven across the two samples. Changes in $\Delta DEPFLOW$ help to predict nominal GNP growth and are marginally related to output growth in the 1929–83 sample, but they are not significantly related to inflation. In the 1951–93 sample, changes in $\Delta DEPFLOW$ are significantly related to changes in inflation but are statistically unrelated to movements in output growth and nominal GNP growth. Thus, the evidence suggests that either both reserve-requirement effects and deposit-flow effects contribute to a relationship between *RAM* and economic activity, or only reserve-requirement effects contribute to *RAM*'s predictive content. These results suggest differences between reserve-requirement effects and deposit-flow effects, but the evidence relates to predictive content and does not bear on whether the two effects should be separated. Presumably, one would want to distinguish between the two effects if combining the two into one measure throws out useful information.

The next step is to directly test the hypothesis that changes in required reserves resulting from changes in reserve requirement ratios (as measured by $\Delta RSI$) have the same regression coefficients as those of the changes resulting from deposit flows. These results bear on the issue of whether there is a need to separate the reserve-requirement and deposit-flow effects. One interpretation is that these coefficients describe the short-run dynamics when shocks hit the system. In vector autoregressions (VARs), these parameter estimates are used to generate impulse response functions. Thus, coefficient equality tests examine whether the short-run dynamic effects of changes in reserve requirement ratios should be constrained to equal the effects of changes in the deposit-flow variable.

Table 4 reports F-statistics from two different tests. In the joint hypothesis tests, the test statistic is calculated under the null hypothesis that all individual coefficients on Δ*RSI* and Δ*DEPFLOW* are equal to one another. On the other hand, the sum of the coefficients test determines whether the sum of the coefficients on lagged values of Δ*RSI* is equal to the sum of the coefficients on lagged values of Δ*DEPFLOW*. As such, the first test examines whether significant differences in the short-run dynamics are present, while the second test examines whether the long-run impacts are statistically different for the two effects. Because the reduced-form models use stationary time series, it is unlikely that movements in Δ*RSI* and Δ*DEPFLOW* will result in long-run changes in inflation, real GNP growth, and nominal GNP growth, as stationarity implies that each series would return to its time-independent mean values.

In Table 4, the top half reports the tests for the 1929–83 sample, while the bottom half reports the findings obtained using the 1951–93 sample. In all six cases, the statistic for the joint hypothesis rejects the null hypothesis, suggesting that the coefficients on lagged values of Δ*RSI* are not equal to coefficients on lagged values of Δ*DEPFLOW*. The short-run predictive content of the two variables is very different. Only in the case of output growth in the 1929–83 sample would one reject the null hypothesis that the sum of the coefficients is equal. Thus, the evidence for output growth in these two samples rather strongly rejects the notion the short-run dynamic path following a shock in *RSI* is identical to the path following a shock to Δ*DEPFLOW*. On the other hand, the general evidence suggests that the long-run effects generally are not significantly different from one another.

We interpret the significant differences between the coefficients on Δ*RSI* and Δ*DEPFLOW* as evidence against combining the reserve-requirement effect and deposit-flow effect, as is done in RAM. Thus, a measure of reserve-requirement effects is useful for looking at pure policy effects.

Table 4
## Test Statistics on the Equality of *RAM* and *DEPFLOW* Coefficients

| Equation | Joint Hypothesis[1] | Sum of the Coefficients |
|---|---|---|
| **Estimating period: 1929–83** | | |
| Inflation | 3.51** | .81 |
| Output growth | 8.17** | 15.73** |
| Nominal GNP growth | 3.65** | .81 |
| **Estimating period: 1951–93** | | |
| Inflation | 4.14** | 1.10 |
| Output growth | 2.27** | .36 |
| Nominal GNP growth | 2.34** | 1.27 |

** Significant at the 5-percent level.

[1] Reported is an F-statistic calculated with degrees of freedom ($n$, 213 – $n$) for the 1929–83 sample and ($n$, 138 – $n$) for the 1951–93 sample, respectively. Here, $n$ is the number of restrictions placed on the regression.

## Summary and conclusions

For many years now, monetary economists have recognized the value of quantifying the effects of reserve requirement ratio changes in measuring the monetary base. In fact, the Federal Reserve System currently provides such a measure to the public. Yet, the methodology used to quantify the effects of reserve requirement ratio changes has been criticized, dating back to at least 1977. Researchers have pointed out that current approaches to quantifying the effects of reserve requirement ratio changes are flawed to the extent that these measures can change even when reserve requirements are not changing. The basic problem is that present approaches to quantifying these policy effects are influenced by deposit-flow shifts. In particular, decisions under the purview of the public or the banking community result in shifts among deposits with different reserve requirements that will result in changes in the current Federal Reserve System measures. Over time, the accumulation or decumulation of deposits changes the measures even though reserve requirements are unchanged.

Why has this problem with the current measures been ignored? One can surmise that the economics profession either does not believe the criticism is valid or, alternatively, believes the measurement error is trivial.

The purpose of this article is to challenge this conventional wisdom. To develop our case, we first construct our own reserve requirement step index (RSI), thus providing an alternative to the measures constructed by the Federal Reserve Bank of St. Louis and the Board of Governors. Our reserve requirement step index excludes, by construction, the most significant movements that result from deposit-flow occurrences. For purposes of comparison, we construct our index for the period 1929–93.

We compare our measure with the conventional measure used by the Federal Reserve Bank of St. Louis. There are several distinct historical episodes in which significant differences between RSI and the St. Louis measure exist. The evidence suggests that significant deposit flows have had rather large impacts on the conventional measures over time. Moreover, we document that such measurement distortions are not temporary but are, indeed, quite long lasting.

The differences in the two measures further result in different statistical associations between macroeconomic variables. We find that the purer measure of reserve-requirement effects generally has strong statistical associations with both inflation and real GNP growth. The deposit-flow effects, which cloud the measures of reserve requirement changes under the current methodologies, do not have a similar strong relationship to these macroeconomic variables. In fact, the evidence suggests that the statistical relationships are quite different for the reserve-requirement effects and the deposit-flow effects. As such, our findings raise serious concerns about using conventional measures of the monetary base, which presume the effects of reserve requirements and deposit flows are the same.

The secondary aim of this article is to provide a better measure of reserve requirement ratio changes. Our efforts in this vein should be viewed as an approximation. One would need individual bank data to accurately measure the reserve-requirement effect. Based on our approximation, however, the conventional wisdom is challenged; that is, the measurement of reserve requirement ratio changes does not represent a mere second-order concern. Current approaches are not sufficient statistics for reserve requirement ratio changes. In contrast to the general view, we believe that it is useful to provide an accurate time series of reserve requirement ratio changes and that this measurement is potentially an important issue for economists in many macroeconomic, monetary, and financial applications.

## Notes

The authors thank John Duca, Milton Friedman, Bill Gavin, Rik Hafer, Evan Koenig, Allan Meltzer, Manfred Neumann, Stephen Prowse, Dan Thornton, and Mark Wynne for helpful comments on earlier drafts of this article. Any remaining errors are our own.

[1] George Tolley (1957, 466) also discusses a measure of changes in the average reserve requirement ratio. His construction of average reserve requirements is "jointly determined by government, banks, and the non-bank public." However, Tolley's concept of an average reserve requirement ratio is quite different from Brunner's. Tolley includes currency in his definition of reserve base. Thus, currency has a reserve requirement ratio of 1, and Tolley's notion is more like a money multiplier, though he refers to it as a reserve requirement ratio. Brunner focuses on liberated reserves exclusively through changes in reserves that are required against deposits, rather than both currency and deposits.

[2] This criticism applies equally to the Board adjustment factor. Because essentially the same criticisms apply, we focus on the St. Louis measure. Moreover, Haslag and Hein (1992, forthcoming) provide evidence suggesting that the St. Louis measure is more closely related to macroeconomic activity, in a statistical sense, than the Board measure.

[3] Here, we take the liberty of treating the adjustment factor equations as if there is one kind of deposits against which reserves must be held. In reality, there are different types of deposits (for example, savings and demand deposits) and bank characteristics (for example, reserve city, nonreserve city, small) that determine the level of a particular bank's required reserves. Anderson and Jordan are careful to specify that the construction procedure for demand deposits also applies to savings accounts. The appropriate vector representation of $D$ and $r$ are omitted without loss of insight into the problems we are identifying.

[4] Neumann (1983) shows that RAM suffers from the same problem that Frost identifies with liberated reserves; that is, the growth rate of the monetary base is not equal to the growth rate of high-powered money during those periods in which there are no changes to reserve requirement ratios.

[5] In addition, Neumann cites the dependence of measuring current monetary policy on the cumulated sum of past changes in reserve requirements. This also is an interesting measurement problem, but our current focus is solely on the deposit-flow issue.

[6] The Board of Governors uses the current reserve requirement ratio structure as the base period. In an earlier article (Haslag and Hein 1990), we provide evidence suggesting that the St. Louis approach is more closely related to nominal GNP growth than the Board measure. Our belief is that the St. Louis base has a closer statistical relationship to nominal GNP growth than the Board base because the 1976–80 base period is more representative of the average reserve requirement ratio structure than today's structure. We gratefully acknowledge the help of Dennis Mehegen at the Federal Reserve Bank of St. Louis for providing us with weekly data for the period January 1968 to June 1991.

[7] In going through the Board of Governors' annual reports, we have selected all changes in reserve requirement structure, including definitional changes and size changes. See Joshua Feinman (1993) for a partial list in which the *major* reserve requirement changes are identified.

[8] As such, our reserve step index is still subject to deposit-flow effects, but only to the extent that deposit flows occur between the weeks in which reserve requirement ratios are changed. Note that in equation 2, the RSI can be rewritten as $r_{t-1}D_{t-1} - r_tD_t$. Changes in deposits from $t$–1 to $t$ will be picked up in the RSI. To correct for this deficiency, one would need the use of detailed deposit data that are not generally available. Specifically, one would need data on deposit levels by type for each bank. This is necessary because differ-

ent reserve requirements have applied to different deposit levels. We believe that this deposit-flow effect is small, especially relative to the deposit-flow effects present in current reserve adjustment indexes that permit change in months in which no reserve requirement ratio changes occur.

[9] It should be noted that RSI represents essentially an average, as opposed to a marginal, concept. If one were to divide RSI by the quantity of deposits against which reserves must be held, the term would represent the average reserve requirement ratio. To construct a marginal reserve requirement series, detailed data are necessary on the quantity of deposits held at individual banks by each reserve requirement distinction. Such data, however, are not available. Thus, our efforts yield a first approximation of changes in average marginal reserve requirement ratios.

[10] Interestingly, Milton Friedman and Anna Schwartz (1963, 526) characterize the 1936 reserve requirement hikes as significant factors in the slowdown in economic activity that began in 1937, an interpretation that is more consistent with the behavior of RSI than RAM.

[11] Several changes in reserve requirement structure were enacted during the 1973–75 period. In short, reserve requirements on demand deposits were raised slightly in 1973, lowered in 1974, and lowered in 1975. On balance, reserve requirements were lowered for the smallest deposit levels ($0 to $2 million) and for the largest banks (over $400 million), with the intermediate-sized deposit levels experiencing no change in reserve requirements.

[12] Haslag and Hein (1989) suggest that the Monetary Control Act of 1980 (MCA) effectively lowered the average reserve requirement for all depository institutions. Our RSI measure supports the inference that MCA effectively freed reserves for the system.

[13] In other words, each series is differenced once and is stationary—I(1). The Phillips–Perron test is applied to RAM and to RSI in both level and percent-change forms to examine the order of integration of each series. RSI is designed as a series in which there are infrequent, permanent shocks. Asymptotically, the distribution theory behind the unit root tests applies to series such as RSI. However, Nathan Balke and Thomas Fomby (1991) argue that standard Dickey–Fuller critical values result in too many rejections of the unit root null hypothesis in finite samples.

Under the null hypothesis that there is a unit root in RAM, the test statistics are 0.80 in level form and –25.67 in percent-change form, whereas the test statistics are 1.88 in level form and –46.38 in percent-change form for RSI. The 5-percent critical value is –3.17. The evidence suggests that RAM and RSI are nonstationary in levels but stationary in percent change.

[14] When RSI was regressed on RAM, the evidence similarly failed to reject the null hypothesis that the series were not cointegrated.

[15] The issue is intertwined with differences between outside and inside money. The deposits against which reserves must be held are liabilities of banks and thus reflect changes in the demand for and supply of intermediated deposits. Changes in reserve requirement ratios, other things held constant, affect the demand for high-powered money. Robert King and Charles Plosser (1984) distinguish between real and monetary effects, arguing that changes in outside money (the monetary base) are nominal changes, whereas movements in inside money (the money multiplier) represent real changes in the financial intermediation process. King and Plosser find that the monetary base is correlated with prices but not with real economic variables. However, the money multiplier is closely correlated with real economic variables. Scott Freeman and Greg Huffman (1991) provide a theoretical model that yields the same qualitative correlations as King and Plosser find. In this case, both changes in reserve requirements and changes in deposits against which reserves must be held are real changes. However, one is a policy variable, and the other may only reflect behavioral changes due to policy changes.

[16] The changes in required reserves during the week in which reserve requirements are changed will generally not equal the difference between RAM measured during the month in which reserve requirements changed and the month before the change occurred.

[17] The calculation of percentage change relative to the quantity of monetary base is as follows: $\Delta SB_t = (SB_t - SB_{t-1})/[(MB_t + MB_{t-1})/2]$, where $SB$ denotes high-powered money and $MB$ denotes the monetary base. Thus, $\Delta MB_t = \Delta SB_t + \Delta RSI_t + \Delta DEPFLOW_t$. Note that the variables are stationary in percent-change form.

[18] In a structural setting, Eugene Fama (1982) argues that a bank's decisions to supply deposits is likely to be related to changes in reserve requirements. By having both deposits and reserve requirements in the regression, we are implicitly examining the effects of changes in reserve requirements on economic activity separately from the effects of changes in deposits.

[19] Table 1 attempts to provide some idea of the regression results without going into too much detail. Reporting the sum of the coefficient saves space compared with reporting each individual coefficient. The full set of parameter estimates and the data series are available from the authors upon request.

[20] The regressions are run with variables that are stationary. With stationary series, the thought experiment seems a bit odd. The tests on the sum of the coefficients determine whether a once-and-for-all movement in the policy would be related to a permanent change in the measure of macroeconomic activity. Yet, the policy variables have not exhibited movements that are

consistent with the sort of permanence suggested by the thought experiment. Indeed, both the policy measures and macroeconomic variables have reverted to their constant mean value.

[21] An important issue is the stability of the regression coefficients over the sample period. We follow the approach taken by Martin Feldstein and James Stock (1993). We use a battery of six different tests for parameter stability. Further, we treat the exact date(s) at which the parameters changed as unknown. In each of the three models estimated (inflation, output growth, and nominal GNP growth), the test statistics fail to reject the null hypothesis that the parameters are constant over the sample. The test statistics are available from the authors upon request.

[22] We adopt 1951 as the starting point because the Treasury–Fed accord establishes an identifiable change in the Federal Reserve's operating procedure. Note that including data back to 1947, when quarterly data for the postwar period become available, does not change the major results presented in this article.

## References

Anderson, Leonall C., and Jerry Jordan (1968), "The Monetary Base: Explanation and Analytical Use," Federal Reserve Bank of St. Louis *Review*, August, 7–14.

Balke, Nathan S., and Thomas B. Fomby (1991), "Infrequent Permanent Shocks and the Finite-Sample Performance of Unit Root Tests," *Economic Letters* 36 (July): 269–74.

———, and Robert J. Gordon (1986), "Appendix B: Historical Data," in *The American Business Cycle: Continuity and Change*, ed. R. J. Gordon (Chicago: University of Chicago Press), A1–A6.

Brunner, Karl (1961), "A Schema for the Supply Theory of Money," *International Economic Review* 2 (August): 79–109.

Burger, Albert, and Robert Rasche (1977), "Revision of the Monetary Base," Federal Reserve Bank of St. Louis *Review*, July, 13–28.

Engle, Robert F., and Clive W. J. Granger (1987), "Cointegration and Error Correction: Representation, Estimation, and Testing," *Econometrica* 55 (March): 251–76.

Fama, Eugene F. (1982), "Inflation, Output, and Money," *Journal of Business* 55 (April): 201–31.

Feinman, Joshua (1993), "Reserve Requirements: History, Current Practices, and Potential Reform," *Federal Reserve Bulletin* 79 (June): 569–89.

Feldstein, Martin, and James H. Stock (1993), "The Use of Monetary Aggregate to Target Nominal GDP," NBER Working Paper Series, no. 4304 (Cambridge, Mass.: National Bureau of Economic Research, March).

Freeman, Scott, and Gregory Huffman (1991), "Inside Money, Output, and Causality," *International Economic Review* 32 (August): 645–67.

Friedman, Milton, and Anna J. Schwartz (1963), *A Monetary History of the United States, 1867–1960* (Princeton, N.J.: Princeton University Press).

Frost, Peter A. (1977), "Short-Run Fluctuations in the Money Multiplier and Monetary Control," *Journal of Money, Credit, and Banking* 9 (May): 165–81.

Haslag, Joseph H., and Scott E. Hein (forthcoming), "Does It Matter How Monetary Policy Is Implemented?" *Journal of Monetary Economics*.

——— (1992), "Macroeconomic Activity and Monetary Policy Actions: Some Preliminary Evidence," *Journal of Money, Credit, and Banking* 24 (November): 431–46.

——— (1990), "Economic Activity and Two Monetary Base Measures," *The Review of Economics and Statistics* 72 (November): 672–76.

——— (1989), "Federal Reserve System Reserve Requirements, 1959–1988," *Journal of Money, Credit, and Banking* 21 (August): 515–23.

King, Robert G., and Charles I. Plosser (1984), "Money, Credit, and Prices in a Real Business Cycle Model," *American Economic Review* 74 (June): 363–80.

Lougani, Prakesh, and Mark Rush (forthcoming), "The Effect of Changes in Reserve Requirements on Investment and GNP," *Journal of Money, Credit, and Banking.*

Neumann, Manfred J. M. (1983), "The Indicator Properties of the St. Louis Monetary Base," *Journal of Monetary Economics* 12 (August): 595–603.

Plosser, Charles I. (1990), "Money and Business Cycles: A Real Business Cycle Interpretation," in *Monetary Policy on the 75th Anniversary of the Federal Reserve System*, ed. Michael T. Belongia (Norwell, Mass.: Kluwer Academic Publishers Group), 245–74.

Tolley, George S. (1957), "Providing for Growth of the Money Supply," *Journal of Political Economy* 65 (December): 465–85.

Toma, Mark (1988), "The Role of the Federal Reserve in Reserve Requirement Regulation," *The Cato Journal* 7 (Winter): 701–18.

## Appendix
## Monthly RSI Series, January 1929–December 1993

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1929 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1930 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1931 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1932 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1933 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1934 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1935 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 |
| 1936 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –3.987 | –5.634 | –5.634 | –5.634 | –5.634 |
| 1937 | –5.634 | –5.634 | –5.634 | –6.106 | –6.106 | –6.81 | –6.81 | –6.81 | –6.81 | –6.81 | –6.81 | –6.81 |
| 1938 | –6.81 | –6.81 | –6.81 | –6.81 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 |
| 1939 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 |
| 1940 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 |
| 1941 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –6.12 | –7.198 | –7.198 |
| 1942 | –7.198 | –7.198 | –7.198 | –7.198 | –7.198 | –7.198 | –7.198 | –6.832 | –7.198 | –6.499 | –6.107 | –6.107 |
| 1943 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 |
| 1944 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 |
| 1945 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 |
| 1946 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 |
| 1947 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 | –6.107 |
| 1948 | –6.107 | –6.107 | –6.667 | –6.667 | –6.667 | –6.667 | –7.101 | –7.101 | –7.101 | –8.955 | –8.955 | –8.955 |
| 1949 | –8.955 | –8.955 | –8.955 | –8.955 | –8.955 | –7.748 | –7.748 | –6.932 | –5.683 | –5.41 | –5.41 | –5.41 |
| 1950 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 | –5.41 |
| 1951 | –5.41 | –7.066 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 |
| 1952 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 |
| 1953 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –7.268 | –6.408 | –6.408 | –6.408 | –6.408 | –6.408 |
| 1954 | –6.408 | –6.408 | –6.408 | –6.408 | –6.408 | –6.408 | –5.827 | –5.154 | –5.115 | –5.115 | –5.115 | –5.115 |
| 1955 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 |
| 1956 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 |
| 1957 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 | –5.115 |
| 1958 | –5.115 | –5.115 | –4.338 | –3.46 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 |
| 1959 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 |
| 1960 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.926 | –2.762 | –2.762 | –3.189 |
| 1961 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 |
| 1962 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.828 | –2.322 | –1.872 |
| 1963 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 |
| 1964 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 |
| 1965 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 |
| 1966 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.872 | –1.991 | –1.991 | –2.787 | –2.787 | –2.787 |
| 1967 | –2.787 | –2.787 | –2.787 | –2.115 | –2.115 | –2.115 | –2.115 | –2.115 | –2.115 | –2.115 | –2.115 | –2.115 |
| 1968 | –2.115 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 | –2.714 |
| 1969 | –2.115 | –2.714 | –2.714 | –2.714 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 |
| 1970 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.657 | –3.331 | –3.331 | –3.331 |
| 1971 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 |
| 1972 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –3.331 | –1.107 | –1.107 |
| 1973 | –1.107 | –1.107 | –1.107 | –1.107 | –1.107 | –1.107 | –1.107 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 |
| 1974 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 | –1.522 |
| 1975 | –1.296 | –1.296 | –.577 | –.577 | –.577 | –.577 | –.577 | –.577 | –.577 | –.577 | –.274 | –.274 |
| 1976 | –.274 | –.193 | –.193 | –.193 | –.193 | –.193 | –.193 | –.193 | –.193 | –.193 | –.193 | –.193 |
| 1977 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 | –.17 |
| 1978 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .249 | –3.184 | –3.184 |
| 1979 | –3.184 | –2.241 | –2.241 | –2.241 | –2.241 | –2.241 | –2.241 | –2.241 | –2.241 | –3.963 | –3.963 | –3.963 |
| 1980 | –3.963 | –3.963 | –3.963 | –3.963 | –3.963 | –3.963 | –.742 | .445 | .445 | .445 | –1.955 | –1.955 |
| 1981 | –1.955 | –1.955 | –1.955 | –1.738 | –2.578 | –2.578 | –2.578 | –2.578 | –1.527 | –1.527 | –1.527 | –.326 |
| 1982 | –.326 | –.326 | –.326 | 1.939 | 1.939 | 1.939 | 1.939 | 1.939 | 2.871 | 3.089 | 3.089 | 3.089 |
| 1983 | 3.498 | 3.498 | 3.498 | 4.328 | 4.328 | 4.85 | 4.85 | 4.85 | 6.289 | 6.681 | 6.681 | 6.681 |
| 1984 | 6.882 | 6.882 | 6.882 | 6.882 | 6.882 | 6.882 | 6.882 | 6.882 | 6.067 | 6.067 | 6.067 | 6.067 |
| 1985 | 7.655 | 7.655 | 7.655 | 7.655 | 7.655 | 7.655 | 7.655 | 7.655 | 6.36 | 6.36 | 6.36 | 6.36 |
| 1986 | 8.912 | 8.912 | 8.912 | 8.912 | 8.912 | 8.912 | 8.912 | 8.912 | 7.217 | 7.217 | 7.217 | 7.217 |
| 1987 | 10.864 | 10.864 | 10.864 | 10.864 | 10.864 | 10.864 | 10.864 | 10.864 | 8.584 | 8.584 | 8.584 | 8.584 |
| 1988 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 | 10.835 |
| 1989 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 | 13.305 |
| 1990 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 15.521 | 20.922 |
| 1991 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.624 | 25.813 |
| 1992 | 25.813 | 25.813 | 25.813 | 31.424 | 31.424 | 31.424 | 31.424 | 31.424 | 31.424 | 31.424 | 31.424 | 32.05 |
| 1993 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.05 | 32.193 |