10-1-1986

# Interest Rate Volatility and the Demand for Money

James McGibany
*Marquette University*, james.mcgibany@marquette.edu

Farrokh Nourzad
*Marquette University*, farrokh.nourzad@marquette.edu

Published version. *Quarterly Review of Economics and Business*, Vol. 26, No. 3 (Autumn 1986): 73-83.

Quarterly Review of Economics and Business
Vol. 26, No. 3 (Autumn 1986)


# Interest Rate Volatility and the Demand for Money*

*James M. McGibany* and *Farrokh Nourzad*

Since 1979, the US economy has witnessed a noticeable increase in the volatility of interest rates.[1] Several explanations for this phenomenon have been offered in the literature. For example, Paul Evans [6] has asserted that the increased interest rate volatility can be attributed in large part to the October 1979 change in the Federal Reserve operating procedure.[2] Others (for example, Angelo Mascaro and Allen H. Meltzer [16] and John A. Tatom [23]) have argued that the higher interest rate volatility can be linked to the recent increase in money growth variability.

Benjamin Friedman [8], among others, has argued that the recent increase in interest rate volatility has led to greater uncertainty in financial markets. Theoretically, this can lead to a reduction in aggregate demand and/or aggregate supply, resulting in a decline in output. Increased interest rate volatility can reduce aggregate demand by increasing the demand for money or by reducing private spending. On the other hand, more volatile interest rates can reduce aggregate supply by increasing the variability of sales expectations, cash flows, or profits.[3]

Recently, several empirical studies have examined the extent to which more volatile interest rates have affected the US economy since 1979. Evans [6] and Tatom [22, 23] have found that interest rate volatility has exerted a significant negative effect on output over the past several years. While Evans' analysis implies that more volatile interest rates have reduced output by reducing aggregate demand, Tatom finds that this effect has been transmitted predominantly through reduced aggregate supply. However, given the reduced-form nature of the models used in these studies, no inference can be drawn from them regarding the channel(s) through which interest rate volatility has affected aggregate demand or aggregate supply.

In this article, we are concerned with the demand-side effect of interest rate volatility. In particular, we wish to examine whether money demand has been a channel of influence through which increased interest rate volatility might have affected aggregate demand since 1979. For this purpose, we first specify and estimate a quarterly model of money demand and examine its properties. We then add to this model a measure of volatility of interest rates, and re-estimate the expanded model to investigate the effect of this variable on money demand. Further, to allow for the role of expectations, we also specify versions of our model in which anticipated and unanticipated interest rate volatility are included separately and jointly. In general, we find evidence supporting the hypothesis that interest rate volatility exerts a direct influence on money demand, independent from the effect of the level of interest rates. However, we find that we cannot discriminate between the effects on money demand of anticipated and unanticipated interest rate volatility.

## THE MODEL

In this section, we specify and estimate a quarterly money demand model, which will be used in the next section for testing our hypothesis. For this purpose, we modify a model suggested by Timothy P. Roth [19]. Several factors influenced the choice of this model. First, Roth's model incorporates the major features of traditional models of money demand. Second, his model also includes both the marginal and average tax rates.[4] Given that the recent increase in interest rate volatility overlapped with the Reagan tax cuts, we feel it is important to control for the effect of tax rate changes. Finally, Roth's model also includes a measure of general liquidity in the economy. This is desirable for the kind of model we are interested in, where interest rate volatility is assumed to affect the demand for money through changes in asset portfolio.

We modify Roth's model in a number of ways. First, we specify a quarterly rather than an annual model. This means that we can include only an average tax rate variable in our model, since the necessary data for constructing an aggregate proxy for the marginal tax rate (for example, from the Internal Revenue Service statistics of income) are not available on a quarterly basis. As Roth has pointed out, this might bias our parameter estimate of the average tax rate.

Second, instead of a log-linear specification, we use a first-difference log-linear functional form. Clive W. Granger and Paul Newbold [11] have shown that first differencing helps achieve stationarity and reduces spurious correlation. Further, Stephen K. Layson and Terry G. Seaks [14] have argued that the first-difference specification of money demand is statistically preferable to its level form.

Finally, we include an expected inflation variable in our model. We believe this is necessary given that in the latter part of our sample period (since 1981) both the actual and expected inflation rates have fallen significantly. By incorporating these modifications into Roth's framework, we specify the following money demand model,

$$\Delta\ln(M/P)_t = a_0 + \sum_{i=0}^{3} a_{1+i}\,\Delta\ln R_{t-i} + \sum_{i=0}^{3} a_{5+i}\,\Delta\ln Q_{t-i} + \sum_{i=0}^{3} a_{9+i}\,\Delta\ln T_{t-i} + \sum_{i=0}^{3} a_{13+i}\,\Delta\ln L_{t-i} + a_{17}\,\Delta\dot{P}_t + e_t, \tag{1}$$

where $M$ is the M1 money stock, $P$ is the GNP deflator, $R$ is Moody's AAA bond yield, $L$ represents general liquidity in the economy, $\Delta\dot{P}$ is the expected inflation rate, $Q$ is real GNP, $T$ is an average tax rate (the ratio of personal and corporate tax revenue to the sum of personal and corporate taxable income), $e$ is a random error term, and $t$ is a quarterly time index.

In this specification, following Roth, we use the ratio of nonhuman to human income as a proxy for liquidity.[5] A negative coefficient for this variable is expected. Our expected inflation specification follows that of Tatom [24] and assumes unbiased expectations. Theory suggests that a negative coefficient is to be expected for this variable. In the case of interest rates, the expected sign is once again negative, while that of real income is positive. Finally, we expect a negative coefficient for the tax rate variable. This is because an increase (decrease) in the average tax rate leads to a decrease (increase) in real disposable income resulting in a decrease (increase) in money demand.

Our quarterly analogue of Roth's annual model assumes a maximum lag of three quarters for all explanatory variables other than expected inflation, so that the effect of these variables is traced over a full year.[6] The expected inflation variable is not lagged because it assumes unbiased expectations. For all other variables, we are interested in the sum of the corresponding regression coefficients, the so-called long-run elasticity. We estimated (1) over the period 1948:I–1983:IV, using the Cochrane-Orcutt autoregressive procedure with maximum likelihood estimate of rho. The results are presented in Table 1.

Consider the traditional determinants of money demand, the rate of interest and real income. The former reaches its maximum within-year effect with a lag of one quarter, with the effect diminishing to zero two quarters later, yielding a long-run elasticity of −0.14. In contrast, the maximum effect of real income is reached contemporaneously and diminishes thereafter, resulting in a long-run elasticity of 0.38. These results are generally consistent with short-run money demand estimates.

Next, consider the variables suggested by Roth, the average tax rate and liquidity. Both variables achieve their peak effect in the second quarter, having had an insignificant contemporaneous effect. The long-run elasticities associated with these two variables are −0.10 and −0.19, respectively. Finally, the expected inflation variable has the expected negative sign and is highly significant.[7]

*Table 1*
**ESTIMATED QUARTERLY MONEY DEMAND EQUATION[a], 1948:I–1983:IV**

| | $t$ | $t-1$ | $t-2$ | $t-3$ | $\Sigma^b$ |
|---|---|---|---|---|---|
| $\Delta \ln R$ | −0.03 | −0.09 | −0.03 | 0.0001 | −0.14 |
| | (−1.74) | (−5.50) | (−1.88) | (0.05) | (−4.75) |
| $\Delta \ln Q$ | 0.17 | 0.15 | 0.14 | −0.08 | 0.38 |
| | (2.94) | (2.34) | (2.29) | (−1.31) | (312) |
| $\Delta \ln T$ | −0.02 | −0.07 | −0.02 | 0.001 | −0.10 |
| | (−1.06) | (−4.09) | (−1.35) | (0.09) | (−2.60) |
| $\Delta \ln L$ | −0.006 | −0.10 | −0.08 | −0.01 | −0.19 |
| | (−0.17) | (−2.82) | (−2.32) | (−0.40) | (−2.55) |
| $\Delta \dot{P}$ | −0.50 | | | | |
| | (−5.59) | | | | |
| Constant | −0.41 | | | | |
| | (−0.07) | | | | |
| $\overline{R}^2$ | 0.48 | | | | |
| F | 9.90 | | | | |
| S.E.E. | 2.40 | | | | |
| D.W. | 2.03 | | | | |
| RHO | 0.28 | | | | |
| | (3.38) | | | | |

[a] T-ratios in parentheses.
[b] Totals may not add due to rounding.

To summarize, all estimated long-run (one-year) elasticities have the expected sign and are statistically significant at any reasonable level. Further, the F-statistic indicates that the overall model is significant. Although the adjusted R-squared is relatively low, it is not a cause for concern, as this is typical of money demand models specified in first-difference form (see, for example, R. W. Hafer [12]). It appears that our model fits the data well enough to be used in the next section for testing our central hypothesis.

## THE HYPOTHESIS

In this section, we test the hypothesis that the volatility of interest rates exerts a direct and independent influence on money demand by adding a measure of actual interest rate volatility to the model of the previous section. We also investigate whether anticipated or unanticipated volatility influences money demand.

The rationale for expecting a direct relationship between money demand and interest rate volatility is quite simple. Increased interest rate volatility brings about increased uncertainty and risk in financial markets (see, for example, Edward J. Bomhoff [3] and Friedman [8]). In a more uncertain environment, one may expect rational economic agents to increase their money holdings relative to (riskier) nonmoney assets. That is, the decision to hold money is responsive not only to the level of interest rates, but also to their volatility. While real money balances are known to be negatively related to the level of interest rates, we expect them to be positively related to the volatility of interest rates, *ceteris paribus.*[8]

To test our hypothesis, we need a measure of volatility of interest rates. We employ a modified version of the measure used by Evans [6]. Our measure, denoted *V*, is the 12-month, moving average standard deviation of the change in the logarithm of the AAA bond yield.[9] We impose a lag structure on this variable consistent with that used in (1). For the reason discussed in the previous paragraph, we expect a positive coefficient for *V*. We estimated the resulting expanded model over the period 1948:I–1983:IV, using the Cochrane-Orcutt autoregressive procedure with maximum likelihood estimate of rho. The results are presented in Table 2.

Consider the variables common to both the model estimated without interest rate volatility (Table 1), and that estimated with the volatility

*Table 2*

**ESTIMATED QUARTERLY MONEY DEMAND EQUATION INCLUDING INTEREST RATE VOLATILITY[a], 1948:I–1983:IV**

| | $t$ | $t-1$ | $t-2$ | $t-3$ | $\Sigma^b$ |
|---|---|---|---|---|---|
| $\Delta\ln R$ | −0.03<br>(−2.26) | −0.08<br>(−5.08) | −0.05<br>(−2.78) | 0.004<br>(0.24) | −0.15<br>(−5.01) |
| $\Delta\ln Q$ | 0.24<br>(4.09) | 0.17<br>(2.62) | 0.14<br>(2.18) | −0.01<br>(−0.15) | 0.54<br>(3.79) |
| $\Delta\ln T$ | −0.02<br>(−1.44) | −0.07<br>(−4.16) | −0.03<br>(−1.91) | −0.001<br>(−0.07) | −0.12<br>(−2.94) |
| $\Delta\ln L$ | −0.02<br>(−0.63) | −0.10<br>(−2.90) | −0.18<br>(−2.44) | −0.03<br>(−0.97) | −0.24<br>(−3.00) |
| $\Delta\dot{P}$ | −0.42<br>(−4.97) | | | | |
| $\Delta\hat{V}$ | 0.01<br>(0.65) | 0.04<br>(1.70) | −0.09<br>(−3.54) | 0.06<br>(3.54) | 0.02<br>(2.87) |
| Constant | −2.49<br>(−2.78) | | | | |
| $\overline{R}^2$ | 0.52 | | | | |
| F | 9.71 | | | | |
| S.E.E. | 2.26 | | | | |
| D.W. | 1.99 | | | | |
| RHO | 0.30<br>(3.73) | | | | |

[a] T-ratios in parentheses.
[b] Totals may not add due to rounding.

measure included (Table 2). The estimated long-run elasticities of these variables in Table 2 are not statistically different from those reported in Table 1, suggesting that the addition of the volatility variables, $V$, does not perturb the structure of our basic model. Finally, observe that the lagged volatility variables are, in general, significant but fluctuate in sign from quarter to quarter.[10] In spite of this, the long-run elasticity of $V$ is positive and statistically significant at any level of significance.

In order to test the joint significance of the volatility variables, we performed an F-test on these variables. The calculated F-statistic of 4.99 indicates that the null hypothesis of no joint effect can be rejected. This is consistent with the fact that the inclusion of interest rate volatility in our basic model of money demand improves the adjusted R-squared from 48 percent to 52 percent. Given that the long-run elasticity of the volatility variable is positive and significant and that the estimated long-run elasticity of the level of interest rates in Table 2 is virtually identical to that in Table 1, our hypothesis that interest rate volatility exerts a direct and discernible effect on money demand can be accepted.[11]

So far, we have not differentiated between anticipated and unanticipated interest rate volatility, in that the volatility variables in Table 2 include both of these components. Both Evans [6] and Tatom [22] have examined the effect on output of anticipated and unanticipated volatility, using annual models.[12] While Evans has found that only lagged unanticipated volatility matters, Tatom has shown that the effects of anticipated and unanticipated volatility cannot be separated in Evans' model. To test whether anticipated or unanticipated volatility matters in a quarterly model of money demand, we follow a procedure suggested by Robert J. Barro [1, 2] and used by Evans and Tatom. According to Barro's method, one should regress interest rate volatility on some relevant information. The predicted values of the regressand are taken to represent the anticipated component of volatility and the prediction errors as the unanticipated component. Using this approach, we regressed $V$ on its past values and a time trend, $t$, and obtained

$$(2) \quad V_t = \underset{(1.85)}{5.07} + \underset{(15.20)}{1.38V_{t-1}} - \underset{(-2.88)}{0.43V_{t-2}} + \underset{(0.68)}{0\ .06V_{t-3}} + \underset{(1.20)}{0.04t} + \hat{U}_t$$

$$\bar{R}^2 = 0.91 \qquad F = 343.04 \qquad D.W. = 1.92.$$

Reestimating (1) with the current and lagged predicted values of interest rate volatility from the above equation included as an additional explanatory variable, $\hat{V}_{t-i}$, $i = 0, 1, 2, 3$, yields the results reported in Table 3. Once again, the estimated long-run elasticities associated with all other explanatory variables are not statistically different from those reported in Tables 1 and 2. As in the case of the actual interest rate volatility (Table 2), the parameter estimates of anticipated volatility fluctuate in sign, and the resulting long-run elasticity is positive and significant. However, in the

*Table 3*

**ESTIMATED QUARTERLY MONEY DEMAND EQUATION INCLUDING ANTICIPATED INTEREST RATE VOLATILITY,[a] $\hat{V}$ 1948:I–1983:IV**

| | $t$ | $t-1$ | $t-2$ | $t-3$ | $\Sigma$[b] |
|---|---|---|---|---|---|
| $\Delta\ln R$ | −0.04<br>(−2.45) | −0.07<br>(−5.01) | −0.05<br>(−3.21) | 0.01<br>(0.32) | −0.15<br>(−5.02) |
| $\Delta\ln Q$ | 0.22<br>(3.74) | 0.11<br>(1.70) | 0.19<br>(2.95) | −0.006<br>(−0.09) | 0.51<br>(3.71) |
| $\Delta\ln T$ | −0.03<br>(−1.44) | −0.07<br>(−4.21) | −0.03<br>(−1.94) | 0.004<br>(0.42) | −0.12<br>(−2.99) |
| $\Delta\ln L$ | 0.03<br>(−0.85) | −0.08<br>(−2.31) | −0.10<br>(−2.92) | −0.03<br>(−0.80) | −0.24<br>(−2.93) |
| $\Delta\dot{P}$ | −0.44<br>(−5.44) | | | | |
| $\Delta\hat{V}$ | 0.03<br>(2.65) | −0.06<br>(−3.82) | 0.06<br>(3.96) | −0.01<br>(−1.17) | 0.02<br>(2.52) |
| Constant | −2.33<br>(−2.58) | | | | |
| $\bar{R}^2$ | 0.56 | | | | |
| F | 10.75 | | | | |
| S.E.E. | 2.19 | | | | |
| D.W. | 1.97 | | | | |
| RHO | 0.36<br>(4.44) | | | | |

[a] T-ratios in parentheses.
[b] Totals may not add due to rounding.

present case, the contemporaneous effect is (positive) significant, while the three-quarter lagged effect is negative but insignificant.

Before any conclusion can be drawn from the above findings, we must examine the possible effects of unanticipated volatility on money demand. For this purpose, we reestimated (1) including the current and lagged prediction errors of $V$ from (2), $\hat{U}_{t-i}$, rather than $\hat{V}_{t-i}$, $i = 0, 1, 2, 3$. The results are reported in Table 4. Once again, as in the case of the actual interest rate volatility (Table 2), the coefficient of the contemporaneous unanticipated volatility is insignificant. Further, the one-quarter lagged unanticipated volatility is positive and significant at the 10 percent level. However, the resulting long-run elasticity is not statistically different from zero. The latter finding, coupled with that regarding the significant positive long-run elasticity of anticipated volatility may lead to the conclusion that only anticipated interest rate volatility has any discernible effect on money demand.

In general, this result is appealing both theoretically and intuitively. However, given that the contemporaneous effect of unanticipated volatility,

*Table 4*

**ESTIMATED QUARTERLY MONEY DEMAND EQUATION INCLUDING UNANTICIPATED INTEREST RATE VOLATILITY,[a] $\hat{U}$ 1948:I–1983:IV**

| | $t$ | $t-1$ | $t-2$ | $t-3$ | $\Sigma$[b] |
|---|---|---|---|---|---|
| $\Delta \ln R$ | −0.04. (−2.38) | −0.07 (−4.75) | −0.05 (−2.95) | 0.007 (0.47) | −0.15 (−4.52) |
| $\Delta \ln Q$ | 0.21 (3.36) | 0.10 (1.46) | 0.16 (2.40) | −0.05 (−0.78) | 0.46 (2.84) |
| $\Delta \ln T$ | −0.02 (−1.61) | −0.07 (−4.26) | −0.03 (−1.50) | 0.005 (0.35) | −0.12 (−2.65) |
| $\Delta \ln L$ | −0.02 (−0.53) | −0.07 (−1.89) | −0.09 (−2.67) | −0.03 (−0.75) | −0.21 (−2.44) |
| $\Delta \dot{P}$ | −0.46 (−5.72) | | | | |
| $\Delta \hat{U}$ | −0.005 (−0.28) | 0.04 (1.88) | −0.04 (−1.99) | 0.02 (1.36) | 0.02 (0.37) |
| Constant | −0.58 (−0.98) | | | | |
| $\overline{R}^2$ | 0.54 | | | | |
| F | 10.07 | | | | |
| S.E.E. | 2.24 | | | | |
| D.W. | 1.99 | | | | |
| RHO | 0.40 (5.08) | | | | |

[a] T-ratios in parentheses.
[b] Totals may not add due to rounding.

$\hat{U}_t$, is insignificant, this conclusion may have to be qualified. As Tatom [22, p. 1011] has pointed out, ". . . unanticipated changes in variables that influence decisions affect those decisions immediately, then, due to information or other adjustment costs, with a lag."

The fact that $\hat{U}_t$ is insignificant implies that in any given quarter unexpected changes in interest rate volatility are incorporated in that quarter's anticipated volatility. Because of this, we should expect the effects on money demand of anticipated and unanticipated changes in interest rate volatility to be inseparable; lagged values of $\hat{U}$ should be insignificant in the presence of contemporaneous anticipated volatility, $\hat{V}_t$. When this was tried, we found that while the coefficient of contemporaneous anticipated volatility remains positive and significant ($t$ = 2.60), one-quarter lagged unanticipated volatility is no longer significant at any level ($t$ = 0.24). This result confirms that we cannot distinguish between the effects of anticipated an unanticipated volatility in our model. The similarity between this finding and that reported by Tatom [22] is striking, although he arrives at this conclusion using an annual model of output, while we obtain it from a quarterly model of money demand.

## SUMMARY

In this article, we have provided evidence pointing to the fact that since 1979 money demand has been influenced by the volatility of interest rates. While money demand has been affected negatively by the level of interest rates, we have shown that it has been influenced positively by the volatility of these rates. We have also found that the effects on money demand of anticipated and unanticipated volatility cannot be separated in our quarterly model of money demand.

In general, the results regarding the effect of actual interest rate volatility are consistent with those of Evans and Tatom who found that increased volatility depressed output after 1979. Evans suggests that this occurred as a consequence of reduced aggregate demand. Our results indicate that money demand may have been one channel of influence through which increased interest rate volatility has adversely affected aggregate demand, and therefore, output since 1979. In addition, our findings concerning the inseparability of the effects on money demand of anticipated and unanticipated volatility are in harmony with Tatom's similar results obtained from a model of output and are contrary to those of Evans.

Analysis of the responsiveness to interest rate volatility of the other channel of influence of aggregate demand, private spending, is a possible extension of our study. On the supply side, the sensitivity to volatility of such factors as the variability of sales expectations and profits should be examined.

## NOTES

* We wish to thank John A. Tatom for his many valuable comments on earlier drafts of this article. Any remaining error is solely our responsibility.

1. For evidence of this see Evans [6, 7] and Tatom [22, 23].

2. Prior to this time, the Federal Reserve targeted the federal funds rate by accommodating any shift in the private demand for or supply of money through changes in nonborrowed reserves. In October 1979, in an attempt to reduce inflation and inflationary expectations, the Federal Reserve switched to controlling money growth by targeting nonborrowed reserves, while allowing interest rates to vary in response to changes in the private demand for or supply of money. For a simple theoretical discussion of alternative operating procedures, see Sellon and Teigen [20]. For analyses of monetary control procedures and interest rate volatility, see Lombra and Struble [15] and Rasche [18].

3. For a discussion of the channels through which increased risk can affect output see Tatom [23], pp. 37–40.

4. Even though the dependency of money demand on tax rates has been established theoretically more than a decade ago (see, for example, Holmes and Smyth [13]), very few recent empirical studies (for example, Tanzi [21]) have included this variable. However, the unusual behavior of velocity in the period

coinciding with the Reagan tax cuts motivated some to include tax rates in their models of velocity (see, for example, McGibany and Nourzad [17]).

5. Nonhuman income is defined as the sum of proprietor's income, rental income, and personal dividend and interest income. Human income is the sum of wages and salaries, other labor income, and transfer payments.

6. Note that the lag structure used in (1) is different from traditional (for example, Goldfeld [9, 10]) money demand models. Carr and Darby [4] have argued that these long-run models fail to capture the contemporaneous effect of changes in monetary aggregates because they do not include monetary shock variables. Since our primary interest is to investigate the effect of interest rate volatility, which serves as a monetary shock variable, we have used the particular lag structure in (1). This will allow us to examine the contemporaneous, as well as the within-year effects of changes in interest rate volatility. In this sense, ours is a short-run model of money demand.

7. In recognition of the fact that the inclusion of the measure of expected inflation may cause an error-in-variable bias, we reestimated (1) using an instrumental variable approach suggested by Durbin [5]. The results were virtually identical to those reported in Table 1.

8. It should be noted that if increased volatility reduces output as Evans [6] and Tatom [22, 23] have shown, then the demand for money would be expected to decline, even if volatility is not directly related to the demand for money. This may also be expected of the effect of inflation on money demand, since, as Tatom [23] has found, increased volatility has a transitory positive effect on inflation. In other words, there may be a simultaneity problem involving some of the right-hand-side variables in our model, resulting in inconsistent estimators given the single-equation estimation technique used in this article. On the other hand, it may be argued that increased volatility does not affect output or prices directly, but only through changes in money demand or private spending (aggregate demand), or changes in the variability of expected sales, profits and cash flows (aggregate supply). Of course, with a lag, there may be a feedback effect from output or inflation to money demand, in which case simultaneity need not be present in the model.

9. Evans uses a 12-month moving average standard deviation of the level of interest rates. As Tatom [22, p. 34] argues, "[i]f risk is measured relative to the expected return, the variability of returns should be measured relative to the mean return. The logarithm of the interest rate provides such a mean-adjusted measure." He uses several alternative measures of the volatility of interest rates, and obtains the most robust results using the 20-quarter standard deviation of the log of the AAA bond yield. We tried several specifications of these alternative measures (1, 2, 6, and 20 quarters), and obtained the most robust results using a four-quarter moving average standard deviation of the *change* in the logarithm of the AAA bond yield. The use of the standard deviation of the change in the log of the interest rate (that is, the percentage change) is suggested by Rasche [18, pp. 48–50].

10. Evans [6] also finds a fluctuating sign pattern for his measure of volatility in his output equation. However, one cannot compare our finding with Evans' since our model uses quarterly data whereas Evans' study is annual.

11. To examine the effect on money demand of interest rate variability prior to the fourth quarter of 1979, we estimated a model similar to that reported in Table 2 over the shorter period 1948:I–1979:IV. While the results pertaining to all variables other than $V$ were generally consistent with those in Table 2, the contemporaneous, lagged, and long-run coefficients of $V$ were not significant at any reasonable level.

12. In a different paper, Tatom [23] analyzes the effects of anticipated and unanticipated volatility on nominal GNP growth, inflation, and output growth using a quarterly model.

## REFERENCES

1. Robert J. Barro, *Money, Expectations, and the Business Cycle* (New York: Academic Press, 1981).

2. ———, "Unanticipated Money Growth and Unemployment in the United States," *Journal of Political Economy,* Vol. 86 (August 1978), pp. 549–80.

3. Edward J. Bomhoff, *Monetary Uncertainty* (Amsterdam: North-Holland, 1983).

4. Jack Carr and Michael R. Darby, "The Role of Money Supply Shocks in the Short-Run Demand for Money," *Journal of Monetary Economics,* Vol. 8 (September 1981), pp. 183–99.

5. James Durbin, "Errors in Variables," *Review of the International Statistics Institute,* Vol. 1 (1954), pp. 323–32.

6. Paul Evans, "The Effect on Output of Money Growth and Interest Rate Volatility in the United States," *Journal of Political Economy,* Vol. 92, (April 1984), pp. 204–22.

7. ———, "Why Have Interest Rates Been So Volatile?" *Federal Reserve Bank of San Francisco Economic Review,* No. 3, (Summer 1981), pp. 7–20.

8. Benjamin Friedman, "Federal Reserve Policy, Interest Rate Volatility, and the U.S. Capital Raising Mechanism," *Journal of Money, Credit, and Banking,* Vol. 14 (November 1982), pp. 721–45.

9. Stephen M. Goldfeld, "The Case of Missing Money," *Brookings Papers on Economic Activity,* No. 3 (1976), pp. 683–730.

10. ———, "The Demand for Money Revisited," *Brookings Papers on Economic Activity,* No. 3 (1973), pp. 577–638.

11. Clive W. Granger and Paul Newbold, "Spurious Regressions in Econometrics," *Journal of Econometrics,* Vol. 2 (July 1974), pp. 111–20.

12. R. W. Hafer, "Monetary Stabilization Policy: Evidence from Money Demand Forecasts," *Federal Reserve Bank of St. Louis Review,* Vol. 67 (May 1985), pp. 21–26.

13. James M. Holmes and David J. Smyth, "The Specification of the Demand for Money and the Tax Multiplier," *Journal of Political Economy,* Vol. 80 (January/February 1972), pp. 179–85.

14. Stephen K. Layson and Terry G. Seaks, "Estimation and Testing for Functional Form in First Difference Models," *Review of Economics and Statistics,* (May 1984), pp. 338–43.

15. Raymond E. Lombra and Frederick M. Struble, "Monetary Aggregate Targets and the Volatility of Interest Rates: Taxonomic Discussion," *Journal of Money, Credit, and Banking,* Vol. 11 (August 1979), pp. 284–300.