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VELOCITY AND THE VARIABILITY OF MONEY GROWTH: EVIDENCE FROM GRANGER-CAUSALITY TESTS REEVALUATED

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ABSTRACT

Hall and Nobel (1987) use the Granger-causality test to show that volatility influences velocity, leading them to conclude that the recent decline in the velocity of M1 is due to increased volatility of money growth which is alleged to be caused by the Federal Reserve's new operating procedures. This note shows that such a conclusion is unwarranted, because the causality result reported in their paper is not robust. When the test is implemented either using first differences of the volatility variable or using the volatility and velocity variables that are based on the broad definition of money or over the sample period that includes the 1985-86 episode of the decline in the velocity of M1, then the test results do not support the inference that volatility influences velocity.

Velocity and the Variability of Money Growth: Evidence from Granger-causality Tests Reevaluated

It is now a common knowledge that the velocity of M1, conventionally measured by the ratio of nominal GNP to contemporaneous money, has behaved abnormally over the 1980s. It fell sharply first in 1982-83 and then in 1985-86. As a result, the velocity of M1, which had previously grown approximately at an annual average 3.0 percent over the 1961 to 1980 period, in fact declined at an annual average 2.3 percent over the 1981 to 1986 period. Some analysts[1] contend that the decline in velocity was caused by the increased volatility of money growth following the announced change in Federal Reserve operating procedures in October, 1979. The main argument is that increased volatility of money growth raised the degree of perceived uncertainty and thereby contributed to increasing the demand for money (or, equivalently, reducing the velocity of money).

Recently, Hall and Noble (1987) has presented evidence in support of the aforementioned money growth volatility hypothesis. They use the Granger-causality method to show that volatility influences velocity.

The main purpose of this note is to argue that the empirical evidence that is produced to prove the existence of Granger-causality between money growth volatility and income velocity is not robust. Hall and Noble (1987) implement causality tests using levels of the volatility variable, assuming implicity that the level of money growth volatility is a stationary time series. However, tests for unit roots that are presented here suggest that such an assumption is not consistent with the data and that the level

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[1] Friedman (1983) and Mascaro and Meltzer (1983).

of money growth volatility is a nonstationary time series that is dominated by a stochastic trend. Hence, when causality tests are implemented using first differences of the money growth volatility variable, test results do not support the inference that volatility influences velocity. Furthermore, the inference that volatility influences velocity is not robust with respect to the broad measures of money used in defining velocity and volatility. And when we consider the 1985-86 episode of decline in the velocity of M1, the bit of favorable evidence that is reported in Hall and Noble (1987) also disappears.

The plan of this note is as follows. The next section provides a discussion of the motives for using the broad measures of money and for conducting tests for the existence of trends in the time series that are used in conducting the Granger-causality tests. Section II presents empirical results.

I

1. Levels or First Differences of the Volatility Variable

In order to implement tests of Granger-causality Hall and Noble (1987) estimate the following regression (1):

$$\dot{V}_t = \alpha_o + \sum_{s=1}^{p} \alpha_s \dot{V}_{t-s} + \sum_{s=1}^{q} \beta_s VOL_{t-s} + \varepsilon_t \qquad (1)$$

where $\dot{V}$ is the growth rate of M1 velocity, and VOL is the measure of the volatility of money growth, which is calculated as an eight-quarter standard deviation of money growth, and ε is a well-behaved disturbance term. Tests of Granger-causality are then based on the computed values of the F statistics that test all coefficients of the lagged values of VOL are jointly insignificant (all $\beta_s = 0$ in (1)).

An important assumption that underlies the regression (1) is that VOL is a stationary time series and that it does not have unit roots. This is an important maintained assumption, the violation of which could generate incorrect inferences about the causal role of money growth volatility in explaining velocity. Quite recently, Sims, Stock and Watson (1986), Ohanian (1986), and Christiano and Ljunqvist (1987) have provided evidence that the asymtotic distributions of causality tests are sensitive to unit roots and time trends in the time series. In particular, the F-statistics in such cases could have non-standard distributions. Hence, before implementing Granger-causality tests it might be important to examine the unit root and time trend properties of the time-series.

The evidence that is presented in the next section show that levels of velocity and volatility are nonstationary time series that are dominated by stochastic trends. As a result, causality tests that are based on levels of the volatility variable do not have the standard F distributions. Hence, the inference that is based on the standard F-test is suspect.

2. Sources of the Decline in Velocity: Money Growth Volatility or Financial Deregulation?

Hall and Noble (1987) focus primarily on the behavior of M1 velocity over the period 1963Q1 to 1984Q2. The period studied includes the 1982-83 episode of the decline in the velocity of M1, which infact was preceded by a large increase in the volatility of M1 growth. However, the velocity of M1 declined again in 1985-86, and this decline in velocity was neither preceded nor accompanied by any perceptible increase in the volatility of M1 growth. This suggests other factors might be at work in causing M1 velocity to decline.

Several analysts[2] have in fact argued that the observed decline in the velocity of M1 is due in part to the recent round of financial deregulation - the introduction nationwide since 1981 of interest-bearing NOWs and SuperNOWs. This financial development could have affected M1 demand (and therefore its velocity) in two interrelated ways. First, the beginning of the payment of explicit, nominal interest rates on some components of M1 means an increase in the own rate of return on money, which could have contributed to an increase in the publics' demand for money and hence to a decline in the velocity of M1. Second and more importantly, because some components of M1 (such as NOWS and SuperNOWs) pay explicit rates the differential that exists between the rates paid on such components and the rates paid on substitute, savings-type accounts (assets that are included in M2 and M3 but not in M1) has declined sharply over the last few years. As a result, the public has been willing to substitute more than before between components of M1 on the one hand and substitute, savings-type non-M1 components of M2 and M3 (such as time deposits, savings deposits, money market mutual funds, and money market deposits) on the other. This could make M1 appear more volatile.

These considerations have an important implication for the volatility hypothesis that is examined in Hall and Noble (1987). In conducting test of the hypothesis - the decline observed in the velocity of M1 is due to the <u>policy-induced</u> increase in the volatility of money growth - one must control for the aforementioned effect of financial deregulation on the volatility of money demand. Since the broad measures of money are

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[2] Kretzmer and Porter (1986), Mehra (1986), Wenninger (1986), and Trehan and Walsh (1987).

likely to internalize such deregulated-induced substitutions by the public tests of the volatility hypothesis should also be conducted using volatility measures that are based on the broad definition of money. Such volatility measures should continue to Granger-cause velocity if the volatility hypothesis is valid.

The empirical work that is reported here therefore implements tests of causality using, in addition, measures of velocity and volatility which are based on the broad definition of money. Furthermore, the causality tests are also implemented over the longer sample period 1963Q1 to 1986Q4, the period that includes the 1985-86 episode of decline in the velocity of M1.

II

Empirical Results

This section presents results of investigating the presence of stochastic trends in the time series on log levels of income velocity and levels of money growth volatility, which are defined using three alternative measures of money - M1, M2, and M3. The Granger-causality tests are also reported in this section. The data consist of quarterly observations over 1963Q1 to 1986Q4.

1. Unit Root Tests

It is now widely recognized that many macro economic series appear to contain units roots (e.g. Nelson and Plosser (1982), Stock and Watson (1986 a,b)), suggesting that levels of such series are nonstationary. As shown in Dickey and Fuller (1979, 1981), one could implement tests for the presence of unit roots in series by estimating the following regression

$$\Delta X_t = a + b\,T + c\,X_{t-1} + \sum_{s=1}^{p} ds\,\Delta\,X_{t-s} + \varepsilon_t \qquad (2)$$

where X_t is the time series in question, T is linear time trend, Δ is the first difference operator, and ε_t is a white noise disturbance term. This regression tests for the presence of a unit root, allowing for the alternative that the series is stationary around a linear time trend. Under the null that there is a unit root in levels of series the coefficient c in the regression (2) should be zero.[3] The test statistic used is the standard t-statistic on the coefficient c, which, as shown in Dickey and Fuller (1979, 1981), does not have the standard t distribution. However, appropriate critical values for the test statistic have been reported in Dickey and Fuller (1979).

The results of implementing the above test are reported in column (1) of Table 1, which contains the estimated coefficent - and t-values (the latter denoted as $\hat{T}_c$) for the six series. As is evident, none of these t-values is significant at the 5 percent significance level, leading one to conclude that each of these series contains a unit root and that levels of these series are, therefore, nonstationary.

Since some macroeconomic series might contain two unit roots (so that even first differences of such series are nonstationary), the Dickey-Fuller test is repeated using second differences of series. That is, the following regression is estimated

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[3]Alternatively, this test could also be implemented by estimating the following regression

$$X_t = \alpha + \beta T + \gamma X_{t-1} + \sum_{s=1}^{p} \Delta X_{t-s} + \varepsilon_t$$

and test the hypothesis that the coefficient γ above is unity (Nelson and Plosser (1982)).

$$\Delta X_t - \Delta X_{t-1} = \tilde{a} + \tilde{b}\, T + \tilde{c}\, \Delta X_{t-1} + \sum_{s=1}^{p} ds\, (\Delta X_{t-s} - \Delta X_{t-s-1}) + e_t \quad (3)$$

where all variables are as defined before. Under the null that there is a second unit root the coefficient $\tilde{c}$ in (3) should be zero. The Dickey-Fuller test statistics are reported in column (2) of Table 1. As is evident, the computed t-values are significant, leading one to conclude that there is not a unit root in first differences of the series. Taken together, these unit root tests support the conclusion that first differences of the log level velocity and the level of volatility are stationary time series.

2. Granger-causality Tests

Tests for unit roots that are presented here thus imply that causality tests based on first differences of series would have the standard F distributions. Table 2 contains F-tests for specifications using growth rates as well as levels. In panel A of Table 2, velocity regressors are in first differences and volatility regressors in levels, as in Hall and Noble (1987). In panel B of Table 2, velocity as well as volatility regressors are in first differences.

If we focus primarily on the behavior of the volatility of M1 growth and conduct causality tests using levels of the volatility variable, the F-statistics (presented in column (1) of Panel A in Table 2) support the conclusion in Hall and Noble (1987) that volatility influences velocity. However, the F-statistics using first differences of the volatility variable do not support such a result (see column (1) of panel B in Table 2).

When we consider volatility variables that are based on the broad definition of money, the F-statistics (reported in columns (2) through (3) of panels A and B in Table 2) do not support the inference that volatility influences velocity.

Table 3 investigates the presence of causality between velocity and volatility over 1963Q1 to 1986Q4, a sample period that is longer than the one considered in Hall and Noble (1987). As noted before, the velocity of M1 declined again in 1985-86 and that this decline in velocity was neither preceded nor accompanied by any notable increase in the volatility of money growth. Adding these two years into the estimation period yields significantly lower F-statistics even in the regressions that use levels of M1 volatility variable (compare the F-statistics reported in columns (1) of panel A in Tables 3 and 4). If we follow Hall and Noble (1987) and use critical values of the standard F distribution (which infact are not valid because levels of the volatility variable are a nonstationary series), the F-values (reported in column (1) of Panel A in Table 3) do not support the inference that volatility influences velocity.[4,5]

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[4]It is worth pointing out that the causality tests that are reported in Tables 2 and 3 were also implmented including, in addition, up to quadratic deterministic time trend variables in the underlying bivariable specifications. None of the inferences concerning the nature of causality between volatility and velocity are, however, sensitive to the inclusion of such time trend variables.

[5]If some theoretical considerations suggest the level of volatility to be relevant in determining the behavior of the growth rate of velocity, then it could be argued that sensitivity analysis should be done using second differences of the levels of velocity and first differences of the level of volatility. In this case too, the causality test results do not support the inference that volatility influences velocity.

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Table 1

Unit Root Tests, 1963Q1-1984Q2

Series	(1) Coefficent c ($\hat{T}_c$)		(2) Coefficient $\tilde{c}$ ($\hat{T}_{\tilde{c}}$)	
VOL-M1	-.11	(-2.3)	-.84	(-4.9**)
VOL-M2	-.21	(-3.4)	-.86	(-5.5**)
VOL-M3	-.09	(-2.7)	-.57	(-4.8**)
lnV-M1	-.05	(-1.0)	-.85	(-4.5**)
lnV-M2	-.14	(-2.9)	-.75	(-4.6**)
lnV-M3	-.11	(-2.5)	-.74	(-4.6**)

** Significant at 1% level.

Notes: VOL-M1, VOL-M2, and VOL-M3 are measures of the volatility of money growth which are based on M1, M2, and M3 measures of money, respectively. Similarly, lnV-M1, lnV-M2, and lnV-M3 are log levels of the velocity of money based on the three measures of money. The variability of money growth is calculated as an eight-quarter standard deviation of money growth. The estimated coefficients, c and $\tilde{c}$, are from the regressions (2) and (3) of the text. Parentheses contain Dickey-Fuller (1979) t-statistics: $\hat{T}_c$ uses first differences of series and $\hat{T}_{\tilde{c}}$ uses second differences. The regressions (2) and (3) of the text were estimated including two lagged values of the dependent variable (increasing lag lengths does not alter the results). 5% and 1% Critical values of $\hat{T}$ are -3.45 and -4.04, respectively (Fuller (1976), p. 373).

Table 2

Granger-causality Tests, 1963Q1-1984Q2

A. Differences on levels and differences: $\Delta \ln V = f(\sum_{s=1}^{p} \Delta \ln V_{t-s}, \sum_{s=1}^{q} X_{t-s})$

Lag lengths (p, q)	Variable Pairs (V,X) (1) (V-M1, VOL-M1)	(2) (V-M2, VOL-M2)	(3) (V-M3, VOL-M3)	Degrees of Freedom
(4,4)	3.4*	1.37	.95	(4,77)
(8,4)	3.6*	1.69	.54	(4,73)
(8.8)	2.9*	1.29	.44	(8,69)
(0,4)	3.3*	1.25	1.41	(4,81)

B. Differences on differences: $\Delta \ln V = f(\sum_{s=1}^{p} \Delta \ln V_{t-s}, \sum_{s=1}^{q} \Delta X_{t-s})$

	Variable Pairs (V,X) (1) (V-M1, VOL-M1)	(2) (V-M2, VOL-M2)	(3) (V-M3, VOL-M3)	Degrees of Freedom
(4,4)	.61	1.36	.17	(4.76)
(8,4)	.78	1.78	.21	(4.72)
(8,8)	1.02	1.37	.41	(8.68)
(0,4)	.75	1.09	.15	(4,80)

* significant at 5% level.

Notes: All variables are as defined in Table 1.

Table 3

Granger-Causality, 1963Q1-1986Q4

A. Differences on levels and differences: $\Delta\ln V = f(\sum_{s=1}^{p} \Delta\ln V_{t-s}, \sum_{s=1}^{q} X_{t-s})$

Lag lengths (p, q)	Variable Pairs (V,X)			
	(1)	(2)	(3)	
	(V-M1, VOL-M1)	(V-M2, VOL-M2)	(V-M3, VOL-M3)	Degrees of Freedom
(4,4)	1.58	1.29	.76	(4,87)
(8,4)	1.62	1.60	.49	(4,83)
(8.8)	.91	.87	.43	(8,79)
(0,4)	4.30*	1.34	1.15	(4,91)

B. Differences on differences: $\Delta\ln V = f(\sum_{s=1}^{p} \Delta\ln V_{t-s}, \sum_{s=1}^{q} \Delta X_{t-s})$

Lag Lengths (p, q)	Variable Pairs (V,X)			
	(1)	(2)	(3)	
	(V-M1, VOL-M1)	(V-M2, VOL-M2)	(V-M3, VOL-M3)	Degrees of Freedom
(4,4)	.45	1.17	.19	(4,87)
(8,4)	.63	1.36	.11	(4,83)
(8,8)	.62	1.09	.33	(8,79)
(0,4)	.49	1.01	.18	(4,91)

* significant at 5% level.

Notes: All variables are as defined in Table 1.