Forecasting M2 Growth: An Exploration In Real Time

Evan F. Koenig
Research Officer
Federal Reserve Bank of Dallas

The focus of earlier work was on developing an empirical model capable of reproducing the recent pattern of money growth. This article examines whether by substituting real-time forecasts of spending growth and interest rates into the model, it can be successfully used to predict changes in money growth.

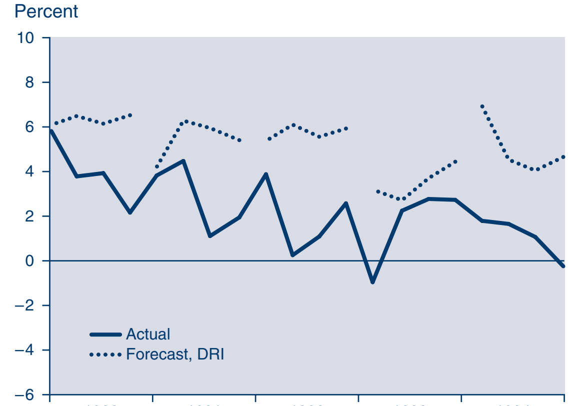
For several reasons, it is important that Federal Reserve policymakers have a good understanding of the relationship between money growth, interest rates, and spending. For example, the Federal Reserve is legally obligated to provide Congress with annual money growth projections. Federal Reserve officials must be prepared to explain the basis for these projections and to interpret deviations of actual money growth from past forecasts. Moreover, several studies have suggested that there is information on future spending and future inflation in the difference between the current money supply and the long-run demand for money (Hallman, Porter, and Small 1991; Feldstein and Stock 1993; Koenig 1994; Duca 1994). Successful extraction of this information requires that the long-run demand for money be accurately estimated.

Unfortunately, many models have systematically overpredicted money growth during the 1990s—often by very large amounts. The forecasting record of DRI/McGraw-Hill (DRI) is typical. Figure 1 shows actual annualized M2 growth from 1990 through 1994, along with the M2 growth forecasts published by DRI each January. In every quarter over this five-year period, DRI overpredicted M2 growth. The average error was over 3 percentage points.

The M2 model developed in the late 1980s by the staff of the Federal Reserve Board also overpredicted money growth.[1] In 1993, citing increased uncertainty in the relationship between M2 and spending, the Federal Open Market Committee announced that it would de-emphasize M2 in the policy-making process (Greenspan 1993).

Recent efforts to explain the unexpectedly weak M2 growth of the early 1990s have fo-

Figure 1
Actual M2 Growth and DRI Forecasts



SOURCES: DRI/McGraw-Hill; Federal Reserve Board.

cused on two fundamental underlying causes: (1) a deterioration in the competitiveness of banks and savings and loans resulting from tighter regulation, higher deposit insurance premiums, and more stringent capital standards and (2) financial innovations that have made nonbank assets like stocks and bonds increasingly attractive to households.[2] Koenig (1996) argues that insofar as banks have become less competitive, their higher costs ought to be reflected in an increase in the spread between the yield on stocks and bonds and the yield on bank deposits. If existing measures of money's opportunity cost fail to show an increase in this spread, it may be necessary to revise those measures. In particular, empirical results suggest that one should allow long-term bond rates to play a role in determining money's opportunity cost. Moreover, Koenig argues that whereas many of the important financial innovations of the early 1980s (such as the introduction of money market deposit accounts) were a result of sudden, discrete changes in the law, recent financial innovation can best be modeled as a continuous, ongoing process. Consistent with this point of view, Koenig reports evidence—even in early sample periods—of a gradual acceleration in M2's velocity growth. An M2 model that allows long-term bond rates to affect M2's opportunity cost and that allows a gradual acceleration in M2's velocity growth does not exhibit a statistically significant money-growth shortfall in the early 1990s. The recent performance of the model is somewhat further improved if the definition of money is expanded to include household bond market mutual funds, as advocated by Duca (1994, 1995).

The focus of my earlier work was on developing an empirical model capable of *reproducing* the recent pattern of money growth. This article examines whether by substituting real-time forecasts of spending growth and interest rates into the model, it can be successfully used to *predict* changes in money growth.[3] The spending and interest rate forecasts in question are obtained from DRI reports published each January. Results of the exercise have generally been encouraging. However, in 1995 a sharp flattening of the yield curve led to a more pronounced than expected acceleration of money growth. Consequently, the future usefulness of the model remains an open question.

This article begins with a review of the M2 growth model developed in my earlier article. Next, I examine the accuracy of DRI forecasts of spending and interest rates. Finally, I use DRI spending and interest rate predictions from January of each year to obtain ex ante forecasts of M2 growth. A similar exercise is undertaken for M2 expanded to include household bond funds. Results for the latter monetary aggregate are generally similar to those for conventional M2. Although the expanded aggregate is somewhat easier to predict through 1994, preliminary data suggest that 1995 errors are even larger than those recorded using conventional M2.

The model

This section makes two points.[4] First, even in early sample periods, there is evidence both that long-term interest rates help explain the pattern of money growth and that money growth has been gradually decelerating relative to spending growth. Second, a model that incorporates these effects does a satisfactory job of reproducing the pattern of M2 growth observed during the first half of the 1990s.

Description. The M2 growth model used in this article has two main components—a long-run equilibrium condition and short-run dynamics. The long-run equilibrium condition is a money-demand relationship of the form

$$(1) \qquad m^*_t = \tau_t - a_3 oc_t + x_t,$$

where m^* denotes the logarithm of the long-run equilibrium demand for nominal M2 balances, x is the logarithm of nominal nondurables and services consumption expenditures, oc is the logarithm of M2's opportunity cost (defined below), and a_3 is a non-negative parameter. A deterministic time trend, τ, is included as a right-hand-side variable in equation 1, as a proxy for the effects of financial innovation on the long-run demand for money. Specifically, it is assumed that

$$(2) \qquad \tau_t = a_0 + a_0' DMMDA_t - a_1 t - a_2 t^2,$$

where *DMMDA* is a dummy variable that equals 1 after the introduction of money market deposit accounts (MMDAs) and zero otherwise.[5] If financial innovation has been accelerating, one would expect to find $a_2 > 0$.

In the short run, money growth is assumed to be greater the greater the gap is between the long-run demand for money balances and the current level of money balances. Money growth also depends upon lagged values of itself, current and lagged values of consumption spending, and current and lagged changes in money's opportunity cost:

Table 1
Estimates of an Error-Correction Model of M2 Growth

	Sample period	
	1964:1–89:4	1964:1–94:4
a_0	6.107**	5.991**
	(.167)	(.134)
a_0'	.0363*	.0539**
	(.0162)	(.0134)
a_1	–.00907**	–.01099**
	(.00202)	(.00150)
a_2	$.417 \times 10^{-4}$**	$.501 \times 10^{-4}$**
	$(.080 \times 10^{-4})$	$(.055 \times 10^{-4})$
a_3	.111**	.115**
	(.016)	(.014)
θ	.359**	.431**
	(.078)	(.061)
c_1	.0269**	.0284**
	(.0041)	(.0038)
c_2	–.00738	–.00996*
	(.00477)	(.00444)
c_3	–.00708*	–.00611*
	(.00318)	(.00292)
c_4	.144**	.128**
	(.028)	(.024)
c_5	–.00830**	–.00770**
	(.00251)	(.00238)
c_{5A}	–.00340	–.00594*
	(.00278)	(.00263)
c_6	.184	.228*
	(.105)	(.089)
c_{6A}	–.227*	–.299**
	(.108)	(.090)
c_{6B}	.114	.147
	(.097)	(.084)
c_7	.362**	.415**
	(.073)	(.065)
Q (4)	6.43	5.05
Q (12)	16.81	13.83
Q (20)	25.36	25.81
SSE	.00127	.00142
SEE	.00380	.00363
Adjusted R^2	.782	.849

* Significant at 5-percent level.
** Significant at 1-percent level.

$$(3) \quad \Delta m_t = \phi_t + c_1 D83Q1 + c_2 D83Q2 + c_3 DCON + c_4 (m^* - m)_{t-1} + c_5 \Delta oc_t + c_{5A} \Delta oc_{t-1} + c_6 \Delta x_t + c_{6A} \Delta x_{t-1} + c_{6B} \Delta x_{t-2} + c_7 \Delta m_{t-1}.$$

Here, ϕ_t is a time trend and

$D83Q1 \equiv$ dummy equal to 1 in 1983:1 to control for MMDAs,
$D83Q2 \equiv$ dummy equal to 1 in 1983:2 to control for MMDAs, and
$DCON \equiv$ 1 in 1980:2 when credit controls were imposed and –1 in 1980:3 after credit controls were lifted.

The (logarithm of the) long-run demand for money, m^*, is given by equation 1.

The opportunity cost of holding money is defined to be a weighted average of long-term and short-term bond rates less the average return on M2 deposits. Thus,

$$(4) \quad oc_t = \ln[\theta R10Y_t + (1 - \theta) R3M_t - RM2_t],$$

where $R10Y_t$, $R3M_t$, and $RM2_t$ are the rates of return on ten-year Treasury bonds, three-month Treasury bills, and M2 deposits, respectively, and where the weighting coefficient, θ, is estimated along with the other parameters of the model. Including a long-term bond rate in the opportunity cost formula allows for the possibility that households regard long-term nonintermediated securities as substitutes for some monetary assets. Theoretical arguments favoring this approach are developed by Orr (1970), Friedman (1977), and Poole (1988). Empirical support has come from Hamburger (1966, 1977, 1983) and, more recently, Feinman and Porter (1992).

As shown in the appendix, the time trends in equations 1 and 3 are not independent. If actual money growth is to have the same unconditional mean as growth in the long-run demand for money, then the time trend in equation 3 must take the form

$$(5) \quad \phi_t = c_0 - 2a_2 [t - c_7 (t - 1)],$$

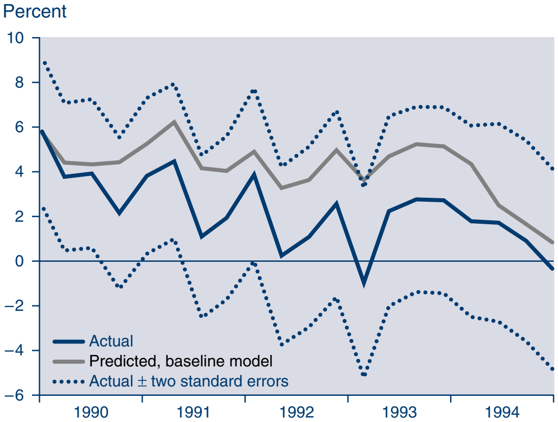
where c_0 is a fixed parameter. Hence, equation 3 can be rewritten as

$$(3') \quad \Delta m_t = c_0 - 2a_2 t + c_1 D83Q1 + c_2 D83Q2 + c_3 DCON + c_4 (m^* - m)_{t-1} + c_5 \Delta oc_t + c_{5A} \Delta oc_{t-1} + c_6 \Delta x_t + c_{6A} \Delta x_{t-1} + c_{6B} \Delta x_{t-2} + c_7 [\Delta m_{t-1} + 2a_2 (t - 1)].$$

Intuitively, insofar as a_2 is greater than zero, equations 1 and 2 imply that long-run trend growth in desired money balances will gradually fall relative to growth in spending. If actual money growth is, on average, to equal desired money growth, then actual money growth must also gradually slow for any given rate of spending growth.

Estimation results. Equations 1, 2, and 4 were substituted into 3′, and the resultant equation was estimated using nonlinear least squares.[6] Results are presented in Table 1. Column 1 of the table reports results for a sample

Figure 2
Actual and Predicted M2 Growth



SOURCES: Federal Reserve Board; author's calculations.

period ending in the fourth quarter of 1989, when M2 was near the height of its popularity as an indicator of the stance of monetary policy and the future direction of the economy. Column 2 extends the sample period through 1994:4, by which time the breakdown of the Federal Reserve Board's money-growth model was evident.

Note, first, that the weight attached to the long-term bond rate in the opportunity cost formula (θ in equation 4) is statistically and economically significant even in the sample ending prior to the recent period of "missing money." There is also evidence of an acceleration in velocity growth in the early sample: the estimate of the parameter a_2 in column 1 of Table 1 implies that annualized money growth falls by about 13 hundredths of a percentage point per year relative to spending growth, all else constant.[7]

Note, second, that the model developed above exhibits relatively few symptoms of instability. Thus, parameter drift is limited: the estimates in columns 1 and 2 of Table 1 are generally within one standard error of each other, and in no case does the difference exceed two standard errors.[8] Moreover, the adjusted R^2 of the model rises from 0.78 to 0.85 as the sample is extended, and the model's standard error falls from about 1.52 percentage points (annualized) in the early sample to 1.45 percentage points (annualized) in the later sample.

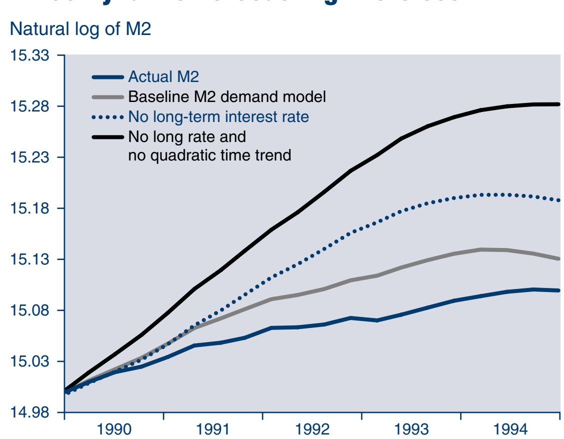
Figures 2 and 3 provide perspective. To construct Figure 2, parameter estimates from column 1 of Table 1 were combined with actual values of right-hand-side variables (including actual lagged money and actual lagged money growth) to generate simulated values of money growth from 1990 through 1994. These simulated values are plotted along with actual money growth and two-standard-error bands. The figure shows that although the model consistently predicts more rapid money growth than was actually observed, with but one exception (1993:1), the errors are not statistically significant.

Figure 3 presents results from several *dynamic* simulation exercises. To generate the plot labeled *baseline M2 demand model*, parameter estimates were taken from column 1 of Table 1. Actual values of nonmonetary right-hand-side variables were substituted into the estimated equations, along with lagged predicted (not actual) values of money and money growth. In fourth-quarter 1994, five years after the beginning of the simulation, the gap between the actual and predicted levels of M2 is only 3.1 percent.

Two other simulated paths are also presented in Figure 3. To generate these paths, the baseline model was reestimated with, first, the long-term bond rate and, second, with both the long-term bond rate and the quadratic trend excluded. Note how poorly the restricted models do in comparison with the baseline model: in the model without the long-term bond rate, the gap between the actual and predicted levels of M2 is nearly 9 percent at the end of the simulation period; in the model without both the long-term bond rate and the quadratic time trend, the corresponding gap is over 18 percent!

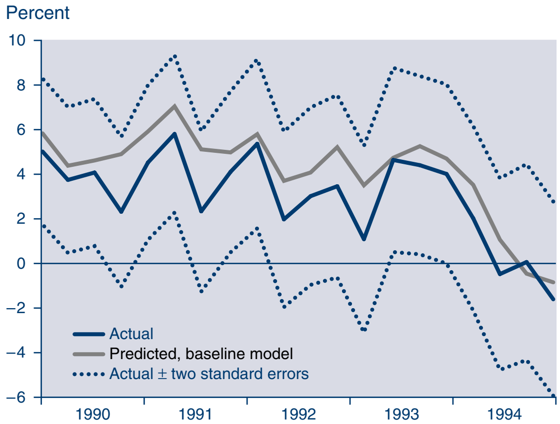
Bond-fund-adjusted M2. The weakness in M2 growth during the early 1990s was associated with large flows out of certificates of deposit (CDs) and large flows into bond market mutual funds (BMMFs). Duca (1995, 1994) has suggested that the definition of money be ex-

Figure 3
Actual and Predicted M2 from Three Dynamic Forecasting Exercises



SOURCES: Federal Reserve Board; author's calculations.

Figure 4
Actual and Predicted M2B Growth



SOURCES: Federal Reserve Board; author's calculations.

panded to include household bond market mutual fund balances, thus internalizing substitution between CDs and BMMFs. Despite this internalization, when the model developed above is reestimated using Duca's bond-fund-adjusted M2 (M2B) in place of conventional M2, the point estimates of the weight attached to the long-term bond rate in equation 4 and of the coefficient of time squared in equation 2 are virtually unchanged (Koenig 1996). As illustrated in Figures 4 and 5 (which are the M2B analogs of Figures 2 and 3), the out-of-sample stability of the model is somewhat better using M2B than using M2.[9] However, the choice of monetary aggregate is of second-order importance compared with the choice of whether to allow long-term interest rates to affect money's opportunity cost and whether to allow for a gradual slowing of trend money growth relative to trend spending growth. In Figure 5, for example, including long-term interest rates and a quadratic time trend in the M2B model reduces the end-of-1994 gap between the actual and predicted levels of money by 14.6 percentage points—from 16.2 percent to 1.6 percent. By comparison, using M2B in place of M2 in the forecasting model causes the end-of-1994 gap between the actual and predicted levels of money to decline by only 1.5 percentage points.

Real-time forecasting

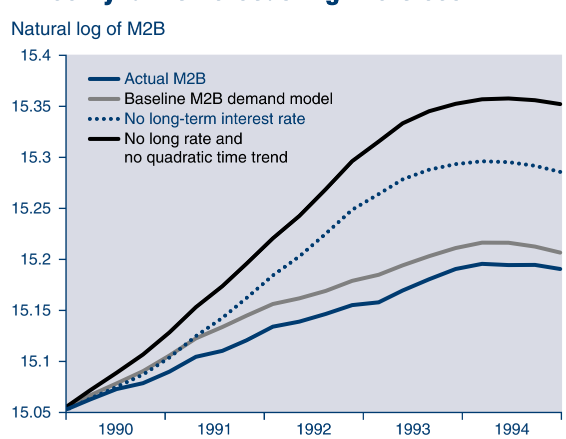
In this section, I take spending and interest rate forecasts published by DRI each January from 1990 through 1995 and find the implied time paths of M2 and M2B, as predicted by the money-growth model described above. The aim is to find out how accurately the model would have predicted money growth in each of the past six years, given DRI's spending and interest rate forecasts. The model does a good job of predicting M2 growth through 1994, provided coefficients are periodically reestimated. However, large underpredictions in 1995 raise questions about the model's future forecasting performance. Results using M2B are less sensitive to periodic reestimation of the model's coefficients. On the other hand, preliminary data suggest that 1995 M2B growth is underpredicted even more dramatically than is 1995 M2 growth.

Real-time forecasts of consumption and money's opportunity cost. Successful real-time forecasts of money growth depend on successful real-time forecasts of spending and interest rates. Therefore, the first step in the forecasting analysis must be an examination of how accurate DRI has been in its consumer spending and interest rate predictions.

Figure 6 shows actual annualized growth in nominal consumer spending on nondurables and services (the solid line), along with a series of DRI forecasts of the same variable (dotted lines). Each year's forecasted values are taken from the DRI *Review of the U.S. Economy* published in January of that year. In particular quarters, the DRI forecast has been off by as much as 2 percentage points. However, the errors are not consistently positive or consistently negative. Nor are the errors persistent: an overestimate is as likely to be followed by an underestimate as another overestimate.

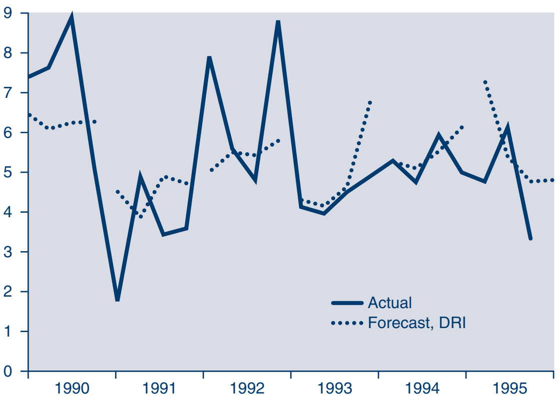
DRI does not publish a forecast of M2's opportunity cost, but a forecast can be constructed by regressing historical opportunity cost data on interest rate series that DRI *does* predict. I started with a sample period extending from 1964 through 1989 and regressed the opportunity cost on a constant, three own lags, the

Figure 5
Actual and Predicted M2B from Three Dynamic Forecasting Exercises



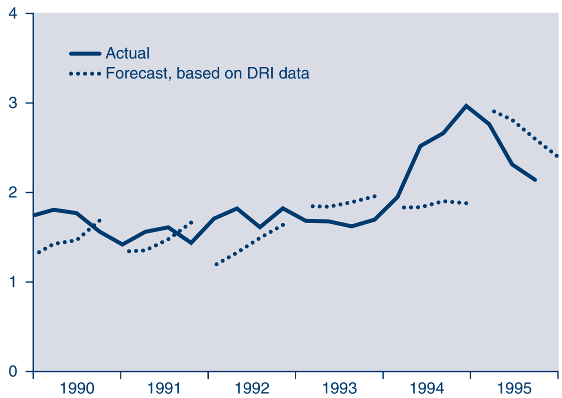
SOURCES: Federal Reserve Board; author's calculations.

Figure 6
Actual and DRI Forecasts of Consumer Spending Growth



SOURCES: U.S. Department of Commerce; DRI/McGraw-Hill.

Figure 7
Actual and Forecasted M2 Opportunity Cost



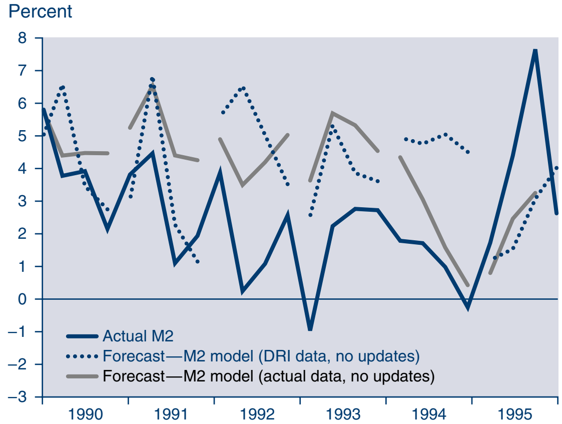
SOURCES: Federal Reserve Board; DRI/McGraw-Hill; author's calculations.

three-month CD rate, the federal funds rate, current and three lagged values of the three-month T-bill rate, and current and four lagged values of the ten-year Treasury bond rate.[10] The regression has an $\bar{R}^2$ of 0.96, and there is no evidence of serial correlation of the residuals.[11] January 1990 DRI forecasts of the three-month CD rate, the federal funds rate, the three-month T-bill rate, and the ten-year T-bond rate were substituted into the fitted equation to obtain a predicted opportunity cost for each quarter of 1990. The whole process was repeated—using a 1964–90 sample and January 1991 DRI interest rate forecasts—to obtain opportunity cost predictions for 1991. Similar predictions were obtained for 1992, 1993, 1994, and 1995.[12] Actual and forecasted opportunity costs are plotted in Figure 7.

As shown in the figure, although they are generally small, deviations of forecasted opportunity costs from actual opportunity costs exhibit considerable intrayear persistence. Thus, DRI's interest rate forecasts would have led one to underpredict M2's opportunity cost during most of 1990 and all of 1992 and to slightly overpredict M2's opportunity cost during 1993. The sharp increase in the opportunity cost during 1994 was entirely unanticipated by DRI. In January 1995, DRI's interest rate forecasts implied that M2 deposit rates would begin to catch up with Treasury bill and bond rates, resulting in a gradual decline in M2's opportunity cost. The actual decline was considerably more rapid.

Real-time forecasts of M2 growth. Given DRI's spending and interest rate forecasts, how accurately would the money-demand model described above have predicted M2 growth in each of the past six years? Figure 8 provides some insight. The figure plots actual M2 growth along with M2 growth predictions based on DRI spending and interest rate forecasts. In addition, to provide a feel for how sensitive the model's predictive performance is to the accuracy of DRI's spending and interest rate forecasts, Figure 8 includes M2 growth predictions based on *actual* spending and interest rate data. In generating both sets of M2 predictions, model coefficients are held fixed at values obtained in an estimation that ends in fourth-quarter 1989 (prior to the recent episode of "missing money"). The forecaster is assumed to observe actual money and money growth for the quarter preceding each forecast year. However, *within* each forecast year, lagged *predicted* values of money and money growth—rather than lagged *actual* values—are substi-

Figure 8
Actual and Forecasted M2 Growth



SOURCES: Federal Reserve Board; author's calculations.

Table 2
Forecasted Four-Quarter M2 Growth Rates

		No Coefficient Updating		Coefficient Updating		
	Actual	Actual RHS	DRI RHS	Actual RHS	DRI RHS	DRI Model
1990	3.91	4.77	4.45	4.77	4.45	6.51
1991	2.83	5.11	3.32	4.67	3.12	5.60
1992	1.94	4.40	5.17	2.63	3.35	5.90
1993	1.69	4.80	3.83	2.40	1.08	3.57
1994	1.06	2.35	4.82	–.72	1.57	5.17
1995	4.08	—	2.45	—	–.28	4.12
Mean*	2.29	4.29	4.32	2.75	2.71	5.35
RMSE*	—	2.16	2.44	1.29	.77	3.18
Mean**	2.58	—	4.01	—	2.22	5.14
RMSE**	—	—	2.32	—	1.91	2.90

* 1990–94.
** 1990–95.

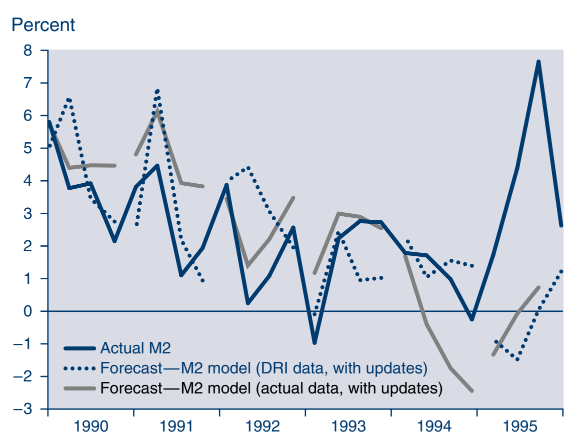
tuted into equation 3′ to generate the current quarter's predicted change in M2. In other words, within each year the M2 growth forecasts are dynamic.

As might be expected, given the results displayed in Figure 2, the model systematically overpredicts M2 growth over most of the forecast horizon. For the M2 growth forecasts based on actual spending and interest rate data, overpredictions are most serious over the two-year period running from 1992:2 through 1994:1. For the real-time M2 growth predictions based on DRI spending and interest rate forecasts, errors are largest in 1992 and 1994. For both sets of M2 growth predictions, preliminary data suggest that the model *under*predicted money growth during most of 1995, especially in the second and third quarters.

Over the forecast period as a whole, an analyst would have done about as well basing his M2 growth predictions on DRI spending and interest rate forecasts as on actual spending and interest rate data. This point is documented in Table 2. The first column gives actual fourth-quarter over fourth-quarter M2 growth rates for each of the years from 1990 through 1995. The second and third columns give fourth-quarter over fourth-quarter growth predictions that correspond to the forecasts plotted in Figure 8. Thus, predictions in column 2 are calculated using actual right-hand-side (RHS) spending and interest rate data. Predictions in column 3 are calculated using right-hand-side spending and interest rate forecasts taken from DRI. Note that the mean growth rates and root-mean-square errors reported in these columns are fairly similar. In both cases, the mean error over the 1990–94 period is about 2 percentage points, and the root-mean-square error is a bit over 2 percentage points. The corresponding figures for DRI's own M2 growth predictions over this period are 3.1 percentage points and 3.2 percentage points, respectively. (See Table 2, column 6.) Thus, although the forecasting performance of the model developed above is hardly an unqualified success, it is substantially better than that of at least one major private forecasting firm.

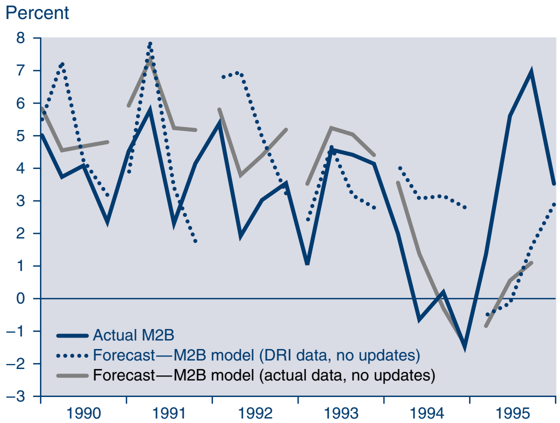
The 1990–94 predictive performance of the baseline model can be improved by allowing reestimation of the model at the beginning of each year, to obtain updated coefficient esti-

Figure 9
Actual and Forecasted M2 Growth



SOURCES: Federal Reserve Board; author's calculations.

Figure 10
Actual and Forecasted M2B Growth



SOURCES: Federal Reserve Board; author's calculations.

mates. Results for this case are plotted in Figure 9. As in Figure 8, during 1992 and 1994, when DRI interest rate forecasts would have led one to underestimate M2's opportunity cost, M2 growth forecasts based on DRI data are noticeably stronger than those based on actual data. Nevertheless, for the forecast period as a whole, the M2 growth forecasts based on DRI estimates of spending and interest rates are no worse than those based on actual spending and interest rate data. The mean forecast error is about one-half percentage point in either case, and the root-mean-square error is about 1 percentage point. (See columns 4 and 5 of Table 2.) Unfortunately, the model with updated coefficients underpredicts 1995 M2 growth by almost 4.4 percentage points. For comparison, without coefficient updating the model underpredicts 1995 M2 growth by about 1.6 percentage points.

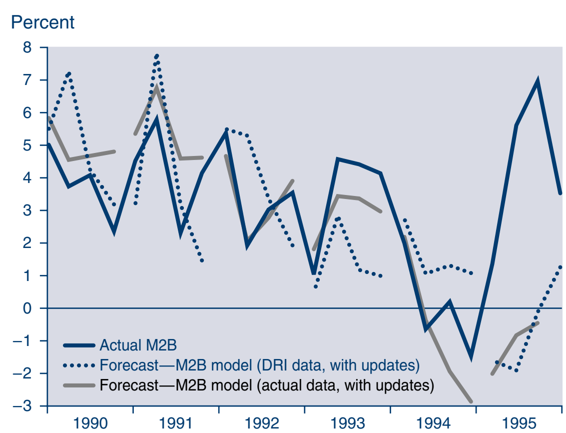
In summary, the biggest constraint on the real-time predictive performance of the M2 demand model developed here comes not from the need to forecast spending and interest rates but from instability in the coefficients of the model. This instability—although not statistically significant—limits the usefulness of the model for forecasting purposes. On the other hand, the results displayed in Figure 8 raise the possibility that coefficient instability may have been largely confined to the two-year period from 1992:2 through 1994:1. Only time will tell whether this conjecture is correct. In the meantime, the M2 growth forecasts generated by the model described in this article must be used with a good deal of caution.

Real-time forecasts of M2B growth. Finally, consider how easy it would have been for an analyst to predict M2B growth, year by year, using the model developed here and spending and interest rate forecasts published by DRI. As shown in Figure 10, even without coefficient updates the model does a good job of predicting the pattern of M2B growth through 1994. Using *actual* spending and interest rate data, the model overpredicts money growth over much of the forecast horizon. However, the errors are noticeably smaller than those plotted in Figure 8. Using real-time *DRI* forecasts of spending and interest rates, the largest M2B growth overpredictions occur during 1992 and 1994—years in which DRI's interest rate forecasts would have led one to underpredict M2B's opportunity cost.[13] According to results displayed in columns 2 and 3 of Table 3, using DRI spending and interest rate forecasts would not have resulted in any significant additional bias in predicted M2B growth but would have increased the model's root-mean-square error by almost 50 percent (from 1.25 percentage points to 1.82 percentage points).

Figure 11 shows the effects of allowing the coefficients of the M2B model to be reestimated at the start of each year. From 1990 through 1994, bias is virtually eliminated and the model accurately traces the quarterly movements in M2B growth—especially when actual spending and interest rate data are used as right-hand-side variables. As shown in columns 4 and 5 of Table 2, it remains the case that using real-time DRI forecasts of spending and interest rates increases the model's 1990–94 root-mean-square error by about 50 percent relative to what it would have been had accurate spending and interest rate forecasts been available.

Unfortunately, available data suggest that the model described in this article underpredicts 1995 M2B growth even more dramatically than it underpredicts 1995 M2 growth.[14] This

Figure 11
Actual and Forecasted M2B Growth



SOURCES: Federal Reserve Board; author's calculations.

Table 3
Predicted Four-Quarter M2B Growth Rates

		No Coefficient Updating		Coefficient Updating	
	Actual	Actual RHS	RHS from DRI	Actual RHS	RHS from DRI
1990	3.79	4.97	5.05	4.97	5.05
1991	4.19	5.92	4.22	5.32	3.91
1992	3.46	4.79	5.48	3.35	4.02
1993	3.54	4.55	3.25	2.89	1.36
1994	.00	.81	3.29	–.76	1.54
1995	4.36	—	.95	—	–.61
Mean*	3.00	4.21	4.26	3.15	3.18
RMSE*	—	1.25	1.82	.86	1.35
Mean**	3.22	—	3.71	—	2.54
RMSE**	—	—	2.17	—	2.37

* 1990–94.
** 1990–95.

result is obtained regardless of whether model coefficients are updated each year. Thus, without coefficient updating the real-time 1995 M2 forecast error is 1.6 percentage points, while the corresponding M2B forecast error is 3.4 percentage points. With coefficient updates, the 1995 M2 and M2B forecast errors are 4.4 percent and 5 percent, respectively. For the 1990–95 forecast period as a whole, M2B is no easier to predict than is conventional M2.

Concluding remarks

Understanding the relationship between money growth, interest rates, and spending is important to Federal Reserve policymakers. Movements in money, properly interpreted, are potentially valuable as indicators of current and future spending and future inflation. Moreover, the Federal Reserve is required by law to announce growth projections for the monetary aggregates, and Federal Reserve officials are expected to explain deviations of actual money growth from those projections.

Results presented here suggest that it is important to control for movements in long-term interest rates when explaining M2 growth and that the pace of financial innovation has been gradually accelerating. A money-growth model that takes these influences into account reproduces much (though not all) of the observed weakness in M2 growth in the early 1990s, a period during which several other M2 models have broken down. Evidence that long-term interest rates affect M2 growth and that the pace of financial innovation is accelerating emerges even in samples that end prior to the recent period of M2 weakness. Nearly identical results are obtained for an M2 aggregate expanded to include household bond funds.

The money-growth model estimated in this article can be combined with DRI forecasts of spending and interest rates to yield real-time money-growth predictions. Results are not entirely satisfactory. When its coefficients are held fixed at 1989 levels, the model substantially overpredicts M2 growth during 1992 and 1993. When its coefficients are updated each year, the model does well for 1990 through 1994 but badly underpredicts 1995 M2 growth. If one confines one's attention to the 1990–94 period, coefficient instability appears to be less of a problem when predicting the growth rate of an M2 aggregate expanded to include bond funds than it is when predicting conventional M2. However, preliminary data indicate that 1995 underpredictions are even more serious for the expanded aggregate than they are for M2.

Notes

Anne King and Whitney Andrew provided patient research assistance. Nathan Balke, John Duca, Ken Emery, Joe Haslag, and Yash Mehra offered helpful comments.

1 For a description of the Board model, see Moore, Porter, and Small (1990). Feinman and Porter (1992) document the breakdown of the Board model.

2 For elaboration, see Feinman and Porter (1992) and the articles contained in the November/December 1994 issue of the Federal Reserve Bank of St. Louis'

Review. The earliest attempts to explain the M2 growth slowdown focused on the impact of the savings and loan crisis (Carlson and Parrott 1991, Duca 1993). This line of attack was largely abandoned, however, when slow M2 growth continued well after the thrift crisis had wound down.

3 Recall that the Federal Reserve is legally obligated to provide Congress with money-growth projections.

4 For a more complete discussion, see Koenig (1996).

5 A similar time trend, but with $a_2 = 0$, is included in the M2 growth model developed by Moore, Porter, and Small (1990). Clearly, a time trend may adequately proxy for financial change over one sample period and not over others.

6 Embedding the long-run equilibrium condition within the short-run dynamics of money growth prior to estimation reduces finite-sample bias (Banerjee, Dolado, Hendry, and Smith 1986).

7 Together, equations 1 and 2 imply that

$$\Delta m^*_t = \Delta x_t + (a_2 - a_1) - 2a_2 t,$$

assuming a constant opportunity cost. Thus, the quarterly growth rate of m^* falls by $2a_2$ each quarter. It follows that the annualized growth rate of m^* falls by $8a_2$ each quarter, or $32a_2$ each year.

8 One of the largest changes—relative to its reported standard error—is in the coefficient (a_2) of time squared in the long-run money-demand equation. However, the size of this change may be more apparent than real. It is well known that the estimated coefficients of nonstationary variables have nonstandard distributions. The reported errors for such coefficients are biased downward.

9 However, the model significantly underpredicts M2B growth during the late 1980s. See Koenig (1996) for details.

10 In calculating the opportunity cost, I used the value of the weighting parameter, θ, obtained from estimation of the money-demand model over a 1964–89 sample period.

11 The test statistic is $Q(26) = 26.075$, with p-value 0.459.

12 The weighting parameter, θ, was revised with each new forecast.

13 The pattern of M2B opportunity cost forecasts is similar to the pattern of M2 opportunity cost forecasts shown in Figure 7.

14 The 1995 M2B data displayed in Figures 10 and 11 and summarized in Table 3 are preliminary. In particular, they are not adjusted to exclude IRA and Keogh bond-fund balances, as advocated by Duca (1995, 1994). Data required to make the adjustment are not yet available. However, inflows into IRA and Keogh accounts would have to have been unrealistically large (exceeding total household bond-fund inflows) to have a material impact on the conclusions of this article.

References

Banerjee, Anindya, Juan J. Dolado, David F. Hendry, and Gregor W. Smith (1986), "Exploring Equilibrium Relationships in Econometrics Through Static Models: Some Monte Carlo Evidence," *Oxford Bulletin of Economics and Statistics* 48 (August): 253–77.

Carlson, John B., and Sharon E. Parrott (1991), "The Demand for M2, Opportunity Cost, and Financial Change," Federal Reserve Bank of Cleveland *Economic Review*, Quarter 2, 2–11.

Duca, John V. (1995), "Should Bond Funds Be Included in M2?" *Journal of Banking and Finance* 19 (April): 131–52.

——— (1994), "Would the Addition of Bond or Equity Funds Make M2 a Better Indicator of Nominal GDP?" Federal Reserve Bank of Dallas *Economic Review*, Fourth Quarter, 1–14.

——— (1993), "RTC Activity and the 'Missing M2' " *Economics Letters* 41 (1): 67–71.

Feinman, Joshua N., and Richard D. Porter (1992), "The Continuing Weakness in M2," Finance and Economics Discussion Paper no. 209, Board of Governors of the Federal Reserve System (Washington, D. C., September).

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).

Friedman, Milton (1977), "Time Perspective in Demand for Money," *Scandinavian Journal of Economics* 79 (4): 397–416.

Greenspan, Alan (1993), "Statement to the Congress," *Federal Reserve Bulletin* 79, September, 849–55.

Hallman, Jeffrey J., Richard D. Porter, and David H. Small (1991), "Is the Price Level Tied to the M2 Monetary Aggregate in the Long Run?" *American Economic Review* 81 (September): 841–58.

Hamburger, Michael J. (1983), "Recent Velocity Behavior, the Demand for Money, and Monetary Policy," in *Monetary Targeting and Velocity: Conference Proceedings* (San Francisco: Federal Reserve Bank of San Francisco, 108–28).

——— (1977), "Behavior of the Money Stock: Is There a Puzzle?" *Journal of Monetary Economics* 3 (July): 265–88.

——— (1966), "The Demand for Money by Households, Money Substitutes, and Monetary Policy," *Journal of Political Economy* 74 (December): 600–23.

Koenig, Evan F. (1996), "Long-Term Interest Rates and the Recent Weakness in M2," *Journal of Economics and Business* 48 (May): 81–101.

——— (1994), "The P* Model of Inflation, Revisited," Federal Reserve Bank of Dallas Research Paper no. 9414 (Dallas, September).

Moore, George R., Richard D. Porter, and David H. Small (1990), "Modeling the Disaggregated Demands for M2 and M1: The U.S. Experience in the 1980s," in *Financial Sectors in Open Economies: Empirical Analysis and Policy Issues*, ed. Peter Hooper, Karen H. Johnson, Donald L. Kohn, David E. Lindsey, Richard D. Porter, and Ralph Tryon (Washington, D.C.: Board of Governors of the Federal Reserve System, 21–105).

Orr, Daniel (1970), *Cash Management and the Demand for Money* (New York: Praeger Publishers).

Poole, William (1988), "Monetary Policy Lessons of Recent Inflation and Disinflation," *Journal of Economic Perspectives* 2 (Summer): 73–100.

Appendix
Connecting the Time Trends in the Long-Run and Short-Run Money Equations

This appendix documents why the time trend in equation 3′ takes the form it does. I focus on a version of the M2 growth model that, for simplicity, has been stripped of dummy variables. In the stripped-down model, equation 3 takes the form

$$\text{(A.1)} \quad \Delta m_t = \phi_t + c_4(m^* - m)_{t-1} + c_5\Delta oc_t + c_{5A}\Delta oc_{t-1} + c_6\Delta x_t + c_{6A}\Delta x_{t-1} + c_{6B}\Delta x_{t-2} + c_7\Delta m_{t-1},$$

while equations 1 and 2 can be combined to yield

$$\text{(A.2)} \quad m^*_t = a_0 - a_1 t - a_2 t^2 - a_3 oc_t + x_t.$$

What form must ϕ_t take to have $E(\Delta m_t) = E(\Delta m^*_t)$ for all t? Empirically, oc_t is stationary. Hence, $E(\Delta oc_t) = 0$. Similarly, the stationarity of Δx_t implies that $E(\Delta x_t) = E(\Delta x_{t-1}) = E(\Delta x_{t-2}) \equiv E(\Delta x)$. Taking the expectation of equation A.1 and the expectation of the first difference of A.2 yields

$$\text{(A.3)} \quad E(\Delta m_t) = \phi_t + (c_6 + c_{6A} + c_{6B})E(\Delta x) + c_7 E(\Delta m_{t-1}),$$

and

$$\text{(A.4)} \quad E(\Delta m^*_t) = (a_2 - a_1) - 2a_2 t + E(\Delta x).$$

It follows that $E(\Delta m_t) = E(\Delta m^*_t)$ for all t only if

$$\text{(A.5)} \quad \phi_t = c_0 - 2a_2[t - c_7(t-1)],$$

where

$$\text{(A.6)} \quad c_0 = (a_2 - a_1)(1 - c_7) + (1 - c_6 - c_{6A} - c_{6B} - c_7)E(\Delta x).$$

Equation A.5 has the same form as equation 5 in the text.