FINANCIAL SECTOR WEAKNESS AND THE M2 VELOCITY PUZZLE

Cara Lown
Research Officer
Federal Reserve Bank of New York

Stavros Peristiani (Steve.Peristiani@ny.frb.org)
212-720-7829 (212-720-1582 -- Fax)
Research Officer
Federal Reserve Bank of New York

and

Kenneth J. Robinson (Kenneth.J.Robinson@dal.frb.org)
214-922-5365 (214-922-5351 – Fax)
Senior Economist and Policy Advisor
Financial Industry Studies Department
Federal Reserve Bank of Dallas

June 2005

A deterioration in the link between M2 and GDP, along with large prediction errors, led the Federal Reserve to downgrade M2 as a reliable indicator in 1993. We argue that the financial condition of depository institutions was a major factor behind this unusual pattern of M2 growth. When constructing measures of M2 based on banks' and thrifts' capital positions, the anomalous behavior of M2 disappears and we obtain superior M2 forecasting results and a more stable relationship between M2 and the ultimate goals of policy. M2 may contain useful information when there are no major disturbances to depository institutions.

JEL Classification: E4, E5, G2.

The views expressed in this paper are those of the authors and not necessarily those of the Federal Reserve Bank of New York, the Federal Reserve Bank of Dallas, or the Federal Reserve System. We thank Kelly Klemme, Dibora Amanuel, and Reagan Murray for excellent research assistance.

FINANCIAL SECTOR WEAKNESS
AND
THE M2 VELOCITY PUZZLE

A deterioration in the link between M2 and GDP, along with large prediction errors, led the Federal Reserve to downgrade M2 as a reliable indicator in 1993. We argue that the financial condition of depository institutions was a major factor behind this unusual pattern of M2 growth. When constructing measures of M2 based on banks' and thrifts' capital positions, the anomalous behavior of M2 disappears and we obtain superior M2 forecasting results and a more stable relationship between M2 and the ultimate goals of policy. M2 may contain useful information when there are no major disturbances to depository institutions.

1. Introduction

There has been a long-running debate over the usefulness of monetary aggregates as intermediate targets or information variables in the conduct of monetary policy. In the mid-1970s the "missing money" episode associated with M1 money demand was documented by Goldfeld (1974) and Judd and Scadding (1982). Passage of the Depository Institutions Deregulation and Monetary Control Act in 1980 and the Garn-St Germain Act in 1982 ushered in a period of financial deregulation, including interest-bearing checking accounts and money market deposit accounts. These innovations affected depositor behavior to such an extent as to make M1 unreliable as a target or indicator of policy. As a result, research efforts focused on M2 demand with initial evidence of stable short-run specifications for this aggregate (Small and Porter, 1989).

This issue remains timely, with the recent example of the European Central Bank debating whether to target a monetary aggregate or inflation in its implementation of monetary policy (Svensson, 1999). In the U.S. Feldstein and Stock (1994) argue that the Federal Reserve should use the M2 monetary aggregate as an intermediate target. On the other hand, a fair amount of work suggests that M2 is not reliable as either a target or an indicator of monetary policy. Friedman and Kuttner (1992) show that by the early 1990s the relationship between M2 and GDP had weakened, and Estrella and Mishkin's (1997) work provides further support for this finding. Miyao (1996) presents evidence that a cointegrating M2 demand relationship broke down in the 1990s.

As the link between M2 and GDP deteriorated, the forecasting ability of M2 money demand equations also suffered. The difficulties in forecasting M2 spurred a number of papers examining whether the deterioration in the M2 equation's forecasting ability was temporary, or whether more fundamental factors -- such as flaws in the construction of the M2 aggregate, the opportunity cost, or both -- were at work. Carlson and Parrott (1991), and Duca (1992) first argued that the existence of troubled thrifts and the length of time it took the Resolution Trust Corporation to resolve the thrifts' difficulties helped explain the weakness in M2. In particular, Duca found that the change in the volume of cumulated deposits at resolved thrift institutions accounted for a large part of the M2 weakness, although he suggested his findings be viewed cautiously because of the short time period of the analysis. In the same article, as well as in one subsequent to it, Duca (1995) also examined whether some of the weakness in M2 reflected substitution by households away from M2-type deposits and into bond and equity mutual funds. He found that adding a bond fund series to M2 reduced estimated M2 growth shortfalls. Orphanides et al. (1994), Carlson and Keen (1996), Feldstein and Stock (1996), and Mehra (1997) also present evidence that the unusual behavior of M2 was related to growth in stock and bond mutual funds.

Koenig (1996a, 1996b) focused on the competitiveness problems of financial intermediaries in the face of tighter regulations and stricter capital standards. He proposed an alternative strategy for empirically modeling M2 by altering the opportunity cost measure to include a long-term Treasury bond rate. This addition substantially improved forecasts of M2 until 1995, when large prediction errors once again appear. Feinman and Porter (1992) and Mehra also attempted to explain recent M2 instability through alternative measures of the opportunity cost.

Rather than refine the opportunity cost or redefine the M2 monetary aggregate, Carlson, Hoffman, Keen, and Rasche (2000) present consistent evidence of a cointegrating relationship through the 1990s between real M2, various scale measures, and an opportunity cost measure. This result is obtained after adjusting for periods of financial restructuring in the early 1990s, characterized by a sharp increase in bond and equity funds and a steep decline in small time deposits. By including broken linear time trends in the cointegrating relationship, the previously observed instabilities in the M2 relationship are overcome.[1]

Explaining shifts or instability in money demand is important to policymakers in their implementation of monetary policy. These shifts not only affect money growth but also important elements in the monetary transmission mechanism, such as the relationship between interest rates and overall economic activity. Our work takes a different approach from most of the prior research. Rather than add additional, and in some cases temporary, explanatory variables to the money demand equation, or attempt refinements in the opportunity cost measure, we construct M2 monetary aggregates based on banks' and thrifts' capital positions in an attempt to pinpoint the sources of difficulty in predicting money growth. This approach allows us to

---

[1]Focusing on the M1 monetary aggregate, Ball (2001) reestimates money demand using data through the mid-1990s. He finds more precise estimates for the income and interest rate elasticities than studies based on data ending in the late 1980s.

show that both stricter capital requirements and the difficulties that confronted banks and thrifts during this time period played an important role in the unpredictable weakness in M2.[2] These alternative monetary aggregate measures are also used to show how financial sector difficulties affected the long-run relationship between M2 and GDP.

We also consider whether the opportunity cost is affected by the financial health of banks and thrifts. We do not find large differences in the opportunity cost variable based on financial institutions' capital positions, possibly reflecting the difficulties in measuring the effective opportunity cost. As we will discuss, such difficulties may have arisen for several reasons, with one example being variation in nonprice terms on deposit accounts across banks, but lack of data prevents us from examining this hypothesis.

Focusing on the recent episode of severe bank and thrift difficulties in the late 1980s and early 1990s, our results show that a substantial part of the deterioration in the link between M2 and GDP can be traced to capital-constrained banks and thrifts. With the resolution of these financial difficulties, the link between M2 and economic growth appears to have strengthened. An implication of our findings is that it may be premature to abandon M2 as an indicator of aggregate real activity. In particular, in the absence of financial sector difficulties, a monetary aggregate such as M2 could possibly provide useful information about the future direction of economic growth.

The remainder of the paper proceeds as follows. In the next section, we provide some background on the breakdown in the predictive ability of the M2 equation. We then discuss in

[2]Peek and Rosengren (1992), and Hilton and Lown (1994) also used bank level data to document a cross-sectional link between bank capital and deposit growth in the early 1990s.

some detail how we construct the various alternative M2 series, and we show how these alternatives appear to provide a good explanation for the deterioration in the forecasting equation. In section three, we use our alternative measures of M2 to re-estimate the demand for M2. We find that the money demand equation's out-of-sample forecast performance does show improvement when using our alternative measures. In section four, we review how the long-run relationship among M2, real GDP, prices, and interest rates has changed over time. We show that relationships among these variables are consistent with our results concerning the forecasting ability of the M2 equation in that the strength of the cointegrating relationship improves considerably after accounting for the effect of bank and thrift difficulties on M2 growth. Section five concludes.

2. Alternative measures of M2 based on bank and thrift capital positions

Prior to the early 1990s, money demand equations forecast M2 growth fairly well. For example, Figure 1 shows actual M2 growth and predicted M2 growth using a model developed by staff at the Federal Reserve Board of Governors (staff model).[3] As Figure 1 also shows, in the early 1990s large forecast errors appeared. This breakdown in the ability to forecast M2 led in part to the de-emphasis of M2 in the policy process (Greenspan, 1993). Perhaps because of this de-emphasis, little attention has been given to the fact that since late 1993, the staff model has again forecasted M2 fairly well.[4]

---

[3]For more on the M2 money demand equation used here, see Small and Porter (1989), and Feinman and Porter (1992). The staff model was not the only money demand equation to exhibit large overprediction errors. See Koenig (1996a).

[4]In its mid-year 1998 monetary policy report to the Congress, the Board stated that "...since 1994, the velocities of M2 and M3 have again moved roughly in accord with their pre-1990 experience, although their levels remain elevated," (Board of Governors, 1998, p. 5).

A large part of the breakdown in the M2 equation stems from the deterioration in the relationship between M2 velocity (defined as nominal GDP/M2) and its opportunity cost. The M2 opportunity cost is defined as the three-month Treasury bill rate less the deposit-weighted average of observed rates paid on M2 deposits. As Figure 2 shows, from 1959 until 1989 these two series tracked each other fairly closely. Since that time, however, the two series have diverged considerably. This divergence suggests that, given the historical relationships with its opportunity cost, M2 should have grown at a much faster pace during the early 1990s. Or alternatively, given the weak growth in M2 during this time period, one would have expected the opportunity cost to be larger during this time period. We explore the former in this section and section three by examining the role of depository institutions' capital positions in affecting observed money growth. We briefly discuss the behavior of the M2 opportunity cost measure at the end of section three.

2.1. Defining capital adequacy positions

Current capital requirements on banks and thrifts, based on the Basel risk-based capital standards, were phased in beginning in 1990. However, even before this time, regulators imposed capital requirements on insured financial institutions. In December 1981, the bank regulatory agencies first announced specific capital requirements applicable to insured commercial banks. Initially, these requirements were based on the size of the institution, with larger institutions required to hold a smaller percentage of assets as capital. In 1985, bank regulators then decided to impose the same capital requirements on all banks, regardless of size. A uniform 5.5-percent minimum primary capital to asset ratio was adopted in June 1985.[5]

The thrift industry's capital requirements were substantially weakened throughout the 1980s, as reflected in a number of redefinitions of what constituted capital, as well as reductions in the actual amount of capital required (Barth, 1991, Appendix D). In response to the resulting thrift industry meltdown, Congress passed the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA) which imposed significantly tougher capital requirements on thrift institutions. Under FIRREA, thrifts were required to meet a minimum leverage ratio of three percent. FIRREA also required that thrifts meet a minimum tangible-capital-to-assets ratio of 1.5 percent.[6]

Utilizing these capital requirements to classify banks and thrifts based on their capital positions, we define a bank as capital constrained if it fails to meet a primary capital ratio of 5.5 percent. A savings and loan is classified as capital constrained if it fails to meet both the 3-percent leverage ratio and the 1.5-percent tangible capital ratio.[7] While thrifts were not subject

[5]Primary capital is defined mainly as common equity plus the sum of loan loss reserves and perpetual preferred stock. A minimum total capital ratio of 6 percent was also adopted. Total capital consists of primary capital, plus the sum of limited life preferred stock and subordinated notes and debentures.

[6]The leverage ratio is defined as the ratio of "core capital" to total assets. Core capital is the sum of common equity, non-cumulative perpetual preferred stock, and minority interests in consolidated subsidiaries, less most intangibles (with the exception of purchased mortgage servicing rights and qualifying supervisory goodwill). Tangible capital is core capital minus supervisory goodwill and all other intangibles except qualifying purchased mortgage servicing rights. FIRREA also imposed risk-based capital requirements on the nation's thrift industry.

[7]The data necessary to calculate an institution's risk-based capital position are not available prior to 1990, making it impossible to use the risk-based criteria in defining capital constrained institutions.

to these requirements over some of our sample period, we feel that utilizing the FIRREA capital requirements more closely matches the requirements imposed on banks, and also that these standards more closely approximate the economic value of the institutions.[8] For every quarter over the time period 1984:1-2004:4, capital levels for each bank and thrift are calculated, and an institution is classified as either nonconstrained or constrained. These calculations are based on data found in individual bank *Reports of Condition and Income*, and from thrift institutions' *Thrift Financial Reports* (call reports). While call report data are available prior to 1984, we chose this as our starting point because of the substantial revisions made to the call reports beginning in 1984. Moreover, the individual deposit account data needed to construct the M2 series are not generally available prior to 1984.

The number of capital constrained banks peaked in the fourth quarter of 1988 at 508 with $100.3 billion in assets. The number of capital constrained thrifts was substantially larger, peaking at 906 in the first quarter of 1985, with $365 billion in assets. By 2004, the number of capital constrained banks totaled only 8, with $8.2 billion in assets, while there were no capital constrained thrifts. Using our capital classifications, money supply measures can be constructed based on the capital positions of individual banks and thrifts in an effort to determine if the unusual behavior of M2 might be the result of depository institutions' financial difficulties.

2.2. Money supply measures and capital positions

---

[8]Calculations for both banks and thrifts are made using book value capital measures. As such, they are not representative of the economic or market value of the institution. However, given that bank capital requirements (as well as the definition of what constitutes capital) were more stringent than thrifts' capital requirements, we feel it is appropriate to use the stricter FIRREA capital standards for thrifts, even though they were not imposed until 1989.

Individual bank and thrift call reports contain most of the items needed to construct the M2 measure of the money supply, based on capital positions.[9] It is not possible, however, to collect the currency, travelers checks, or retail money market mutual funds components of M2 from call reports. Our measure of M2, constructed from data on individual banks and thrifts, consists of demand deposits, other checkable deposits, savings deposits (including money market deposit accounts), and small time deposits. These components capture, on average, 72 percent of M2 over the time period of our analysis. A simple comparison of the growth rates of actual M2 and our M2 measure constructed from bank and thrift call reports shows a close association. Although the M2 measure constructed from individual banks and thrifts is choppier, the correlation coefficient between the two series is approximately 50 percent over the 1984-2004 period, indicating that our measure of M2 is a reasonable proxy for movements in actual M2.[10]

The separate categories of M2 constructed from nonconstrained banks and thrifts and from constrained banks and thrifts, highlight the relative importance of the deterioration in the thrift industry's financial condition compared to banks. For every deposit category (e.g., demand deposits, savings deposits, small time deposits), the level of constrained thrift deposits

[9]The bank and thrift deposits that are included in the actual money supply measures reported in the Board of Governors H(6) statistical release are not obtained from bank and thrift call reports, but rather from what is known as the FR2900. Depending on their size, institutions file the FR2900 weekly, quarterly, or annually. All banks and thrifts must file a call report at the end of each quarter. Credit unions also file the FR2900, and their deposits are part of the money supply. While credit unions also complete a call report, we did not include them in our calculations. Most credit unions only file their call report semi-annually, and more important for our analysis, they were not required to maintain a minimum level of capital like banks and thrifts.

[10]Our measure of M2 indicated no seasonal pattern, and therefore this measure is not seasonally adjusted.

exceeds the level of constrained bank deposits (until the early 1990s, when most of the troubled thrifts had been resolved), while the opposite is true for all nonconstrained deposit categories. Within individual deposit categories, the most interesting development is what occurred with small time deposits. Nonconstrained banks and thrifts were almost equal in their offerings of small time deposits until 1989. Then, despite the subsequent improvement in the thrifts' capital profile, small time deposits began to decline steadily even at nonconstrained thrifts. While small time deposits also declined at nonconstrained banks from 1992 through 1994 (in response to lower interest rates), they recovered in late 1994, while nonconstrained thrift time deposits continued to decline. These trends in small time deposits are consistent with those studies that point to a rise in bond and equity funds in explaining M2 growth since time deposits likely flowed into these capital market funds.[11]

Based on these comparisons of the M2 components between banks and thrifts, it appears that the thrift industry accounted for a proportionately larger share of constrained deposits, especially when considering small time deposits. By 1993, the difficulties at financial institutions had largely been resolved, as evidenced by the virtual disappearance of deposits in the constrained category. Previous researchers have suggested that the unprecedented increase in the velocity of M2 during the early 1990s (as shown in Figure 2) might be related to the unusual financial difficulties faced by banks and thrifts. Carlson, Craig, and Schwarz (2000)

[11]Over this period the importance of thrift industry small time deposits in M2 reached a peak of 21.8 percent in 1984:4 and declined to 4.2 percent by 2004. For banks, small time deposits as a percent of M2 reached a peak of 18.7 percent in the first quarter of 1991, and declined to 8.4 percent by 2004. Carlson, Craig, and Schwarz (2000) report evidence that velocity constructed from M2 measures that exclude small time deposits does not display the unusual movements that M2 velocity showed in the early 1990s.

find that a permanent upward shift in M2 velocity occurred in 1991. Recently, with financial difficulties resolved, M2 velocity has stabilized to a level about 20 percent higher than that of the 1980s, reflecting the likelihood that bond funds have become a permanent and significant part of households' portfolios at the expense of time deposits. Our findings also suggest that the difficulties plaguing the nation's bank and thrift industry during the late 1980s and early 1990s might have been an important factor behind the breakdown in the M2 money demand equation, and that the influence of thrifts might have been greater than that of the banking industry.

2.3. *Adjusted M2 money supply measures*

Beginning in 1989, M2's opportunity cost began to decline while M2 velocity began a steady increase. Consequently, models of M2 demand began to over-predict money growth by larger and larger margins. In an effort to provide empirical support for our hypothesis on the role of bank and thrift difficulties in explaining the M2 overprediction, we construct several alternative measures of M2 that attempt to eliminate the distortions resulting from financial-sector difficulties. We first construct an M2 series that uses actual M2 from 1959 until 1983. Then, beginning in 1984 when the individual bank and thrift data are first available, this series is constructed by assuming that it grew at the rate of M2 that was observed at all nonconstrained banks and thrifts. We refer to this series as NCM2. Next, in an effort to judge the relative importance of the thrift industry's decline, we construct an M2 series that, once again, uses actual M2 from 1959 through 1983, and then assumes that M2 grew at a rate equal to the growth rate of M2 that was observed at all banks. We refer to this series as BANKM2. Finally, we construct an M2 series that uses actual M2 from 1959 through 1983, and then assumes M2 grew at a rate equal to the M2 components observed at all nonconstrained banks beginning in 1984.

We refer to this series as NCBANKM2. This final series is intended to account for the effects of capital constrained banks on movements in M2.[12]

2.4. Adjusted M2 velocity measures

Using these different measures of M2, we calculate M2 velocity series. The movements in the different velocity measures can then be compared with movements in the opportunity cost of M2 in an effort to determine if recent bank and thrift difficulties might have played a role in affecting the relationship between M2 velocity and its opportunity cost. The three different panels in Figure 3 show these different velocity measures and how they track with M2's opportunity cost. In Figure 3a the sharp divergence between the velocity of M2 and its opportunity cost that began in 1989 is apparent. However our NCM2 measure of velocity now shows a closer relationship with the opportunity cost, at least initially.

The movements in M2's velocity show even more promise when the effects of the entire thrift industry are excluded (Figure 3b). The velocity of BANKM2 fails to exhibit a sharp increase, and tracks the opportunity cost fairly closely. A similar pattern is observed if the velocity of NCBANKM2 is compared with the opportunity cost, as indicated in Figure 3c. The sharp run-up in velocity disappears, and this measure of velocity and the opportunity cost bear a much closer relationship than that found using actual M2.[13]

---

[12]Admittedly, our assumption that without financial sector difficulties M2 would have grown at the rate recorded by the nonconstrained institutions overstates the growth rate of this series if some depositors merely switched from capital-constrained to nonconstrained institutions. To the extent that depositors did not move their accounts, or switched out of the banking sector altogether, our assumption is realistic.

[13]These comparisons assume that the M2 opportunity cost is also the relevant measure for our derived M2 series. Correlations between our various derived M2 measures and the opportunity cost also indicate a substantially closer relationship than with actual M2. The correlation

From this evidence, the breakdown in the relationship between M2 and its opportunity cost appears to be related to financial-institution difficulties experienced during the 1980s and early 1990s. When M2 is adjusted to account for these difficulties, the anomalous relationship between M2 and its opportunity cost disappears. More formal statistical evidence from money demand regressions using these alternative M2 measures provides additional support for the role of financial-sector difficulties in accurately predicting movements in M2.

3. Money demand equations

3.1. Estimates and forecasts

Given the relationships indicated in Figure 3, money demand regressions estimated with M2 measures that eliminate the influence of troubled financial institutions should produce superior forecasting performance than models using the actual measure of M2. In an effort to test this assertion, we use the Board of Governors staff M2 money demand model to compare the forecasting performance of our alternative monetary aggregate measures. Although other M2 equations likely produce similar results, we focus on this model for several reasons. First, it was developed in the late 1980s and hence incorporates recent time series developments. Second, until the early 1990s this equation was relatively accurate in forecasting M2. Third, previous research into the issue of the money demand breakdown has also made use of this equation. We estimate the following equation:

$$\begin{aligned} \Delta \ln M_t = \beta_0 + \beta_1 \tau_t + \beta_2 \ln OPCOST_{t-1} + \beta_3 \ln V_{t-1} + \beta_4 \Delta \ln C_t + \beta_5 \Delta \ln C_{t-1} \\ + \beta_6 \Delta \ln C_{t-2} + \beta_7 \Delta OPCOST_t + \beta_8 \Delta \ln M_{t-1} + \varepsilon_t \end{aligned} \quad (1)$$

---

between M2 velocity and the opportunity cost is only 7 percent over the period shown in the figures. The correlation between NCM2 and the opportunity cost is 37 percent, while the correlations using BANKM2 and NCBANKM2 are 58 percent and 59 percent, respectively.

Data for the opportunity cost ($OPCOST$), and M2 (M) are obtained from the Board of Governors, while velocity (V) is calculated as GDP/M. Information on consumption (C), and GDP are obtained from the Bureau of Economic Analysis. The variable (τ_t) represents a deterministic trend.

For each of the M2 aggregates that lie behind the velocity measures in Figure 3, we estimate the staff M2 demand equation using quarterly data from 1959-1990. When employing our alternative measures of M2, we use actual M2 up to 1983, and then we splice in our derived M2 series from 1984 to 1990.[14] Using the results from these money demand estimations, we conduct out-of-sample dynamic forecasts from 1991-1994, which covers the time period when the largest forecast errors in predicting M2 occurred (see Figure 1). Table 1 shows the results from estimating these equations. The lagged opportunity cost variable is statistically significant in all of the models as is the coefficient on the velocity measure. At least one consumption variable is significant in every model, and the change in the opportunity cost is significant in all of the models estimated. More important for our analysis, however, is the forecasting ability of the different measures of M2.

[14] The staff model that we use also includes a dummy variable for credit controls in the second quarter of 1980, as well as a short-run dummy variable for the introduction of MMDAs in the first and second quarters of 1983. The model also includes a dummy variable for MMDAs that is zero through 1982:4 and 1 thereafter. To take account of possible discontinuities in our derived M2 series, we use four dummy variables for each of the first four quarters when NCM2, BANKM2, and NCBANKM2 are introduced into the estimating equation. For all the models estimated, these dummy variables to account for discontinuity are jointly statistically significant. Finally to incorporate the convergence restriction contained in the staff model, the coefficients on the changes in consumption and the lagged dependent variable are constrained to sum to one. See Small and Porter (1989).

Table 2a compares the forecast performance of the dynamic forecasts using the root mean square error from each forecasting equation. As the table shows, the root mean square forecast error for actual M2 in this model is 2.85 percent. When the estimated equation is based on the measure of M2 constructed from nonconstrained banks and thrifts (NCM2), the generated forecasts show an improvement. In this case, the root mean square forecast error is 2 percent. The final two forecast evaluation measures indicate that excluding the thrift industry's influence on M2, as well as the influence of capital constrained banks, also improves the forecasting ability of the M2 money demand equation. Forecasting M2 with a series that grows at the rate of all banks (BANKM2) decreases the root mean square forecasting error to 1.51 percent and eliminating the effect of capital constrained banks on M2's growth improves the forecasting ability a bit further, to 1.33 percent. F-test statistics of whether these differences in the root mean square error are statistically significant are also shown in Table 2a. The forecast errors are significantly different between M2 and BANKM2 (F=2.72), M2 and NCBANKM2 (F=8.0), NCM2 and NCBANKM2 (F=5.56), and BANKM2 and NCBANKM2 (F=2.94).

To judge the robustness of our results, Table 2b and Table 2c show results from dynamic forecasts using different definitions for capital constrained institutions. In Table 2b, our alternative measures of M2 are constructed assuming that a bank is capital constrained if it fails to meet a primary capital ratio of 6 percent, while a thrift is classified as capital constrained if it fails to meet a leverage ratio of 3.5 percent and a tangible-capital-to-assets ratio of 2 percent. In Table 2c, a bank is capital constrained if it fails to meet a primary capital ratio of 5 percent, and thrifts are capital constrained if they do not record a leverage ratio of 2.5 percent and a tangible capital ratio of 1 percent. Our results from the dynamic forecasts are qualitatively similar using these alternative definitions of capital constrained institutions. Our measures of M2 constructed to account for financial difficulties provide better forecasting performance, and many of these differences in performance are statistically significant.[15]

Overall, our results from estimates of various specifications of the M2 money demand equation provide evidence consistent with the velocity movements shown in Figure 3. The sharp increase in the velocity of M2, and its unusual divergence from the path of the opportunity cost appear to reflect the influence of financial-sector difficulties. After adjusting M2 to account for these developments, the forecasting ability of the M2 equation improves considerably.

3.2. Opportunity cost

If banks and thrifts were experiencing financial difficulties that contributed to weak deposit growth, we should have observed differences in the behavior of the opportunity cost between capital constrained and nonconstrained institutions. Unfortunately, an investigation of this issue did not prove fruitful when examining an important component of the M2 opportunity cost. The difference between time deposit rates offered by capital constrained and nonconstrained institutions during this time period was, at most, 50 basis points. Such a small difference can not explain the large divergence in deposit growth across these two types of institutions.

An alternative explanation is that the nonprice terms associated with bank deposits, such as charges for withdrawals, service charges, advertising costs, etc., rather than the price terms, were less favorable at capital-constrained institutions. However, we have no data on these terms over the time period in question in order to prove or disprove this hypothesis. A recent paper by

[15]The relationship between our measures of M2 based on these alternative definitions of capital

Stavins (1999) offers some results consistent with our hypothesis, however. Using 1997 survey data, she provides evidence that interest rates on checking accounts are not an important determinant for the supply of checking account deposits. Instead, bank customers appear to be more responsive to various fees and restrictions imposed on the use of checks.

Yet another explanation for a mismeasured opportunity cost was put forth by Carlson, Hoffman, Keen and Rasche (2000). These authors argue that investors shifted out of time deposits and into bond funds due to a decline in transactions costs associated with bond funds. In addition, insolvent banks and thrifts were unable to bid for time deposits. As a result, the *measured* opportunity cost understated the rise in the *effective* opportunity cost. This distinction reflects the absence in the measured opportunity cost of a risk or call premium on time deposits. As these authors point out, the measured opportunity cost does not consider such a premium, and it is not evident how to measure it. Both of these alternative explanations suggest that in times of banking sector difficulties, nonmeasurable aspects of the opportunity cost of holding M2 deposits could play a role in M2's growth.

4. Re-examining the cointegrating relationship

The money demand equation used in our analysis in the previous section consists of two parts: a long-run cointegrating relationship between money, income, and the opportunity cost, and a short-run dynamic relationship among these variables. The assumption of a long-run cointegrating relationship among the variables implies that any disturbance to the relationship is short-lived; the variables eventually return to their long-run equilibrium relationship. The

---

positions and the opportunity cost are similar to those presented in Figure 3.

existence of such a long-run relationship is a primary factor motivating a focus on the monetary aggregates as an intermediate target of policy.

In this section, we explore the long-run relationship among money, income, prices, and interest rates in some detail using our alternative measures of M2. Such an exploration allows us to investigate whether the breakdown in our ability to predict M2 and the breakdown in the relationship between M2 and the ultimate goals of policy are related. And as with M2's predictive ability, examining the long-run relationship embedded in the M2 money demand equation allows us to consider whether the breakdown between M2 and the ultimate goals of policy was a temporary or a more permanent phenomenon.

The cointegrating relationship of the money demand equation has been examined extensively (Hafer and Jansen (1991), Miller (1991), Stock and Watson (1988, 1993), Friedman and Kuttner (1992). A brief survey of the literature is given by Miyao (1996). Generally, these papers explore the existence of a cointegrating relationship in the multivariate system defined by various functional forms of the vector $(\mathrm{M}_t, P_t, r_t, Y_t)$, where the component M_t represents a nominal measure of money, P_t represents the price level, Y_t is real output, and r_t denotes a nominal interest rate. In addition to different specifications, these studies employ a wide variety of measures of interest rates and monetary aggregates, and test the hypothesis of no cointegration over different sample periods using a variety of statistical methodologies. Overall, these studies find that evidence for cointegration is inconsistent and sensitive to different specifications or statistical tests. However, although the results are somewhat inconclusive, the evidence does confirm at least a weak form of cointegration among the variables.

While the evidence for cointegration is at best tentative for subsamples before 1990, Miyao (1996) points out that the null of cointegration is rejected more often in sample periods that include the 1980s. This is an interesting finding because it corresponds with our result that the ability to predict M2 was quite weak over this period. At the same time, this result raises some important questions. If the M2 equation is back "on track" as of the mid-1990s, as our analysis in the previous section suggests, does this imply that the strength of the cointegrating relationship among M2 and the other variables in the vector autoregressive system has also improved over this period? Second, if alternative measures like NCBANK2 appear to move more closely with M2's opportunity cost, do these measures provide more robust cointegration results? We address both of these issues in the analysis below.

This study uses Johansen's (1988, 1991) cointegration framework to investigate the strength of the cointegrating relationship among the alternative measures of monetary aggregates with output, interest rates and prices. The Johansen test is generally defined by the following vector autoregressive (VAR) system

$$\Delta Z_t = \delta_0 + \delta_1 \tau_t + \Pi Z_{t-1} + \sum_{j=1}^{k} \Gamma_j \Delta Z_{t-j} + \upsilon_t \tag{2}$$

In our framework, the vector Z_t is defined as $(\ln \mathrm{M_t}, \ln P_t, \ln r_t, \ln Y_t)'$. The variable τ_t again represents a linear trend, υ_t is the residual vector with mean zero and variance Σ. For our estimation, we assumed a fourth-order VAR system ($k = 4$), however, our findings are robust to other higher order autoregressive values. The cointegration hypothesis in the Johansen framework can be expressed in terms of the rank the matrix Π. In particular, our study investigates the hypothesis test $\mathrm{H_0} : \mathrm{rank}(\Pi) = \mathrm{r}^*$ against $\mathrm{H_1} : \mathrm{rank}(\Pi) = \mathrm{r}^* + 1$. The $\mathrm{rank}(\Pi)$

typically is referred to in the literature as the cointegration rank. The null of no cointegration is defined by $r^* = 0$. To test this null hypothesis, we use the maximum eigenvalue approach developed by Johansen and Juselius (1990).

Consistent with previous studies, we measure M_t by the nominal seasonally adjusted M2 monetary aggregate, Y_t is real gross domestic product, and P_t represents the implicit price deflator. We utilize four different alternative measures of the interest rate variable r_t: the three-month Treasury bill rate (TBILL), the three-month commercial paper rate (CP), the ten-year Treasury bond rate (TBOND), and finally the M2 opportunity cost measure (OPCOST). Clearly, the choice of variables and specifications are fairly large, however we believe that our findings encompass most of the specifications examined in the empirical literature.

Table 3 reports the findings for the Johansen cointegration tests. In addition to M2, the null is tested using our three adjusted measures of M2 – NCM2, NCBANKM2, and BANKM2 – which are spliced into the M2 series beginning in 1984. The strength of the cointegrating relationship is estimated over three sample periods. Initially, we compute the Johansen maximum eigenvalue test for the period 1959:1-1988:4. This period replicates the analysis of previous studies (Miller (1991) and Miyao (1996)). More importantly, we use this sample period to establish a baseline for the maximum eigenvalue statistics. Subsequently, the cointegrating relationship is estimated for the periods 1959:1-1992:4 and 1959:1-2004:4.

The top panel in Table 3 presents the maximum eigenvalue test for the M2 monetary aggregate. Consistent with previous studies, we find that the hypothesis of no cointegration cannot be rejected for any of the interest rate measures during 1959:1-1988:4. More important, however, the middle column of the first panel reveals a resurgence in the level of significance of the maximum eigenvalue statistics. In fact, for the period 1959:1-2004:4 (last column of Table 3) the null of no cointegration is rejected at the 5 percent level for all interest rate measures. These findings demonstrate that the "degree" of cointegration among M2, income, prices, and interest rates strengthened after the resolution of financial sector difficulties that transpired during the 1980s.

Our prior analysis showed that the adjusted M2 measures provide more accurate forecasts of monetary growth during the early 1990s. One might therefore expect that these alternative measures may also yield a stronger and perhaps more consistent cointegrating relationship. The remaining three panels in Table 3 examine the cointegrating capacity of the three alternative measures of M2. The table shows a sharp rise in the level of significance of the maximum eigenvalue statistics for these alternative M2 measures, especially during the 1959-1988 period.

To better illustrate the deterioration in the cointegrating relationship of the demand for money equation, Figure 4 presents a time profile of the Johansen maximum eigenvalue test between 1980:1 and 2004:4. In particular, the three panels in Figure 4 trace a relative measure of cointegration given by the maximum eigenvalue statistic divided by the critical value at the 5-percent level. Any value greater than 100 lies in the rejection region. Each quarterly point in the three panels represents the relative eigenvalue statistic for a sample period from 1959:1 and that point of time. An artifact of the cumulative framework of applying the Johansen test is that these relative measures of cointegration become smoother as the sample size increases.[16]

---

[16]The first and last points in each panel represent the relative maximum eigenvalue test for the period 1959:1-1980:1 and 1959:1-2004:4, respectively. A rolling sample period approach is also useful in indicating a structural shift in the money demand relationship. However, results of the

Figure 4 reveals a gradual but noticeable drop in the significance level of the cointegration statistic for M2 starting in the early 1980s, a result others have also found. While for earlier subsamples before 1980 various studies have found mixed results sometimes supporting or rejecting cointegration, starting in 1980 there is strong evidence of a significant change in the structure of M2 demand.

In contrast to the relative maximum eigenvalue statistics for M2 that are consistently below 100 throughout the 1980s, Figure 4 illustrates that the evidence for cointegration is quite strong during the 1980s when using NCBANKM2. The more significant maximum eigenvalue statistics for this period support the view that the financial problems among depository institutions likely contributed to the observed decline in cointegration among these variables. In particular, it appears that eliminating the drag created by thrift industry deposits as well as constrained banks uncovers a more stable long-run relationship among the M2 monetary aggregate, income, prices, and interest rates.

Although all alternative M2 measures appear to do better during the 1980s, our findings suggest that the cointegrating relationship for M2 re-emerges in the 1990s. In fact, the maximum eigenvalue scores for the M2 monetary aggregate are similar or at times stronger during this time period than the alternative M2 measures. This result likely signifies the importance of capturing the timing of the onset of financial difficulties at depository institutions. By 1992 most depositories resolved their financial difficulties so that growth in M2 returned to a more normal pattern.

---

rolling sample approach are less transparent and more difficult to interpret because they are influenced by the changing mix of observations drawn from the different structural regimes.

Overall the cointegration tests reported in this section are consistent with the results of the previous section suggesting that depository institutions' capital problems of the late 1980s and early 1990s played a role in affecting movements in M2. The cointegration tests demonstrate that capital problems also played a role in the deterioration in the long-run relationship between M2 and the ultimate goals of policy. When considering an estimation period that encompasses the peak years of bank and thrift difficulties, a strong cointegrating relationship is found when using alternative M2 measures that account for these difficulties. With these problems behind us, the relationship among money, interest rates, prices, and income has returned to its pre-difficulties stance.

5. Conclusion

The debate over the efficacy of monetary aggregates as intermediate targets or indicators continues. Forecasting M2 growth proved increasingly problematic in the late 1980s and early 1990s, and M2's relationship with inflation and economic growth deteriorated as well. In this paper, we argue that financial difficulties at banks and thrifts were an important factor behind these events. After constructing alternative measures of the M2 monetary aggregate that adjust for these difficulties, we show that the anomalous relationship between M2 velocity and its opportunity cost disappears. We also show that using these M2 measures in money demand equations yields more accurate forecasts of monetary aggregate growth, and that these adjusted measures indicate an improvement in the relationship between M2 and the ultimate goals of policy during the early 1990s. Our hypothesis is consistent with the results of a stronger cointegrating relationship among money, income, prices, and interest rates for adjusted measures of M2 around the time that financial difficulties peaked, and with a return to cointegrating relationships observed before the onset of these difficulties.

Our work identifies a main factor behind the decreased reliability of M2 as an indicator of monetary policy in the late 1980s and early 1990s, and shows that in all likelihood this decreased reliability was temporary. In particular, our findings suggest that during periods of time when there are no disturbances to financial institutions, the M2 monetary aggregate might very well contain useful information about the future direction of the economy. At a minimum, attempts to completely dismiss M2 as a useful indicator of economic activity may be overstated.

References

Ball, Laurence, 2001. Another Look at Long-Run Money Demand. Journal of Monetary Economics 47, 31-44.

Barth, James R., 1991. The Great Savings and Loan Debacle. AEI Press, Washington, D.C.

Board of Governors of the Federal Reserve System, 1998. Monetary Policy Report to the Congress Pursuant to the Full Employment and Balanced Growth Act of 1978, July 21.

Carlson, John B., Ben Craig, and Jeffrey C. Schwarz, 2000. Structural Uncertainty and Breakpoint Tests: An Application to Equilibrium Velocity. Journal of Economics and Business 52, 101-15.

Carlson, John B., Dennis L. Hoffman, Benjamin D. Keen, and Robert H. Rasche, 2000. Results of a Study of the Stability of Cointegrating Relations Comprised of Broad Monetary Aggregates. Journal of Monetary Economics 46, 345-383.

Carlson, John B., and Benjamin D. Keen, 1996. MZM: A Monetary Aggregate for the 1990s? Federal Reserve Bank of Cleveland Economic Review, 15-23.

Carlson, John B., and S.E. Parrott, 1991. The Demand for M2, Opportunity Cost, and Financial Change. Federal Reserve Bank of Cleveland Economic Review, 2-11.

Duca, John, 1992. The Case of the Missing M2. Federal Reserve Bank of Dallas Economic Review, 1-24.

Duca, John, 1995. Should Bond Funds Be Added to M2? Journal of Banking and Finance 19, 131-52.

Estrella, Arturo, and Frederic S. Mishkin, 1997. Is There a Role for Monetary Aggregates in the Conduct of Monetary Policy? Journal of Monetary Economics 40, 279-304.

Feinman, Joshua N., and Richard D. Porter 1992. The Continuing Weakness in M2. Board of Governors of the Federal Reserve System Finance and Economics Discussion Paper No. 209.

Feldstein, Martin, and James H. Stock, 1994. The Use of a Monetary Aggregate to Target Nominal GDP, in N.G. Mankiw, ed., Monetary Policy, University of Chicago Press for the National Bureau of Economic Research, 7-62.

Feldstein, Martin and James H. Stock, 1996. Measuring Money Growth when Financial Markets are Changing. Journal of Monetary Economics 37, 3-27.

Friedman, Benjamin M., and Kenneth N. Kuttner, 1992. Money, Income, Prices, and Interest Rates. American Economic Review 82, 472-92.

Greenspan, Alan, 1993. Statement to Congress. Federal Reserve Bulletin 79, September, 849-55.

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

Hafer, Rik W., and Dennis W. Jansen, 1991. The Demand for Money in the United States: Evidence from Cointegration. Journal of Money, Credit, and Banking 23, 155-68.

Hilton, R. Spense, and Cara. S. Lown, 1994. The Credit Slowdown and the Monetary Aggregates, in Studies on Causes and Consequences of the 1989-92 Credit Slowdown. Federal Reserve Bank of New York, 397- 428.

Johansen, Soren, 1988. Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamics and Control 12, 231–254.

Johansen, Soren, 1991. Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. Econometrica 59, 1551–1580.

Johansen, Soren, and Katarina Juselius, 1990. Maximum Likelihood Estimation and Inference on Cointegration – With Applications to the Demand for Money. Oxford Bulletin of Economics and Statistics 52, 169–210.

Judd, John P., and John L. Scadding, 1982. The Search for a Stable Money Demand Function: A Survey of the Post-1973 Literature. Journal of Economic Literature 20, 993-1023.

Koenig, Evan, 1996a. Long-term Interest Rates and the Recent Weakness in M2. Journal of Economics and Business 48, 81-101.

Koenig, Evan, 1996b. Forecasting M2 Growth: An Exploration in Real Time. Federal Reserve Bank of Dallas Economic Review, 16-26.

Mehra, Yash P., 1997. A Review of the Recent Behavior of M2 Demand. Federal Reserve Bank of Richmond Economic Quarterly, 27-43.

Miller, Stephen M., 1991. Monetary Dynamics: An Application of Cointegration and Error-Correction Modeling. Journal of Money, Credit, and Banking 23, 139-54.

Miyao, Ryuzo, 1996. Does a Cointegrating M2 Demand Relationship Really Exist in the United States? Journal of Money, Credit, and Banking 28, 365-380.

Orphanides, Athanasios, Brian Reid, and David H. Small, 1994. The Empirical Properties of a Monetary Aggregate That Adds Bond and Stock Funds to M2. Federal Reserve Bank of St. Louis Review, 31-51.

Peek, Joe, and Eric S. Rosengren, 1992. The Capital Crunch in New England. Federal Reserve of Boston New England Economic Review, 21-31.

Small, David H., and Richard D. Porter, 1989. Understanding the Behavior of M2 and V2. Federal Reserve Bulletin, Board of Governors of the Federal Reserve System, Washington, D.C., 244-254.

Stavins, Joanna, 1999. Checking Accounts: What Do Banks Offer and What Do Consumers Value? Federal Reserve Bank of Boston New England Economic Review, 3-13.

Stock, James H. and Mark Watson, 1988. A Simple Estimator of Cointegrating Vectors in Higher-Order Integrated Systems. Econometrica 61, 783-820.

Stock, James H. and Mark Watson, 1993. Testing for Common Trends. Journal of American Statistical Association 83, 1097-1107.

Svensson, Lars, 1999. Monetary Policy Issues for the Eurosystem. National Bureau of Economic Research Working Paper No. 7179.

Table 1
Estimates of M2 Money Demand Equations Using Various Measures of M2
1959:1 – 1990:4

Independent Variables	Dependent Variables			
	$\Delta\ln(M2)$	$\Delta\ln(NCM2)$	$\Delta\ln(BANKM2)$	$\Delta\ln(NCBANKM2)$
Constant	-0.0425*** (0.0088)	-0.0404*** (0.0132)	-0.0556*** (0.0204)	-0.0288* (0.0152)
τ_t	-0.0009 (0.0020)	-0.0005 (0.0004)	0.0020 (0.0060)	0.006 (0.006)
$\ln OPCOST_{t-1}$	-0.0071*** (0.0011)	-0.0127*** (0.0021)	-0.0115*** (0.0025)	-0.0113*** (0.0026)
$\ln V_{t-1}$	0.0910*** (0.0178)	0.0894*** (0.0266)	0.1188*** (0.0410)	0.0642** (0.0303)
$\Delta\ln C_t$	0.2471*** (0.0636)	0.2509** (0.1202)	0.2061 (0.1529)	0.1864 (0.1510)
$\Delta\ln C_{t-1}$	0.1116* (0.0628)	0.5754*** (0.1129)	0.6443*** (0.1423)	0.6563*** (0.1407)
$\Delta\ln C_{t-2}$	0.1100* (0.0597)	0.1833 (0.1211)	0.1639 (0.1537)	0.1943 (0.1521)
$\Delta OPCOST_t$	-0.0034** (0.0013)	-0.0074*** (0.0025)	-0.0057* (0.0032)	-0.0068** (0.0032)
Lagged Dependent Variable	0.5313*** (0.0732)	-0.0100 (0.0925)	-0.0142 (0.0942)	-0.0371 (0.0948)
$\bar{R}^2$	0.64	0.58	0.20	0.54

NOTES: The full specification is given by Equation (1). V_t = velocity, defined as GDP divided by the level of the dependent variable C_t = nominal personal consumption expenditures. Data for GDP and C are from the Bureau of Economic Analysis. M2 = actual M2, from the Federal Reserve Board's H.6 release, *Money Stock and Debt Measures*; NCM2 = M2 measure derived by assuming that M2 grew at the same rate as the M2 components at all nonconstrained banks and thrifts; BANKM2 = M2 measure derived by assuming that M2 grew at the same rate as the M2 components at all banks; NCBANKM2 = M2 measure derived by assuming that M2 grew at the same rate as the M2 components at nonconstrained banks. NCM2, BANKM2, and NCBANKM2 were constructed from bank and thrift call reports from 1984-2004 and spliced in to the actual M2 series. OPCOST = opportunity cost, the three-month Treasury bill rate less a weighted average of interest rates on M2 deposits; the Treasury bill rate is from the Federal Reserve Board's G.13 release; the M2 components used to construct the weights are from the H.6 release; the deposit rates are from the monthly supplementary table of the H.6 release. Dummy variables to account for credit controls, the introduction of MMDAs, and for potential discontinuities associated with our derived M2 measures are not shown. Standard errors are in parentheses. The symbols (***), (**), (*) indicate statistical significance at the one, five, and ten percent level, respectively.

Table 2A
Summary Measures of M2 Forecasts
Primary Capital=5.5%; leverage ratio=3%; tangible=1.5%
Models Estimated from 1959:I - 1990:IV
Dynamic Forecasts from 1991:I - 1994:IV

M2 Measure	Forecast Evaluation Measures			
	RMSE	F-Statistics		
		M2	NCM2	BANKM2
M2	2.85			
NCM2	2.00	1.44		
BANKM2	1.51	2.72**	1.89	
NCBANKM2	1.33	8.01***	5.56***	2.94**

Table 2B
Summary Measures of M2 Forecasts
Primary Capital=6%; leverage ratio=3.5%; tangible=2%
Models Estimated from 1959:I - 1990:IV
Dynamic Forecasts from 1991:I - 1994:IV

M2 Measure	Forecast Evaluation Measures			
	RMSE	F-Statistics		
		M2	NCM2	BANKM2
M2	2.85			
NCM2	1.89	1.58		
BANKM2	1.51	2.72**	1.73	
NCBANKM2	1.29	7.72***	4.90***	2.83**

Table 2c
Summary Measures of M2 Forecasts
Primary Capital=5%; leverage ratio=2.5% tangible=1%
Models Estimated from 1959:I - 1990:IV
Dynamic Forecasts from 1991:I - 1994:IV

M2 Measure	Forecast Evaluation Measures			
	RMSE	F-Statistics		
		M2	NCM2	BANKM2
M2	2.85			
NCM2	2.45	0.62		
BANKM2	1.51	2.72**	4.37***	
NCBANKM2	1.46	4.21***	6.76***	1.55

NOTES: Dynamic forecasts of various M2 measures are obtained using Equation (1). Variables are defined in Table 1. RMSE is the root mean square forecast error. F-statistics test for differences in RMSE across the different M2 specifications.

Table 3. Testing the Long-Run Stability of the Cointegrating Relationship: Johansen's Test

Multivariate system: $Z_t = (\ln M_t, \ln P_t, \ln r_t, \ln Y_t)'$

Cointegration rank (r) test: $H_0 : r = 0$ versus $H_0 : r = 1$

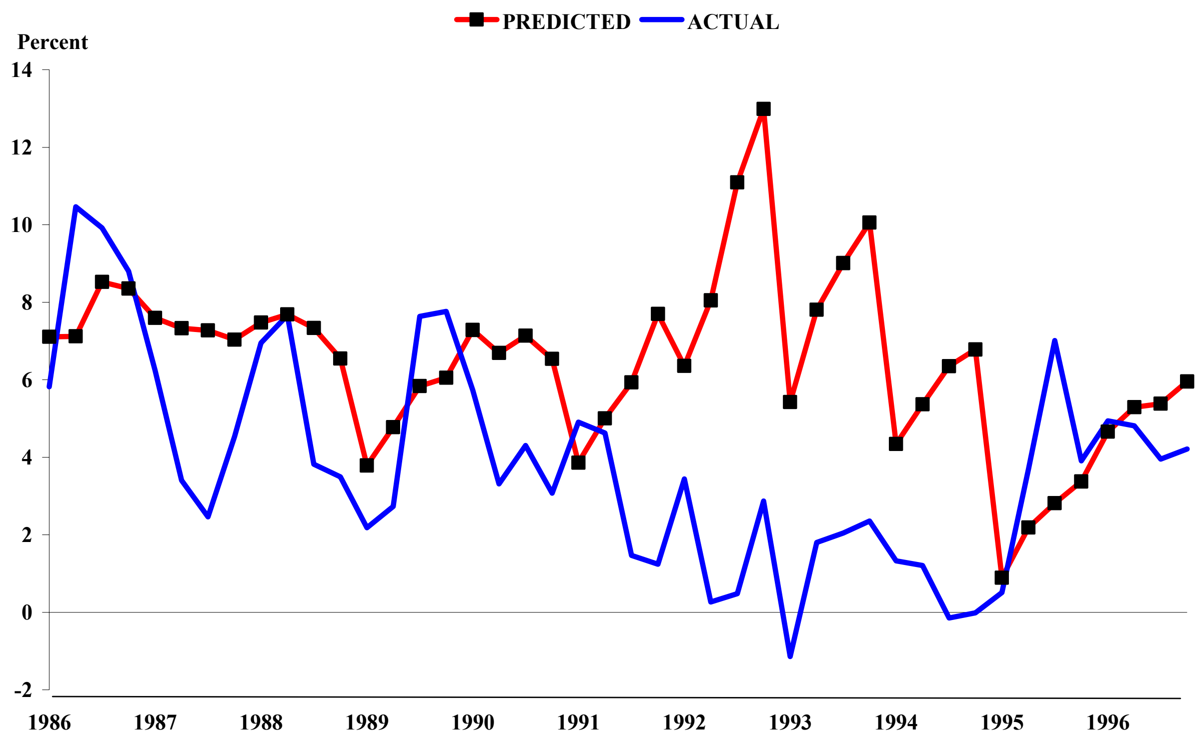
Monetary Aggregate	Interest Rate	1959:1 - 1988:4	1959:1 - 1992:4	1959:1 - 2004:4
M2	TBILL	24.24	29.70**	31.04**
	CP	22.67	29.50**	30.15**
	TBOND	24.52	26.32*	30.59**
	OPCOST	21.51	24.80	30.02**
NCM2	TBILL	36.13**	35.47**	37.36**
	CP	36.24**	32.78**	36.47**
	TBOND	36.49**	27.75	34.44**
	OPCOST	37.04**	31.41**	37.61**
NCBANKM2	TBILL	36.03**	43.73**	36.83**
	CP	36.02**	40.82**	37.56**
	TBOND	36.16**	35.85**	34.86**
	OPCOST	36.20**	43.86**	43.40**
BANKM2	TBILL	29.81**	34.42**	35.64**
	CP	27.76*	31.00**	34.68**
	TBOND	32.83**	29.98**	34.07**
	OPCOST	27.05**	32.44**	38.31**

NOTES: Values in the table represent cointegration maximum eigenvalue test. The Johansen test is based on the model

$$\Delta Z_t = \delta_0 + \delta_1 \tau_t + \Pi Z_{t-1} + \sum_{j=1}^{k} \Gamma_j \Delta Z_{t-j} + \upsilon_t$$

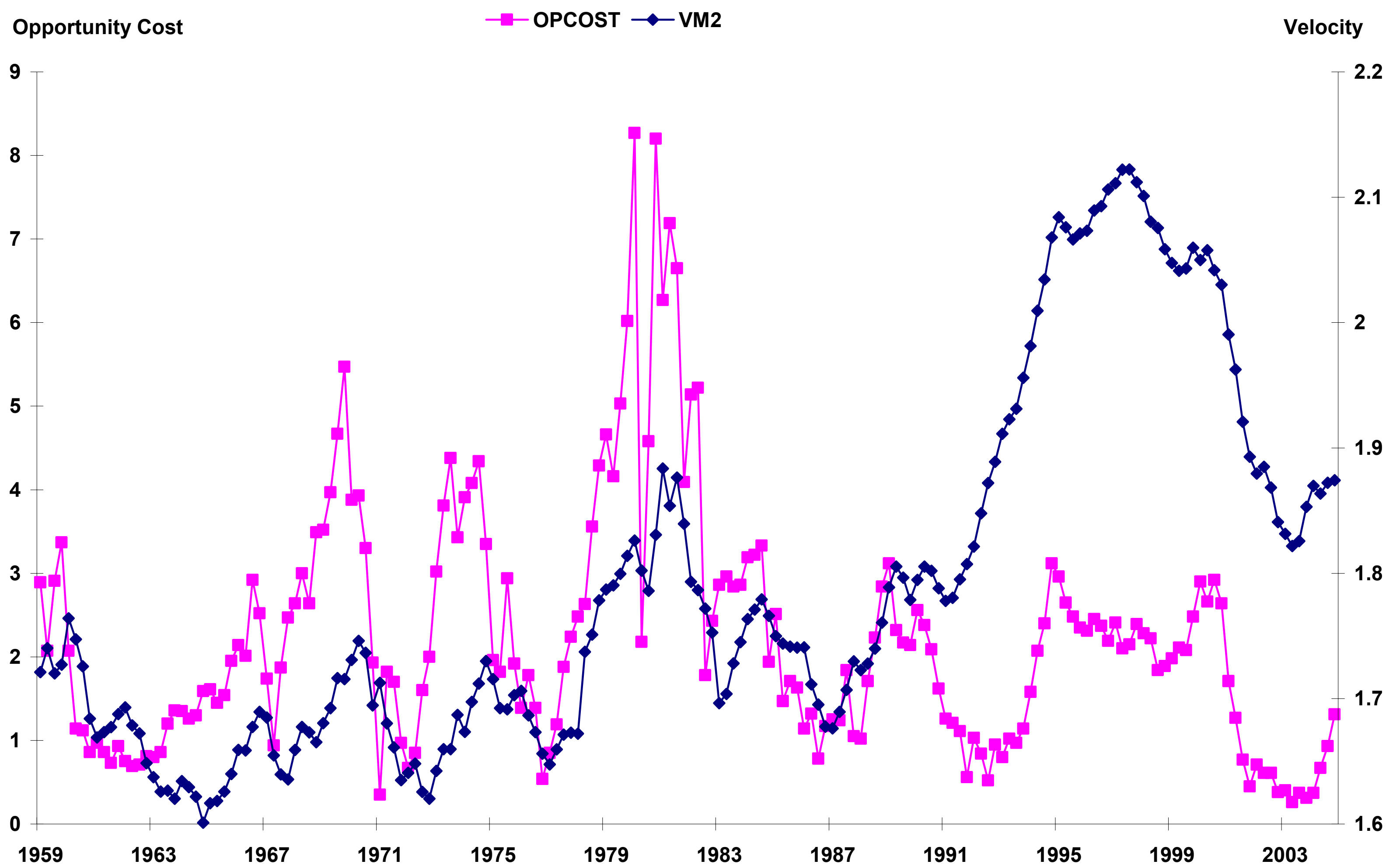
where τ_t represents a linear trend, υ_t is the residual term, and in our case $k = 4$. Johansen's cointegration test can be expressed in terms of the ranks of the matrix Π: $H_0 : \text{rank}(\Pi) = \overline{r}$ against $H_1 : \text{rank}(\Pi) = \overline{r} + 1$. The symbols (**) and (*) indicate statistical significance at the five- and ten-percent level, respectively. TBILL = three-month Treasury bill rate, TBOND = ten-year Treasury bond rate, CP= three-month Commercial Paper rate. M_t =nominal seasonally adjusted M2 monetary aggregate, Y_t =real gross domestic product, and P_t =implicit price deflator. Monetary aggregate measures are defined in Table 1.

Figure 1: M2 Forecast Errors



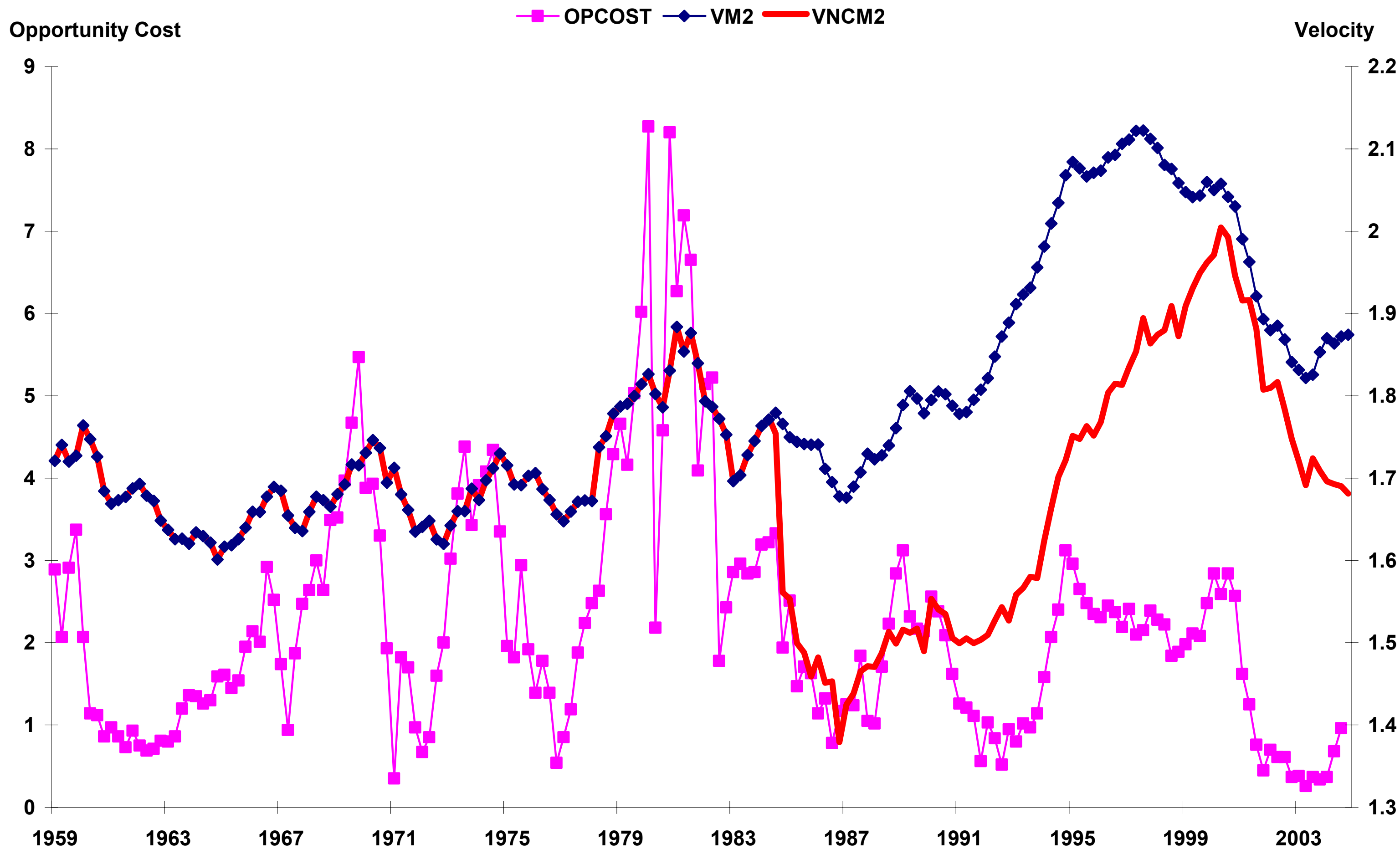
Notes: Results from estimating Equation (1).

Figure 2: M2 Velocity and Opportunity Cost



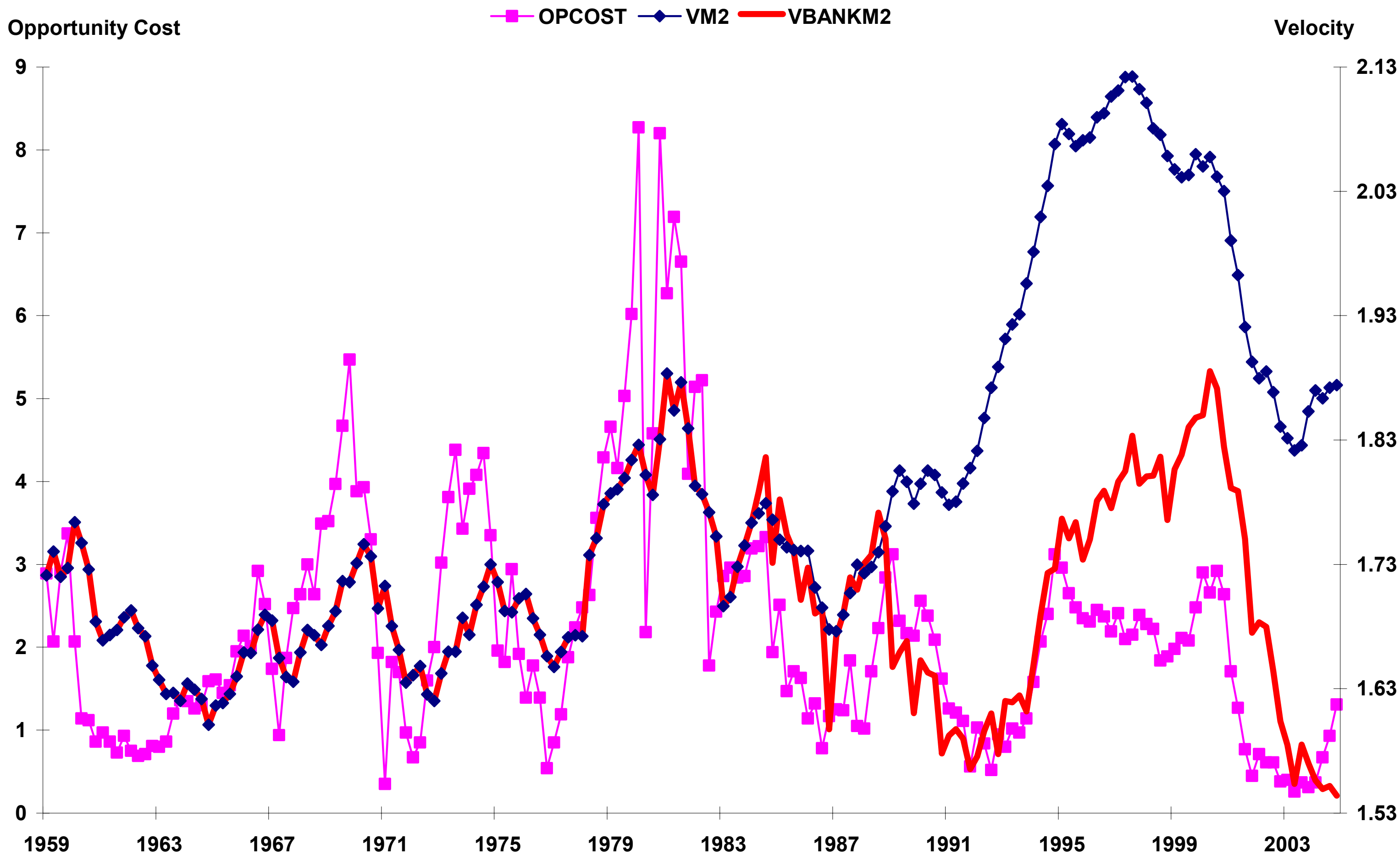
Notes: Opcost is the M2 opportunity cost. Velocity is calculated as GDP/M2.

Figure 3a: Alternative M2 Velocity and Opportunity Cost



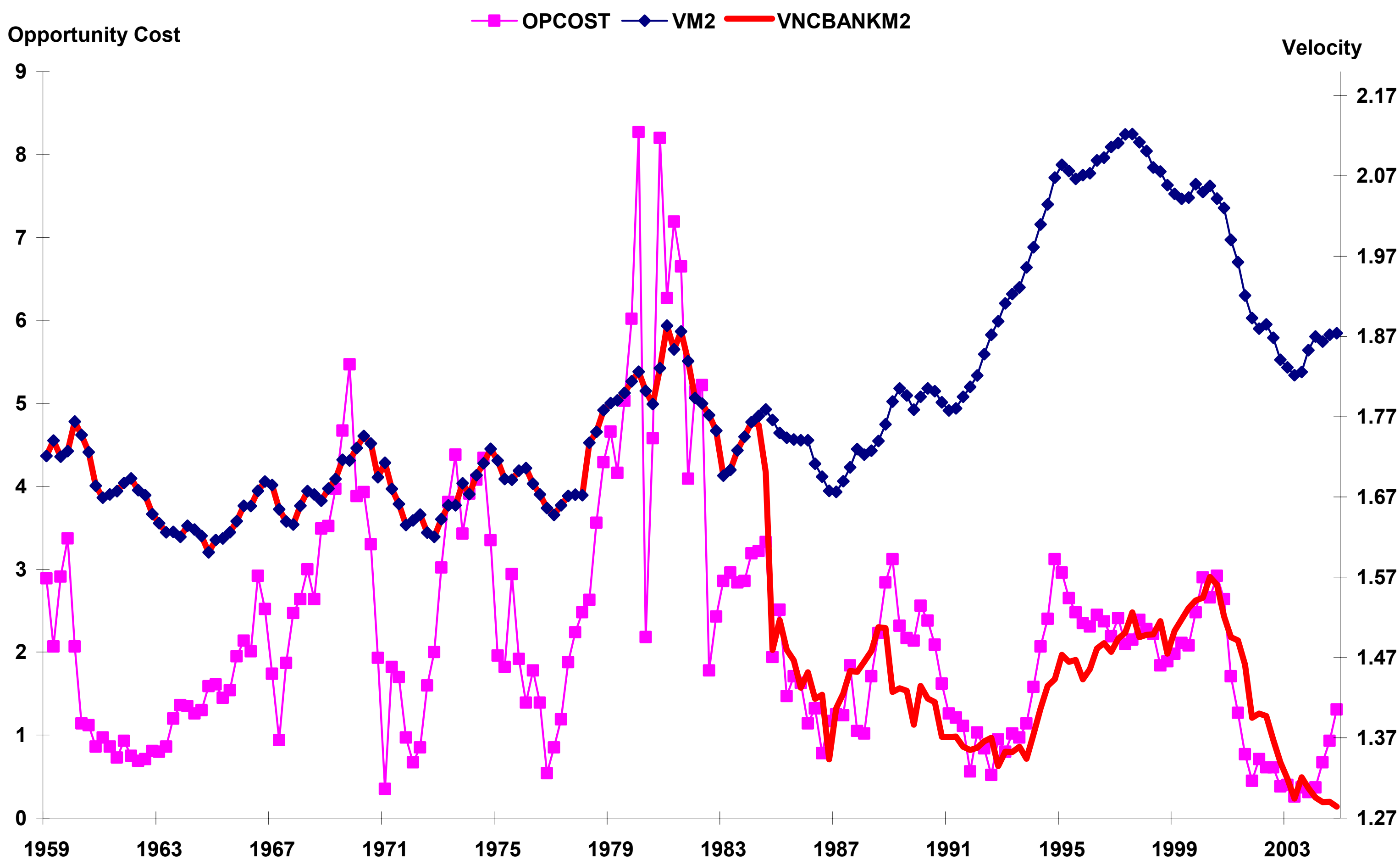
Notes: Opcost is the M2 opportunity cost. Velocity is calculated as GDP/monetary aggregate. NCM2 is calculated by assuming that M2 grew at the rate observed at all nonconstrained banks and thrifts from 1984-2004.

Figure 3b: Alternative M2 Velocity and Opportunity Cost



Notes: Opcost is the M2 opportunity cost. Velocity is calculated as GDP/monetary aggregate. BANKM2 is calculated by assuming that M2 grew at the rate observed at all banks from 1984-2004.

Figure 3c: Alternative M2 Velocity and Opportunity Cost



Notes: Opcost is the M2 opportunity cost. Velocity is calculated as GDP/monetary aggregate. NCBANKM2 is calculated by assuming that M2 grew at the rate observed at all nonconstrained banks from 1984-2004.

Figure 4. Strength of Cointegration of M2 and its Alternative Measures, 1980-2004

The vertical axis in each panel represents the relative value of the maximum eigenvalue statistic testing the null hypothesis of no cointegration at the 5% significance level. A value greater than 100 is in the rejection region of the null hypothesis of no cointegration (that is, the null that the cointegration rank (r) r=0 versus the alternative of r=1). The interest rate process is measured using the 3-month Treasury bill rate.