
Doaa Akl Ahmed  
Department of Economics,  
Benha University, Egypt.  
Email: doaa.ahmed01@fcom.bu.edu.eg

Abstract

The Central Bank of Egypt has announced its intention to move to an inflation targeting framework when its prerequisites are satisfied. This raises an important question regarding the rationality of shifting to inflation targeting instead of monetary aggregate targeting currently applied. Thus, if the monetary authorities can achieve monetary stability using its current monetary policy, it should continue target monetary aggregates. A successful monetary aggregate targeting regime hinges on two pillars: (1) the stability of the relationship between that targeted monetary aggregate and nominal GDP which implies a stable velocity of circulation. (2) The monetary aggregate must be under the control of the central bank which requires the stability or predictability of money multiplier. Therefore, the paper aims at examining the stochastic structure of both money multiplier and velocity of M1 and M2 using Variance Ratio tests of LO and MacKinlay (1988) and (1989), Chow and Denning (1993) and wild bootstrap of Kim (2006).

The paper used a sample of quarterly data for the period (1991:1-2009:2) for velocity variables and the period (2001:4-2009:2) for the money multiplier. The results indicate that the three variables follow random walk process. Therefore, they are unpredictable random sequences. With respect to money multiplier, this means that the linkage between money supply and money base is broken. Therefore, the Central bank of Egypt cannot achieve its main goal of low inflation as the money supply would be outside its control. Concerning velocity of circulation, as it provides the linkage between the monetary aggregate and GDP, the monetary authorities would not be able to achieve the required nominal GDP target since the velocity of money is instable. Based on that, the goals of low inflation and promoting output growth cannot be attained under the current policy framework and central bank should take further steps towards the full-fledged inflation targeting regime.

Key words: variance ratio, random walk hypothesis, wild bootstrap, monetary policy, money multiplier, velocity of money.  
JEL classification: E51, E52
1. Introduction

The velocity of money (VM) and money multiplier (MM) are significant variables from theoretical in conjunction with policy perspective due to their vital role in the economy. The VM is defined as the ratio of nominal output to a given money stock, whereas the MM is defined as the ratio of the money supply to the monetary base. In a monetary aggregate targeting (MAT) framework, the choice of monetary aggregate for policy purposes depends on the predictability of the relationship between that aggregate and nominal GDP where the velocity is the link. Additionally, MAT requires that monetary aggregate must be under the control of the central bank which implies that the MM must be predictable. That is to say that the monetary authorities could control the money supply by altering the monetary base conditional on the prediction of MM. Thus, by determining the desired level of money supply in the next period, and given the projection of MM, the central bank changes the monetary base to achieve the desired level of money supply (Agenor, 2000; Awad, 2010; Mishkin, 1999; Moosa & Kim, 2004).

Concerning VM, as it provides the link between the monetary aggregate and GDP, given that the central bank can achieve the desired level of money supply, the attainment of achieving a nominal GDP target is dependent on the accuracy of the VM forecast. Precisely, stability of VM indicates the existence of a stable relationship between the general price level and the money supply per unit of real output (Moosa & Kim 2004).

From theoretical perspective, the classical quantity theory of money assumes that the VM is constant. However, modern quantity theory suggests that the VM is a stable function of various macroeconomic variables includes interest rates, inflation rate, and gross national product (GNP). Under this analysis, researchers aimed at proving that changes in money stock leads to reasonably predictable changes in national income (Gould et al. 1978). On the other hand, Fisher treated VM as a black-box. According to him, it is not constant but instead it drifts over time in response to structural changes in the economy. Based on this view of velocity, financial economists assume that VM follows a random walk (RW) process (Karemera et al. 1998; Gould et al. 1978).

The stability of MM and the controllability of monetary base is controversial issue. Some economists claim that however the variations in MM in the short run will dominate variations in money supply, it becomes relatively stable and predictable over longer time horizon. On the other hand, other economists assert that the main determinants of MM such as currency ratios to deposits,

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1 These short-run fluctuations are mainly attributed to changes in publics and banks preferences of money holdings, deposits volume.
excess reserve ratio to total deposits are determined by public’s and banks’ behaviour which implies sensitivity to changes in relative rates of return, risk, technology in financial markets, income and preferences of these agents. This sensitivity is a key reason of instability of MM and lack of the controllability of reserve money by the monetary authorities (Darbha, 2000).

Given the announcement that the central bank of Egypt (CBE) intended to shift to inflation targeting (IT) once the preconditions are met, the paper aims at answering the following question: Should the CBE adopt an IT or continue with MAT as a monetary policy framework? As indicated earlier, a prerequisite for MAT framework is a stable money demand function, which in turn requires stability in velocity. Additionally, instability of the MM also contradicts with the essence of MAT regime. Thus, if VM or MM is unpredictable, this would imply the inappropriateness of the current monetary policy based on monetary aggregates. Therefore, the main objective of the study is to answer the following questions: (i) is the relation between monetary aggregates and GDP stable?, (ii) is the relationship between money stock and reserve money predictable?

To answer the first question, the paper tests Fisher hypothesis that VM follows a RW process (i.e., VM is unpredictable). Additionally, to answer the second question the paper hypothesises that the MM follows RW process (i.e., it is unforecastable due to its sensitivity to changes in agents behaviour).

The implications of testing the random walk hypothesis (RWH) of VM and MM originate from the statistical decisions to accept or reject the RWH. Acceptance of the null hypothesis indicates that current-period VM and MM involves all the required information in predicting future VM and MM respectively. In other words, changes in VM and MM are unpredictable random events and cannot be used to predict future changes for the related variable. Alternatively, rejection of the RWH implies the need to structural modelling for the prediction of future values (Kim, 1985; Karemera et al., 1998).

According to (Gould & Nelson, 1974), if the VM follows a RW process, this does not mean that there is no meaningful relationship between the money supply and national income. Nevertheless, it indicates the need to be more careful in drawing inferences about that relationship based on historical behaviour of velocity only. In other words, that would suggest that there are several factors that affect the VM. Furthermore, for short-run forecasting and policy evaluation, it is useless to try identifying apparent deviations from trend. The reason behind this is that if velocity follows RW, we should not expect that any such deviations will be corrected in the future.
As stated by Kim (2006), variance ratio (VR) tests are now the methodology that applied mostly for testing the RWH. Consequently, the employed methodology assumes that both variables are stable if they are mean-reverting over a period of time. Thus, the procedure is as follows: first, testing for the RWH using the VR tests. Then, if the RWH is rejected, the value of the VR should be examined. Checking the value of VR would result into two cases: first, when the VR is less than unity, this suggests a negative serial correlation in the first differences and hence the series is mean-reverting, i.e., stable. Second, if the VR is greater than one, then there exist positive serial correlation and hence the series is not stable. Finally, non-rejection of the null hypothesis also indicates instability of both variables (Liu & He, 1991; Karemera et al., 1998).

The VR tests were initially created by the pioneer work of LO & MacKinlay (LOMAC) (1988) and (1989). However, Chow & Denning (CHODE) (1993) criticises LOMAC (1988) and (1989) that the latter fails to control the joint-test size and is associated with a large probability of Type-I error. However the multiple VR test of CHODE (1993) is quite powerful testing for homoscedastic or heteroscedastic nulls, it is limited as well as LOMAC (1988) and (1989) test as both tests are asymptotic in their sampling distributions which are approximated by their limiting distributions. Recently, Kim (2006) developed a wild bootstrap\textsuperscript{2} version of CHODE (1993) test to improve small sample properties of VR tests. This procedure has desirable size properties and superior testing power than its alternatives. To the best of my knowledge, Kim’s (2006) wild bootstrap test has never been used in the evaluation of the RWH of VM and MM. Accordingly, this paper applies the aforementioned different VR tests to VM and MM as its empirical methodology.

The remainder of the paper is organised as follows. Section two is devoted to review the existing literature. Section three presents the underlying methodology while the empirical results are displayed in section four. Finally, section five concludes.

2. Literature review

Forecasting MM has attracted the attention of many empirical studies due to its vital role in setting monetary policy. Most of the empirical research on stability and predictability of MM employed various time series techniques. Burger et al. (1971) classified three methods for predicting the multiplier: (a) the definitional method, in which the MM is defined as the ratio of the money supply to the monetary base; (b) the regression method, where the MM is specified to be a function of some explanatory variables and estimated each period by multiple regression analysis,

\textsuperscript{2} A wild bootstrap is a computer intensive resampling method which is used to approximate the sampling distribution of the test statistic and from which critical values are obtained (Smith & Rogers, 2006).
and (c) the behavioural method, in which each of the ratios of the MM is specified as a function of various variables like interest rates, policy instruments. Bomhoff (1977) developed a Box–Jenkins model to predict the MM in USA and Netherlands, and found that his model is more accurate in comparison with the model developed by Burger et al. (1971). Later, Johannes & Rasche (1979) developed a component or indirect approach\(^3\) to forecast the MM by estimating two models for the reserve ratio M0 and the money supply M. Then, they used the estimated models to forecast each variable. Predicted values of M and M0 are then used to calculate the predicted MM according to the definition of the multiplier. Their results suggest that the forecasting power of the component approach is superior to modelling and forecasting the MM itself. In Contrast, Hafer & Hein (1984) conclude that direct model forecasts the MM as well as the indirect procedure does. Recently, Moosa & Kim (2006) estimated and forecasted the MM and VM in the UK using two models. They compared direct and indirect methods of forecasting. Results are mixed but the overall evidence seems to be supportive of the direct method.

Testing the stability of MM was examined by Nachnae (1992), Ford and Morris (1996) and Sen and Vaidya (1997). They assessed if there is a long run relationship between money supply and monetary base using cointegration analysis. According to this methodology, if the two variables are cointegrated, this is an evidence of stability of MM and vice versa. However, the findings of these studies are subjected to the limitations that they mainly used conventional Augmented Dickey-Fuller and Phillip-Peron tests of unit roots in the MM. The aforementioned tests do not account for the possibility of regime shifts as they assume that the cointegrating vector is time-invariant under the alternative hypothesis which implies that they have low power in detecting the structural breaks in data. To deal with this limitation, Darbha (2002) applied Gregory and Hansen (1996) tests that allows for a cointegrated relation with structural break. He concluded that there exists a stable, but time varying, long-run relation between measures of money supply and Monetary base in the India.

Regarding VM, Studies could be classified into two broad categories, (1) examining the structural change of VM, (2) determinants of VM. This review focus on the first type as it is much relevant to the purpose of the paper\(^4\). Concerning the structural change of VM, researchers applied

\(^3\) As VM and MM are defined variables, i.e., constructed of other variables, it could be forecasted directly or indirectly. The direct method is simply done by estimating a model from historical data for the whole series whereas the indirect method is based on estimating separate models for the components and generating forecasts for the components, then using the definition to generate forecasts of the defined variable.

\(^4\) A summary of MM and VM studies is presented in the appendix.
different empirical definitions of VM. Those who focus on transaction demand for money use income velocity of M1 while those who emphasise money as an asset prefer income velocity of broad money M2. Most of previous studies applied in the 1960s, 1970s and 1980s used the available methodologies to test the RWH of velocity. These conventional RW tests include unit root tests of Dickey & Fuller (1979, 1981) and the white noise tests of Box-Pierce and Ljung-Box. Gould & Nelson (1974) examined the RWH of VM in USA during the period (1869-1960). They have applied Box-Jenkins methodology to test for the autocorrelation in the first differences. Their results indicate the uncorrelatedness of first differences implying that VM is RW without drift. However, Gould et al. (1978) found these results are sensitive to the frequency of data, and the definition of velocity. Thus, however their results support the RWH for annual VM, it gives mixed results when applying to quarterly data. Later, Stokes & Neubuger (1979) used a different sample, however applying the same methodology of Gould & Nelson (1974). They concluded that VM is not RW but it drifts over time which indicates the sensitivity of results to the choice of the sample. Moreover, they criticised the Gould & Nelson (1974) results, as residuals are found to be heteroscedastic which violates the OLS assumptions. Ahking (1982), applied autocorrelation test in studying the stochastic structure of VM in 5 developed countries and found that VM is unpredictable. He also showed that the hypothesis was neither sensitive to the period of data sample or the definition and measure of VM or data frequency. In contrast, Kim (1985) used quarterly VM series for different industrialised countries and found mixed results, with more evidence suggesting that the behaviour of the VM significantly deviates from RW which contradicted with Ahking (1982) while it is consistent with Gould et al. (1978). As the accuracy of aforementioned methodologies was suspected when applying the new tests which are more sensitive to RW, Karemera et al. (1998) examined VM in G7 countries using VR tests developed by LOMAC (1988, 1989) and CHODE (1993). Their results suggests that VM do not follow RW process for most of G7 excluding US M1 and M2 velocities. Additionally, results are sensitive to the chosen sample and monetary aggregate.

Thus, Studies that tested the RWH of VM obtained different and often contradictory results. These results varied with model assumptions and techniques used. Additionally, Most of these studies has been applied to USA and developed economies. Regarding Egypt, the studies of VM in Egypt are quite low whereas the behaviour of Egypt’s MM has not been ever investigated. Baliamoune-Lutzand & Haughton (2004) tested Friedman’s velocity hypothesis that increased volatility in the growth of money supply decreases VM. Using cointegration tests, they proved a
statistically significant long-run relationship between the variability in monetary growth and VM, for both M1 and M2 aggregates. However, they found that Friedman’s hypothesis is only supported for M2, while increased variance of the growth of M1 has no effect on VM which could be attributed to the continuous change of the definition of M1 over time. Additionally, they found that anticipated movements in M2 volatility are not neutral as they affect velocity. Based on their results, they suggested that the scope for discretionary monetary policy in Egypt is moderately limited in the short run. Accordingly, they recommend that CBE should make its decisions more transparent and pre-announce its policies to improve the predictability of VM. In addition, Awad (2010) applied cointegration and Chow breakpoint and forecasts tests on VM and found that the VM is not stable in Egypt. Therefore, he recommended that CBE should abandon MAT and adopt IT regime.

Based on the abovementioned analysis, the behaviour of MM and VM in Egypt needs to be adequately explored especially under the current applied MAT regime.

3. Methodology

Conventional RW tests such as the unit root tests of Dickey & Fuller (1979, 1981) and the white noise tests of Box-Pierce and Ljung-Box has been applied by previous studies. However, the accuracy of these tests is suspected when applying the new tests which are more sensitive to RW. LOMAC (1988 and 1989) developed VR tests for RWs that explore the stochastic behaviour of macroeconomic aggregates such as GNP, stock prices, equity returns, and exchange rate series. Subsequently, CHODE (1993) extended and generalized the methodology to allow for testing a set of multiple VRs over a number of periods to determine whether the multiple VRs are jointly equal to one. However, both LOMAC (1988 and 1989) and CHODE (1993) are criticised as they are asymptotic tests. To cover this limitation, Kim (2006) proposed a wild bootstrap version of the CHODE (1993) test to improve small sample properties of VR tests. This procedure has desirable size properties and superior testing power in comparison to previous tests. The VR tests of RWH are appealing because of two important properties. First, they focus on the uncorrelatedness of the increments in the velocity series. This is because conventional unit root or “white noise” tests cannot detect some deviations from RW. Second, the autocorrelation feature of the VM has interesting economic and modelling implications. That is to say, a negative serial correlation in the first differences implies that the series is mean-reverting, i.e., stable while a positive serial correlation indicates instability of the series (Liu & He 1991; Karemera et al. 1998). The derivation of the abovementioned tests is sequentially discussed below.
3.1. LOMACs (1988 and 1989) single VR test

Let \( X_t \) denote the log of the series under consideration at time \( t \). The hypothesis of the pure RW is given by the recursive equation:

\[
X_t = \mu + X_{t-1} + \varepsilon_t \tag{1}
\]

where \( \mu \) is a drift parameter and \( \varepsilon_t \) is a random error term. The usual stochastic assumptions about \( \varepsilon_t \) apply, i.e. \( E(\varepsilon_t) = 0 \), \( E(\varepsilon_t^2) = \sigma^2 \), and \( E(\varepsilon_t \varepsilon_{\hat{t}}) = 0 \), for \( \hat{t} \neq t \). LOMAC (1988 and 1989) developed tests of RW under alternative assumptions of homoscedasticity and heteroscedasticity on \( \varepsilon_t \).

As stated by LOMAC (1988 and 1989), the core of the test is that under the RWH, the increments of \( X_t \) series are uncorrelated and the variance of the increments is linear in the sampling intervals. Suppose that we obtain \( nq + 1 \) observations \( X_0, X_1, X_2, ..., X_{nq} \) of \( X_t \) at equally spaced intervals. If the series follows a RW, then the variance of the \( q^{th} \) difference would be equal to \( q \) times the variance of the first difference. Thus, if the data generating process of \( X_t \) is correctly specified by equation (1), then the variance of the first difference is defined by equation (2). Additionally, that variance increases linearly so that the variance of the \( q^{th} \) difference is expressed in equation (3)

\[
\sigma^2_t = \text{var}(X_t - X_{t-1}) \tag{2}
\]

\[
\sigma^2_q = \text{var}(X_t - X_{t-q}) = q \text{var}(X_t - X_{t-1}) \tag{3}
\]

where \( \text{var} \) is the variance operator.

LOMAC (1988 and 1989) provides a single test of the RWH by testing the null hypothesis that the ratio of variances is given by

\[
VR(q) = \frac{1}{q} \frac{\sigma^2_q}{\sigma^2_t} = 1 \tag{4}
\]

Where \( VR(q) \) is the VR of the \( q^{th} \) difference, \( \sigma^2_q \) is an unbiased estimator of \( 1/q \) times the variance of the \( q^{th} \) differences of \( X_t \), and \( \sigma^2_t \) is an unbiased estimator of the variance of the first difference of \( X_t \). The RW hypothesis is tested under both the homoscedastic and heteroscedastic specifications of the variances. For the heteroscedastic case, LOMAC (1988 and 1989) weaken the iid assumption and allow for fairly general forms of conditional heteroscedasticity and dependence which is sometimes termed as the martingale null. The standard normal test statistic under homoscedasticity, \( Z(q) \) is computed as

\[
Z(q) = \frac{VR(q)-1}{(\sigma^2_t)^{0.5}} \sim N(0,1) \tag{5}
\]
Where $\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$ is the asymptotic variance of the VR.

While the test statistic under heteroscedasticity is calculated as

$$Z^*(q) = \frac{VR(q) - 1}{\phi^*(q)} \sim N(0,1)$$

(6)

Where $\phi^*(q) = \sum_{j=1}^{q-1} \left( \frac{2(q-j)}{q} \right)^2 \delta_j$ and

$$\delta_j = \frac{\sum_{t=j+1}^{nq} (X_t - X_{t-1} - \bar{\mu})^2 (X_{t-j} - X_{t-j-1} - \bar{\mu})^2}{\sum_{t=1}^{nq} (X_t - X_{t-1} - \bar{\mu})^2}$$

However the LOMAC (1988 and 1989) test is simple to implement as it depends on comparing the test statistics $Z(q)$ and $Z^*(q)$ with the critical values of the standard normal tables, they are essentially asymptotic tests which can have low power and result in misleading inferences in finite samples (Smith & Rogers, 2006). Additionally, LOMAC VR test is a single hypothesis unit test of each VR at alternative intervals $q$, which is not consistent with the VR approach to RWH that requires that all VRs to be jointly equal to unity (Karemera et al. 1998). Thus, as pointed by Hung (2009) that although LOMAC test proves that heteroscedasticity-robusted VR is more powerful and efficient than the Box–Pierce or Dickey-Fuller test (1979), it fails to control the joint-test size and is associated with a large probability of Type-I error.

3.2. CHODEs (1993) multiple VR test

To correct the second limitation of LOMAC (1988 and 1989) test, CHODE (1993) designed a corrective expansion to allow for multiple hypothesis tests. Thus, they provide a multiple hypothesis test of unity of all VRs, with control for the test size (Karemera et al. 1998). The test is briefly illustrated below. Recall, from equation (4), that the VR minus one, $Mr(q)$, can be rewritten as

$$Mr(q) = \frac{\sigma^2(q)}{\sigma_1^2(q)} - 1$$

(7)

Consider a set of $m$ VR estimates, $Mr(q_i)$ where $i=1, 2, \ldots, m$ corresponding to selected values of the aggregation intervals, $q_i$. Under the RW model, multiple hypotheses are given as:

$$H_0: Mr(q_i) = 0 \quad \text{for } i = 1, 2, \ldots, m$$

(8)

$$H_1: Mr(q_i) \neq 0 \quad \text{for } i = 1, 2, \ldots, m$$

(9)

The RWH is rejected if any one of the estimated VR is significantly different from unity. Under CHODE (1993) test, the maximum $Z$ or $Z^*$ statistics (in absolute value) is compared with the asymptotic $\alpha$-point critical value of the SMM($\alpha, m, N$) distribution instead of the critical values of the standard normal distribution, where $N$ represents degrees of freedom (the sample size).
3.3. Kim’s (2006) wild bootstrap test

Kim (2006) introduced the wild bootstrap procedure as a development based on CHODE joint test. He uses the wild bootstrap to approximate the unknown sampling distribution. Thus, this is a finite sample test which does not rely on any asymptotic approximations. The test consists of three steps are briefly explained below:

1. Generate a bootstrap sample $X^*_t = \eta_t X_t$ where $\eta_t$ is a random sequence of zero mean and unit variance. 

2. Using $X^*_t$, we calculate the test statistic $JZ^*$ by calculating $Z^*(q)$ and choosing the maximum absolute value from a set of $m$ test statistics.

$$JZ^* = \max |Z^*(q)| \quad (10)$$

3. Repeat (1) and (2) a large number of times, to create, say, 10,000 values for the test statistic, which is its bootstrap distribution.

4. Empirical results

4.1. Data and preliminary examination

The VM is defined as the ratio of nominal GDP to money supply while the MM is defined as the ratio of the money supply to the reserve money. The data consists of quarterly data covers the period 1991:1 to 2009:2 obtained from the CBEs monetary reporting to the IMFs International Financial Statistics (Standardized Reporting Forms, or SRFs). These include four variables, M0, M1 and M2 as measures for reserve, narrow and broad money, and nominal GDP. The MM2 variable represents the MM for broad money while the velocity variables VM1 and VM2 are the velocities of M1 and M2 respectively. As quarterly data of GDP for the sample periods is not available for Egypt, a quarterly series for GDP is extrapolated from annual data. In May 1990, the Egyptian government has initiated the Economic Reform and Structural Adjustment Programme (ERSAP) with support of International Monetary Fund (IMF) and the World Bank. Prior to ERSAP, the Egyptian economy has witnessed high double-digit inflation rates accompanied by low interest rates which resulted in decreasing the purchasing power of the Egyptian pound leading depositors to shift their savings to foreign currencies mainly the dollar (deposits in dollar represented 59.2% and 50.7% of total deposits and M2 respectively). The dollarization of the Egyptian Economy

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The wild bootstrap results are not sensitive to the choice of $\eta_t$, Kim (2006).

Calculated by author based on Ministry of Finance (2004).
means that the CBE had lost of its control of domestic liquidity. Based on that, the selected sample excluded the period before ERSAP to avoid structural break in the data.

Figures (1) to (3) display the graphs of VM using its two definitions as well as MM2 series. However, figure (3) shows the MM2 over the period (2001:4-2009:2) only. The reason is that the denominator of the reserve ratio has been modified in March 2001 to exclude balances of savings systems for 3 years or more. This modification resulted in a structural break in MM2 at the third quarter of 2001. Therefore, the stability of MM2 will be examined using the sample that includes the data after the break.

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7 The CBE aimed at providing greater long-term sources of funds freed up from the proportion of reserve and to encourage savings in the national currency.
4.2. Results

The paper aimed at testing two hypotheses: (1) the relation between monetary aggregates and GDP is unstable supporting Fisher hypothesis that VM drifts over time in response to structural changes in the economy (i.e., VM is follows a RW process), (2) the relation between money stock and reserve money is unpredictable due to the sensitivity of MM to changes in currency ratios to deposits, excess reserve ratio to total deposits. To test these hypotheses, the VR tests of LOMAC (1988 and 1989), CHODE (1993) and Kim (2006) are applied. The results provide the estimates of the VRs, the asymptotic $Z$ and $Z^*$ statistics and their corresponding probabilities under homoscedasticity and heteroscedasticity assumptions, respectively. The $Z$ and $Z^*$ statistics are calculated for horizons 2-quarter, 4-quarter, 8-quarter, 16-quarter as computations of higher VRs would be inappropriate and may result on over-rejection the null hypothesis. As shown in the upper panel of table (1), the p-values of $Z$ and $Z^*$ suggests that there is sufficient evidence to non-rejection of the RWH for both velocity definitions with exception of the 16 horizon of VM2 under heteroscedasticity. To control the size of multiple tests, CHODE (1993) methodology is applied by comparing test statistic with the critical value of 2.491 from the SMM distribution. Thus, however the VR of VM2 at quarter 16 is significantly differ from unity when comparing with the critical value of the standard normal distribution; it is jointly insignificant when compared with the SMM critical value at 5%. Consequently, applying CHODE (1993) indicates inferential errors arisen from using the LOMAC (1988 and 1989) single test alone and ignoring the joint nature of the VR approach to test the RWH. This result is consistent with CHODE (1993) that more caution must be paid in investigating the results of VR using LOMAC (1988 and 1989) tests only.
As the abovementioned methodologies are asymptotic tests, the lower panel of table (1) presents the results of the VR test based on the wild bootstrap of Kim’s (2006) to avoid that limitation. The results show that the RWH of both velocities cannot be rejected and therefore, both VM1 and VM2 follow RW process. Consequently, it could be conducted that velocity of money in Egypt is unpredictable. Based on these results, the hypothesis of instability of the relationship between monetary aggregate and GDP cannot be rejected. This result is consistent with the findings of Awad (2010) who reports the instability of VM in Egypt using cointegration analysis.

Concerning MM2, the displayed results in table (2) indicate that, under LOMAC (1988 and 1989), the null hypothesis of RW cannot be rejected excluding q=2 and 4 assuming heteroscedasticity. As before, comparing the Z* statistics with the critical value of 2.491 of SMM distribution lead to acceptance of the RWH. This result is then confirmed by the application of Kim’s (2006) wild bootstrap test. Consequently, the failure to reject the RWH indicates the unpredictability of MM2. Therefore, we cannot reject the hypothesis that the relation between money supply and monetary base is instable. Thus, changes in public’s and banks’ behaviour concerning their holding of currency and excess reserves leads to instability of MM which in turn implies lack of the controllability money supply by the monetary authorities. Combining the instability of MM with that of VM, we can claim that the current MAT regime is inappropriate for achieving price stability.

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<th>Table 1: Estimates of VR tests of LOMAC, CHODE and Kim for VM</th>
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5. Conclusion

As the CBE intends to shift to IT when the prerequisites are met, the paper aimed at investigating the appropriateness of MAT regime in Egypt by addressing the following question: Should the CBE move to IT framework or continue with the current applied MAT regime. Under MAT, the choice of monetary aggregate for policy purposes depends on the predictability of the relationship between that aggregate and nominal GDP where the velocity is the link. Moreover, monetary aggregate must be under the control of the central bank which implies that the MM must be
If both MM and VM are predictable, then the monetary authorities could control the money supply through modifying the reserve ratio conditional on the forecast of MM. Therefore, the main objective of the study is to answer the following questions: (i) is the relation between monetary aggregates and GDP stable?, (ii) is the relationship between money stock and reserve money predictable? To answer these questions, the study examined fisher’s hypothesis that VM follow a RW process along with the hypothesis that the relation between money stock and reserve money is unpredictable due to the sensitivity of MM to changes in currency ratios to deposits, excess reserve ratio to total deposits.

These hypothesises are tested using quarterly data for the period (1991:1-2009:2) for velocity variables and the period (2001:4-2009:2) for the MM, by employing the VR tests of LOMAC (1988 and 1989), CHODE (1993) and wild bootstrap of Kim (2006). The employed methodology assumes that both variables are stable if they are mean-reverting over a period of time. Thus, the procedure is as follows: first, testing for the RWH using the VR tests. Then, if the RWH is rejected, the value of the VR should be examined. Checking the value of VR would result into two cases: first, when the VR is less than unity, this suggests a negative serial correlation in the first differences and hence the series is mean-reverting, i.e., stable. Second, if the VR is greater than one, then there exist positive serial correlation and hence the series is not stable. Finally, non-rejection of the null hypothesis also indicates unpredictability or instability of both variables.

The results indicate that the three variables follow RW process. Therefore, they are unpredictable random sequences. Since the CBE still employs a MAT framework to conduct its monetary policy, it relies mainly on monetary aggregates to achieve its goals that include low inflation and promoting economic growth. In the short run, the CBE depends on its ability to influence growth of nominal income to achieve ultimate policy objectives. Therefore, it sets the monetary growth targets to be consistent with the desired growth in income. The CBE can achieve the desired growth rate of income by controlling monetary growth if the behaviour of velocity is predictable. Since the results indicate that the velocity is unpredictable, the CBE cannot successfully achieve the targeted rate of output growth. Moreover, the CBE is required to control money supply to be consistent with maintaining low inflation rate by altering the monetary base conditional on the prediction of MM. That is to say that given the instability of MM, the CBE cannot achieve the desired level of money supply by changing the monetary base. Therefore, the CBE cannot achieve its main goal of low inflation as the money supply would be outside its control. Based on these results, the study recommends that CBE must take further serious steps towards the
implementation of the full-fledged IT regime. The results are consistent with Awad (2010) who provides an evidence of instability of velocity of circulation using cointegration analysis and recommended that CBE should move rapidly to satisfy the preconditions of IT to help in a smooth transition of monetary policy.

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References


## Appendix: Summary of VM and MM studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Case study</th>
<th>Variables studied</th>
<th>Methodology</th>
<th>Sample</th>
<th>Main results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gould and Nelson (1974)</td>
<td>USA</td>
<td>VM</td>
<td>autocorrelation test for first differences</td>
<td>1869-1960</td>
<td>The results indicate the uncorrelatedness of first differences, and implying that VM is RW without drift.</td>
</tr>
<tr>
<td>Bomhoff (1977)</td>
<td>USA and Netherland</td>
<td>MM</td>
<td>Box-Jenkins model</td>
<td>1962:Jan-1971:Dec</td>
<td>The results suggest that if the Dutch CB invested more resources in the collection of data from the banks, then predictions could be made sufficiently precise for use in the control of the money stock.</td>
</tr>
<tr>
<td>Stokes and Neubuger 1979</td>
<td>USA</td>
<td>VM</td>
<td>autocorrelation test for first differences</td>
<td>1869 to 1940</td>
<td>They found that Gould and Nelsons (1974) results are sensitive to the choice of sample and may be affected by heteroscedasticity. They conclude that VM is not RW but it drifts over time.</td>
</tr>
<tr>
<td>Johannes and Rasche (1979)</td>
<td>USA</td>
<td>MM</td>
<td>ARIMA model</td>
<td>1955:Jan-1978-March</td>
<td>They developed a component approach to forecasting the MM. Their results suggest that the forecasting power of the component approach is superior to forecasting the MM itself.</td>
</tr>
<tr>
<td>Ahking 1982</td>
<td>EEC countries*</td>
<td>VM</td>
<td>autocorrelation test for white noise</td>
<td>1960:1-1978:4</td>
<td>RWH cannot be rejected. Results are not sensitive to the selected sample, definition of velocity or data frequency</td>
</tr>
<tr>
<td>Hafer and Hein (1984)</td>
<td>USA</td>
<td>MM</td>
<td>OLS</td>
<td>1959:1-1979:12</td>
<td>They compared the relative abilities of two forecasting procedures for MM. The. They presented evidence that</td>
</tr>
</tbody>
</table>
Kim  1985  UK  VM  Ljung-Box autocorrelation test for white noise  1871-1975  RW hypothesis cannot be rejected.


Hall and Noble (1987)  1987  USA  VM  Granger Causality  1960:1 1984:4  Variability of money growth helps predict VM providing empirical verification for Friedmans velocity hypothesis that the decline in velocity was partly due to the increase of the volatility of money growth.

Chowdhuty (1988)  1988  Canada, Germany, Italy and Japan  VM  Granger causality  1964:1 1986:4  The results indicate that the variability of money growth rates help predicting VM supporting Friedmans velocity hypothesis.

Brocato and Smith  1989  USA  VM  Granger causality  1962:Feb-1985:Sep  In contrast to Hall and Noble (1987), their results suggest that the increased volatility of money growth following the late 1979 contributed to a breakdown in the money growth/velocity relationship which contradicts with Friedmans hypothesis which would suggest that the causality results should be even stronger after late 1979. Furthermore, the Friedman hypothesis is not met over the relatively stable period prior to 1979.

Mehra (1989)  1989  USA  VM  Granger Causality  1963:1-1984:2  They showed that Hall and Nobles (1987) results are not robust to some changes in specification as the VM declined in the absence of any further increase in volatility. Hence, it may be necessary to re-examine the role of monetary variance in a more general framework.

---

The aggregate model forecasts the MM as well as the component procedure does.
that controls the influence of other factors on VM. Thus, the results of Hall and Noble (1987) must be viewed with caution.

The existence of unit root is sensitive to the choice of the sample. In addition, results may be sensitive to the choice of the money stock and income measures and the sources of the data.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Country(s)</th>
<th>Method</th>
<th>Sample Period</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siklos (1989)</td>
<td>USA</td>
<td>Dickey-Fuller Unit root test</td>
<td>1870-1986 and 1947:1-1984:4</td>
<td>These countries are France, Germany, Netherland, Italy, and UK.</td>
</tr>
<tr>
<td></td>
<td>Canada</td>
<td></td>
<td>1870-1986</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UK</td>
<td></td>
<td>1870-1985</td>
<td></td>
</tr>
<tr>
<td>Serletis (1990)</td>
<td>USA</td>
<td>Granger causality</td>
<td>1973:2 1988:1</td>
<td></td>
</tr>
</tbody>
</table>

They provide evidence supporting Friedmans velocity hypothesis that money volatility leads VM to change.

He tested the relation between VM changes and anticipated and unanticipated monetary growth and its volatility. The results indicate that a multivariate model including anticipated and unanticipated monetary growth and its volatility improved the predictability of VM.

He concludes that the misbehaviour of the velocity of M1 in the 1980s originates from a shift in the process generating VM and is not attributed to unusual volatility in the determinants of VM.

He tested Friedmans velocity hypothesis regarding the relationship between the volatility of money growth and VM and found mixed results. That is, the results are sensitive to the choice of the lag structure used as well as proxies for money growth variability.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Country</th>
<th>VM</th>
<th>Method</th>
<th>Sample Period</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karfakis (2002)</td>
<td>Greece</td>
<td>VM</td>
<td>ARDL model</td>
<td>1948-1997</td>
<td>The VM is stationary process. There is a proportional relation between nominal income and money suggests that shocks which affect the money supply are reflected in the nominal income. Thus, VM will not fluctuate widely and its movements will be predictable.</td>
</tr>
<tr>
<td>Moosa and Kim (2006)</td>
<td>UK</td>
<td>MM and VM</td>
<td>AR model and Harveys structural time series model</td>
<td>1970:1–1999:3</td>
<td>They compared direct and indirect methods of forecasting. Results are mixed but the overall evidence seems to be supportive of the direct method.</td>
</tr>
<tr>
<td>Omer and Saqib (2009)</td>
<td>Pakistan</td>
<td>VM</td>
<td>ADF unit root test</td>
<td>1975- 2006</td>
<td>The results showed that VM are not stable as it is integrated of order one.</td>
</tr>
<tr>
<td>Author</td>
<td>Country</td>
<td>Method</td>
<td>Data Range</td>
<td>Result</td>
<td></td>
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</tr>
<tr>
<td>Rami (2011)</td>
<td>India</td>
<td>VM</td>
<td>OLS</td>
<td>1972-2004</td>
<td>The results support the monetarist model as the velocity of M3 is predictable.</td>
</tr>
</tbody>
</table>

***G7 countries are France, Germany, Netherlands, Italy, UK, Japan and USA.

**** It is a methodology used to decompose an observed time series into unobserved components. These components are the trend component that represents the long-run changes, the cyclical, the seasonal and the random component. These components can be predicted individually and combined to produce a forecast for the total series.