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THE STOCHASTIC PROPERTIES OF VELOCITY: A NEW INTERPRETATION

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ABSTRACT

A number of recent studies have concluded that velocity for the United States for the past century displays the characteristics of a random walk without drift. In this study, we confirm this result for four other countries for which we have over a century of data — Canada, the United Kingdom, Sweden and Norway.

One implication of a random walk is that past changes in velocity cannot be used to predict future changes. However, this does not mean that past changes in variables that economic theory deems important determinants of velocity cannot be used to predict future changes. In this study we find that past changes in the traditional determinants of velocity — permanent income and interest rates, as well as a number of institutional variables, can be used to predict future changes in velocity.

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The Stochastic Properties of Velocity: A New Interpretation*

1. Introduction

In the last two decades there has been considerable interest in the stochastic properties of velocity. Research in this area has been self-contained in the sense that it has been separated from the standard literature on the determinants of velocity (the demand for money). Here we attempt to reconcile these two different strands by jointly examining the stochastic properties of velocity and the influence of the traditional determinants of velocity, aiming at a synthesis. Practically all work on the time-series properties of velocity have covered the US experience. Here we examine not only the evidence from the United States but also the evidence from other countries, anchoring the analysis in a broad international context.

The work on the stochastic properties of velocity was started by Gould and Nelson (1974) who in a seminal article[1] questioned the predictive content of the long run time series of velocity used by Friedman and Schwartz in _A Monetary History of the United States 1867-1960_ (1963). According to Gould and Nelson, the discussion of meaningful patterns in the long-run movement of velocity, and of deviations from trend taken directly from the time series, presumes that future velocity behavior can be extrapolated from its past history. They examined the stochastic structure of velocity 1869 to 1960 to determine whether a statistical basis can be found for extrapolative predictions. Zero autocorrelations of the first differences of velocity as well as an insignificant coefficient on the trend term led them to conclude that velocity is a random walk without drift.

Subsequently, Stokes and Neuberger (1979) demonstrated that the Gould and Nelson result is highly period sensitive. They noted that the 1867-1960 period covered by Friedman and Schwartz combines three distinct historical periods:

1867-79 — the Greenback episode; 1940-60 — World War II and the subsequent rise in V; and the intermediate gold standard period, 1880-1940. A reexamination of the evidence for the homogeneous period, 1880-1940, led Stokes and Neuberger to reverse Gould and Nelson's results — velocity is not a random walk and the trend has a significant negative coefficient.

More recently Nelson and Plosser (1982), following a procedure developed by Dickey and Fuller (1979) have developed an approach distinguishing between two classes of time series processes: trend stationary, or TS, processes; differenced stationary or DS processes. A trend stationary (TS) process characterizes a time series whose deviations from trend are stationary or self-reversing while a differenced stationary (DS) process characterizes a nonstationary series which does not revert to trend. A simple example of a DS process is a random walk.[2] The application of tests developed by Nelson and Plosser to U.S. velocity data found it to be a DS process, consistent with the original Gould and Nelson findings.

In this paper, we follow the tests pioneered for the United States case by Gould and Nelson, and by Nelson and Plosser, to five countries for which we have assembled close to a century of data, that is, the United States, Canada, United Kingdom, Sweden and Norway, from the 1880's to the mid 1970's. Our findings for the majority of countries examined here support those of the earlier studies — velocity over the past century is characterized by a random walk without drift.

A key question that arises from this evidence on the stochastic nature of velocity is how to reconcile it with evidence that we have found in previous studies, (Bordo and Jonung, 1981 and Bordo and Jonung, 1987) as have others (see interalia, Friedman and Schwartz, 1982; and for a survey Laidler, 1985) —

that velocity behavior over the past century is well explained by permanent real income, the interest rate, and by a number of institutional variables.

An implication of a random walk is that since only the current value of velocity can be used to predict that of the next period, past values of velocity should have no influence in prediction. Alternatively changes in velocity should be random — future changes cannot be predicted by past changes. However, the fact that velocity displays the characteristics of a random walk does not say that changes in variables which economic theory views as important determinants of velocity cannot be used to predict future changes.

We thus proceed in the following way. First, we test whether velocity follows a random walk, then we test whether changes in velocity can be explained by past changes in velocity in addition to past changes in a set of variables which can be viewed as potential important determinants of velocity.

2. Is Velocity a Random Walk?

Table 1 reports the results for the five countries for the type of test conducted by Gould and Nelson. We estimated the regression:

(1) $\log V_t = A + B \log V_{t-1} + u_{1t}$.

Unlike in Gould and Nelson, regression (1) is expressed in logs rather than levels to avoid the problem of heteroscedacity.[3] Following Gould and Nelson we test the hypothesis that A is not significantly different from zero and B is not significantly different from one. To avoid the problem of bias observed in the use of a standard t distribution in the Gould and Nelson study we compared the calculated t ratios to the correct distribution suggested by Dickey and Fuller (1979). t tests based on the Dickey Fuller distribution show that A differs significantly from zero and B is not significantly different from one for all countries except the U.S.. A joint F test of the hypotheses that A =

0, B = 1 based on a distribution suggested by Dickey and Fuller (1981) confirms the null hypothesis for all countries except the U.S.

A key problem with these results is that the distribution of B involves the true value of A which we do not know. The values calculated in Dickey and Fuller are valid only under the maintained hypothesis that the true value of A is zero. Thus the results that the null hypothesis A = 0, B = 1 is rejected for the U.S. may reflect either that A is different from zero or B is different from 1 or both.[4]

We next conduct the type of test suggested by Nelson and Plosser (1982). The test, designed to ascertain whether the time series pattern of velocity can be characterized as a DS process, is based on the following regression equation:

(2) $\log V_t = A + B \log V_{t-1} + CT + u_{2t}$

where T is a time trend.

Table 2 reports the results of regressions of equation (2) for the five countries. The test devised to determine whether (2) can be characterized as a DS process is B = 1, C = 0. As in the previous case, we conducted both t tests and joint F tests using the distributions suggested by Dickey and Fuller. With the addition of the time trend, the distribution of the test statistics does not depend on unknown parameters such as the true value of A so interpretation of the statistics is more clear cut.[5].

Based on t tests, B is not significantly different from one in all five countries, and C is not significantly different from zero in all except Canada and Norway. The joint F tests that B = 1, C = 0 is not rejected in all cases except the U.S. and then only at the ten percent level of significance. These results suggest that velocity follows a DS process in all five countries. It follows a random walk without drift for all countries except for Canada and Norway where it follows a random walk with a drift.[6]

Considerable recent interest in the relationship of monetary regimes to macroeconomic performance, combined with the proposal by Stokes and Neuberger that the stochastic process of velocity may be sensitive to the monetary regime suggests that we split our data sample for the five countries into two regimes: the gold standard, encompassing the years up to 1914; and managed money — the subsequent period. This demarcation is admittedly rough, since these countries were on a gold exchange standard for a portion of the interwar period, and were all part of the gold based Bretton Woods fixed exchange rate system over virtually the whole post-World War II period covered in this study. However in all five countries the extent to which national money supplies were managed increased considerably after 1914.

Under the gold standard, according to Klein (1975), the money supply (in the U.S.) displayed the properties of a stationary series — with a tendency to revert to its trend level. This finding reflected the tendency under the gold standard of gold flows to be self-reversing. Under managed money, according to Leijonhuvud (1984), the money supply process (in the U.S.) is a nonstationary series characterized by a random walk in rates of changes.

In Table 3, we present the results of Nelson and Plosser type regressions for these two subperiods for our five countries. Based on the Dickey-Fuller distributions both the "t" and "F" tests indicate that during the gold standard period the random walk hypothesis is rejected for the U.S. but not for the other countries.[7] In the period of managed money all five countries are characterized by a DS process.

These results suggest that for at least one country — the United States — the nature of the monetary regime may have influenced the velocity process.

Under the gold standard, the predictable nature of the money supply regime may have made velocity predictable. For the other countries, velocity may have been unpredictable because theirs were more open economies buffeted both by real and nominal shocks originating abroad. Under managed money, for all five countries, the more stochastic nature of the money supply process may also have influenced the velocity process.

3. Are Changes in Velocity Predictable?

Evidence that velocity displays the characteristics of a random walk in the majority of countries examined here does not mean that velocity is a will of the wisp, that is, that it merely reflects random walks in nominal income and money, and hence that the relationship between money and income is totally unpredictable. Indeed there is a large body of evidence to the contrary (Friedman and Schwartz, 1982, Poole, 1986). Rather the random walk suggests that there are numerous forces which systematically affect velocity and it is impossible without prior information to predict which set of forces is paramount.[8] Thus, for example, an acceleration in money growth will initially cause velocity to fall (below its trend) but then as holders of cash balances adjust their actual holdings to the original desired level, velocity will eventually rise and may even overshoot (Friedman and Schwartz, 1982). If such a pattern is at work changes in velocity would display negative serial correlation following a burst of monetary growth. Alternatively a shock to aggregate demand raising nominal income without any increase in money growth would, if it persisted, raise velocity for several periods in a row and, as a consequence velocity would display positive serial correlation.

The two types of disturbances may be about equally frequent. When, for example, a rise in velocity is observed, the rise by itself provides no predictive information as to whether velocity is likely to rise further or decline. Thus past changes in velocity cannot be used to predict future changes; but there is no reason why prior information on other variables which systematically affect velocity may not aid in predicting future changes.

In what follows we test whether successive past changes in the determinants of velocity are significant in explaining future changes in velocity. Initially we estimate two regressions:

(3) $\Delta \log V_t = A + B_1 \Delta \log V_{t-1} + u_{3t}$

(4) $\Delta \log V_t = A + B_1 \Delta \log V_{t-1} + B_2 \Delta \log V_{t-2} + u_{4t}$

The results are presented in Table 4. An implication of a random walk in (3) is that $A = B_1 = 0$ and in (4) that $A = B_1 = B_2 = 0$. As can be seen in Table 4 based on joint F tests, the null hypothesis is accepted for all countries for equation (3), but when a second lagged term is added in equation (4), the hypothesis is rejected for Sweden and Norway. The presence of significant coefficients on both lagged changes in velocity for these countries suggest that a more complicated autoregressive process may be at work.

Finally, we include as additional regressors to those in Equation (4) changes in the long run determinants of velocity isolated in our earlier work (Bordo and Jonung, 1981). In our previous work, we argued that the secular pattern of velocity reflects in addition to the standard long-run determinants — real permanent income and the interest rate — the evolution of institutional factors. These institutional factors include the processes of: monetization; the spread of commercial banking; financial development; and growing economic stability.

Empirical results in Bordo and Jonung (1981) (for the five countries discussed above using annual data over the 1870-1975 period) show that inclusion of proxies for these institutional factors significantly improve a benchmark regression of velocity on permanent income, interest rates and a variable to capture the business cycle. In addition, in the majority of cases the institutional variables are of the correct sign and statistically significant.

The variables to be included as additional regressors to those of equation (4) are: y^p real per capita permanent income, i the long term bond yield; cycle the ratio of measured to permanent per capita income, $(\frac{LNA}{L})$ the ratio of the labor force in nonagricultural pursuits to the total labor force — a proxy for monetization; $(\frac{C}{M})$ the currency money ratio — a proxy for the spread of commercial banking; $(\frac{TNBFA}{TFA})$ the ratio of total non bank financial assets to total financial asset — a measure of financial development; and $S\hat{y}$ a six year moving standard deviation of real per capita income — a measure of growing economic stability.[9]

Equation (5) includes as additional regressors to those in (4) changes in the long-run determinants of velocity discussed above. Inclusion of these additional independent variables will enable us to ascertain whether prior changes in velocity's determinants can predict future changes in velocity.[10]

$$
\begin{aligned}
(5)\quad \Delta\log V_t = {} & A + B_1\,\Delta\log V_{t-1} + B_2\,\Delta\log V_{t-2} + C_1\,\Delta\log y^p_{t-1} \\
& + C_2\,\Delta\log y^p_{t-2} + D_1\,\Delta i_{t-1} + D_2\,\Delta i_{t-2} \\
& + E_1\,\Delta\log \text{cycle}_{t-1} + E_2\,\Delta\log \text{cycle}_{t-2} + F_1\,\Delta\log\left(\frac{LNA}{L}\right)_{t-1} \\
& + F_2\,\Delta\log\left(\frac{LNA}{L}\right)_{t-2} + G_1\,\Delta\log\left(\frac{C}{M}\right)_{t-1} + G_2\,\Delta\log\left(\frac{C}{M}\right)_{t-2} \\
& + H_1\,\Delta\log\left(\frac{TNBFA}{TFA}\right)_{t-1} + H_2\,\Delta\log\left(\frac{TNBFA}{TFA}\right)_{t-2} + J_1\,\Delta\log S\hat{y}_{t-1} \\
& + J_2\,\Delta\log S\hat{y}_{t-2} + u_{5t},
\end{aligned}
$$

Table 5 presents the results of regressions of equation (5). In addition to the individual coefficients and their t values, we also present for each determinant the t values of the sum of the lagged coefficients.[11]

For each country significant coefficients (based on t tests of individual coefficients and on the sum of the coefficients) on a number of the lagged independent variables were detected. Thus of the traditional determinants of velocity, significant (at least at the ten percent level) lagged changes can be found in permanent income for every country; in the cycle variable for the U.K., Sweden and Norway; and in the interest rate for Norway. Of the traditional variables significant lagged changes can be detected in $\left(\frac{LNA}{L}\right)$ for the U.S. and U.K. and (C/M) for Sweden and Norway.

These results combined with rejection of the null hypothesis $F(A = 0, B_i = 0, C_i = 0 \ldots J_i = 0)$ and a considerable improvement in $\bar{R}^2$ in every country — compared to the equations in Table 4 including only lagged changes in velocity as regressors — suggests that prior knowledge of changes in velocity's determinants improves predictions of future changes in velocity.[12]

Conclusions

In sum, the results over the past century for the five countries in our study, with application of the approaches of Gould and Nelson, Nelson and Plosser, confirm for all five their characterization of the behavior of velocity as a random walk. For the gold standard subperiod velocity displays a random walk for all countries except the U.S. but for the period of managed money velocity is a random walk in all countries. The fact that velocity behavior in the U.S. becomes unpredictable after the demise of the gold standard may be a consequence of the switch to a more unpredictable monetary regime.

An implication of the random walk hypothesis is that past changes in velocity cannot be used to predict future changes. Our tests of this implication were confirmed for three countries but not for Sweden and Norway. This result may reflect a more complicated autoregressive process in these countries.

Finally, we demonstrated that though for the majority of the five countries future changes in velocity cannot be predicted by past changes in velocity alone, changes in the determinants of velocity can in every country be used to predict future changes in velocity. Thus changes in velocity are better predicted given prior information, and the random walk hypothesis is consistent with our earlier findings on the long-run determinants of velocity.

These results point to the limitations on the use of simple univariate time series models such as the random walk to explain the evolution of important economic variables, since these models run the risk of omitting such key factors as the long-run determinants of velocity discussed above.

FOOTNOTES

*Michael Bordo is a Professor of Economics at the University of South Carolina and Research Associate at the National Bureau of Economic Research, Lars Jonung is a docent at the University of Lund and Visiting Scholar at Harvard University. For helpful suggestions and comments, we would like to thank Roy Batchelor, Charles Nelson and Dean Taylor. Able research assistance was provided by Alvaro Aguiar.

[1] Also see Gould, Nelson, Miller and Upton (1978).

[2] For an application of this distinction to recent U.S. velocity behavior see Haraf (1986).

[3] See Stokes and Neuberger (1979).

[4] We wish to thank Charles Nelson for bringing this to our attention.

[5] See Dickey and Fuller (1981) pp. 1068-9.

[6] Evidence of significant serial correlations for Norway as judged by the Box Pierce Q Statistics may call into question the findings for that country. The period covered includes a large gap in the data for World War II, when data was unavailable. However, a similar regression run over the period 1880-1939 yielded similar coefficients, test statistics and a high value for the Q statistic.

[7] For Canada the small number of observations for the gold standard period would make the results unreliable.

[8] See Poole (1986).

[9] For the data used see the Appendix to Bordo and Jonung (1987).

[10] For a similar testing procedure see Hall's (1978) approach to the permanent income hypothesis.

[11] We experimented with lags of two, three and four years. Based on an F test, the two year lag performed best.

[12] As a test of the monetarist hypothesis that velocity changes can be predicted by past accelerations in money growth (Friedman and Schwartz 1982, Taylor, 1976), we also experimented with lagged accelerations in money growth as additional explanatory variables in the regressions explaining velocity change. We obtained a significant (at the five percent level) negative coefficient for a two year lagged acceleration in money growth for the U.S. and a significant negative coefficient for a one year lagged acceleration for Norway, thus confirming Taylor's results. However, for the other countries this variable was insignificant.

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Table 1 Gould and Nelson (1974) Tests for a Random Walk

(1) $\log V_t = A + B \log V_{t-1} + u_{1t}$

Country (Period)	Coefficients of independent variables) (t values in brackets) A	B	SEE	$\bar{R}^2$	Durbin h	Q	"F" (A=0, B=1)	"F" Critical 5% (10%)	"t" $B_1=1$	"t" Critical 5%
U.S. (1881-1972)	.038 (2.43)*	.927 (44.89)*	.063	.957	1.02[b]	30.71[c]	7.82[d]	4.71 (3.86)	-3.51	-2.89
Canada (1901-1975)	.091 (1.85)**	.901 (16.81)*	.071	.792	1.96	20.95[c]	1.72	4.86 (3.94)	-1.85[a]	-2.93
U.K. (1877-1974)	.031 (1.68)**	.943 (27.52)*	.056	.886	.93[b]	25.90[c]	1.44	4.71 (3.86)	-1.68[a]	-2.89
Sweden (1881-1974)	.065 (2.18)*	.926 (30.43)*	.066	.909	2.52	26.50[c]	3.21	4.71 (3.86)	-2.42[a]	-2.89
Norway (1881-1939) (1954-1974)	.030 (1.51)	.941 (28.86)*	.079	.913	1.80	53.39	1.67	4.71 (3.86)	-1.81[a]	-2.89

* Statistically different from zero at the five percent level
** Statistically different from zero at the ten percent level
a Not statistically different from one at the 5% level (using Dickey and Fuller 1979)
b Rejection of first order autocorrelation at the 5% level
c Rejection of higher order correlation at the 5% level
d Rejection of H_0: A = 0, B = 1, at five percent level (using Dickey and Fuller 1981)

Table 2 Nelson and Plosser (1982) Tests for a DS Process

$$\log V_t = A + B \log V_{t-1} + CT + u_{2t} \quad (2)$$

Country (Period)	Coefficients of independent variables) (t values in brackets) A	B	C	SEE	$\bar{R}^2$	Q	"F" (B=1, C=0)	"F" Critical Dickey & Fuller 5% (10%)	"t" (B=1)	"t" Critical 5%
U.S. (1881-1972)	.058 (1.40)	.914 (26.91)*	-.0002 (-.51)	.063	.956	30.57[c]	6.26	6.49 (5.47)	-2.54[a]	-3.45
Canada (1901-1975)	.089 (1.84)**	.872 (15.88)*	.0007 (1.85)**	.069	.798	22.63[c]	3.47	6.49 (5.47)	-2.33[a]	-3.50
U.K. (1877-1974)	0.30 (1.43)	.942 (27.33)*	.00003 (.15)	.056	.885	25.86[c]	1.40	6.49 (5.47)	-1.67[a]	-3.45
Sweden (1881-1974)	.046 (1.37)	.931 (30.47)*	.0003 (1.24)	.066	.909	27.36[c]	3.71	6.49 (5.47)	-2.10[a]	-3.45
Norway (1881-1939) (1954-1974)	.003 (.12)	.943 (29.35)*	.0006 (1.85)**	.078	.916	58.17	3.40	6.49 (5.47)	-1.77[a]	-3.45

NOTES: Same as in (1) except: d rejection of H_0: B = 1, C = 0 at the five percent level (using Dickey and Fuller 1981).

Table 3 Tests for A DS Process by Monetary Regimes: The Gold Standard and Managed Money

(3) $\log V_t = A + B \log V_{t-1} + CT + u_{3t}$

Country (Period)	Coefficients of independent variables) (t values in brackets) A	B	C	SEE	$\bar{R}^2$	Q	"F" (B=1, C=0)	"F" Critical 5% (10%)	"t" (B=1)	"t" Critical 5%
U.S. (1881-1913)	.443 (3.07)*	.650 (6.63)*	-.006 (-2.48)*	.044	.962	11.22[c]	10.46[d]	7.24 (5.91)	-3.57	-3.55
(1914-1972)	.025 (.48)	.905 (16.51)*	.0003 (.57)	.071	.830	20.35[c]	2.02	6.73 (5.61)	-1.73[a]	-3.50
Canada (1901-1913)	.773 (2.30)*	.327 (1.14)	0.017 (-2.22)**	.044	.831	1.92[c]	2.77	7.24 (5.91)	-2.34[a]	-3.60
(1914-1975)	.108 (2.00)**	.816 (10.90)*	.001 (2.02)*	.073	.799	15.36[c]	3.22	6.73 (5.61)	-2.46[a]	-3.50
U.K. (1877-1913)	.143 (2.49)*	.715 (5.94)*	.001 (1.65)	.026	.823	18.08[c]	2.93	7.24 (5.91)	-2.36[a]	-3.55
(1914-1974)	-.011 (-.31)	.913 (19.29)*	.0008 (1.48)	.067	.886	19.62[c]	2.04	6.73 (5.61)	-1.85[a]	-3.50
Sweden (1881-1913	.207 (1.19)	.838 (7.30)*	-.003 (-1.06)	.049	.959	15.73[c]	1.45	7.24 (5.91)	-1.41[a]	-3.55
(1914-1974)	.090 (2.01)*	.726 (7.91)*	.002 (2.49)*	.071	.860	25.60[c]	4.45	6.73 (5.61)	-2.98[a]	-3.50
Norway (1881-1913	.166 (1.33)	.810 (6.90)*	-.003 (-1.26)	.037	.970	12.36[c]	2.05	7.24 (5.91)	-1.62[a]	-3.55
(1914-1939) (1955-1974)	-.091 (-1.70)**	.745 (7.94)*	.003 (2.63)*	.093	.894	38.13	3.86	6.73 (5.61)	-2.71[a]	-3.50

NOTES: Same as in (1) except: d rejection of H_0: B = 1, C = 0 at the five percent level (using Dickey and Fuller 1981).

Table 4 Changes in Velocity Regressed on Successive Past Changes in Velocity

(3) $\Delta \log V_t = A + B_1 \Delta \log V_{t-1} + B_2 \Delta \log V_{t-2} + u_{3t}$

(4) $\Delta \log V_t = A + B_1 \Delta \log V_{t-1} + B_2 \Delta \log V_{t-2} + u_{4t}$

Coefficients of independent variables)
(t values in brackets)

Country (Period)		A	B_1	B_2	SEE	$\bar{R}^2$	Durbin h or (t value)[e]	Q	F (A=0, B_1=0, B_2=0)	F Critical 5% (10%)
U.S. (1883-1972)	(3)	.009 (-1.26)	.114 (1.12)	-	.065	.0029	.53[b]	26.56[c]	1.72	3.10 (2.37)
	(4)	-.009 (-1.25)	1.127 (1.19)	.002 (.02)	.065	-.006	(.89)[b]	25.84[c]	1.20	2.71 (2.15)
Canada (1903-1975)	(3)	.001 (.13)	.157 (1.35)	-	.072	.0111	(.83)[b]	17.73[c]	.92	3.13 (2.38)
	(4)	.001 (.12)	.173 (1.45)	-.099 (-.83)	.073	.007	(.05)[b]	17.06[c]	.84	2.74 (2.17)
U.K. (1979-1974)	(3)	.001 (.25)	.061 (.59)	-	.057	-.0068	(-1.68)[b]	27.14[c]	.21	3.09 (2.37)
	(4)	.0007 (.12)	.049 (.48)	.174 (1.68)**	.056	.012	(1.07)[b]	26.00[c]	1.07	2.71 (2.15)
Sweden (1883-1974)	(3)	-.004 (-.64)	.234 (2.26)*	-	.067	.0427	5.84	21.72[c]	2.85	3.10 (2.37)
	(4)	.004 (-.58)	.282 (2.70)*	-.196 (-1.87)**	.066	.071	(-.18)[b]	23.61[c]	3.13[d]	2.71 (2.15)
Norway (1883-1939)	(3)	-.002 (-.17)	.175 (1.54)	-	.080	.0177	11.14	54.38	1.22	3.21 (2.38)
	(4)	-.002 (-.28)	.252 (2.39)*	-.431 (-4.08)*	.074	.19	.91[b]	18.61[c]	6.50[d]	2.73 (2.17)

* Statistically different from zero at the five percent level
** Statistically different from zero at the ten percent level
b Rejection of first order autocorrelation at the five percent level
c Rejection of higher order autocorrelation at the five percent level
d Rejection of H_0: $A = 0$, $B_1 = 0$, $B_2 = 0$, or H_0: $A = 0$, $B_1 = 0$, at the five percent level.
e When the statistic could not be computed, the value of the coefficient of e_{t-1} in the regression of e_t on e_{t-1} plus all the independent variables, is reported.

Table 5 Changes in Velocity Regressed on Successive Past Changes in Velocity and Successive Past Changes in the Determinants of Velocity

$$(5)\ \Delta\log V_t = A + B_1\,\Delta\log V_{t-1} + B_2\,\Delta\log V_{t-2} + C_1\,\Delta\log Y^P_{t-1} + C_2\,\Delta\log Y^P_{t-2} + D_1\,\Delta i_{t-1} + D_2\,\Delta i_{t-2}$$

$$+ E_1\,\Delta\log \text{cycle}_{t-1} + E_2\,\Delta\log \text{cycle}_{t-2} + F_1\,\Delta\log\left(\frac{LNA}{L}\right)_{t-1} + F_2\,\Delta\log\left(\frac{LNA}{L}\right)_{t-2} + G_1\,\Delta\log\left(\frac{C}{M}\right)_{t-1}$$

$$+ G_2\,\Delta\log\left(\frac{C}{M}\right)_{t-2} + H_1\,\Delta\log\left(\frac{TNBFA}{TFA}\right)_{t-1} + H_2\,\Delta\log\left(\frac{TNBFA}{TFA}\right)_{t-2} + J_1\,\Delta\log \hat{Sy}_{t-1} + J_2\,\Delta\log \hat{Sy}_{t-2} + u_{5t}$$

Coefficients of independent variables and t values for the sum of coefficients[f]
(t values in brackets)

Country (Period)	A	B_1	B_2	C_1	C_2	t_Σ	D_1	D_2	t_Σ	E_1	E_2
U.S. (1883-1972)	.037 (1.78)**	-1.24 (-.61)	.056 (.30)	-.706 (-1.46)	-.241 (-.46)	-2.56*	-.235 (-.26)	.506 (.58)	.18	.406 (1.64)	.056 (.27)
Canada (1903-1975)	.018 (.88)	-.178 (-.77)	.084 (.37)	1.615 (2.18)*	-1.591 (-2.27)*	.59	-3.957 (-1.46)	.856 (.28)	-.88	.151 (.42)	.110 (.39)
U. K. (1879-1974)	-.007 (-.81)	-.009 (-.07)	.108 (.85)	-.707 (-2.36)*	.272 (.89)	-1.91**	.226 (.32)	-.668 (-.95)	-.41	.381 (1.67)**	.884 (3.79)*
Sweden (1883-1974)	.016 (.85)	.337 (1.79)**	-.533 (-2.97)*	-.178 (-.52)	-.321 (-.97)	-1.84**	-.144 (-.02)	9.936 (1.45)	1.39	-.517 (-1.74)**	.313 (1.17)
Norway (1883-1939) (1955-1974)	-.003 (-.24)	-.196 (-.94)	-.205 (-1.17)	-.220 (-.71)	-.244 (-.76)	-2.22*	7.881 (3.27)*	-2.383 (-.96)	1.49	.278 (.63)	-.983 (-2.40)*

Notes: Same as in (4), except:
d Rejection of H_0: $A = 0, B_1 = 0, B_2 = 0, C_i = 0, \ldots, J_i = 0$, at the 5% level.
f the t_Σ reported after each pair of coefficients is the t value of the sum of the two coefficients.

Table 5 (Cont'd)

Country (Period)	t_Σ	F_1	F_2	t_Σ	G_1	G_2	t_Σ	H_1	H_2	t_Σ	J_1	J_2	t_Σ	SEE	R^2	Durbin h or (T Value)[e]	Q	F ($A=0$, $B_1=0$, $C_1=0$ ... $J_1=0$)	F Critical 5% (10%)
U.S. (1883-1972)	1.55	-1.898 (-.67)	-2.976 (-1.06)	-1.76**	-.116 (-1.02)	-.007 (-.06)	-.99	-.314 (-.50)	-.047 (-.07)	-.81	-.029 (-1.03)	.014 (.47)	-.36	.060	.147	(.67)[b]	31.08[c]	1.99[d]	1.78 (1.55)
Canada (1903-1975)	.57	-1.209 (-.23)	-.891 (-.17)	-.68	.054 (.29)	-.245 (-.31)	-.92	-.031 (-.12)	-.225 (-.87)	-.92	-.024 (-.68)	-.008 (-.43)	-.82	.070	.070	(1.91)[b]	21.94[c]	1.26	1.82 (1.60)
U.K. (1879-1974)	3.80*	9.674 (1.94)**	1.880 (.40)	2.08*	-1.43 (-1.18)	.099 (.77)	-.26	.181 (.51)	-.620 (-1.57)	-.86	-.007 (-.35)	-.0003 (-.02)	-.25	.050	.221	(-.82)[b]	26.08[c]	2.53[d]	1.75 (1.56)
Sweden (1883-1974)	-.53	1.561 (.53)	-2.381 (-.83)	-.51	.329 (1.82)**	.379 (2.19)*	2.78*	.969 (.87)	-.899 (-.81)	.09	-.043 (-2.07)*	.010 (.51)	-1.16	.062	.182	(-.29)[b]	19.81[c]	2.16[d]	1.77 (1.56)
Norway (1883-1939)	- .13	.933 (.85)	-.380 (-.37)	.87	.506 (2.74)*	.291 (1.53)	2.80	-.195 (-.18)	.985 (.91)	1.43	-.026 (-1.13)	-.021 (-.98)	-1.52	.063	.397	(.17)[b]	25.16[c]	3.89[d]	1.80 (1.58)