

Money Market Rate Variability and the Velocity of Money: Some International Evidence

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Abstract

This paper re-examines the Friedman hypothesis that uncertainty about the future course of money supply growth influences velocity by focusing on the relationship between interest rate variability and the income velocity of money in nine industrialized countries. As an indicator of the stance of monetary policy, we use the money market rate. Cointegration and error-correction modeling techniques are used to test the hypothesis that the variability of the money market rate impacts velocity. Eight of the nine countries studied exhibit a statistical relationship between the variability of the money market rate and the income velocity of money.

I. Introduction

The relationship between monetary uncertainty and the behavior of the income velocity of money has been extensively examined in the literature. Specifically, the relationship between the monetary sector and the real sector rests upon the stable and predictable behavior of velocity. Milton Friedman (1983) suggested there is a relationship between velocity of money and monetary uncertainty. According to the Friedman hypothesis economic agents undertake portfolio adjustments in response to uncertain changes in the growth of the money supply. This uncertainty with respect to money growth induces economic agents to increase their demand for money, thereby reducing velocity. Moreover, if such an increase in money demand takes place in the absence of accommodative monetary policy, interest rates may well rise

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(Hetzl and Mehra, 1989). Mascaro and Meltzer (1983), as well as Spindt and Tarhan (1987), argue that rising interest rates may be partially attributable to increased variability of money growth.

Hall and Noble (1987), Brocato and Smith (1989), Mehra (1989), Fisher and Serletis (1989), McMillin (1990), Payne (1992, 1993), Darrat and Suliman (1994), Lynch and Ewing (1995), Thornton (1995), and Basu and Dua (1996) have focused on the relationship between velocity and money growth volatility using Granger-causality tests; however, the results have been mixed. The previously mentioned research concentrated upon the impact of money growth volatility upon velocity. However, a crucial assumption within Friedman's hypothesis is that the public undertakes portfolio adjustments in response to changes in money growth. Tatom (1985) argues that money growth variability may

lead to interest rate variability, thus failure to acknowledge this may account for the contradictory results of previous studies.¹ As such, the variability in the yields of financial assets may be a more appropriate measure to evaluate Friedman's hypothesis for two reasons. First, it is, after all, a reasonable assertion that economic agents use interest rate information when deciding how to allocate wealth. Second, most central banks around the world use a short-term interest rate, rather than a monetary aggregate, as their principal operating instrument. Central banks typically have greater control over short-term rates than they do over long-term rates; therefore, we take the money market rate as an indicator of the stance of monetary policy. Slovin (1986) and Marquis (1989) provide mixed evidence on the impact of interest rate volatility upon money demand. Katsimbris and Miller (1993) find that nominal interest rates rather than money growth variability affects the behavior of velocity. Payne (1995) provides evidence in the case of the U.S. that variability in the yields of financial assets Granger-cause velocity. The task of this paper is to examine the temporal relationship between volatility of the money market rate and the income velocity of money for nine industrialized countries. Examining the same nine countries, Thornton (1995) concluded that "the volatility of the money supply is of little help in predicting income velocity" (p. 290). We find that the variability of the money market rate helps to predict velocity. Section II describes the data and sets forth the econometric methodology while section III presents the empirical results. Section IV provides concluding remarks.

II. Data and Methodology

Following Thornton (1995), we obtain quarterly data from the International Financial Statistics CD-ROM database for the following nine industrialized countries: Austria, Australia, Canada, France, Germany, Italy, Japan, Switzerland, and United Kingdom. Velocity is measured as the ratio of nominal GNP to the contemporaneous stock of seasonally adjusted narrowly defined money. Availability of data differ across

countries. We use the longest sample period possible for each individual test. Following the literature on testing the Friedman hypothesis, interest rate variability is computed as the eight quarter (current and seven lags) moving standard deviation of the interest rate. Sample periods, by country, are given in the first column of Table 1.

Granger (1986), Engle and Granger (1987), Engle and Yoo (1987), Johansen (1991), Stock and Watson (1987), as well as Johansen and Juselius (1990) have examined the causal relationship between two variables when a common trend exists between them and have emphasized the need to examine the time-series properties of variables used in macroeconomic research. Therefore we begin by examining the time-series properties of the individual variables by conducting unit root tests. A time series containing a unit root follows a random walk and a variable which contains a unit root requires first-differencing to obtain stationarity and is said to be first-order integrated, I(1). A variable that is stationary in level form is I(0). We use the augmented Dickey-Fuller (ADF) test to check for the presence of unit roots. The ADF test is conducted from the ordinary least squares estimation of equation (1).

$$\Delta X_t = \rho_0 + (\rho_1 - 1) X_{t-1} + \rho_2 t + \sum_{i=1}^m \phi_i \Delta X_{t-i} + u_t \quad (1)$$

where X is the individual time-series under investigation, Δ is the first-difference operator; t is a linear time trend; u_t is a covariance stationary random error and m is determined by Akaike's information criterion to ensure serially uncorrelated residuals. The null hypothesis is that X_t is a nonstationary time series and is rejected if $(\rho_1 - 1) < 0$ and statistically significant. The finite sample critical values for the ADF test developed by MacKinnon (1991) are used to determine statistical significance.

A pair of I(1) time series are said to be cointegrated if some linear combination of them is stationary. Tests for cointegration seek to discern whether or not a stable long-run relationship

Table 1
ADF Unit-Root Tests

Country (time period)	Variable	Levels	1st-Differences
Austria (1971:1-95:2)	ln(velocity)	-1.2154	-2.9449**
	σ (money market rate)	-1.9671	-4.6760*
Australia (1971:2-95:4)	ln(velocity)	-1.6805	-2.7698***
	σ (money market rate)	-2.4711	-3.5539*
Canada (1976:4-1995:2)	ln(velocity)	-2.1824	-3.8755*
	σ (money market rate)	-2.4429	-5.7135*
France (1965:1-95:1)	ln(velocity)	-2.3770	-4.2650*
	σ (money market rate)	-2.2223	-3.9973*
Germany (1960:1-89:4)	ln(velocity)	-1.2434	-5.0356*
	σ (money market rate)	-2.3222	-4.3658*
Italy (1972:4-95:2)	ln(velocity)	-1.3144	-5.2584*
	σ (money market rate)	-2.0764	-3.8544*
Japan (1968:3-94:4)	ln(velocity)	-2.1367	-3.0468**
	σ (money market rate)	-3.0020	-3.8466*
Switzerland (1977:3-95:2)	ln(velocity)	-2.6416	-4.1873*
	σ (money market rate)	-2.8068	-3.5429*
UK (1973:4-94:1)	ln(velocity)	-1.1853	-3.0612**
	σ (money market rate)	-2.3699	-3.3462**

Note: *, **, *** denote significance at 1%, 5%, and 10% levels, respectively, as determined by critical values in MacKinnon (1991). "ln" denotes natural log and " σ " denotes the eight-quarter standard deviation of the money market rate. The sample period for Germany ends in 1989:4 to avoid complications from reunification.

exists among a set of variables. The existence of a common trend among velocity and interest rate variability means that in the long-run the behavior of the common trend will drive the behavior of the two variables. Shocks that are unique to one time-series will die out as the variables adjust back to their common trend. In the context of this study, a finding of cointegration would simply mean that the transmission mechanism between the variability of interest and velocity is stable and thus more predictable over long periods. In the presence of a cointegrating relationship the long-run behavior of the two variables will be highly correlated, even though they may diverge considerably in the short run. The

Engle-Granger (1987) procedure will be used to test for the presence of cointegration² between the natural log of velocity and the variability of the short-term interest rate. Given that we are interested in testing to see if the variability of the money market rate impacts velocity, we specify velocity as the dependent variable in the cointegrating equation. If both time series are integrated of the same order then one can proceed with the estimation of the following cointegrating regression:

$$\ln(\text{velocity})_t = a + b \sigma_{mm}_t + e_t \quad (2)$$

where $\ln(\text{velocity})$ denotes the natural logarithm

of velocity, σ_{mm} denotes variability of the money market rate, and e is the error term. The residuals from the above cointegrating regression are then tested for stationarity to determine whether or not the two time-series are cointegrated using the following ADF unit root tests on the residuals:

$$\Delta e_t = \alpha_0 + \delta e_{t-1} + \sum_{i=1}^n \alpha_i \Delta e_{t-i} + v_t \quad (3)$$

where e_t are the residuals from equations (2); v_t represents a stationary random error and n is determined by Akaike's information criterion. The null hypothesis of nonstationarity (not cointegrated) is rejected when δ is significantly negative. If the residuals from (2) are determined to be stationary using ADF unit root tests then the two variables are cointegrated.

If the series are cointegrated then it is appropriate to estimate the following error-correction models to test for Granger-causality.

$$\begin{aligned} \Delta \ln(\text{velocity})_t = & \Psi_0 + \sum_{i=1}^p \Psi_{1i} \Delta \ln(\text{velocity})_{t-i} \\ & + \sum_{i=1}^q \Psi_{2i} \Delta \sigma_{mm}_{t-i} + \gamma e_{t-1} + \varepsilon_t \end{aligned} \quad (4)$$

where $\ln(\text{velocity})_t$ and σ_{mm}_t are first-difference stationary and cointegrated, and e_{t-1} represents the lagged values of the error term from the cointegrating regression given by equation (2). From equation (4) the null hypothesis that $\Delta \sigma_{mm}_t$ does not Granger-cause $\Delta \ln(\text{velocity})_t$ is rejected not only if the coefficients Ψ_{2i} 's are jointly significant but also if the coefficient on e_{t-1} is significant. One can interpret the lagged changes in the independent variable in equations (4) as representing the short-run causal impact while the error-correction term provide the adjustments of $\Delta \ln(\text{velocity})_t$ and $\Delta \sigma_{mm}_t$ towards their respective long-run equilibrium.

In the case where σ_{mm} and $\ln(\text{velocity})$ are not cointegrated then no error-correction term is included in equation (4). Further, when the two variables are integrated of different orders, or when both are $I(0)$, and therefore not cointegrated, the standard Granger-causality test

may be undertaken which examines whether or not inclusion of the lagged values of the independent variable are jointly significant.

III. Empirical Results

The Augmented Dickey-Fuller (ADF) unit root test statistics for the variables in both levels and first-differences are presented in the last two columns of Table 1. Based on the ADF test statistics all variables are integrated of order one, $I(1)$. Given that all the respective time-series are stationary in first-differences, we proceed to test for cointegration between velocity and interest rate variability using the Engle-Granger bivariate methodology outlined above. Equation (2) is estimated by ordinary least squares and the residuals tested for stationarity via ADF unit root tests given by equation (3).³ The second column of Table 2 displays these ADF unit root tests for cointegration.⁴

We find evidence of a cointegrating relationship between money market rate variability and velocity in five of the nine countries investigated. In each of these cases, which occur in Austria, Germany, Italy, Japan, and Switzerland, volatility of the money market rate is cointegrated with velocity. Given these findings, the possibility that short-term interest rate variability may have a long run equilibrium relationship with velocity should not be ignored.⁵

Equation (4) is estimated in order to test the hypothesis that interest rate variability "causes" velocity. Note that when no cointegration was detected, an error-correction term was not included for that particular case. Causality can emerge through the lagged coefficients on changes in σ_{mm} , through the error-correction term, or both. The standard Granger test is conducted by constructing an F-statistic that tests the null hypothesis of the joint insignificance of the coefficients on the lagged values of changes in σ_{mm} . Interest rate variability is said to Granger-cause velocity if the prediction error of current velocity declines by using past values of σ_{mm} in addition to past values of velocity. Rejection of the null indicates that σ_{mm} causes velocity in a

Table 2
Cointegration Results and Model Results

Country	Engle-Granger ADF	Lag Structure	F-statistic	EC
Austria	-3.2206**	8, 1	0.0126	-0.0533***
Australia	-0.7106	2, 1	11.3842*	
Canada	-1.9651	2, 1	1.6597	
France	-0.9920	4, 6	2.0518***	
Germany	-3.4612**	2, 1	0.2172	-0.0664***
Italy	-3.1816**	1, 1	2.1115	-0.0524**
Japan	-3.0940**	2, 1	3.5915***	-0.0683***
Switzerland	-3.2939*	2, 8	1.2715	-0.0429***
United Kingdom	-0.7050	1, 1	3.7962**	

Note: *, **, *** denote significance at the 1%, 5%, 10% levels, respectively, as determined by critical values in MacKinnon (1991). The Granger-causality F-statistic tests the hypothesis that all the coefficients on σ_i are zero. The lag structure (p, q) on $\Delta \ln(\text{velocity})$ and $\Delta \sigma_{mm}$ used in the estimation of equation (4) was determined by the AIC criterion. EC is the estimated coefficient on the error-correction term, if included.

Granger sense. Additionally, a significant coefficient on the error-correction term indicates causality. Since Granger tests may be sensitive to choice of lag structure, with too few lags resulting in biased estimates and too many lags leading to unbiased but inefficient estimates, Akaike's Information Criterion (AIC) method was used to determine optimal lag lengths. Table 2 presents the results from estimating equation (4).⁶

We begin by discussing the results of the Granger-causality tests for the cases in which no cointegration was detected. In these cases, equation (4) does not include an error-correction term. For Australia, France and the United Kingdom, the variability of the money market rate Granger-causes velocity at conventional levels of significance. The variability of the money market rate helps to predict velocity in these countries. In each of the countries that exhibited no cointegration between interest rate variability and velocity, except for the case of Canada, we detect evidence of a causal relationship between them. The lack of a finding for Canada is consistent with the results of Haug and Lucas (1996) who are unable to provide robust support for a


velocity specification of money demand using Canadian data.

For the cases of Austria, Germany, Italy, Japan, and Switzerland, where a cointegrating vector is present, the error-correction term is included in the estimation of equation (4). In each case, the error-correction term is negative and statistically significant. This indicates that the variability of the money market rate establishes a long run equilibrium with velocity. The size of the error-correction coefficient may be interpreted as a measure of the speed at which velocity adjusts to a change in equilibrium conditions. The coefficients on the error-correction terms are pretty close in absolute value and imply that the movement of velocity towards eliminating disequilibrium within one quarter is somewhere between 4-7%, with the fastest adjustment occurring in Japan and the slowest in Switzerland. Additionally, the Granger-causality F-statistic is significant in the case of Japan when we estimate the error-correction model. These findings complement the mixed results reported by others appearing in the literature.

IV. Concluding Remarks

This paper tested for a relationship between the volatility of the money market rate and the income velocity of money using data from nine industrialized countries. Given that all variables were found to be first-difference stationary, we performed cointegration tests. Based on the findings, and where appropriate, we augmented the standard Granger-causality models with error-correction terms. The results indicate that the variability of this short-term interest rate may help to predict velocity. Eight of the nine countries studied exhibit a statistical relationship between interest rate variability and velocity. The results are an important empirical addition to the debate on the conduct of monetary policy. In particular, these findings may be used as support for policies aimed at reducing interest rate volatility and suggest an avenue for reducing financial market uncertainty.

V. Suggestions For Future Research

The findings of this paper suggest two avenues for further investigation. First, given that velocity of money depends on the volatility of the short term money market rate in eight of the nine industrialized countries studied, it would be useful to determine if the relationship holds for other, less developed, economies. Second, it has been suggested by some that money growth variability has an adverse effect on national output; thus, a natural extension of this line of research is to examine the impact of interest rate variability on real output. The answers to both of these queries would aid central bankers in developing better monetary policy. 

The authors thank Dawn Anderson Scott for her valuable research assistance. Professor Ewing gratefully acknowledges support from a GSU College of Business Administration Summer Research Grant.

Endnotes

1. In a related line of research, Evans (1984), Tatom (1985), and McMillin (1988) ex-

amine the impact of money growth and interest rate variability upon the macroeconomy.

2. The results are confirmed using the Johansen (1991) methodology.
3. To conserve space cointegrating regression results are available upon request from the authors.
4. For the stationarity tests of the residuals from the cointegrating regressions the number of lags on the augmenting term was determined by choosing the lag structure that minimized Akaike's information criterion. This method of choosing the variable lag length from the data has been shown by Hall (1994) to considerably improve the ADF unit root test.
5. As a check of the results we also conducted likelihood ratio tests developed by Johansen (1991) to test for cointegration. The Johansen procedure does not require the researcher to arbitrarily select which variable will be on the left-hand side of the equation and which will be on the right-hand side. Though not reported here in the interest of brevity, these tests confirmed the ADF findings.
6. No evidence of autocorrelation was detected based on Ljung-Box tests. Additionally, CUSUM tests suggested parameter stability and the models estimated were free of structural change based on the Chow test.

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