Trend Reversion in the Velocity of Money: Some International Evidence Based on the STAR Approach

Abstract

This paper examines the presence of trend reversion in the velocity of money for a sample of major industrial countries by testing the null hypothesis of a unit root in the velocity against two distinct alternatives. Against the alternative of stationarity around a linear trend, the standard Dickey-Fuller test fails to reject the null for any of the sample countries, thus lending support to the unpredictability of the velocity of money in these countries. However, against the alternative of stationarity around a nonlinear (STAR) trend, the null is rejected for all the countries in the sample, thus confirming the presence of trend reversion in the velocity for all cases. Given the less restrictive nature of the nonlinear trends, our findings provide strong support for fixed monetary rules in the conduct of monetary policy.

JEL: time-series, international financial markets, money velocity

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1. Introduction

Since the pioneering work of Nelson and Plosser (1982), it is widely believed that most macroeconomic and financial time series are characterized by the presence of unit roots in their linear autoregressive representations. Taken at face value, this work indicates that for most of these series, the short run departures from the long run equilibrium values or paths are frequent and fairly persistent, a finding which is at odds with many of the existing equilibrium theories of economic and financial behavior, where such departures are assumed to be infrequent and temporary. Given these unconventional implications, there have been extensive attempts to determine whether the failure to reject the null of unit roots in many macroeconomic and financial variables can be attributed to the use of inadequate alternative hypotheses. In particular, instead of testing for unit roots against the alternative of stationarity around a linear trend, as is commonly done in standard unit root tests, it has been recommended that these tests be conducted against the alternative of stationarity around a nonlinear trend. Examples of these nonlinear alternative hypotheses, often justified by the presence of nonlinearities in the underlying adjustment processes, include the use of threshold autoregression (Balke and Fomby, 1997), shifted intercepts and broken trends (Perron, 1989; Zivot and Andrews, 1992), autoregressions subject to ceilings and floors (Pesaran and Potter, 1997), asymmetric autoregression (Enders and Granger, 1998), and smooth transition autoregression (Terasvitra, 1994; Kapetanios, Shin, and Snell, 2002).

Among the above nonlinear alternative hypotheses, the smooth transition autoregression (STAR) has received considerable attention in recent years (see van Dijk, Terasvitra, and Franses, 2002, for an excellent survey). Like many other nonlinear approaches to time series modeling, the STAR approach is based on the existence of a number of distinct regimes, each becoming operational at a different time in response to a different set of circumstances. Unlike other approaches, however, where the transition from one regime to another is usually sudden and abrupt, the STAR model assumes these transitions to be gradual and smooth. In other words, by allowing the existence of middle ground regimes, the STAR model provides a potentially more flexible framework to capture the time series behavior of many macroeconomic and financial time series.

In the light of the preceding discussion, the purpose of this paper is to use the STAR framework to analyze the time series properties of the velocity of money, both narrowly and broadly defined, for a sample of major industrial countries over the 1987-2009 period. More specifically, the STAR model is used as the alternative hypothesis for testing the null of unit roots in the velocities against the alternative of stationarity within a nonlinear STAR process. As such, our results should shed some additional light on the empirical literature dealing with the issue of the stability of the velocity of money. Such stability is called for to render various fixed money supply growth rules optimal in the conduct of monetary policy. In this connection, Gould and Nelson (1974), Nelson and Plosser (1982), Haraf (1986), Friedman and Kuttner (1992) and Serletis (1995) have presented evidence which they interpreted as inconsistent with the stability of velocity. On the other hand, Meltzer (1963), Wilbratte (1975), Lucas (1980), Siklos (1993), Choudhry (1996), Bordo, Jonung, and Siklos (1997), Mehra (1997), and Anderson and Rasche (2001), have found evidence in support of the proposition that velocity is stable. None of these earlier studies, however, has relied on the STAR framework to assess the stationarity of the velocity of money. In this light, our paper can be interpreted as an attempt to advance the empirical evidence on the behavior of the velocity by relying on a more robust time series approach.

The rest of the paper is organized as follows. Section II discusses the econometric methodology employed. Section III presents the empirical results. Section IV concludes.

2. Model

Friedman (1956) provides a forceful case for the importance of velocity to monetary policy, basing his assertion on both theoretical underpinnings and statistical evidence. Essential to Friedman's argument is the stationarity of the velocity of money in the standard equation of exchange, which can be written as follows:

$$MV = PY \tag{1}$$

where M = the money supply, narrowly or broadly defined, V = the velocity of money, P = the general price level, and Y = real national output. The above equation can be slightly rewritten in terms of the rates of growth of the relevant variables, as follows:

$$\Delta M/M + \Delta V/V = \Delta(PY)/(PY) \tag{2}$$

Under these conditions, it is clear that should the velocity follow a stationary process, such as mean or trend reversion, a fixed money supply growth can have a predictable effect on the growth rate of nominal income. In contrast, any erratic behavior in the velocity can doom efforts to control changes in the nominal income through targeting the money supply. Thus, the credibility of the monetarist fixed money supply rule in the conduct of monetary policy boils down to an empirical test of whether the velocity of money can be adequately modeled by a stationary process. This test will be performed in the following pages.

3. Methodology

As stated earlier, the main objective of this paper is to test the null hypothesis of unit roots in the velocity of money, both narrowly and broadly defined, for a sample of major industrial countries against the alternative of stationarity within a smooth transition autoregression (STAR) framework. A univariate STAR process in a mean-zero (i.e., detrended) stochastic process y_t can be expressed as:

$$y_t = \beta y_{t-1} + \gamma y_{t-1}\Theta(\theta; y_{t-d}) + \varepsilon_t, t = 1,...,T, \tag{3}$$

where $\varepsilon_t \approx iid(0,\sigma^2)$, β and γ are unknown parameters, representing two alternative autoregressive regimes, and $\Theta(\theta; y_{t-d})$ is the transition function, with θ = speed of trend-reversion, and d = delay parameter. In addition, the transition function is assumed to take the following exponential form:

$$\Theta(\theta; y_{t-d}) = 1 - \exp(-\theta y_{t-d}^2), \tag{4}$$

where it is assumed that $\theta \geq 0$ and d$\geq$ 1. Clearly, the transition function can adopt any value between zero and one. Combining (1) and (2), we obtain:

$$y_t = \beta y_{t-1} + \gamma y_{t-1}\left[1 - \exp(-\theta y_{t-d}^2)\right] + \varepsilon_t, \tag{5}$$

which can alternatively be rewritten as:

$$\Delta y_t = \phi y_{t-1} + \gamma y_{t-1}\left[1 - \exp(-\theta y_{t-d}^2)\right] + \varepsilon_t, \tag{6}$$

where $\phi = \beta - 1$. Clearly, if $\phi = \theta = 0$, y_t will have a unit root as one possible autoregressive regime, and if $\phi = 0$ and $\theta > 0$, y_t will follow a nonlinear but stationary process as an alternative regime, assuming that -2< γ <0. Furthermore, the delay parameter d is chosen to maximize the goodness of fit of (4) over {1, 2,…., d_{max}}, where d_{max} is determined by using one of the usual lag selection procedures.

If, following Kapetanios, Shin, and Snell (2002, henceforth, KSS), the condition $\phi = 0$ is imposed, (4) can be rewritten as:

$$\Delta y_t = \gamma y_{t-1}\left\{1 - \exp(-\theta y_{t-d}^2)\right\} + \varepsilon_t. \tag{7}$$

Now, the null hypothesis of a unit root against the alternative of a nonlinear STAR stationarity can be expressed as:

$$H_0 : \theta = 0, \tag{8}$$

$$H_1 : \theta > 0. \tag{9}$$

Since, under the null hypothesis, the nuisance parameter γ cannot be identified (Davies, 1987), the paper follows Luukkonen, Saikkonen, and Terasvitra (1988) and derives a t test by approximating (5) by a first order Taylor expansion (with lagged values of the first differences of y_t added to whiten the error process a la Dickey and Fuller, 1979):

$$\Delta y_t = \sum_{j=1}^{\rho} \rho_j \Delta y_{t-j} + \delta y_{t-1} y_{t-d}^2 + e_t \tag{10}$$

Thus, the null hypothesis can be tested as a t test of $\delta = 0$, against the alternative of $\delta < 0$, by using the following statistic:

$$t_{NL} = \delta / s.e.(\delta), \tag{11}$$

using the critical values tabulated by KSS. KSS also suggest an alternative joint F test of ϕ = $\delta = 0$ in the following:

$$\Delta y_t = \sum_{j=1}^{\rho} \rho_j \Delta y_{t-j} + \phi y_{t-1} + \delta y_{t-1} y_{t-d}^2 + e_t , \tag{12}$$

based on the critical values provided by Enders and Granger (1998).

4. Empirical Results

In this section, we present the empirical results of testing for the presence of unit roots in the money velocities of a sample of major industrial countries, using the methodology discussed in the preceding section. In addition to Canada, Japan, UK, and US, which are not members of the European Monetary System (EMS), we also use the aggregate data for the entire EMS membership. The data, which are taken from the OECD files of the RATS package, are quarterly, expressed in the logarithms of real terms, seasonally adjusted, detrended, and cover the 1987:01-2009:02 period. In addition, we use total industrial production as a proxy for national output (the GDP data for EMS are available only after 1995) and use both the narrow and broad definitions of money in calculating the velocities.

As a first step in the analysis of the time series properties of the velocities in the sample, this section conducts the standard Dickey-Fuller unit root tests of these velocities against the alternative hypotheses that they are stationary around linear trends. As is well known, the implementation of the Dickey-Fuller test requires the whitening of the error terms associated with the auxiliary equations of these tests by adding an appropriate number of lags of the first differences of the underlying variables to these equations. To establish the appropriate lag length for each of the sample countries, the Akaike information criterion (Akaike, 1973) is used. The Dickey-Fuller unit root test results are given in Table 1. As seen from the table, the null of a unit root cannot be rejected for any of the sample countries, indicating no trend-reversion for their narrow or broad velocities. This finding is in clear agreement with the assertion that money velocities in major industrial countries are essentially unpredictable and follow random walks due to the instability of the demand for money in these countries. Under these conditions, it is also clear that any monetary policy which relies on a stable growth in the supply of money will be doomed to failure, as the constant imbalances between the demand and supply of money will inevitably result in an erratic behavior of nominal income.

Table 1

Unit Root Test Results

(Dickey and Fuller, 1979)

Country	Lags	Narrow Velocity	Lags	Broad Velocity
Canada	12	21.53	12	3.14
EMS	12	-0.24	12	-0.56
Japan	12	-2.81	12	-2.68
UK	12	-1.80	12	0.25
US	12	1.98	12	0.22

* Indicates significant at the 5 percent level.

Having established the random walk behavior of the velocities within the standard Dicky-Fuller framework, this section now proceeds to examine the time series properties of these variables within a STAR model. As stated in the preceding section, the STAR model tests for the presence of unit roots in the G7 stock prices against the alternative hypothesis that these prices are stationary within a smooth regime-switching framework. As also seen from the previous section, the implementation the STAR approach requires tests of significance of certain estimated coefficients in the auxiliary equations (8) and (10). Specifically, this involves a t test of significance of δ in the following equation:

$$\Delta y_t = \sum_{j=1}^{\rho} \rho_j \Delta y_{t-j} + \delta y_{t-1} y_{t-d}^2 + e_t \qquad (13)$$

Or, alternatively, an F test of joint significance of φ and δ in the following equation:

$$\Delta y_t = \sum_{j=1}^{\rho} \rho_j \Delta y_{t-j} + \phi y_{t-1} + \delta y_{t-1} y_{t-d}^2 + e_t , \qquad (14)$$

where the numbers of the lags used in the above equations are the same as those previously selected by the Akaike method for the Dickey-Fuller tests. The estimation of the above equations, however, also requires the selection of an appropriate value for d, the delay parameter. To this end, and for each of the sample countries, each of the above equations is first estimated for all values of $1 \leq d \leq d_{max}$, where d_{max} represents the optimal lag length previously selected by the Akaike method. Next, the value of d with the best fit, i.e., with the lowest significant p-value, is selected as the optimal delay parameter to be used in the estimation of the corresponding country equations. These estimated equations are then used to conduct the STAR significance tests. The results of these tests are reported in Tables 2 (for the narrow velocity) and 3 (for the broad velocity). It can be seen from the tables that, based on both test results, the null of unit roots is rejected for both velocities against the alternative of stationarity around a nonlinear trend for all the sample countries.

Table 2

STAR Test Results (Narrow Velocity)

(Kapetanios, Shin, and Snell , 2002)

Country	d for t test	t statistic	d for F test	F satistic
Canada	11	-3.86*	11	37.49*
EMS	9	-3.09*	8	122.95*
Japan	6	-4.65*	5	29.82*
UK	10	-6.37*	10	182.27*
US	7	-3.95*	3	27.09*

*Indicates significant at the 5 percent level.

Table 3

STAR Test Results (Broad Velocity)

(Kapetanios, Shin, and Snell , 2002)

Country	d for t test	t statistic	d for F test	F satistic
Canada	4	-3.42*	10	73.37*
EMS	8	-3.45*	12	30.71*
Japan	7	-8.40*	6	45.30*
UK	12	-6.70*	12	547.36*
US	3	-40.50*	3	1,370.17*

*Indicates significant at the 5 percent level.

These results indicate that for all the sample countries, there is significant evidence that money velocities have a tendency to revert to their long term trends, with any short term departures from these long term trends being transitory and short-lived. Thus, these results are clearly consistent with similar findings in the literature mentioned above, which document the long run trend-reversion of the velocities. These results, however, are clearly at odds with the standard Dickey-Fuller test results, which, as we have seen earlier, tend to support the random walk character of the velocities.

As a final word, there is a need to justify the nonlinear stationarity of the velocities for almost all the countries in the sample. This is in line with recent findings of nonlinearities in many aspects of financial and monetary behavior and dynamics (e.g., Scheinkman and LeBaron, 1989; Hsieh, 1991; Abhyanker, Copeland, and Wong, 1997; Lutkepohl, Trasvitra, and Wolters, 1999; Huang, Lin, and Cheng, 2001). Since the autoregressive equations (10) and (12) above are essentially short run adjustment paths of the velocities towards their long run trend paths, the nonlinear stationarity can be interpreted as the nonlinear adjustment behavior of the velocities. More specifically, the STAR model assumes that the speed of adjustment is a function of the size of the deviation of the actual velocities from their long run equilibrium values. This situation can arise if due to transactions costs, such as those stipulated in the buffer stock models of the money demand, the adjustments are triggered more strongly in response to a larger disequilibrium in the velocities. For small deviations from the equilibrium values, the transactions costs may prove too prohibitive to cause the velocities to quickly return to their fundamental values. In addition to transactions costs, the nonlinearity of the speed of adjustment can be attributed to a host of institutional and psychological factors, which render the velocity of money more volatile in economic downturns than in recoveries (Muscatelli and Spinelli, 1996; Wolters, Teravistra, and Lutkepohl, 1998).

5. Conclusion

This paper has shown that, based on the standard Dickey-Fuller unit root test, the money velocities of all the major industrial countries in our sample follow random walks and are, thus, largely unpredictable. This finding clearly lends support to those who advocate activism, as opposed to passive fixed money supply growth rules, as the optimal approach to the conduct of monetary policy. The paper, however, has also shown that most of these velocities are stationary within a nonlinear STAR framework, which renders them predictable in the long run. This result clearly reinstates the case for a passive approach to the formulation of monetary policy in major industrial countries, once we allow for nonlinearity in the speeds of adjustment of our sample country velocities towards their long run equilibrium values. Finally, the paper has attributed the nonlinear stationarity of the velocities to certain nonlinearities caused by various transactions costs and institutional constraints that characterize the short run adjustment paths of these velocities.

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