VELOCITY AND THE VARIABILITY OF YIELDS ON FINANCIAL AND OTHER ASSETS

by James E. Payne*

Abstract

This paper examines the effects of the variability of yields on financial and other assets upon M1 velocity. The empirical results present some evidence that the variability in the yields on financial assets Granger-cause velocity.

I. Introduction

This paper extends the money growth variability-velocity debate that has emerged in the literature. It addresses the effect of the variability in the yields of several financial and other assets upon M1 velocity. As Friedman (1983, 1984) has argued, the heightened variability of money growth corresponding to the Federal Reserve's October 1979 shift to nonborrowed reserves targeting, generated uncertainty about monetary policy. In turn, uncertainty about money growth induced the public to increase their demand for money. This, according to Friedman, explains the 1982 decline in M1 velocity. In addition, if such an increase in money demand takes place in the absence of accommodative monetary policy, then interest rates may rise (Hetzel and Mehra, 1989). Mascaro and Meltzer (1983) as well as Spindt and Tarhan (1987) attribute the high nominal interest rates of the post-1979 period to increased variability of money growth.[1]

Hall and Noble (1987) investigated Friedman's hypothesis within a Granger-causality framework. They found that money growth variability Granger caused velocity over a quarterly time frame 1963:1 to 1984:2. Using monthly data, Brocato and Smith (1989) separated the pre- and post-1979 periods: the pre-1979 period confirmed the results of Hall and Noble while the post-1979 period yielded no causal influence of money growth variability upon velocity. Mehra (1989), over a quarterly period 1963:1 to 1987:4, adjusted for the presence of unit roots in both velocity and money growth variability time series. His findings suggest that when denoted in first-differences money growth variability does not help predict velocity in the Granger-causality sense. Fisher and Serletis (1989) examine nine measures of velocity over a monthly period 1970:02 to 1985:07 and found that money growth variability Granger-causes velocity growth. McMillin (1990), within a multivariate time series model, found that the erratic behavior of velocity in recent years does not reflect unusual variability in the determinants of velocity, but a shift in the process generating velocity.

The above research has concentrated upon the impact of money growth volatility upon velocity; however, a key assumption within Friedman's hypothesis is that the public undertakes portfolio adjustments in response to changes in money growth. We argue that perhaps a more appropriate measure to evaluate when making portfolio adjustments is the variability in the yields of financial and other assets. Slovin and Sushka (1983) demonstrated that greater interest rate variability increases money demand. Using a policy variant model of money demand, Falls and Zangeneh (1989) found that interest rate variability is insignificant, in contrast to Slovin and Sushka's findings. Garner (1986) found interest rate variability to have a negative impact upon money demand over the period 1959 to 1973. He argues that this may be due to inflation uncertainty dominating the relatively constant real interest rate. However, Garner found interest rate variability to have a positive yet insignificant effect upon money demand over the period 1976 to 1984. Furthermore, Marquis (1989), within a partial equilibrium model of household money demand, rejected the hypothesis that greater short-term interest rate variability increases money demand. Thus, as can be seen, the empirical evidence on the impact of interest rate variability upon money demand and hence velocity is mixed.

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The task of this paper is severalfold. First, like previous work on money growth variability, we investigate the effect of the variability of yields on financial and other assets upon velocity within a Granger-causality framework. In the implementation of the Granger-causality tests we explicitly test for the presence of unit roots as well as address the possibility of cointegration and its importance in tests of Granger-causality. Second, we analyze five periods: (1) full period 1960:1 to 1990:4, (2) pre-1979 period 1960:1 to 1979:3, (3) post-79 period 1979:4 to 1990:4, (4) pre-1982 period 1960:1 to 1981:4, and (5) post-1982 period 1982:1 to 1990:4, to determine whether or not the variability of yields on financial and other assets Granger-cause velocity. Third, the analysis will utilize four measures of yields on financial and other assets based upon Friedman's quantity theory of money. The variability measures are constructed from long-term and short-term interest rates, yield on equities as well as the return on physical assets. Section II will discuss the Granger-causality framework augmented to include an error correction term, as well as provide the empirical results and concluding remarks.

II. Methodology, Results and Concluding Remarks

The question addressed with respect to methodology is whether the standard Granger-causality framework is appropriate or whether it should be augmented to include an error-correction term. Recently, work by Granger (1986), Engle and Granger (1987) as well as Engle and Yoo (1987) have examined the causal relationship between two variables when a common trend exists between them. In general, if two time series, x_t and y_t, are nonstationary, but some linear combination of them is a stationary process, then x_t and y_t are said to be cointegrated. A time series is said to be stationary if its mean, variance, and covariances are all invariant with respect to time, and is denoted I(0), meaning integrated of order zero. If the time series requires first-order differencing to achieve stationarity, it is denoted I(1), meaning integrated of order one. Any linear combination of two I(1) time series will also be an I(1) series. However, if there exists some linear combination of the two series which is I(0), then cointegration exists. The presence of cointegration considers the possibility that the lagged level of a variable y_t may aid in explaining the current change in x_t even if past changes in y_t do not. Indeed, if x_t and y_t are cointegrated, then the current change in x_t is partially the result of x_t adjusting to the trend value of y_t.[2]

First, we need to determine whether or not velocity and the respective variability measures of the yields on the financial and other assets are I(1) via the following augmented Dickey-Fuller (ADF) test:

$$\Delta x_t = \alpha_0 + \delta x_{t-1} + \sum_{i=1}^{n} \phi_i \Delta x_{i-l} + \epsilon_t \qquad (1)$$

where Δ is the first difference operator; ϵ_t is a stationary random error and n is chosen to ensure serially uncorrelated residuals. The null hypothesis is that x_t is a nonstationary series (requiring first-order differencing, I(1), to be stationary) and is rejected if $\delta < 0$ and statistically significant.[3] If the respective time series are difference stationary processes, I(1), then cointegrating regressions (see footnote 2) can be undertaken to determine whether or not the residuals are stationary.

Before analyzing the unit root and cointegration tests we need to discuss the data used in this study. Velocity, V_t, is based upon the Ml money supply measure. The short-term interest rate is proxied by the six-month commercial paper rate while the long-term interest rate is given by Moody's AAA corporate bond yield. The yield on equities is the dividend-price ratio plus the capital gain yield for Standard and Poor's Composite Common Stock Price Index. The return on physical assets is proxied by the expected rate of inflation.[4] The expected rate of inflation was constructed from an AR(2) model of inflation based upon the GNP implicit price deflator as follows:

$$\underset{}{(1 - \underset{(.08455)}{.50788B} - \underset{(.08469)}{.34461B^2})}\ \pi_t = a_t$$

$$Q(18) = 20.57 \qquad D.F. = 16 \qquad S.E.E. = .0042 \qquad (2)$$

where the standard errors are in parentheses. The stationarity conditions are fulfilled. The Box-Pierce Q-statistic tests the joint hypothesis that all autocorrelation coefficients are zero. The critical value at the 5 percent significance level is 24.996; thus we fail to reject the null hypothesis that all the autocorrelation coefficients are zero. Therefore, a decomposition of inflation into its expected and unexpected components can be achieved. The forecasts generated by the AR(2) model are then used as measures of expected inflation. The above yields on financial and other assets are then converted to variability measures using an eight-quarter moving standard deviation of each of the series.[5]

Table 1A displays the results of the augmented Dickey-Fuller tests. Each of the variables fail to reject the null hypothesis suggesting that each of the respective variables are non-stationary which requires first-order differencing to achieve stationarity.[6] Given that each of the respective variables are integrated of order one I(1), we next perform cointegration tests, following Engle and Yoo (1987), to determine if cointegration exists. Table 1B shows that we fail to reject the null hypothesis of no cointegration in each of the four cases. Thus, instead of Granger-causality tests augmented to include an error correction term we simply use the standard Granger-causality tests. The following regression will provide a test for Granger-causality.

$$\Delta V_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta V_{t-i} + \sum_{i=1}^{q} \alpha_{2i} \Delta \sigma_{j,\,t-i} + \epsilon_t \qquad (3)$$

where Δ is the first-difference operator and the subscript j denotes the alternative yield variability measures to be used. In the implementation of the Granger-causality tests we need to determine the appropriate lag lengths. We use Akaike's final prediction error (FPE) criterion as well as arbitrary lag lengths of 4, 6, and 8 lags. Following Hsiao (1981) we first estimate an autoregressive equation with only lags of velocity on the right-hand side and choosing the number of lags of velocity, p, that minimizes FPE(p) over an interval of ten lags using the following expression:

$$FPE(p) = [(T + p + 1)/(T - p - 1)] * [SSR(p)/T] \qquad (4)$$

where SSR is the sum of squared residuals and T is number of observations. With p chosen to minimize the above expression, the velocity equation is expanded to include lagged values of the variability of yields, q, chosen to minimize the following:

$$FPE(p,q) = [(T + p + q + 1)/(T - p - q - 1)] * [SSR(p,q)/T] \qquad (5)$$

The Granger tests are implemented by first estimating the unrestricted version of Equation (3) to obtain the unrestricted sum of squared residuals, SSR_u. Next, the restricted version of Equation (3) is estimated to obtain the restricted sum of squared residuals, SSR_R. Given both the restricted and unrestricted sum of squared residuals, F-statistics can be calculated under the null hypothesis that all the coefficients of lagged values of the variability of yields are jointly insignificant (all $\alpha_{2i} = 0$) for Equation (3). If the null hypothesis cannot be rejected, then one can conclude that the alternative variability measures do not Granger-cause velocity. However, if the null hypothesis is rejected, then one can conclude that the variability measures do Granger-cause velocity.

TABLE 1A
Augmented Dickey-Fuller Tests
Unit Roots

Variable	ADF
V	−1.877
σ_L	−2.045
σ_S	−2.012
σ_E	−2.718
σ_π	−2.857

In estimating equation (3), the value of n was set at eight which was sufficient to provide for "white-noise" residuals. Critical values are found in Fuller (1976, Table 8.5.2, p. 373) with sample size set at 100. Critical values are −3.45 for the 5% level and −3.15 for the 10% level.

TABLE 1B
Cointegration Tests
Engle-Yoo

Variable	E-Y
σ_L	−1.374
σ_S	−1.395
σ_E	−1.821
σ_π	−1.900

In estimating equation (4), the value of p was set at eight. The critical values for higher-order systems are from Engle and Yoo (1987, Table 3, p. 158). Critical values are −3.17 for the 5% level and −2.91 for the 10% level.

Table 2 presents the results of Granger causality tests. Over the full time frame 1960:1 to 1990:4 the short- and long-term interest rate variability measures are significant at the 5 percent level for the FPE lags with marginal significance at the 10 percent level for the short-term interest rate variability at 4 lags. Also, the equity yield variability measure is significant at the 10 percent level for the FPE lags determined. The pre-1979 period shows the short-term interest rate variability measure is significant at the 10 percent level for the FPE lags and at 6 lags while the variability in equity yield is significant at the 5 percent level for the FPE lags as well as lags 6 and 8. The post-1979 period, corresponding to the Federal Reserve's change in operating procedure, yielded only the long-term interest rate variability measure significant at the 5 percent level for FPE, 4, and 6 lags as well as marginally significant at the 10 percent level at 8 lags. The pre-1982 period suggests that the long-term interest rate variability measure is significant for the FPE lags and at 8 lags while the short-term interest rate variability measure is significant for the FPE, 4, and 6 lags with marginal significance found at the FPE lags for the variability in equity yield. The post-1982 period corresponding to the apparent decline in M1 velocity finds none of the variability measures significant This last finding runs counter to what one would anticipate. If the public does indeed make portfolio adjustments in response to the heightened variability on asset yields, then one would expect that the variability measures would be significant in the post-1982 period.

TABLE 2
Granger Causality Tests
Calculated F-statistics

Time Period	FPE Lags	4 Lags	6 Lags	8 Lags
A. Full Period 1960:1-1990:4				
σ_L	2.897**	1.791	1.566	1.641***
σ_S	3.420**	1.963***	1.527	1.538
σ_E	2.855***	.8349	1.153	.9135
σ_π	5754	8137	1.122	1.065
B. Pre-1979 Period 1960:1-1979:3				
σ_L	.3830	7104	.8257	1.256
σ_S	2.662***	1.945	2.090***	1.549
σ_E	4.403**	1.397	2.831**	2.259**
σ_π	1.893	1.705	1.267	1.131
C. Post-1979 Period 1979:4-1990:4				
σ_L	3.160**	2.859**	2.170**	1.922***
σ_S	2.205	1.041	.9455	.8782
σ_E	.4047	.1968	.2590	.3619
σ_π	2.050	.6454	.7214	.5689
D. Pre-1982 Period 1960:1-1981:4				
σ_L	3.154**	1.547	1.556	1.810***
σ_S	5.628*	2.529**	2.191***	1.707
σ_E	3.949***	.8194	1.570	1.412
σ_π	.2038	.4872	.4698	.6722
E. Post-1982 Period 1982:1-1990:4				
σ_L	.6820	1.309	1.143	.9084
σ_S	.5447	.5553	.6324	.6574
σ_E	.0165	4355	.2822	.5516
σ_π	.4056	.6296	.5783	1.018

*Significant at the 1 percent level.
**Significant at the 5 percent level.
***Significant at the 10 percent level.

In conclusion, this paper has examined the effect of the variability of alternative measures of yields on financial and other assets upon M1 velocity. Appealing to Friedman's quantity theory of money we analyze the impact of the variability of a short-term interest rate, long-term interest rate, yield on equities, and expected inflation in a Granger sense upon velocity. We find some evidence that variability in the short-term interest rate and in some cases the long-term interest rate have an impact upon velocity. The variability in the yield on equities is significant over the full period as well as the pre-1979 and pre-1982 periods while variability in expected inflation does not have any significant effect upon velocity in any of the periods analyzed. Perhaps the absence of statistical significance of any of these variability measures upon velocity in the post-1982 period may be attributed to the Federal Reserve's policy of smoothing interest rates by using borrowed reserves as an operating target. Unlike previous studies, it seems that in addition to money growth variability the variability of interest rate measures Granger-cause velocity.

Notes

1. For a more detailed discussion of the macroeconomic effects of both money growth and interest rate volatility, see Evans (1984), Tatom (1985), and McMillin (1988).
2. To examine Granger-causality when the two variables are cointegrated, the following error correction specification is warranted:

$$\Delta x_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta x_{t-i} + \sum_{i=1}^{q} \beta_{2i} \Delta y_{t-i} + a u_{t-1} + \epsilon_t \quad (1)$$

where Δx_t and Δy_t are first-difference stationary and cointegrated time series with u_{t-1} as the lagged value of the error term from the following cointegrating regression run in levels:

$$x_t = \gamma y_t + u_t \quad (2)$$

where u_t must be stationary. The null hypothesis that y_t does not Granger cause x_t is rejected not only if the coefficients β_{2i} are jointly significant but also if the coefficient on u_{t-1} is significant. If the residuals from the cointegrating regression are stationary then cointegration exists. We test the null hypothesis that x_t and y_t are not cointegrated by implementing the ADF test with respect to the residuals from the cointegrating regression as follows:

$$\Delta u_t = \alpha_0 + \rho_1 u_{t-1} + \sum_{i=1}^{p} \rho_i \Delta u_{t-1} + v_t \quad (3)$$

where u_t is the residual from the cointegrating regression; v_t is a stationary random error. The null hypothesis of nonstationarity (not cointegrated) is rejected when ρ_1 is significantly negative. Indeed, if cointegration does not exist then an error correction model is inappropriate.
3. Engle and Granger (1987) examine the properties of seven tests for unit roots. Engle and Granger (1987) prefer the ADF test due to the stability of its critical value as well as its power over different sampling experiments.
4. According to Friedman's quantity theory of money the rate of return for the possession of a physical good such as gold is reflected in the rate of inflation. Thus, the value may appreciate or depreciate in money value (see Friedman, 1956, p. 7). As a note the physical assets in question are nondepreciable.
5. Previous studies by Hall and Noble (1987), Mehra (1989), and McMillin (1988, 1990) utilize an eight-quarter moving standard deviation of money growth. For comparison purposes we construct the variability of yields on financial assets using a similar interval of eight quarters. Variability in long-term interest rates is denoted by σ_E, short-term interest rates by σ_S, yield on equities by σ_E, and the return on physical assets by σ_π.
6. Second-order unit roots were not present in the data.

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