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Policy Analysis Unit (PAU)
Bangladesh Bank
Head Office, Dhaka, Bangladesh
(www.bangladeshbank.org.bd)
(www.bangladesh-bank.org)

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Financial Development and Velocity of Money in Bangladesh: A Vector Auto-Regression Analysis

Md. Akhtaruzzaman[1]

Abstract

The study uses co-integration and vector auto-regression (VAR) techniques to identify the determinants of income velocity of money (VM) in Bangladesh. The analysis covers both narrow money (M1) and broad money (M2). The co-integration results support a negative relationship of VM with economic growth indicating a declining VM over time in Bangladesh. It is observed that financial development, as measured by its proxies, affects VM negatively. As such, having a declining VM with financial development, the potential adverse impact of expansionary monetary policy is likely to be small in Bangladesh. The VAR estimates show that two variables, real GDP growth and financial development, jointly account for around half of the variance of speed of VM for both M1 and M2. Inflation expectation appears to have a strong influence on VM. The results show that it is important for the monetary authorities to take into account both stages of economic and financial development in forecasting VM for designing effective monetary policy in Bangladesh.

Key words: velocity of narrow and broad money, safe limit to monetary expansion, financial development, inflation expectation, Cambridge equation of exchange, money multiplier, rate of monetization, co-integration, unit root test, VAR, forecast error variance.

JEL Classifications: C32, E44, E47, E51, E58

[1] Senior Research Economist, Policy Analysis Unit (PAU), Bangladesh Bank, Dhaka, Bangladesh. The author is extremely grateful to Dr. Mustafa K. Mujeri, Chief Economist, Bangladesh Bank for giving useful guidance, valuable comments and suggestions in preparing this paper. The views expressed in the paper, are, however, author's own and do not necessarily reflect those of Bangladesh Bank. The usual disclaimer applies. Comments and suggestions on the paper are most welcome and should be forwarded to raisaakhtar@yahoo.com.

I. Introduction

A good understanding of the behavior of the income velocity of money (VM) is important in setting credible monetary policy programs since VM exerts powerful influence in determining the desired (or required) future stock of money in the economy. In fact, the numerical value of VM and its determining factors play substantial role in ensuring the effectiveness of monetary policy for promoting price stability and stimulating economic growth. In other words, reliable estimates of VM and its forecasts on likely changes in future especially in a country like Bangladesh where yearly economic growth fluctuates due to exogenous shocks resulting from natural disasters and other unforeseen events, are critical to conducting efficient monetary policy operations. It is important since when VM is unpredictable, demand for money is likely to be unstable making the standard relationship between GDP, inflation, and money supply uncertain contributing to weak effectiveness of monetary policy.

In recent years, VM has gained increasing importance in analyzing the efficacy of monetary policy in Bangladesh. As such the objective of this paper is to identify the determinants of VM in Bangladesh. Also, the paper examines whether the stage of economic development has any influence on the historical value of velocity. This has been examined by using a hybrid model of Friedman's modern quantity theory and the Keynesian version of the liquidity preference theory. In addition, the issue as to whether the behavior of prices governs the value of income velocity of money has been analyzed since a critical concern of the monetary authority is to ensure adequate supply of money without causing inflation. If VM falls as per capita real GDP rises, the monetary authority can issue more money and obtain a greater leverage on resources than if VM remains constant or rises. The paper examines these issues in the context of Bangladesh and draws relevant policy implications.

The paper is organized as follows. After this brief introduction, section II provides an outline of relevant conceptual issues while section III reviews the theoretical underpinnings related to VM. Section IV analyzes the present status of financial sector liberalization and development in Bangladesh and its potential impact on the predictability of the velocity of money. Section V outlines a basic theoretical analysis of the specification of income velocity of money function. Section VI discusses the data base and its sources and explores the empirical methodology related with the estimation of the velocity of money equation and the econometric estimation results are discussed subsequently. Finally, section VII summarizes the major findings and their policy implications.

II. Income Velocity of Money: Conceptual Issues

In practice, VM is taken as the average number of times that a national currency (Taka for Bangladesh) is spent in a year. Hence, it can be defined as the ratio of nominal GDP (P*Y) to money supply (M). There are some closely related concepts like the degree of monetization of the economy (M/PY) which is the reciprocal of VM. Similarly, VM is the reciprocal of money multiplier (MM). As such, the estimate of the safe limit to monetary expansion for year (t+1) is conditioned by the forecasted value of VM together with expected future growth of GDP and projected inflation rate for the year t+1.[2] In this

[2] Let Y_t = real income and y_t = nominal income. Then

context, the modern version (cash balance version) of the quantity theory of money (known as the Cambridge equation of exchange) gives:

$$M_t \, VM_t = P_t \, Y_t$$

The above equation for period t+1 is,

$$M_{t+1} \, VM_{t+1} = P_{t+1} \, Y_{t+1} \; ;$$

which, using growth formula can be written as:

$$M_t (1 + m) \, VM_t (1 + vm) = P_t (1 + p) Y_t (1 + y)$$

or, $(1 + m)(1 + vm) = (1 + p)(1 + y)$ since $P_t \, Y_t / M_t \, VM_t = 1$

Therefore, $(1 + m)(1 + vm) = (1 + p)(1 + y)$

From above we get

$$M = [(1 + p)(1 + y) / (1 + vm)] - 1$$

where, M = money supply, VM = income velocity of money, P = price level, and Y = real income; and all lower case letters indicate growth rate of the corresponding variables.

As Short (1973) has suggested, the behavior of VM is an important determinant of how much financial resources an economy can generate through the operations of its financial system without eroding it through higher inflation. Therefore, it is clear that the behavior of VM determines the extent of command that the monetary authority has over monetary institutions to ensure higher economic growth without causing inflation. For example, if VM falls as per capita real GDP rises, the monetary authority can issue more money and obtain a greater leverage on resources than if VM remains constant or rises.[3]

$y_t = P_t \, Y_t$ and $y_{t+1} = P_{t+1} \, Y_{t+1.}$ Taking p as the growth rate of price and $\hat{y}$ as the GDP growth rate, we can write:

$(1 + \hat{y}) = (1 + p)(1 + \hat{y})$; since, $P_t \, Y_t / y_t = 1$

$y_t (1 + \hat{y}) = P_t (1 + p) \, Y_t (1 + \hat{y})$.

Therefore we get $\Rightarrow \hat{y} = [(1 + p)(1 + \hat{y})] - 1$ ------------------ (1)

As we know $d(\log y)/dt = 1/y * dy/dt$; $\Rightarrow d \log y = dy/y = \hat{y}$

$\Rightarrow$ therefore, also $\Rightarrow d \log Y = dY/Y = \hat{Y}$; $d \log P = dP/P = p$

Since income elasticity of the demand for nominal money $= \zeta_{md} = M/\hat{y}$,

after putting the value of $\hat{y}$ from (1) and re-arranging terms we get $\Rightarrow$

$M = \zeta_{md} * \hat{y} = \zeta_{md} * [\{(1 + p)(1 + \hat{y})\} - 1]$

3 Assuming the income elasticity of nominal demand for money $\zeta_{md} = 1.25$, the safe limit of monetary expansion under alternative assumptions of income growth and inflation rate can be estimated as follows:

Case 1: Let $p = 8.0\%$, $\hat{Y} = 6.0\%$, $\zeta_{md} = 1.25$; then $\hat{y} = 14.48\%$, $M = 18.1\%$, $VM = -3.1$

Case 2: Let $p = 8.5\%$, $\hat{Y} = 6.0\%$, $\zeta_{md} = 1.25$, then $\hat{y} = 15.01\%$, $M = 18.8\%$, $VM = -3.2$.

Case 3: $p = 10.0\%$, $\hat{Y} = 6.0\%$, $\zeta_{md} = 1.25$, then $\hat{y} = 16.6\%$, $M = 20.8\%$, $V = -3.4$

The above examples imply that when growth of V declines, we need to increase the money supply at a higher rate and when VM grows we need to increase the size of money stock at a slower rate.

III. Review of Literature

The origin of the theoretical analysis on VM can be traced back to the classical quantity theory of money giving direct causal nexus between two variables; price (only unknown variable) and the money supply (determined by the monetary authority that is, central bank and/or ministry of finance). The other two variables, velocity of money (VM) and real income (Y) are taken as constant so that VM has only a passive role. The theoretical justification behind holding VM constant originates from the belief of the classicists that real income (volume of GDP) stays constant in both short and long runs and hence, VM is also constant, that is, the real income is given as fixed since the economy operates in full employment equilibrium and any deviations will be automatically cleared by price and money (so that the equilibrium is stable). The classicists believed that VM depends on some exogenous factors, that are not subjected to much change both in short and long runs, such as:

- psychology of individuals regarding lending and borrowing behaviors;
- social and institutional factors determining mode of payment and people's saving behavior; and
- customs and conventions prevailing in society and affecting people's lending-borrowing behaviors;

Classicists believed that since these factors are unlikely to change substantially even in the long run, VM can rightly be assumed as constant (Kurihara 1951, Chandler 1962). In this way, classicists made the role of VM passive or subsidiary (as parametric constant); that can be taken as constant for a long time.

However, Keynes' 'liquidity preference theory' injected new dimensions into the monetary theoretic aspect of the quantity theory using the income-expenditure macroeconomic framework. The liquidity preference theory of Keynes argued that the classical quantity theory provides a partial view of money demand forces in the economy. In fact, classical quantity theory only considers transaction and precautionary demands for money but does not take into account other important components such as the speculative money demand for money, important to explain cyclical fluctuations of macroeconomic variables like aggregate demand. So the quantity theory was reformulated by adding the speculative money demand component to transaction and precautionary demand components in order to obtain realistic money demand estimates. But the potential role of velocity of money remained inadequately addressed.

In the modern version of the quantity theory, Friedman argued against treating VM as a parameter and explored the variables which could determine the size of VM.[4] Since then VM has been gaining due attention of researchers. After recent developments of the monetary theoretic approach to balance of payments and its integration into aggregate macroeconomic model, developed by Polak and rigorously formulated by Mundel and Flemming, the role of VM has gained increasing importance in the analysis of monetary policy and its effectiveness.

[4] Modern quantity theory $\Rightarrow$ Md/P (real money demand) = f (Yp, h, r, pexp) * Y $\Rightarrow$ V = PY/Md
where Yp = permanent income; h = human/non-human wealth; r = interest rate; pexp = expected inflation that can be defined either by past rate of inflation or an average of growth of P over past P.

A closer look of the estimation techniques of the safe limit to monetary expansion, as discussed above, emphasizes the importance of the role of income velocity. As we have seen, appropriate estimation of safe limit of money growth rate critically depends on correct forecasting of the growth rate of VM and two related parameters, rates of inflation and income growth. That implies that for effective price stabilization, it is pertinent that the monetary authorities predict the movement of income velocity of money with some level of accuracy, which is not always an easy task. While predicting, the policy makers should not only take into account the changes in some monetary variables like interest rate but also the behavior and likely decisions of the households, businesses, and financial institutions despite the fact that these parties operate and make decisions independently (Hassan 1993). Therefore, error in forecasting VM is not rare that consequently affects the effectiveness of monetary policy as well.

IV. Financial Development and Movement of VM in Bangladesh

In the rapidly changing and emerging characteristics of the Bangladesh economy where saving and deposit, lending and borrowing, and other financial behaviors are rapidly changing, the assumption that VM remains constant is not likely to be realistic. With growth in financial transactions, advancement in loan distribution techniques, financial innovation and service automation, and other structural changes, significant psychological, social, and institutional changes in the lending-borrowing behaviors of individuals and businesses have taken place in the economy including changes in customs and conventions in society. It is, therefore, expected that VM would undergo changes in response to the changing lending-borrowing behavior of the people.

Several other factors may be identified that are likely to add complexity in forecasting VM and its movement over time. *First,* Bangladesh has undergone deep and radical changes in the banking sector and experienced significant financial deepening under the financial liberalization and reforms policies since the 1990s. Many important liberalization policies have already been implemented such as liberalization of deposit and lending interest rates, more flexible and transparent rules for opening new banks in the private sector, and removal of government restrictions and controls over the exchange rate and capital flows. As a result, 40 new banks and many other non-bank financial institutions started operating in the private sector. It is likely therefore that financial liberalization measures might have brought stronger interest rate sensitivity of money demand and in lending-borrowing behaviors of the people.

Second, as a part of the privatization process, two public sector banks (e.g. Uttara Bank and Pubali Bank) were denationalized in 1983/84. In 2008, three other nationalized commercial banks were transformed into public limited companies. This move toward corporatization is likely to have important implications for market-oriented operation in the banking sector since these banks constitute the country's largest commercial banks which previously operated in the public sector. *Third,* another important factor is the development and spread of rural banking system that may also shift funds from the informal sector to the banking system, a fact which is reflected in the increasing rate of monetization of the Bangladesh economy. Such changes may affect money demand through holding of more monetary aggregates and consequently the movement of VM would be highly impacted.

The present study seeks to identify the determinants of VM in the Bangladesh economy and differs from existing studies on the subject in a number of ways. First, we use a recent data set over the period 1973-2007 to identify the determinants of velocity. Since the monetary sector of Bangladesh has undergone deep structural changes through the financial sector reforms since the 1990s, the coverage of the present study is likely to reveal the impact of these changes. Second, like many other countries, Bangladesh conducts monetary policy by targeting the growth of broad money supply with a pre-determined value. Implicit in such monetary targeting approach is the presumption that money demand is stable and income velocity of money is correctly predictable. We shall examine the degree of stability of VM through using econometrically identified determinants of velocity.

Third, we propose to study the stationary properties of various parameters of velocity by employing Augmented Dickey-Fuller test to examine time series properties of velocity, real income, interest rate, and other indicators of financial development and inflation expectations. Finally, we shall examine the relative role of various determinants in the variation of velocity within a vector auto regression framework using the variance decomposition (VDC) technique.

V. Model Specification

Modern quantity theory indicates that the velocity function depends on some measure of income and inflation. Short (1973) has investigated the income velocity of money for Malaysia and Singapore using data for the period 1951-1966. He found that the velocity was positively related to the number of bank branches and negatively related to per capita GDP. In this study, interest rate was found to be statistically insignificant. As discussed above, the rapid growth of institutions, especially the banking system, also affect the way people conduct their economic transactions. A measure of financial sector development should therefore enter the velocity function along with measures of income and inflation. In the light of the theoretical and empirical discussion in the earlier sections, we propose the following model of velocity for econometric estimation:

$$VM = f(Y, i, FDEV)$$

where FDEV = a proxy for financial development, Y = real income, i = interest rate.

Several alternatives can be considered as proxy for financial development, such as growth of financial institutions that is, evolution of number of bank branches, financial innovation, demand deposit-currency ratio (DD/C), time deposit-currency ratio (TD/C), demand deposit-time deposit ratio (DD/TD) and similar other variables (Bordo and Jonung 1981, Aghevli 1980). Although the number of bank branches is often positively related with bank deposits in developing countries, this may not always be a good proxy for financial development. The banks contribute to economic development by intermediating funds from surplus-spending household units to deficit-spending business sectors. The intermediation approach treats banks as collectors of funds which are then intermediated into loans and other assets. So, it is expected that with the development of the banking industry, bank output increases in terms of demand deposits. Therefore, the volume of deposits would be the appropriate measure of bank output (Sealy and Lindley 1977) and the deposit volume, rather than the number of bank branches, plays the critical role in the development process.

In the absence of alternative financial assets to money in most developing countries, people tend to substitute demand deposits for time deposits as income increases and financial maturity of investors gets momentum.[5] The financial development also reduces transaction costs associated with transfer of funds between demand and time deposits. Lower transaction cost is likely to increase the proportion of total savings held in time deposits. Therefore, financial development is likely to increase the collection of time deposits (TD) at a higher rate than demand deposits (DD) implying declining DD/TD ratio with financial development. So, the expected sign of DD/TD could either be positive or negative in velocity function depending on the level of development of Bangladesh economy as proxied by GDP growth. With increasing financial maturity, people will hold more money in time deposits which slows the speed of velocity via lowering the value of credit and money multipliers and therefore, velocity will be inversely related with DD/TD.

Considering the state of financial development in a growing economy like Bangladesh, the interest rate might not play its due role as the rate of return on alternative assets (e.g. substitute to money as a store of value). Although several newly introduced financial assets are available in the financial market at present, these are still inadequate to serve as substitutes of money. Furthermore, in Bangladesh interest rate is not yet fully market determined. Hence, the asset choice of wealth holders is largely limited between money and real assets; and not so much between money and financial assets. So some alternative measures of opportunity cost of assets substitution can be considered. Assets held in the form of liquid money depreciate its value at the rate of inflation while real assets usually appreciate with inflation. So, in order to explain asset substitution between money and real assets, expected rate of inflation could be a more appropriate measure of opportunity cost of holding money compared with the nominal interest rate. Assuming static expectations as in Driscoll and Lahiri (1983), the actual inflation rate in any given period is used as a proxy for expected inflation rate in the next period (Δp_{t-1}). The theoretically plausible sign of expected inflation rate is positive implying an inverse relationship with holding domestic money and hence, a direct relationship with velocity. Since assets held in the form of liquid money depreciate its value at the rate of inflation, people are expected to substitute into holding more real assets.

In Bangladesh, with a gradually evolving financial market, the role of interest rate as a rate of return is expected to play increasing role in substitution between money and financial assets. Hence, the role of deposit interest rate (*DEPOINT*) as a determinant is separately treated in the model to identify the potential impact of interest rate. So, the specification of the velocity function takes the following form:

$$VM = f\{\underset{+/-}{DD/TD} \text{ (or } \underset{+/-}{C/D}), \quad \underset{+/-}{Y}, \quad \underset{-}{i}, \quad \underset{+}{\Delta P/P}\}$$

where, the signs + and – indicate direct and inverse relationships respectively between VM and the independent variables defined in the model. So, DD/TD could have either direct or inverse relation with VM. Likewise, C/D, Y might also have direct or inverse relationship with VM. Here DD/TD or C/D is used as a proxy for measuring the level of financial development of the Bangladesh economy. The remaining two variables namely, i and ΔP/P are likely to have negative and positive values respectively.

[5] Demand deposit includes all short term deposits such as all checkable and current account deposits, traveler's checks, and IOUs (see line 24 and 25, IMF's International Financial Statistics).

Many studies have found VM as a negative function of per capita income but this result contradicts the quantity theory. Fry (1988) points out that the sign of correlation between VM and per capita income (negative or positive) depends on the stage of economic development, especially the stage of financial development. At the initial stage, velocity should fall with higher growth of income but at a later stage, velocity and income become positively correlated. This is because the initial stage in economic development is characterized by increasing monetization of the economy that is, spread of banking habits and relatively rapid expansion of purely financial or monetary transactions which contribute to proportionately higher demand for money making income elasticity of money demand highly elastic and hence, velocity is likely to fall.[6]

At advanced stages, financial development affects VM positively so that VM increases with financial development. These stages are characterized by transaction efficiency, financial innovation, and technological progress which ensure the availability and use of money substitutes and provide a wide range of money substitutes or quasi-money that reduce the demand for money which brings the speed of VM up. While some researchers mention the possibility of a U shaped velocity function with respect to economic development, the hypothesis has not been tested empirically. Bordo and Jonung (1981) mentions that forces (speed of monetization and more intensive use of money stock) that pull VM in different directions may operate simultaneously and VM may remain stable.

The velocity of money is usually defined as the ratio of nominal GDP to money supply (GDP/M). The definition of money supply used in empirical analysis, however, should reflect the underlying changes in the monetary sector of the economy. In the early stages of development, transaction and precautionary needs can be satisfied by using currency or demand deposits. In this case, therefore, the narrow definition of money, M1 (demand deposit plus currency in circulation) would be more appropriate. At later stages of financial development, a large number of monetary instruments become available and the transactions as well as other needs are satisfied through the use of time deposits as well. A broader definition of money supply would be more appropriate in this case and it has been found in many empirical studies that the broad money function is more stable than the narrow money function in both developed and developing countries. However, in the absence of any objectively defined demarcation of socio-economic and financial development, the appropriateness of the use of narrow or broader definitions of money could be determined empirically. The present study uses both definitions of money to test the degree of development of the monetary sector and the nature of its contribution in affecting the income velocity of money.

VI. Data, Empirical Methodology and Estimation Results

Data

All data sets used in the present analysis are taken from the Quarterly International Financial Statistics (IFS) of the International Monetary Fund (IMF), covering the period 1973: I to 2007: V. The nominal M1 consists of currency outside banks and demand

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[6] One study shows that VM has a positive relation with growth of income $\Rightarrow$ GDP $\uparrow$ $\Rightarrow$ VM $\uparrow$ which implies that Bangladesh is now at later stages of economic development. (Howlader and Khan 1990). But, monetary and credit programming by Bangladesh Bank takes a declining value of VM in calculating the safe limit of monetary expansion.

deposits. The broad money (M2) supply consists of M1 plus sum of quasi money that consists of time deposits, saving deposits, and foreign currency deposits held by all depositors excepting government deposits. We prefer to use quarterly data, thereby improving the power of the test statistics by increasing the number of observations which stands at 140 observations. In case of Bangladesh, one limitation of the use of quarterly data set is that there is no quarterly data for GDP. But, timely data is available on agricultural production on a quarterly basis and therefore, to overcome this problem we estimated the quarterly GDP data by our own method.[7] The real GDP is at 1995/96 constant prices. The weighted average deposit interest rate and the 1995/96 consumer price index (CPI) have been used.

Empirical Methodology and Analysis of Econometric Estimation Results

The empirical analysis of the present study involves several steps. First, unit root tests are conducted to determine whether the variables included in the analysis are stationary and the order of integration of each series. Second, the co-integration relation between velocity (VM) and the variables specified in model are tested. We have obtained two co-integrating relations using two alternative definitions of velocity functions which show correct signs for independent variables. Finally, variance decomposition of the variables are done using vector auto regressive (VAR) model.

Stationarity Properties of Time Series Data

For meaningful understanding of the relationship between two or more economic variables using the regression technique, the time series (TS) need to satisfy some stationarity properties. For example, shocks to the stationary TS are necessarily temporary; overtime the effects of the shocks dissipate and the series revert to its long-run equilibrium mean value while shocks to the non-stationary TS make it explosive. Non-stationarity in TS generally arises due to the presence of trends in the data which is stochastic in nature (random walk process) and it confirms that the data has a unit root process. Stochastic behavior of TS is sometimes characterized by what is called “drifts” (first upward and then downward). Any regression result with non-stationary TS provides spurious relationships because in any dynamic specification of a model in the levels of the series with unit root (such as the partial adjustment model) is likely to be inappropriate, and may be plagued by problems of spurious regression between variables and therefore, provide misleading implication of the relationship. Therefore, the variables in any economic model are required to be tested for its stationarity property and the order of long-run integration prior to estimating statistical relationship between economic variables.

Results of Unit Root Test

The tests of stationarity in the TS of all the variables (in log form except interest rate and inflation rate) in question are performed by applying three popular tests, namely,

[7] In constructing quarterly GDP we follow seasonal factors for the variation of agricultural production. We first categorized six major agricultural crops, rice (three varieties), wheat, tea and jute, whose production is heavily influenced by seasonality. For example, in rice production we have taken three major harvesting period; aman rice (October-December); boro rice (April-June); aus rice(July-September). For other three agricultural goods, the harvesting periods are: wheat (January-March), tea (July-December) and jute (July-September). For other major sectoral outputs i,e, industrial and service sector outputs, there are very little seasonal variation and therefore, their outputs are distributed equally into four quarters of each year.

Augmented Dickey-Fuller (ADF) test, Phillips-Perron test (PP) and KPSS test. The results of all three unit root tests are presented in Table1 (see Annex 1). The results show that the null hypothesis, H_0, (have unit roots) can not be rejected for all variables in question, that is, velocity of narrow money ($VM1_t$), velocity of broad money ($VM2_t$), price expectation, $pexp_t$ (Δp_{t-1}), and currency-deposit ratio (C/D_t) are non-stationary in levels form for both cases with and without time trend. The variables DD/TD_t, is seen to be stationary in level form in PP test though in other two tests it is non-stationary. For the variable deposit interest rate ($DEPOINT_t$), y_t we find that it is stationary in KPSS test but non-stationary in other two tests. So, after observing the minor differences in unit root test results of ADF, KPSS and PP statistics, it can be concluded that all variables are at least non-stationery in level form which means that they are integrated of order one, I(1), and therefore, included in the co-integration analysis. So, the next step is to establish a co-integrating relationship between these non-stationary variables in the model.

Co-integrating Relationship and Long-Run Behavior of Determinants of VM

Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series (which have the same order of integration) may be stationary. If such a stationary linear combination exists, the non-stationary TS are said to be co-integrated. The stationary linear combination is called the co-integrating equation and may be interpreted as a long-run equilibrium relationship among the variables. In order to test the existence of co-integrating relationships between non-stationary variables in the model we applied the Johansen (1988, 1991, 1995) and Johansen and Juselius (1990, 1992) multivariate co-integrating methodology which jointly determine empirically the number of r (maximum $k-1$) co-integrating vectors from a vector of k endogenous variables in the model along with coefficients of the variables and the adjustment parameters. Johansen procedure is based on the technique of reduced rank regression where r is the rank of the original vector of variables with order $k \times r$.[8]

Estimation of Co-integrating Relation between VM and Determinants: Result Analysis

Following the Johansen procedure, we applied a fifth order VAR (with a maximum lag of five) to test for co-integration in two sets of velocity equation. In choosing co-integrating equations we use regression specification with deterministic trend component in our empirical estimate which means we adopt case-3 specification out of 5 alternatives.[9]

The estimation results (Tables 2 and 3) show that there exists a co-integrating (or long-run) relationship between two types of velocity of money ($VM1_t$ or $VM2_t$) and different explanatory variables, namely, level of real income (y_t) price expectation (Δp_{t-1}), proxy for

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[8] In the original Engle and Granger approach to co-integration it is established that if the μ_t,s are stationary, differences between the x_t series ultimately die out and the variables x_t are thought to exists in a long run balance. In the case of tests for co-integration, the critical values for the test statistics differ according to the number of variables, k, in the co-integrating regression as well as according to the assumptions regarding the intercept and deterministic trend component (five different specifications are available).

[9] We assumed that the level series of endogenous variables have linear deterministic trends but the co-integrating equations have only intercepts (constants) and this choice is based on our experience from the unit root tests which have shown that the critical values of ADF statistics for all the variables were improving when we consider a time trend and also they are stationary in first difference (integrated of order one). Again, we observed that inclusion of time trend in the vector auto-regressive scheme (VAR) did not make any significant effect on the value of Trace statistic or maximum eigenvalue statistic in determining the co-integrating relationships. The results are presented in Tables 3 to 6 in the annex.

financial development such as demand deposit-time deposit ratio (DD/TD_t), or currency-deposit ratio (C/D_t), and measures of the opportunity cost of holding money balances relative to interest bearing assets, or relative to the real rate of return in the economy, as proxied by the deposit rate of interest ($DEPOINT_t$).

We have estimated two different co-integrating relationships for two velocity models separately: for narrow money velocity ($VM1_t$) and broad money velocity ($VM2_t$) using the technique of multivariate co-integrating relationships using Johansen and Juselius method. In all the cases, the critical values of the maximal eigenvalue statistics and trace statistics (strongly) reject the null hypothesis of no (zero) co-integrating vector in favor of a one co-integrating vectors in each case at both the 1 and 5 percent levels of significance. These imply that there are long run stationary relationships between velocity of money ($VM1_t$ or $VM2_t$) and the independent variables captured in our theoretical specification; put it in another way, the velocity of narrow money or broad money in Bangladesh expressed in ($VM1_t$ or $VM2_t$) is significantly influenced by the level of scale variable y_t, (real income) and also by the expected rate of inflation (Δp_{t-1}), deposit interest rate ($DEPOINT_t$), and demand deposit-time deposit ratio (DD/TD_t). However, for one variable, currency-deposit ratio (C/D_t), the coefficient sign is not found theoretically acceptable in co-integrating relations of broad money velocity and also its coefficient is not statistically significant. The possible reason of such absent of co-integrating relation of broad money velocity with currency-deposit ratio might be that in the context of Bangladesh, the major component of broad money is the quasi money (almost 80 percent of broad money) which could not be affected so strongly by the change of currency-deposit ratio and hence, velocity is not much influenced by that ratio. In fact, quasi money is basically term deposits which are used for such activities that usually could not be affected by the currency-deposit ratio and hence, could not impact on the speed of velocity effectively.

Several important observations follow from the results of co-integrating relations.[10] *First,* Tables 2 and 3 show that in both velocity models, the coefficient value (in co-integrating relations) for the explanatory variables y_t is stronger than the coefficient of any other variable which means that the speed of velocity in Bangladesh is essentially related to the stage of development. The negative signs of y_t in both models indicates that income growth affects the velocity inversely showing similarity with results of past studies. This also implies that the economy of Bangladesh is still operating in the early stage of development (see Hassan 1993). *Second,* one common phenomenon which is strongly evident in every co-integration estimates (models) is that the price expectation variable (one year lagged inflation rate) has substantial role in controlling the speed of velocity. *Third,* the variable opportunity cost of holding money, as proxied by deposit interest rate, has shown co-integrating relation with both $VM1_t$ and $VM2_t$ which contradicts the results of past studies on velocity.

Finally, the proxy for financial development also affects the velocity negatively, implying that the lower the value of the proxy variable, the greater the level of financial development and the higher the velocity of money. Furthermore, the impact of level of financial development is very important on the speed of income velocity (for both definitions of velocity, $VM1_t$ or $VM2_t$) but it plays stronger role on narrow money velocity which is seen from the high coefficient value of variables in co-integrating relation in $VM1_t$ model. So, in the context of Bangladesh, the role of financial development is very

[10] All econometric estimations were done using econometric view (E-View) software.

important in forecasting the future value of income velocity of money. In the next sub-section we shall employ innovation accounting approach using a VAR to determine the relative contribution of different variables of interest (forecast error variance, FEV) in the variation of the speed of velocity of money which is known as variance decomposition.

VAR Methodology and Innovation Accounting Approach to Velocity

Vector auto-regression (VAR) is an econometric technique for estimating and analyzing the interrelationships among multi-variable time series. It is essentially a system of reduced form dynamic linear equations in which each variable is expressed as a function of serially uncorrelated errors and an equal number of lags of all variables in the system. Unlike structural models, all variables in the system become endogenous, and a VAR model therefore specifies a relatively unrestricted dynamic process. The primary appeal of the VAR approach is that the model is free from structural restrictions of any particular model builder (see Sims 1980, Fischer 1981). The VAR model assumes that the contemporaneous correlations of errors across equations are nonzero. Since there are no contemporaneous explanatory variables in the model, their error terms (also called *innovations*) provide a potential source of new information about the movements in a variable during the current period.[11] Individual coefficients estimated in a VAR are not very meaningful because of the problem of severe multicollinearity among the lagged variables. One, therefore, infers interrelationships among the model variables from either Granger Causality tests (Granger 1969) or Forecast Error Variance (FEV) decomposition (also called innovations accounting) following Sims. This study employs the FEV decompositions to derive economic interpretations of the data following Sims (1980a, 1980b).[12] Innovations accounting involves the decomposition of the FEV for each variable into components attributable to its own innovations and to shocks to other variables included in the model.

Problem of Contemporaneous Correlations

While by construction the innovations in any series are serially uncorrelated, they may be correlated contemporaneously. Therefore, it is not proper to interpret the effects of an innovation in a given variable, say, **x**, as deriving solely from $e_{x.}$ Part of an innovation in **x** may be due to the contemporaneous influence of other innovations on the **x** innovations. For example, if the innovations in output growth and velocity are contemporaneously correlated, it is not correct to interpret the effect of an innovation in velocity as solely due to "exogenous" influence on changes in the output growth. The coefficient of output on the first lagged innovation to velocity may be interpreted as the effect on output of last period shock to velocity. However, if the last period's innovation to velocity is highly correlated with last period's output innovation (which is contemporaneous as of last period), then it is improper and incorrect to attribute all of the velocity innovation to the independent effect of velocity on output. The contemporaneous correlation links the innovations of the variables in a way that may prohibit further meaning of decomposition of the FEV.[13]

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[11] For technical details about VAR system equation, its solutions and innovation accounting see Appendix I.

[12] See Appendix I.

[13] The estimated contemporaneous correlation of the innovations provides useful information concerning co-movements of the variables. As we will see that a strong contemporaneous correlations generally (but not always) indicate dynamic relationship between two variables that may follow over a longer time horizon.

Exogeneity Tests

We conduct the exogeneity tests, because if these variables are exogenous then there is no point in continuing with further analysis to identify their determinants. The test is based on forecast error variance decompositions and proceeds as follows: the variable whose exogeneity is to be examined is placed in the first position of the ordering in the Choleski decomposition scheme. The correlations of all other variables are placed next to it in the sequence. It's own innovations and the contemporaneous correlation of the remaining variables now explain the FEV of the variable in the system. So if a significantly large proportion of the FEVs of the variable remain uncorrelated for, the variable is considered exogenous. We also computed the FEV by placing the variables in the last position of the ordering. The estimated FEVs of the variables in the last position of the ordering are completely free of conditional correlations. Its own innovations and the effects of other variables only through the lag structure now account for its FEVs. Based on the proportion of FEVs explained by own innovations neither the variables income velocity of narrow money (VM1) nor velocity of broad money (VM2) can be considered exogenous as very a small proportion of the variation is explained by these variables (Box 1). This means that macroeconomic and financial market variables contribute to the speed of both definitions of income velocity of money.

Box1: Exogeneity of Dependent Variables in the Model

Position in the ordering	Variable	Forecast horizon	% of FEV explained
1st position	VM1	36 months	23.26
Last position	VM1	36 months	12.03
1st position	VM2	36 months	17.20
Last position	VM2	36 months	16.65

Specifying the Empirical VAR System

Initially we considered a set of six variables for empirical analysis. The economic rationale for choosing these variables was based on theoretical reasoning as discussed earlier. However, a six variable VAR model is not empirically feasible given the serious degrees of freedom constraint, and the severity of multicollinearity. As a result, interpretation of causal linkages would also be problematic and misleading. Which variable or variables should be included in the VAR specification, however, is an empirical question. Therefore, several alternatives of five variable VAR models were

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These correlations also indicate the direction of movements of the two correlated variables. In multiple time series modeling, the size of the correlations between two variables may provide some guidance as to their appropriateness for inclusion in the same model at the same time to avoid the problem of multicollinearity. To overcome the above, we have to quantify the cumulative response of an element of $\mathbf{X_t}$ to an innovation in such a way that confirms that the components of 'ϵ_t' be orthogonal. The effect of the orthogonalization is to allocate the contemporaneous correlation of the innovations among them. The standard practice is to choose some particular ordering of the variables, motivated by economic theory, prior to orthogonalization. The most widely used orthogonalization procedure is the *Choleski factorization*. The procedure eliminates any contemporaneous correlation between a given innovation series and all those series which precede it in the chosen ordering. One consequence of the *Choleski factorization* is that a variable that is placed later in the ordering will be assigned a reduced importance in the decomposition. Thus the ordering of variables is crucial in interpreting the results of the decomposed FEVs. See Cooley and Leroy 1985.

estimated in a multiple regression framework and the best model is judged based on a minimum standard error (SE) criterion. In specifying the optimal lag length of the VAR model, we employed the widely used likelihood ratio test following Enders (1996). The test was conducted at a step of 1-quarters up to a maximum of k=16 periods.[14]

Analysis of Results of Variance Decomposition Estimates

To compute variance decompositions, we use intuitive economic reasoning for ordering the variables following Sims (1985), among others. The ordering of variables in the Choleski decomposition scheme follows a causal ordering. The variable, which is believed to be exogenous, is placed in the first position and then, other variables follow in a sequence as if the next variable is caused by the one preceding it. The variable $VM1_t$, or $VM2_t$, in our case is placed in the last position on the assumption that all other variables affect those variables. The following causal chain is used to estimate the FEVs of VMs:

Velocity of broad money; model 1: DD/TD_t y_t $pexp_t$(or Δp_{t-1}) $DEPOINT_t$ $VM2_t$
Velocity of broad money; model 2: C/D_t y_t $pexp_t$(or Δp_{t-1}) $DEPOINT_t$ $VM2_t$

The estimated FEV decompositions are presented in Table 4 to7 for a forecast horizon of maximum 14 quarters; periods are based on one unit shock (one standard deviation, SD) to the system. During the initial periods, the system experiences instabilities and FEVs are not very meaningful. They are presented simply to show the dynamics of the evolution of the shock. The effects of the shock evolve over time to attain a stable equilibrium. The results in Tables 4 and 5 indicate that for velocity of broad money (and also for velocity of narrow money in Tables 6 and 7) the system attains stability at about 16 periods from where the decomposed FEVs changes very slowly indicating that the system is in its stable equilibrium. At 16 period horizon, growth of real GDP account for 34.4 percent of the variance of speed of velocity followed by proxy variable for stages of financial development or economic development (15.4 percent). Both of these variables jointly account for nearly 50 percent of the variance of velocity of narrow money. The other factor, interest rate accounts for only 2.8 percent of the FEV of the velocity of broad money, $VM2_t$.

Note that the $VM2_t$'s own innovations accounts for 45.8 percent. The fact that velocity's own innovations accounts for a significant proportion of the FEV indicates that past speed or growth of velocity is an important determinant of current speed of velocity which means long run demand for money behavior in Bangladesh is stable and predictable (Akhtaruzzaman 2007). The most important determinant of inflation, apart from velocity itself, is the growth of real GDP which is not surprising given that in the initial stage of development, monetization takes place at a rapid rate that is, the spread of banking habit and the relatively rapid expansion of purely financial or monetary transactions will contribute to proportionately higher demand for money which means income elasticity of money demand is highly elastic and hence, velocity will change accordingly. Stages of financial development and price expectation are the 2nd and 3rd most important factors respectively in influencing or explaining the variation of speed of velocity, a result which is also consistent with the theoretical as well as empirical reasoning in the context of Bangladesh.

The above findings are consistent with available empirical evidence. To discern the role of stages of financial and economic development, we specify and analyze another VAR(1 5)

[14] For technical details see Appendix I

model, using an alternative definition, proxy or indicator of financial development or stages of economic development. For example, we replace ratio of demand deposit to time deposit (*DD/TD_t*) by currency-deposit ratio (*C/D_t*). The FEV decompositions based on this alternative model are presented in Table 5 with the *$VM2_t$* placed in the last position as usual. The results show that the system attains stability at about 16 quarter periods. At 16 quarter periods horizon, growth of real GDP still accounts for the major portion of the variance of speed of velocity but with a bit less proportion (24.5 percent) followed by proxy variable for stages of financial development. In this later model, the alternative indicator of economic development (*C/D_t*) explains greater proportion of variance in changes of velocity (22.2 percent). The contribution of *$VM2_t$*'s own innovation accounts again for greater proportion of variance (44.3 percent). The interest rate variable is found as 3rd most important variable followed by price expectation variable which explains 3.4 percent and 2.6 percent FEV of speed of velocity respectively.

The same causal chain or ordering, as for velocity of narrow money, is used to estimate the FEV decompositions of the income velocity of narrow money equation:

Velocity of narrow money; model 1: DD/TD_t y_t $pexp_t(or\ \Delta p_{t-1})$ $DEPOINT_t$ $VM1_t$
Velocity of narrow money; model 2: C/D_t y_t $pexp_t(or\ \Delta p_{t-1})$ $DEPOINT_t$ $VM1_t$

The variance decompositions of *$VM1_t$* are presented in Tables 6 and 7. In Table 6, we find almost similar results like *$VM2_t$* model. The only difference is that in this *$VM1_t$* model, innovation of price expectations has a marginal role and the innovation of interest rate is weak as well. The result shows that 13.8 percent of FEV of velocity is explained by proxy indicator of stages of economic development, (*DD/TD_t*). But the contribution of growth of real GDP and of own innovation of velocity of narrow money in explaining the variance of *$VM1_t$* show almost similar proportions as in the *$VM2_t$* model, 31.5 percent and 46.6 percent respectively.

In the 4th velocity model we replaced demand deposit-time deposit ratio (*DD/TD_t*) by currency-deposit ratio (*C/D_t*). The FEV decompositions based on this alternative model are presented in Table 7 with *$VM1_t$* placed in the last position as usual. The FEV decomposition results show that the system attains stability at about 16 quarter periods same as in other models. At 16 quarter periods horizon, growth of real GDP though account for important portion but lower proportion (29.8 percent) of the variance of speed of velocity followed by proxy variable for stages of financial development, (*C/D_t*), which explains relatively less proportion of variance of changes of velocity (17.9 percent). The contribution of *$VM1_t$*'s own innovation accounts higher proportion of variance (43.0 percent) which again indicates that past speed or growth of velocity is an important determinant of current speed of velocity of narrow money. The price expectation variable is found to be relatively strong which accounts 5.7 percent of the FEV speed of velocity.

VII. Conclusions and Policy Recommendations

This paper employs the vector autoregression (VAR) technique to identify the important macroeconomic variables, which are believed to generate greater or lesser variation of the speed of income velocity of both definitions of money. Two variables, such as money multiplier and velocity of money are among the most closely watched variables by the monetary authority in estimating the safe limit of monetary expansion and thereby, formulating prudent monetary policy. It is true that the changes of the growth rate or speed of velocity is a relatively long run phenomenon but it occupies a central place in monetary policy. One would therefore like to know which macroeconomic variables they should watch closely to get signals relating to variation in the speed of velocity. The present paper provides an analysis in order to achieve this modest goal.

Our analysis of the determinants of the speed of velocity shows that the two variables, growth of real GDP and the proxy indicator of stages of financial development, jointly account for the lion's share of the variance of speed of velocity (around 75 percent) irrespective of the definition of velocity, followed by price expectations. The inflation expectation of the households creates a reasonably strong influence on the variance of velocity. A direct implication of the above result is that forecasting future values of the speed of velocity is important for estimating the safe limit of monetary expansion which is likely to increase the effectiveness of monetary policy. The behavior of VM determines the degree of command that the monetary authority has over monetary institutions to support higher economic growth without fueling inflation since if VM falls as per capita real GDP rises, the monetary authority can issue more money and obtain a greater leverage on resources than if VM remains constant or rises. The cointegration results of the analysis support the assertion that VM is negatively related with economic growth which means VM has been declining over time in Bangladesh. Therefore, properly designed expansionary monetary policy may not always create adverse effects on aggregate demand due to declining velocity of money with financial development.

The result of the co-integration analysis shows that the proxy for financial development affects the velocity negatively, a result that supports the hypothesis that the Bangladesh economy might be operating at earlier stages of financial development so that the role of financial development is important in forecasting income velocity of money. In an age of instant communication and easy access to information, the stage of economic and financial development has strong implications on changing lending-borrowing and asset substitution behaviors of the people and hence on the speed of income velocity of money. The traditional view of constancy of velocity of money does not seem to hold in the dynamically changing economic environment of Bangladesh and this should be explicitly taken into account in designing effective monetary programs and formulating credible monetary policy in the country.

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Table 1: Unit Root Tests for Individual Series (1973-2007)

Series in level (Log)	without trend			with trend			Decision
	ADF	PP	KPSS	ADF	PP	KPSS	
Income Velocity of Broad Money **($VM2_t$)**	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)*
Income Velocity of Narrow Money **($VM1_t$)**	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)*
Currency in Circulation **(C_t)**	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)*
Demand Deposit **(DD_t)**	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Time Deposit **(TD_t)**	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)	I(1)
Total Deposit **(D_t)**	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)
Lagged Inflation **($pexp_t$)**	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)
Deposit Interest Rate **($DEPOINT_t$)**	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)*
Gross Domestic Product **(y_t)**	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)

Notes 1:

1. I(1) = unit-root, I(0) = stationary, and I(0)* = trend stationary.
2. Lag length for ADF tests are decided based on Akaike's information criterion (AIC).
3. Maximum bandwidths for PP and KPSS test are decided based on Newey-West (1994).
4. All tests are performed on the basis of 5% significance level.

Notes 2:

The variables are defined (as given in the text) as follows: p_t = log of consumer price Index, $pexp_t$ = price expectation (last year's inflation rate), $(DD/TD)_t$ = ratio of demand deposit to time deposit, $(C/D)_t$ = ratio of currency to deposit, y_t = log of real GDP, $DEPOINT_t$ = deposit interest rate, $VM1_t$ = income velocity of narrow money, $VM2_t$ = income velocity of broad money,

Table 2: Income Velocity Model of Circulation of Narrow Money

Co-integration Analysis of Income Velocity of Narrow Money ($VM1_t$) with real GDP (y_t), expectation of inflation (Δp_{t-1}), interest rate ($DEPOINT_t$), and demand deposit-time deposit ratio $(DD/TD)_t$

Eigenvalues	0.44	0.27	0.09	0.07
Hypotheses	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
Trace Statistics (Lambda Trace)	101.42*	44.33	24.23	8.21
95% Critical Values	69.82	47.86	29.80	15.50
Maximum Eigen-Statistic	57.09*	20.10	16.02	7.31
95% Critical Values	33.88	27.58	21.13	14.26

Standardized Co-integrating Vector of Coefficients (or Eigenvectors)

$VM1_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$(DD/TD)_t$
1.00	0.07	-0.41	0.08	0.09
	(0.08)	(0.06)	(0.02)	(0.16)

Standardized Adjustment Coefficients (Alpha Coefficients)

$VM1_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$(DD/TD)_t$
-0.13	0.30	-2.72	0.12	-0.05

Table 3: Income Velocity Model of Circulation of Broad Money

Co-integration Analysis of Income Velocity of Broad Money ($VM2_t$) with real GDP (y_t), inflation expectation (Δp_{t-1}), interest rate ($DEPOINT_t$), and demand deposit-time deposit ratio $(C/D)_t$

Eigenvalues	0.44	0.27	0.09	0.07
Hypotheses	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
Trace Statistics (Lambda Trace)	76.69*	37.57	13.75	5.31
95% Critical Values	69.82	47.86	29.80	15.49
Maximum Eigen-Statistic	39.10*	23.82	8.44	4.63
95% Critical Values	33.88	27.58	21.13	14.26

Standardized Co-integrating Vector of Coefficients (or Eigenvectors)

$VM1_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$(C/D)_t$
1.00	-1.19	-0.29	-0.17	-2.50
	(0.26)	(0.06)	(-0.05)	(0.47)

Standardized Adjustment Coefficients (Alpha Coefficients)

$VM1_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$(C/D)_t$
0.03	-0.09	-1.94	0.08	-0.03

The VAR includes 4 lags on each variable, a constant term and a linear deterministic term. The * denote significant at 1% level respectively. The critical values for the trace statistics are from Hansen-Juselius (1995) and the critical values for Lambda Max are taken from Osterwald-Lenum (1992). The figures in parenthesis are standard errors (not τ-statistics for significance) of coefficients for variables.

Table 4: Variance Decomposition of Income Velocity of Broad Money

(based on VAR(1 5) and ordering of variables as in column1)

Variance decomposition of currency-deposit ratio ($(C/D)_t$)

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.05	100.00	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
4	0.06	91.45	0.47	0.51	4.38	3.16
		(5.18)	(1.73)	(2.19)	(3.62)	(3.10)
8	0.08	71.25	1.67	2.58	15.39	9.08
		(8.84)	(2.53)	(4.47)	(7.57)	(5.63)
12	0.10	50.99	4.43	6.36	24.90	13.29
		(10.10)	(4.29)	(6.74)	(9.81)	(7.36)
16	0.11	38.71	8.03	8.85	29.51	14.82
		(9.70)	(6.24)	(8.06)	(11.12)	(8.16)

Variance decomposition of gross domestic product (y_t)

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.28	0.26	99.73	0.00	0.00	0.00
		(1.26)	(1.26)	(0.00)	(0.00)	(0.00)
4	0.31	0.80	91.83	0.94	1.61	4.80
		(2.31)	(5.23)	(2.60)	(2.43)	(3.68)
8	0.38	1.22	87.28	1.13	1.28	9.08
		(2.93)	(6.15)	(2.76)	(2.43)	(4.47)
12	0.43	1.92	85.34	1.10	1.13	10.48
		(4.05)	(7.49)	(3.15)	(2.78)	(5.05)
16	0.47	2.54	84.41	1.05	1.09	10.88
		(5.29)	(8.94)	(3.56)	(3.30)	(5.54)

Variance decomposition of inflation expectations (Δp_{t-1})

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	2.54	3.14	0.10	96.74	0.00	0.00
		(2.95)	(1.03)	(3.07)	(0.00)	(0.00)
4	2.78	5.38	7.47	84.14	1.71	1.28
		(4.14)	(3.91)	(5.64)	(2.87)	(1.92)
8	2.95	8.56	9.41	75.12	4.25	2.64
		(4.84)	(3.92)	(6.33)	(3.79)	(2.34)
12	3.07	9.53	10.07	69.76	6.80	3.82
		(5.42)	(4.02)	(6.90)	(4.58)	(2.84)
16	3.17	9.31	10.44	66.32	9.35	4.55
		(5.74)	(4.17)	(7.52)	(5.61)	(3.25)

Variance decomposition of deposit interest rate ($DEPOINT_t$)						
Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.50	0.41	0.05	5.77	93.75	0.00
		(1.31)	(1.02)	(3.74)	(4.00)	(0.00)
4	1.12	0.18	0.03	4.74	94.94	0.09
		(2.26)	(1.75)	(4.86)	(5.67)	(1.36)
8	1.58	0.50	0.30	9.31	89.81	0.06
		(3.99)	(2.35)	(8.35)	(9.50)	(2.19)
12	1.92	1.58	0.82	12.80	84.72	0.05
		(6.01)	(3.35)	(10.38)	(12.09)	(2.85)
16	2.16	2.99	1.50	13.99	81.45	0.05
		(7.94)	(4.51)	(11.12)	(13.77)	(3.67)

Variance decomposition of broad money ($VM2_t$)						
Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.14	0.00	4.68	1.50	0.30	93.50
		(1.13)	(3.52)	(2.11)	(1.21)	(4.31)
4	0.17	7.71	5.80	2.60	1.99	81.87
		(4.93)	(3.22)	(2.75)	(3.12)	(6.07)
8	0.24	10.82	12.08	2.67	2.70	71.70
		(6.63)	(4.49)	(2.83)	(3.73)	(7.55)
12	0.29	11.83	15.05	2.66	3.14	67.30
		(7.67)	(5.51)	(3.21)	(4.24)	(8.48)
16	0.32	22.24	27.46	2.56	3.39	44.33
		(8.45)	(6.55)	(3.41)	(4.70)	(9.28)

Cholesky ordering: LOG(C/D) LOG(NGDP) INFLATION(-1) DEPOINT LOG(M2_VELOCITY)

Table 5: Variance Decomposition of Income Velocity of Broad Money

(based on VAR(1 5) and ordering of variables as in Column1)

Variance decomposition of demand deposit-time deposit ratio ($(DD/TD)_t$)

Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.09	100.00	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
4	0.12	97.43	0.18	0.75	1.61	0.01
		(3.48)	(1.28)	(2.23)	(2.47)	(0.47)
8	0.15	95.57	1.53	1.37	1.44	0.06
		(5.53)	(3.41)	(3.35)	(2.85)	(0.66)
12	0.17	94.42	2.65	1.46	1.32	0.12
		(7.44)	(5.52)	(4.04)	(3.39)	(0.99)
16	0.18	93.50	3.64	1.42	1.24	0.18
		(9.18)	(7.28)	(4.44)	(4.09)	(1.40)

Variance decomposition of gross domestic product (y_t)

Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.28	0.64	99.35	0.00	0.00	0.00
		(1.80)	(1.80)	(0.00)	(0.00)	(0.00)
4	0.30	1.68	90.46	0.42	1.38	6.03
		(2.78)	(4.31)	(1.91)	(2.49)	(2.17)
8	0.35	6.13	81.60	0.63	1.28	10.33
		(4.01)	(5.66)	(2.18)	(2.61)	(3.25)
12	0.38	11.25	74.05	0.70	1.19	12.77
		(5.35)	(6.79)	(2.34)	(2.83)	(3.93)
16	0.41	16.17	67.88	0.75	1.16	14.02
		(6.46)	(7.68)	(2.48)	(3.27)	(4.39)

Variance decomposition of inflation expectations (Δp_{t-1})

Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	2.52	0.10	0.00	99.88	0.00	0.00
		(1.05)	(1.01)	(1.44)	(0.00)	(0.00)
4	2.71	4.17	5.11	88.05	1.32	1.33
		(3.43)	(3.03)	(4.89)	(2.63)	(1.07)
8	2.86	4.92	7.56	79.48	5.98	2.04
		(3.39)	(3.55)	(5.80)	(3.82)	(1.18)
12	2.98	5.07	8.29	73.49	10.42	2.71
		(3.43)	(3.92)	(6.51)	(5.13)	(1.37)
16	3.07	5.02	8.47	69.37	13.85	3.28
		(3.46)	(4.22)	(7.12)	(6.30)	(1.64)

Variance decomposition of deposit interest rate (*$DEPOINT_t$*)						
Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1})	$DEPOINT_t$	$VM2_t$
1	0.50	0.32	0.00	5.51	94.15	0.00
		(1.26)	(0.97)	(3.66)	(3.90)	(0.00)
4	1.14	1.23	0.06	5.53	93.09	0.07
		(3.10)	(1.61)	(4.84)	(5.74)	(0.33)
8	1.63	1.71	0.04	8.36	89.81	0.06
		(3.82)	(2.80)	(7.43)	(8.69)	(0.59)
12	1.94	2.31	0.03	9.82	87.67	0.15
		(4.56)	(4.21)	(8.97)	(10.96)	(1.16)
16	2.13	2.79	0.03	10.61	86.22	0.33
		(5.16)	(5.54)	(9.80)	(12.63)	(1.95)

Variance decomposition of broad money (*$VM2_t$*)						
Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM2_t$
1	0.16	0.36	8.18	0.25	0.01	91.18
		(1.43)	(4.31)	(1.24)	(0.85)	(4.64)
4	0.16	0.90	8.57	2.42	1.31	86.78
		(2.15)	(3.80)	(2.86)	(2.76)	(5.09)
8	0.23	2.20	18.74	1.96	1.73	75.35
		(2.69)	(5.31)	(2.78)	(3.11)	(6.31)
12	0.27	3.74	22.79	1.72	2.21	69.51
		(3.46)	(6.21)	(2.8)	(3.70)	(7.33)
16	0.30	15.39	34.42	1.59	2.76	45.82
		(4.24)	(6.85)	(3.05)	(4.44)	(8.14)

Cholesky ordering: LOG(DD/TD) LOG(NGDP) INFLATION(-1) DEPOINT LOG(M2_VELOCITY)

Table 6: Variance Decomposition of Income Velocity of Narrow Money

(based on VAR(1 5) and ordering of variables as in column 1)

Variance decomposition of currency-deposit ratio ($(C/D)_t$)

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.05	100.00	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
4	0.06	88.22	1.06	1.37	3.94	5.39
		(6.25)	(2.10)	(2.78)	(3.57)	(4.14)
8	0.08	65.27	4.12	5.28	13.30	12.00
		(9.83)	(3.58)	(5.99)	(7.16)	(6.84)
12	0.10	47.40	8.70	9.55	20.67	13.66
		(10.71)	(5.57)	(8.37)	(9.59)	(8.03)
16	0.12	36.54	13.87	12.30	24.75	12.51
		(10.37)	(7.64	(9.81)	(11.22)	(8.23)

Variance decomposition of gross domestic product (y_t)

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.28	0.24	99.75	0.00	0.00	0.00
		(1.19)	(1.19	(0.00)	(0.00)	(0.00)
4	0.31	1.74	91.00	1.63	1.29	4.32
		(3.04)	(5.51)	(2.71)	(2.44)	(3.59)
8	0.38	2.32	89.13	1.74	1.07	5.71
		(3.88)	(6.10)	(3.10)	(2.55)	(3.65)
12	0.43	2.60	88.69	1.74	0.93	6.01
		(4.61)	(6.97)	(3.73)	(2.94)	(3.70)
16	0.47	2.70	88.68	1.75	0.83	6.01
		(5.18)	(7.98)	(4.46)	(3.49)	(3.89)

Variance decomposition of inflation expectations (Δp_{t-1})

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	2.6	1.53	0.28	98.18	0.00	0.00
		(2.07)	(1.20)	(2.37)	(0.00)	(0.00)
4	2.87	2.32	8.406	86.44	2.00	0.81
		(2.82)	(4.12)	(5.53)	(3.13)	(1.64)
8	3.04	4.24	11.01	78.04	5.71	0.98
		(3.43)	(4.25)	(6.60)	(4.51)	(1.86)
12	3.15	4.62	11.93	72.79	9.31	1.33
		(3.76)	(4.38)	(7.22)	(5.51)	(2.12)
16	3.25	4.71	12.34	69.30	12.08	1.55
		(4.01)	(4.51)	(7.73)	(6.32)	(2.31)

Variance decomposition of deposit interest rate ($DEPOINT_t$)

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.50	0.39	0.04	5.85	93.70	0.00
		(1.46)	(0.99)	(3.73)	(4.07)	(0.00)
4	1.12	0.19	0.045	4.10	95.52	0.13
		(2.47)	(1.83)	(4.75)	(5.60)	(1.25)
8	1.58	0.64	0.17	8.44	90.58	0.15
		(4.13)	(2.18)	(8.23)	(9.35)	(2.47)
12	1.92	1.44	0.55	12.43	85.43	0.12
		(5.77)	(2.75)	(10.86)	(12.15)	(3.51)
16	2.15	2.17	1.09	14.45	82.05	0.21
		(7.18)	(3.51)	(12.32)	(14.02)	(4.43)

Variance decomposition of narrow money ($VM1_t$)

Forecast Horizon	S.E.	$(C/D)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.13	0.07	3.75	0.82	0.37	94.97005
		(1.04)	(3.19)	(1.70)	(1.26)	(3.79)
4	0.14	8.05	3.97	4.76	0.38	82.81
		(5.19)	(2.95)	(3.65)	(2.03)	(6.42)
8	0.18	7.53	13.01	5.32	1.86	72.26
		(5.19)	(4.78)	(3.87)	(2.72)	(6.88)
12	0.21	7.43	17.41	5.60	3.00	66.54
		(5.38)	(5.77)	(4.12)	(3.27)	(7.42)
16	0.22	17.90	29.82	5.70	3.58	42.98
		(5.93)	(6.34)	(4.27)	(3.72)	(7.88)

Cholesky ordering: LOG(C/D) LOG(NGDP) INFLATION95(-1) DEPOINT LOG(M1_VELOCITY)

Table 7: Variance Decomposition of Income Velocity of Narrow Money

(based on VAR(1 5) and ordering of variables as in column 1)

Variance decomposition of demand deposit-time deposit ratio ($(DD/TD)_t$)

Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1})	$DEPOINT_t$	$VM1_t$
1	0.09	100.00	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
4	0.12	96.33	0.97	0.60	1.55	0.52
		(4.29)	(2.18)	(2.16)	(2.32)	(1.99)
8	0.16	93.53	2.51	0.99	1.92	1.03
		(6.66)	(3.55)	(3.43)	(3.14)	(3.16)
12	0.18	92.39	3.62	0.94	1.87	1.15
		(8.25)	(4.82)	(4.23)	(3.63)	(4.02)
16	0.20	91.73	4.48	0.87	1.77	1.13
		(9.44)	(5.78)	(4.78)	(4.19)	(4.69)

Variance decomposition of gross domestic product (y_t)

Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.27	1.11	98.88	0.00	0.00	0.00
		(1.99)	(1.99)	(0.00)	(0.00)	(0.00)
4	0.29	1.89	87.80	0.79	1.15	8.34
		(2.97)	(5.60)	(2.17)	(2.42)	(4.32)
8	0.34	6.46	77.71	1.25	1.23	13.33
		(4.66)	(7.26)	(2.50)	(2.66)	(5.72)
12	0.37	11.08	71.35	1.44	1.21	14.89
		(6.41)	(8.37)	(2.74)	(2.98)	(6.58)
16	0.40	15.16	66.85	1.51	1.18	15.26
		(7.89)	(9.21)	(3.01)	(3.46)	(7.14)

Variance decomposition of inflation expectations (Δp_{t-1})

Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	2.58	0.00	0.04	99.95	0.00	0.00
		(0.94)	(1.03)	(1.39)	(0.00)	(0.00)
4	2.75	3.36	4.11	90.22	1.71	0.57
		(3.37)	(3.04)	(4.81)	(2.72)	(1.60)
8	2.92	5.30	5.91	80.78	6.61	1.38
		(3.87)	(3.28)	(5.79)	(4.07)	(2.42)
12	3.03	5.39	6.17	75.35	11.29	1.78
		(3.91)	(3.32)	(6.33)	(5.17)	(2.73)
16	3.13	5.17	6.21	71.60	15.02	1.98
		(3.87)	(3.30)	(6.94)	(6.25)	(2.95)

Variance decomposition of deposit interest rate ($DEPOINT_t$)						
Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.51	0.56	0.00	6.37	93.05	0.00
		(1.51)	(0.94)	(3.87)	(4.24)	(0.00)
4	1.15	2.08	0.05	4.92	92.82	0.11
		(3.86)	(1.86)	(4.83)	(6.46)	(1.42)
8	1.65	3.60	0.07	10.30	85.80	0.21
		(5.84)	(2.70)	(8.52)	(10.66)	(3.13)
12	2.00	4.52	0.21	14.30	80.55	0.39
		(6.88)	(3.44)	(10.69)	(13.22)	(4.74)
16	2.25	5.55	0.47	16.24	77.15	0.57
		(7.75	(4.06)	(11.76)	(14.95)	(6.04)

Variance decomposition of narrow money ($VM1_t$)						
Forecast Horizon	S.E.	$(DD/TD)_t$	y_t	Δp_{t-1}	$DEPOINT_t$	$VM1_t$
1	0.13	2.79	3.53	1.11	0.33	92.2
		(2.87)	(3.17)	(1.72)	(1.17)	(4.51)
4	0.15	4.57	5.61	3.93	0.35	85.51
		(4.32)	(3.68)	(3.37)	(2.18)	(6.00)
8	0.19	4.21	15.09	4.66	1.59	74.41
		(4.16)	(5.14)	(3.57)	(2.85)	(6.85)
12	0.21	4.04	19.13	5.20	2.22	69.38
		(4.19)	(6.03	(3.92)	(3.27)	(7.58)
16	0.23	13.80	31.48	5.50	2.62	46.57
		(4.28)	(6.59)	(4.17)	(3.61)	(8.03)

Cholesky ordering: LOG(DD/TD) LOG(NGDP) INFLATION(-1) DEPOINT LOG(M1_VELOCITY)

Note: Symbols for the variables in column 1 are those explained in the footnote of Table 1. The standard errors of variance decompositions (VDC) are estimated using the Monte Carlo simulations described in the E-VIEWS manual. The estimates are based on 1,000 random draws, which are made directly from the posterior distribution of the VAR coefficients [see Runkle (1987), Sims (1987)]. The usual two standard error (2SE) criterion is used to judge the statistical significance of an estimated VDC.

Appendix I

The VAR system can be expressed in a stacked form, in which **X** represents the vector of variables of interest in the model: $\mathbf{X_t} = \mathbf{A} + \mathbf{B}(\mathbf{L})\ \mathbf{X_t} + \epsilon_t$; Where, $\mathbf{X_t}$ is a stationary stochastic process which composed of all variables in the model, **L** is the lag operator such that $\mathbf{LX_t} = \mathbf{X_{t-i}}$, $\mathbf{B}(\mathbf{L})$ represents the polynomial of autoregressive parameters and consists of innovations and is referred to as the vector of structural disturbances and is serially uncorrelated. For the above VAR equation system to exist, the roots of $det(\mathbf{I} - \mathbf{B}(z)) = 0$, have a modulus greater than 1 so as to ensure that $(\mathbf{I} - \mathbf{B}(z))$ is invertible. Since the explanatory variables in a VAR model include lagged observations and no current observations, the error term captures the movements of the explanatory variables in the current period and thus adds new information to explain the movements of dependent variable. That is why in the VAR literature, the current disturbance term in the equation for a given dependent variable is called *innovation* for that variable in the current period. A time series of such innovations is associated with each variable in the VAR system. Estimation of VAR system requires a large number of observations because of the number of parameters to be estimated. When a constant is included in each equation, the number of parameter in each equation equals the number of variables in the system times the number of lags plus one. Accordingly, one must either limit the number of variables and /or limit the lags in the system to avoid the depletion of degrees of freedom [Sims (1980b) for details regarding the approach which restricts the number of freely estimated parameter]. The variables included in the model are mainly motivated by economic theory and by the types of hypothesis to be conducted. The set of variables in the system is not based on prior statistical testing. The VAR is estimated using the seemingly unrelated regression estimation technique (SURE). It involves first estimating the unrestricted VAR out of which the estimates of the first step innovations are obtained and then finally estimate the coefficients by using sequential Two Stage Least Squares (2SLS) approach. Our estimations show that lags beyond (1 5) periods are not statistically significant. We therefore conducted all hypothesis testing based on VAR(1 5) models.

Innovations accounting involve the decomposition of the FEV for each variable into components attributable to its own innovations and to shocks to other variables included in the model. This is accomplished by utilizing the moving average representation (MAR) of the VAR system as follows: $\mathbf{X_t} = \mathbf{C_t} + \mathbf{a}(\mathbf{L})\ \mathbf{X_t} + \epsilon_t$; where, $E(\epsilon_t) = 0$ and $E(\epsilon_t\ \epsilon_t) = W$ for $|k| = 0$; and also $E(\epsilon_t\ \epsilon_t) = 0$ for $|k| \neq 0$

Where $\mathbf{C_t}$ is the perfectly predictable component of $\mathbf{X_t}$ and the moving average coefficients $\mathbf{a}(\mathbf{L})$ at lag 0 is the identity matrix. According to the Wold decomposition theorem, the vector of innovations "ϵ_t" is the forecast error of the auto-regression based on information available at time t-1 given that the roots of ***a(z)*** lie outside the unit circle. In other words, the MAR expresses the current values of the dependent variables in terms of current and lagged values of the innovations in all variables of the system. In principle, an infinite number of lags are needed to obtain the entire moving average representation (to get the system convergence). By assumption, all innovations at time t and earlier are known. If we use the variation of past innovations as the estimate of the variation of future innovations, it is possible to obtain an estimate of the forecast error variance (FEV). Hence, the word "variation" refers not only to the variance of each innovation series but to the contemporaneous co-variances among all pairs of innovations as well.

The FEV for a given variable is equal to a sum of terms in the variances and co-variances of all the innovation series. The variance decomposition presents a summary of this information by listing the fraction of the overall FEV accounted for by each of the type of innovation. This variance accounting can be done for the forecast error of each variable for any forecast horizon. In this way, one can analyze the way in which the variances of each variable's innovations influences the movements (i,e, variation) in each of the variables in the system. In principle, the variance decomposition contains very important information because it shows which variables have relatively sizeable independent influence on other variables in the system.