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Mohammad S. Hasan
King Fahd University of Petroleum and Minerals, Saudi Arabia

ABSTRACT

The purpose of this paper is to re-examine the empirical relationship among alternative monetary aggregates (M1 and M2), output, prices, interest rates and exchange rates in India. The results of a five-variate vector error correction model are indicative of a bi-directional causality between each of the monetary aggregates and prices. Our findings of a feedback relationship make each of the monetary aggregates a poor intermediate target and informational variable. Moreover, contrary to most recent research in this area, the results are supportive of the real business-cycle view and the Keynesian monetary accommodation hypothesis rather than the monetarists' theory of the business cycle.

JEL Classifications: C32, E30, O11
Keywords: Money-Income Relationship, Real Business Cycle Theory, Keynesian Monetary Accommodation Hypothesis, Vector Error correction Model, Variance Decompositions
Corresponding Author's Email Address: mshasan@kfupm.edu.sa

INTRODUCTION

Identification of the causal role of monetary forces to induce business cycle fluctuations has been the subject of ongoing debate among researchers and policy-makers. The classical, Keynesian, monetarist, new classical, new Keynesian and real business-cycle theorists have formulated a wide variety of theories to explain the causes of business cycles. For the sake of brevity, these theories can be grouped into two wide classes of theories: equilibrium and disequilibrium theories of business cycles. The theoretical underpinnings of equilibrium theories are the classical, monetarist, new classical and real business-cycle (RBC) theories which contend that output and employment in the economy normally tend to hover around the long-run equilibrium level or at the *natural level*.(1) Monetary or real shocks are the primary causes of business cycles which tend to produce short-run deviations of output from the trend. The monetarists argue that observed changes in the growth rate of money are responsible for the divergence of output from its trend [see, for example Chowdhury *et al* (1994), Friedman (1968)]. The new classical economists contend that anticipated demand-management such as anticipated monetary policy has no lasting effects on real output and employment when economic participants form expectations rationally. Only unexpected movements in 'aggregate demand' or 'money' are the driving forces behind business cycles [see, for example Lucas (1975), Sargent and Wallace (1975)]. The real business-cycle theory contends that all movement in aggregate output arises from exogenous technological shocks and forces of productivity [see, Kydland and Prescott (1982)]. Masih and Masih (1996a, p. 88) succinctly summarized the RBC views as: "The RBC economists view the historical association between money and output as the case of money supply endogenously responding (rather than leading) to an increase in output. To the RBC school, money-output correlations observed in the data should be attributed to 'reverse causation'. That is, the banking sector responds to increased demand for transactions by creating more inside money. To them, monetary expansion whether short or long (as focused by the Monetarists), and anticipated or unanticipated (as focused by the early New Classical School) will have no positive effect on output; it will only raise interest rates and the price level. The RBC school, therefore, views money supply as endogenous and a function of output which is determined exogenously by factors such as technology or real 'stochastic' shocks." Despite varying theoretical propositions, classical, monetarists, new classical and real business-cycle theories have a common conclusion regarding the long-run neutrality of money stock to affect output and employment.

The Keynesian as well as the new Keynesian views, grouped together as disequilibrium theories of business cycle, argue that aggregate demand shocks cause the cyclical variations of output from the trend. The traditional Keynesian model regards money stock to be endogenously determined which accommodates rising income and prices by increasing money supply. The new Keynesian economists contend that regardless of the anticipated or unanticipated components, actual demand management policy proxies by discretionary government expenditure, tax cuts and monetary policy determine real output and employment due to price and wage inertia [See, for example Gordon (1982), Demary (1984)]. Despite the varying theoretical propositions, the new Keynesian economists have a common conclusion regarding the non-neutrality of the stabilization policy.(2) Several interesting papers have empirically examined the relationship between money and income for both developed and developing countries [For developed countries, see, Atesoglu and Dutkowsky (1992), Friedman and Kuttner (1992), Sims (1980a, 1980b), Stock and Watson (1989) and a list of references in Masih and Masih (1996a); for developing countries, see Masih and Masih (1995, 1996b)]. The primary motivation of these studies is to unveil a just identified theoretical explanation of business cycles. Another motivation of the papers is to identify the empirical characteristics of alternative monetary aggregates in terms of a good intermediate target and informational variable of monetary policy.

The usefulness of monetary aggregates as intermediate targets rests on two attributes: (1) the authorities' ability to control the intermediate target variable with the aid of policy instruments (i.e., reserve requirements, discount rates, open market operations etc.) and operating targets (i.e., monetary base, base rates); (2) a consistent and predictable relationship between the intermediate target variable and ultimate goal variables such as output, employment, inflation, and exchange rate without any feedback from goal variables to the intermediate target variable.(3) However, as Bernanke and Mishkin (1997) contend, using an intermediate target approach such as money growth is feasible in an optimal framework only if the intermediate target contains all information relevant to forecasting the goal variable. If any variable other than the intermediate target contains marginal information about the future values of the goal variable, then targeting the goal variable, such as the inflation forecast or nominal GDP forecast, should strictly dominate monetary targeting strategy. Furthermore, if a reverse causality flows from goal variable to intermediate target variable, no improvement is available by using an intermediate target framework. As Barnhart and Darrat (1992) have noted, it would be hard to predict or control the intermediate target variable because it becomes unclear whether movements in the intermediate target emanate from policy actions, from changes in the ultimate goal variable, or perhaps from both.

Although in recent years several interesting papers have examined the empirical relationship between money supply and goal variables in the case of India, no clear-cut consensus has yet emerged. For example, Masih and Masih in a recent paper (1996a) have investigated the causal relationships among monetary aggregates, output, interest rate, prices, and exchange rate variables in an attempt to identify which macroeconomic paradigm explains the observed data generation process of India. Monetary aggregates were measured both by narrow money stock (M1) and broad money stock (M2). They succinctly summarized the empirical results as (Masih and Masih, 1996a, p. 85): "The results, more or less tend to support on balance, that in the Granger-causality sense, money supply (particularly M1) appears to have played the leading role of a policy variable being the most exogenous of all, and the other variables including output, rate of interest, exchange rate and prices appear to have borne most of the brunt of short-run adjustment endogenously in different proportions in order to re-establish the long-run equilibrium. The Granger-causal chain implied by our evidence is consistent more with the Monetarist than with the Keynesian or the recent Real Business Cycle macroeconomic paradigms." Moosa (1997) employed seasonal integration and cointegration techniques to test the hypothesis of long-run neutrality of monetary aggregates. Moosa (1997) finds that money is cointegrated with prices but not with output at the zero frequency. Moosa (1997) interpreted this evidence to imply that money affects nominal but not real variables in the long-run. Support to the monetarists' proposition implies that the ability of the monetary authority to control price levels by exogenously controlling the monetary aggregates. [(4)] Luintel (2002) investigated whether the money stock could exogenously be used to control the movements of price levels in India. In contrast, Luintel (2002) finds overwhelming evidence of endogeneity of money in India which raises the question regarding the ability of the monetary authority's policy stance to control the price level through the control of the money stock.

Ramachandran (2004) investigated the stability of the relationship among M3 money, real output and prices using annual data over the period 1951-1952 to 2000-2001 within the framework of conventional money demand function by employing stability tests and cointegration methodology. The study reported a fairly stable relationship among those variables based on which Ramachandran (2004) recommended to use M3 money as one the indicators of future price changes in the present context of multiple indicator approach of the Reserve Bank of India.[(5)] The study also found a bi-directional causality between M3 money and prices. The empirical literature evaluating the closeness and reliability of the relationship between alternative monetary aggregates and the ultimate goal variables proceeds in two directions. First, the estimation method proceeds in the framework of a conventional money demand function to explore a stable long-run equilibrium relationship between alternative monetary aggregates and the ultimate goal variables where the real money supply is regressed on a set of explanatory variables such as income and interest rates. Second, previous studies conducted a series of causality tests between alternative monetary aggregates and ultimate goal variables.

The problem of estimation and inference associated with a money demand function approach are that they restrict the relationship between interrelated variables by imposing *a priori* causal structure, for example, econometric exogeneity of income, price and interest rate in the money demand regression. In the present framework of the target-goal relationship, it is important for the policy makers and researchers to know whether monetary aggregates are causally prior to the ultimate goal variables. Furthermore, given the conflicting evidence of the empirical relationship between monetary aggregates and the interrelated macroeconomic variables, in this article we attempt to investigate the empirical characteristics of the target-goal relationship among monetary aggregates and output, prices, interest rates, and exchange rates in terms of a good intermediate target and informational variable in a developing country using India as an interesting case study in the context of a vector error-correction (VEC) model. More specifically, this paper assesses the information content of monetary aggregates to see whether monetary aggregates are informative about future movements in output, prices, interest rates and exchange rates by evaluating cointegration relationships, Granger causality and variance decompositions (VDCs). The paper also attempts to identify as to which macroeconomic theory, such as the real business cycle, Keynesian or monetarists' theories of business cycles, explains the observed data generation process in India. The paper is organized as follows: Section II presents the model, while section III discusses the empirical results and policy implications. Section IV provides a summary and conclusion.

SPECIFICATION, DATA, AND METHODOLOGY

The empirical analysis in this paper is based on a five variate vector-autoregressive model over the period 1957-2001.[(6)] The variables are: real output (*y*), money stock (*m*), prices (*p*), interest rate (*i*), and a measure of exchange rate (*e*). Traditional reaction function studies have employed four classes of information variables: monetary aggregates, measures of real economic activity, measures of financial market stability, and measures of inflation (see Hakkio and Sellon 1994, Barnhart and Darrat, 1992). Several empirical models have underscored the role of the real output, prices, money stock, and interest rate in the macro income determination model, including Sims (1980b), Friedman and Kuttner (1992), Litterman and Weiss (1985), Stock and Watson (1989). An exchange rate variable would capture the role of the foreign sector of the Indian economy (see Masih and Masih, 1996a). Monetary aggregates are represented by the both measures of narrow and broad monetary aggregates, such as M1 and M2 measures of the Reserve Bank of India; aggregate economic activity is proxied by the real GDP with 1995 as the base year; the inter-bank money lending rate or call money rate proxies short-term interest rates, that in turn represent financial market stability; the price level is represented by the cost of price index (CPI) due to its availability over the long sample period; and exchange rate is measured by the average market rate measure (RF) of the IMF. *m* and *i* are treated as the intermediate target variables, while *y*, *p* and *e* are regarded as goal variables. This target-goal framework assumes that the policy manipulation of *m* and *i* potentially plays an important role in the determination of output, price and exchange rate. All data series are downloaded from the

DATASTREAM International. With the exception of real GDP, all data series are measured in nominal magnitude and are extracted at annual frequency.

In the specification of the vector error correction model, we have utilized the concepts of unit root, cointegration and lag lengths with suitable diagnostics to test for cointegration, and Granger causality among monetary aggregates, real output, interest rates and prices and exchange rates. The cointegration and vector error-correction modelling techniques are now well known and widely used in applied econometrics. For detailed methodological exposition, readers are referred to Engle and Granger (1991), Hargreaves (1994) or any econometrics textbook. This technique seeks to explore whether a set of interrelated variables share a common trend such that the stochastic trend in one variable is related to the stochastic trend in some other variable(s). The Johansen and Juselius (JJ) (1990) system approach is employed to test for cointegration among variables. The Johansen maximum likelihood approach sets up the non-stationary time series as the vector autoregressive process of order k in reparametrised form :

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots.. + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-k} + U_t \qquad (1)$$

where $Y(t)=\{y(t), m(t), i(t), p(t), e(t)\}$ is a 5x1 vector of the first-order integrated variables of real output, money stock, interest rate, price and exchange rate respectively; Γ_i is a 5xk coefficient matrix; and U_t is a vector of normally and independently distributed error terms. The rank of the long-run multiplier matrix, Π determines the number of cointegrating vectors which could at most be equal to m_y, i.e., 5 and the rank deficiency of Π could be represented by Rank $(\Pi_y) = r < m_y$. The Johansen method provides two likelihood ratio tests, the trace test and the maximum eigenvalue test to determine the number of co-integrating vectors and Osterwald-Lenum (1992) furnishes the appropriate critical values. If Π is rank deficient such that $0 < r < 5$, then it can be decomposed as: $\Pi = \alpha\beta'$, where the $\alpha_{(5xr)}$ matrix contains the adjustment coefficients towards a long-run equilibrium and $\beta_{(5xr)}$ matrix contains the co-integrating vectors. μ is a 5x1 vector of constant terms which captures the trending characteristics of the time series involved. The formulation and estimation of the short-run error correction model and the detection of Granger causality is discussed in the next section. The VDCs, in percentage terms, decompose the forecast error variance of a dependent variable into components attributable to own innovations and innovations of other explanatory variables.(7) The VDC results provide an indication of relative causal strength. Sims (1980a) contends that the absolute sizes of coefficients of an economically important variable in an equation, such as the interest rate, are important regardless of what the F and χ^2 tests indicate. The coefficients of theoretically important variables should not be set equal to zero even if they are found to be statistically insignificant. VDCs should deepen our understanding regarding the strength of the causal chain implied by the Granger causality test results.

EMPIRICAL RESULTS

(A) Cointegration Tests and Results

The values of several descriptive statistics relating to the key macro aggregates are presented in Table 1. These statistics are: mean, standard deviation, maximum, minimum and a measure of average annual growth. It is evident from the table that the average annual growth rates of real output and inflation in India are 4.34% and 7.3%, respectively with a monetary growth of 11.63% (M1) and 13.87% (M2) respectively. This indicates that the Indian economy witnessed a long period of economic stability during the sample period compared to many developing countries.

TABLE 1. DESCRIPTIVE STATISTICS OF MACRO AGGREGATES

Statistics	Real Output (million rupees)	Narrow Money (billion rupees)	Broad Money (billion rupees)	Interest Rate (percent)	Price Level 1995=100	Exchange Rate Rupees per US$
Mean	4811758.88	702.71	2099.90	8.006	43.64	15.03
Std. Dev.	2876269.17	1023.28	3354.95	3.81	42.77	12.72
Maximum	11986850	3845.99	13368.00	19.35	149.3	47.186
Minimum	1750680	22.96	29.87	2.57	6.00	4.762
Average Annual Growth	4.34%	11.63%	13.87%	1.88%	7.30%	5.21%

Since the Granger causality test requires the use of covariance stationary time series, all the data series have been checked for stationary characteristics in their univariate properties using the Elliott-Rothenberg-Stock Dickey-Fuller generalized least squares (DF-GLS) test. It is well known that Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root tests have low power in rejecting the null of a unit root and are prone to size distortion. Elliott, Rothenberg and Stock (1996) proposed an alternative DF-GLS test which involves the application of a generalized least squares method to detrend the data. Recently, Ng and Perron (2001) in their simulation exercise have shown that the test statistics perform well in a fairly small sample size and the test yields asymptotically valid results with desirable properties. In the process of performing this test, the autoregressive truncation lag length is determined by the modified Akaike Information Criterion (AIC). The results of the DF-GLS test are reported in Table 2. The DF-GLS unit root test indicates that variables: real output (y), money stock (m), price (p), interest rate (i), and exchange rate (e) have single unit roots.

In the next step, the data series are further checked for the presence of cointegration using the Johansen and Juselius (JJ) maximum likelihood procedure to see whether stochastic trends of these variables move together in the long-run. The main advantage of the JJ method is that it indicates the presence of the number of cointegrating vectors and provides a more reliable estimate of the long-run parameters. Johansen's vector autoregressive (VAR) models comprised of both narrow and broad money stock variables are specified with an intercept and deterministic trend, as there appears to be a linear trend in all the nonstationary series. Akaike's information criterion (AIC) is used to determine the optimal lag length of the Johansen's VAR system. Use of the AIC criterion, in conjunction with the inspection of serial correlation of residuals of individual equations indicates a lag length of two for the VAR model.

TABLE 2. UNIT ROOT TESTS

A. Elliott-Rothenberg_Stock DF-GLS test

	L		Δ	
Variable	t_μ	t_τ	t_μ	t_τ
y	0.553	-1.060	-2.897	-7.790
M1	0.266	-1.271	-3.200	-6.564
M2	-0.296	-1.767	-2.782	-4.114
i	-1.094	-1.856	-6.331	-7.128
p	0.011	-1.234	-4.528	-4.796
e	0.870	-1.446	-3.132	-4.629

Notes: t_μ and t_τ are the *t*-statistics based on augmented Dickey-Fuller (ADF) regression with allowance for a constant and trend, respectively. 5% critical values of t_μ and t_τ are -1.948 and -3.190 (see Elliot-Rothenberg-Stock 1996, Table 1). *L* and Δ signify the level and first difference of a variable respectively.

The Indian economy has witnessed several structural changes induced by major economic events, various deregulatory measures and financial innovations which might had impacted the transmission mechanism of monetary policy and dynamics of the macro variables chosen in the present study over the sample period. Jadhav (1994) found two structural breaks around 1975 and 1982-1983 in the money demand function. The first one coincides with the first oil price shock and the second one signifies the on shot of financial deepening through the proliferation of new financial instruments, changes in payment technology and deregulation. Most notable deregulatory measures occurred during the 1990s which include dismantling administered interest rates, unification of dual exchange rates by the introduction of a market based exchange rate system and a phase move towards convertibility on current account. Bhanumurty (2000) reported a structural break in the money demand function over the period 1991-1995. Ramachandran (2004) reported two structural breaks: one during the period 1978-1980 and the second during 1991-1995. Therefore, we have specified the Johansen's VAR system with intercept dummy identifying the years of 1975-1982 and 1991-1995 as sources of hypothesized breaks in the estimation period to account for possible structural breaks.

TABLE 3. JOHANSEN TESTS FOR COINTEGRATING RELATIONSHIPS BETWEEN REAL OUTPUT, MONEY STOCK, INTEREST RATES, PRICES, AND EXCHANGE RATES

System: (a) *VAR* model with M1		Test statistics		90% critical value	
H0:	H_1:	Max Eigenvalue	Trace	Max Eigenvalue	Trace
r = 0	*r* = 1	38.69*	97.74*	37.92	93.13
r ≤ 1	*r* = 2	24.13	59.04	32.12	68.04
r ≤ 2	*r* = 3	17.20	34.91	26.10	46.00
r ≤ 3	*r* = 4	9.21	17.70	19.79	27.96
r ≤ 4	*r* = 5	8.49	8.49	13.31	13.31

Estimated Cointegrating Vector (Normalized on *y*); *m, i, p, e, d, trend*:-[1.00, -.58654, .082818, .80969, -.074537, .00435, -.032961]

Chi-Square Test: $\chi^2_{M1(1)}$ = 18.96 (.000), $\chi^2_{i(1)}$ = 7.85 (.005), $\chi^2_{p(1)}$ = 16.65 (.000), $\chi^2_{e(1)}$ = 3.16 (.075)

b) VAR model with M2		Test statistics		90 critical value	
H0:	H_1:	Max Eigenvalue	Trace	Max Eigenvalue	Trace
r = 0	*r* = 1	36.04	94.12*	37.92	93.13
r ≤ 1	*r* = 2	18.96	58.06	32.12	68.04
r ≤ 2	*r* = 3	16.31	36.03	26.10	46.00
r ≤ 3	*r* = 4	11.16	19.71	19.79	27.96
r ≤ 4	*r* = 5	8.55	8.55	13.31	13.31

Estimated Cointegrating Vector (Normalized on *y*); *m, i, p, e, d, trend*:-[1.00, -.97937, .47130, 2.4163, -.68200, .063600, -.047463]

Chi-Square Test: $\chi^2_{M2(1)}$ = 18.71, (.000), $\chi^2_{i(1)}$ = 26.11 (.000), $\chi^2_{p(1)}$ = 21.48 (.000), $\chi^2_{e(1)}$ = 3.10 (.078)

Notes: *r* indicates the number of cointegrating relationships. * indicates rejection at the 90% critical values. The chi-square statistics $\chi^2_{M(1)}$, $\chi^2_{i(1)}$, $\chi^2_{p(1)}$, and $\chi^2_{e(1)}$ test the restriction that money stock, interest rate, price, and exchange rate variables are statistically significant in the cointegrating vector. Figures in the brackets alongside the values of the chi-square statistics are the associated probability value.

The results of Johansen's eigenvalue and trace tests are presented in Table 3. Cheung and Lai (1993) have argued that Johansen's likelihood ratio (LR) tests are derived from asymptotic results and standard inferences in finite samples may not be appropriate. Johansen's LR tests are biased toward finding cointegration frequently in finite samples when asymptotic critical values are used. The finite sample bias of Johansen's test is a positive function of $T/(T-nk)$ where T, n and k signify the sample size, the number of variables in the estimated system and the lag length, respectively. Reimers (1992), and Reinsel and Ahn (1992) have suggested adjusting Johansen's test statistics by a scaling factor of $(T-nk)/T$ and comparing them with their asymptotic critical values. Following Reinsel and Ahn (1992), the computed test statistics were adjusted using the scaling factor.

The results of Johansen's eigenvalue and trace tests in the M1 VAR system indicate the existence of at least one cointegrating relationship among real output, monetary aggregates, interest rates, prices, and exchange rates since the calculated test statistics exceed the 10% critical values which hypothesised the existence of a zero cointegrating vector. The trace test, on the other hand suggests that there is one cointegrating vector in the M2 VAR systems. Since there is growing evidence in favour of the robustness of the trace statistic compared to the maximal eigenvalue statistic (Cheung and Lai, 1993; Kasa, 1992), we accept the trace test results. A unique cointegrating vector among real output, money stock, interest rate, price, and exchange rate variables suggests a single stochastic shared trend. Given that there are (n-r) common trends within the system, we can conclude that there exist four common trends within the vector. The estimated cointegrating vector is reported beneath the tests for cointegration after normalizing on variable real output (y). The elements of the cointegrating vector are tested individually with the aid of a likelihood ratio test. The likelihood ratio test indicates that money stock, interest rate, price, exchange rate variables enter significantly in the cointegrating vector normalized on real output.

The finding of cointregration has several implications. First, consistent with the theory this finding indicates that real output, monetary aggregates, interest rates, prices, and exchange rates have a long-run equilibrium relationship which may be exploited by the monetary authorities in the formulation of monetary policy. Second, the evidence of cointegration also rules out the possibility of spurious correlation and Granger non-causality among the real output, money stock, interest rates, prices and exchange rates

(B) Test Results for Granger Causality

Following the Granger representation theorem, the above unit root and cointegration test results also imply that the dynamic modeling of real output, money stock, interest rate, price and exchange rate variables has a valid error-correction representation with a cointegrating constraint embedded in them. The VEC model estimates provide important information about the short-run relationship among real income and money stock, interest rate, price and exchange rate variables. The optimal error-correction model is specified using a hybrid of AIC and Engle-Granger's (1987) VEC modeling strategy. Use of the AIC criterion, in conjunction with the inspection of serial correlation of residuals of individual equation indicates a lag length of two, which constitutes the following VEC model:

$$\begin{bmatrix} \Delta \log y_t \\ \Delta \log m_t \\ \Delta \log i_t \\ \Delta \log p_t \\ \Delta \log e_t \end{bmatrix} = \begin{bmatrix} d_{11}^2(L) & d_{12}^2(L) & d_{13}^2(L) & d_{14}^2(L) & d_{15}^2(L) \\ d_{21}^2(L) & d_{22}^2(L) & d_{23}^2(L) & d_{24}^2(L) & d_{25}^2(L) \\ d_{31}^2(L) & d_{32}^2(L) & d_{33}^2(L) & d_{34}^2(L) & d_{35}^2(L) \\ d_{41}^2(L) & d_{42}^2(L) & d_{43}^2(L) & d_{44}^2(L) & d_{45}^2(L) \\ d_{51}^2(L) & d_{52}^2(L) & d_{53}^2(L) & d_{54}^2(L) & d_{55}^2(L) \end{bmatrix} \begin{bmatrix} \Delta \log y_t \\ \Delta \log m_t \\ \Delta \log i_t \\ \Delta \log p_t \\ \Delta \log e_t \end{bmatrix} + \begin{bmatrix} \xi_{11,t-1} \\ \xi_{21,t-1} \\ \xi_{31,t-1} \\ \xi_{41,t-1} \\ \xi_{51,t-1} \end{bmatrix} \begin{bmatrix} \delta_y \\ \delta_m \\ \delta_i \\ \delta_p \\ \delta_e \end{bmatrix} + \begin{bmatrix} d_1 \\ d_2 \\ d_3 \\ d_4 \\ d_5 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad (2)$$

where Δ is the difference operator that induces stationarity; the lag polynomial d_{ij}^k represents the *k* lag coefficients on variable *j* in equation *i*; $\delta_i \xi_{ir,t-1}$ refers to the lagged error-correction term in equation *i* derived from the *r* long-run cointegration vector via the johansen maximum likelihood procedure. ε_{it} is the serially-uncorrelated random error term in equation *i* with zero mean; d_i signifies a constant in the *i*-th equation. In the model (2), the null hypothesis of non-causality from money stock to real output is rejected if either the group of coefficients on the money stock variable, *m*, in the output equation, $d_{12}^k(L)$ is statistically significant or the coefficient of lagged error-correction term, δ_y is negative and statistically significant. The equations in the VEC model are estimated by applying the ordinary least squares method. A battery of diagnostic tests were applied for each equation to see whether the test statistics are prone to inconsistencies due to non-spherical disturbances. The results of the diagnostic tests are reported in Appendix Table A1. The estimated equations in general appear to validate the diagnostic tests of residual correlation, ARCH and normality in most cases. The residuals in the exchange rate equation exhibit some non-normality.

The results from the VECM are presented in Table 4 which summarizes the significance levels of *'F'* and *'t'* statistics. In the income equation of the M1 system, none of the *F*-values related to money stock, interest rate, price and exchange rate variables as well as the *t*-statistic associated with the lagged error correction term are statistically significant. This result indicates that real output is statistically exogenous which appears to support the real business cycle hypothesis that financial variables are not the driving forces underlying the movement of real income. Prices cause narrow money stock in the money equation and narrow money stock causes prices through the error correction term in the price equation. These results suggest that a bi-directional causality exists between prices and narrow money stock. The result of a bi-directional relationship between price and monetary aggregates is consistent with Ramachandran (2004). In the interest rate equation, prices unidirectionally cause movements in interest rates. The lagged error correction is negative and statistically significant in the price equation which also implies that movements in income, narrow money stock, interest rates and exchange rates induce movements in prices. Consistent with the various exchange rate theories, a unidirectional causality flows from output to exchange rate.

The lower panel of Table 4 reports similar results for the M2 system. The results in the M2 system are slightly different from the M1 system. The insignificant '*F*' and '*t*' statistics in the output equation indicate that output is free of feedback from the right hand variables. The results also suggest that a reverse causality flows from prices and a unidirectional causality from interest rates to M2. The existence of such reverse causality from interest rates and prices to broad money stock again appears to support the Keynesian 'monetary accommodation' hypothesis. The lagged error correction is again negative and statistically significant in the price equation. This finding suggests that whenever the monetary authorities have an overriding objective of price stability, M2 in conjunction with an assortment of financial market indicators and money market conditions, such as output, interest rates, and exchange rates should be used as informational variables.

In order to analyze the dynamic characteristics of the major macroeconomic variables, VDCs were computed as suggested by Sims (1980b). We consider the following ordering depending on the primary focus of our research: (*m i y p e*). Monetary aggregates and interest rate variables are placed prior to output, prices and exchange rate variables.[(8)] Placement of monetary policy variables prior to output, prices and exchange rate variables allows macroeconomic goal variables (or the latter

TABLE 4. TEMPORAL CASUALITY RESULTS BASED ON VECTOR ERROR-CORRECTION MODEL (VECM)

Dependent Variable	*F*-statistics (Marginal Significance level)					ξ_{t-1} (*t*-statistics)
M1 Model	Δy	Δm	Δi	Δp	Δe	
Δy	0.833 (.444)	2.229 (.126)	0.327 (.723)	0.752 (.480)	0.478 (.624)	-0.272 (-1.166)
Δm	0.023 (.976)	0.471 (.628)	0.353 (.705)	4.606** (.018)	0.415 (.663)	-0.122 (-.294)
i	1.245 (.303)	0.191 (.826)	3.152* (.058)	2.643* (.0887)	1.165 (.326)	-2.721 (-1.315)
Δp	0.657 (.526)	0.610 (.550)	0.655 (.526)	4.220** (.024)-	.816 (.452)	-0.971** (-2.695)
Δe	2.788* (.078)	0.856 (.435)	0.317 (.730)	1.821 (.180)	0.844 (.445)	0.130 (.242)

Dependent Variable	F-statistics (Marginal Significance level)					ξ_{t-1} (t-statistics)
M2 Model	Δy	Δm	Δi	Δp	Δe	
Δy	2.899* (.0717)	1.054 (.361)	0.071 (.931)	0.564 (.575)	0.852 (.437)	0.024 (.549)
Δm	0.313 (.733)	0.170 (.844)	4.277** (.023)	2.453* (.104)	1.701 (.200)	0.133 (3.982)
Δi	1.156 (.329)	1.441 (.253)	1.784 (.186)	2.062 (.146)	0.236 (.790)	-0.563 (-1.433)
Δp	0.319 (.729)	2.165 (.133)	0.410 (.667)	2.670* (.086)	0.497 (.613)	-0.116* (-1.706)
Δe	2.466* (.103)	0.361 (.699)	0.309 (.736)	2.103 (.140)	0.435 (.651)	0.037 (.383)

Note: ξ_{t-1} signifies the lagged error correction term. Marginal significance levels are in the parentheses underneath the F-statistics.

variables) to bear all the burden of adjustment which is induced by monetary shocks. This ordering puts forth a Keynesian-type channel in which monetary shocks influence interest rates, and then the two shocks contemporaneously affect output, price level and exchange rate. Since VDCs account for the absolute size of an economically important variable regardless of its statistical significance, readers are advised to exercise caution if the causal inferences embodied in the VEC model are slightly different from the causal inferences obtained in the VDCs analysis. Table 5 summarizes VDC results of each variable at the horizons of 1, 2, 3, 4, 5 and 10 periods in order to convey a sense of dynamics of the system. The VDC results in the M1 system demonstrates that a strong causality flows from M1 to output and a weak reverse causality runs from output to M1. At the end of ten-period forecast horizon, *m* innovations explain 18.18% of the forecast error variance of real output while *y* innovations only explain 9.97% of the variation in M1. Price innovations explain 11.43% of the forecast error variance in narrow money stock at the end of ten-period forecast horizons which suggests a weak causality runs from prices to M1.Table 5 also shows that the interest rate behaves like a nearly feedback free process albeit with interest rates which incorporate a weak price effect. *y* innovations explain a large proportion of the forecast error variance in *p* at the ten-period horizon. *i* innovations explain 9.71% of the forecast error variance in *p* at the ten-period horizon. The implication of these findings is that both output and interest rate, proxying the degree of demand pressure and cost of borrowed funds respectively, are the driving forces underlying the price movements in India. In the case of the exchange rate, *p* innovations exert a significant and discernible effect on the movements of exchange rate

TABLE 5. DECOMPOSITION OF VARIANCE FOR M1 MODEL

Variable	Horizon	Percentage of forecast error variance explained by innovations in				
		y	*m*	*i*	*p*	*e*
				Relative Variance in *y*		
y	1	95.43	0.102	4.46	0	0
	2	87.67	4.99	5.41	1.36	0.544
	3	72.18	18.26	4.51	4.03	0.988
	4	72.12	18.07	4.43	3.98	1.37
	5	70.24	18.41	4.32	4.96	2.04
	10	68.08	18.18	5.15	6.33	2.23
				Relative Variance in *m*		
m	1	0	100.00	0	0	0
	2	0.662	97.58	0.001	1.70	0.036
	3	10.19	76.90	2.09	8.63	2.17
	4	10.13	73.04	3.67	10.34	2.80
	5	9.80	72.42	5.01	10.03	2.72
	10	9.97	70.37	5.32	11.43	2.88
				Relative Variance in *i*		
i	1	0	1.89	98.10	0	0
	2	0.017	3.45	93.00	1.69	1.83
	3	0.121	2.97	84.72	9.34	2.83
	4	4.43	5.24	77.73	9.67	2.91
	5	5.50	5.09	75.39	11.09	2.91
	10	7.67	5.47	70.75	13.17	2.92
				Relative Variance in *p*		
p	1	42.33	6.88	0.143	50.63	0
	2	34.20	5.07	5.36	53.35	2.00
	3	29.24	5.81	6.57	56.55	1.82
	4	26.22	5.11	7.12	59.54	1.59
	5	24.93	4.73	9.02	59.69	1.62
	10	22.22	3.91	9.71	62.80	1.33
				Relative Variance in *e*		
e	1	4.10	8.09	0.261	12.06	75.47
	2	4.11	9.38	0.235	15.32	70.93
	3	4.16	14.75	0.349	23.15	57.58
	4	5.61	13.47	3.42	25.75	51.73
	5	10.28	11.53	3.53	31.62	43.01
	10	9.79	9.42	5.99	41.25	33.52

while *y* innovations exert a weak effect on the movements of exchange rates. Interestingly, most of the results as derived from the VDCs analysis coincide with the preceding results as obtained from the VEC model. In terms of non-zero entries in the VDCs table, M1 has the largest temporal effects on output at the end of the ten-period forecast horizon. However, M1 itself is subjected to a reverse causality from non-policy variables such as price and output.

The VDC results pertinent to the M2 system are presented in Table 6. Unlike the M1 model, *i* innovations exert significant and discernible effects on the real output variance. Furthermore, prices and interest rate innovations explain a larger proportion of forecast error variance of broad money stock (M2). For price variability, innovations in *m* and *y* explain a substantial variation of observed variation in *p*. This indicates that M2 and output are important determinants of *p*. Therefore, M2 money stock may serve as an appropriate monetary aggregate to attain the objective of price stability. For interest rate variability, both price and M2 innovations collectively explain substantial observed variance in interest rates.

To sum up, *M1* exerts a very discernible impact on income while *M1* itself is subject to a reverse causality flowing from prices and real output. *M2* appears to exert a discernible and significant impact on price, which reaffirms its role as a leading indicator in explaining inflation. Given the fact that the monetary authorities used monetary targeting strategy from the mid-1980s to 1997-98, this finding strengthens the case against using M1 and M2 as intermediate targets for monetary policy, since it is possible that movements in M1 and M2 can also result from similar movements in the goal variables such as prices and real income. Interest rates continue to exert a significant influence on income and money stock in the M2 VAR system. This finding accords well with Reddy (2002) which noted that output response to monetary policy operating through the interest rate channels are gradually gaining importance over the quantum channel in recent years. Reddy (2002) also contended that the impact of an expansionary monetary policy on inflation is found to be stronger through interest rates than exchange rates, given the relatively limited openness of the economy.

TABLE 6. DECOMPOSITION OF VARIANCE FOR M2 MODEL

Variable Forecasting horizon (Quarters)		Percentage of forecast error variance explained by innovations in				
		y	*m*	*i*	*p*	*e*
				Relative Variance in *y*		
y	1	85.21	0.046	14.73	0	0
	2	74.56	2.27	15.44	4.69	2.57
	3	71.31	3.96	14.84	4.48	5.39
	4	68.26	3.96	17.42	5.11	5.22
	5	67.11	3.98	17.17	6.57	5.15
	10	66.42	4.19	17.07	7.17	5.12
				Relative Varience in *m*		
m	1	0	100	0	0	0
	2	0.479	55.86	31.01	10.20	2.43
	3	2.59	43.50	25.95	25.10	2.84
	4	2.39	40.98	22.17	31.95	2.44
	5	2.46	40.87	22.45	31.76	2.44
	10	2.70	39.49	21.79	33.51	2.48
				Relative Variance in *i*		
i	1	0	0.042	99.95	0	0
	2	0.650	6.62	89.07	2.82	0.832
	3	0.871	9.23	80.40	8.63	0.855
	4	1.53	8.80	78.17	10.58	0.909
	5	1.59	9.17	72.37	16.01	0.842
	10	2.78	9.31	70.32	16.53	1.03
				Relative Variance in *p*		
p	1	18.84	1.87	2.39	76.88	0
	2	16.94	11.02	5.13	65.39	1.49
	3	15.92	14.65	5.37	62.46	1.57
	4	15.61	14.00	8.09	59.76	2.45
	5	14.62	13.80	8.32	60.77	2.47
	10	14.27	14.11	8.12	61.09	2.38
				Relative Variance in *e*		
e	1	2.86	.001	.333	15.63	81.16
	2	3.11	.174	1.67	22.25	72.77
	3	3.80	.164	3.20	33.79	59.03
	4	6.16	.833	3.27	34.61	55.11
	5	6.38	1.14	3.26	34.60	54.59
	10	6.60	1.47	3.40	34.68	53.82

CONCLUSION

Previous research documented conflicting evidence regarding the nature and direction of the relationship between money and output as well as the role of monetary forces in inducing business cycles in India. For example, a recent paper of Masih and Masih (1996a) examined the causal relationships among alternative monetary aggregates (M1 and M2), output, price, interest rate and exchange rate variables. Their results suggest that narrow money stock (M1), being statistically exogenous, is the driving forces underlying the movements of output, interest rates, prices and exchange rates. Masih and Masih (1996a) contend that their results are supportive of the monetarists' theory of business cycles. In contrast, Luintel (2002) finds overwhelming evidence of endogeneity of monetary aggregates in India which appears to support the Keynesian monetary accommodation hypothesis. The endogeneity issue of monetary aggregates raises questions regarding the efficacy of the monetary authority's policy stance in controlling the price level through the control of money stock. Therefore, identification of the empirical characteristics of monetary aggregates in terms of a good intermediate target and informational variable has become a topic of ongoing research interest to the researchers and policy-makers in India.

This paper has investigated the empirical characteristics of target-goal relationship among various monetary aggregates, and output, price, interest rate and exchange rates in terms of a good intermediate target and informational variable. The results of a five-variable VAR analysis indicate that two of the Reserve Bank of India's monetary aggregates, M1 and M2, are subject to feedback from the economy and thus may not serve well as good intermediate targets and informational variables of monetary policy. The results also find that interest rate is subject to a feedback from the nonpolicy variable such as prices. These results are supportive of the real business cycle view and Keynesian monetary accommodation hypothesis rather than the monetarists' theory of business cycles. Given the limited information content and forecasting value of any particular indicators, such as monetary aggregates or interest rates, monetary authorities and policy-makers should focus on a range of potentially influential real and financial variables that are mutually interactive, i.e., output, employment, monetary aggregates, exchange rates, and interest rates. From the year 1998-1999, the Reserve Bank of India has shifted its focus from the monetary aggregates to a much wider array of economic indicators that have shown predictive power for real output and inflation. The bank now monitors monetary aggregates, interest rates, exchange rates, fiscal position, trade, capital flows and other variables of money market conditions available with high frequency in order to draw inferences regarding movements in real output and inflation. Overall, the results in this paper suggest that the monetary authorities in India are moving in the right direction.

ENDNOTES

[1] This idea is consistent with the notion of Friedman's (1968) natural rate hypothesis.
[2] Precisely speaking, the chronological development of major macroeconomic debates among Keynesian, monetarists, new Keynesian and new classical economists so far has been centred on three major issues [see, Brunner (1986)]: (a) the relative effectiveness of monetary and fiscal policy; (b) transitory real effects and permanent nominal effects of fiscal policy vs. real effects of monetary influence; and (c) the relative potency of stabilisation policy. In the first round discussion of the mid 1960s, monetarists contended that money stock matters more than autonomous expenditure while the Keynesians counterclaim that both money stock and autonomous expenditure matter significantly [see, Friedman and Meiselman (1965), Ando and Modigliani (1965)]. In the second round discussion during the second half of the 1960s and early 1970s, monetarists argued that expansionary fiscal actions have transitory real effects and permanent nominal effects on output and employment due to 'crowding out' effects. Friedman (1968) concluded that discretionary stabilisation policies have little scope to stabilise the economy and any trade-off between unemployment and inflation is a transitory phenomenon. In the third round discussion, during the second half of the 1970s, the new classical economists corroborate the impotency of anticipated demand management policy while the new Keynesian economists empirically verified short-run non-neutrality of anticipated demand management policy [see, Gordon (1982), Demary (1984)].
[3] For example see, McMillin and Feckler (1984).
[4]The study of Moosa (1997) used quarterly data of money, real output and prices covering the period 1972:1 to 1990:4. Money stock, real output and price level were proxied by currency in circulation, the industrial production index, and the wholesale price index, respectively.
[5] Ramachandran (2004) contended that the money demand function of India is likely to be stable with respect to few determinants compared to many developed economies given its inheritance of a repressed financial system characterized by administered interest rate structure, insignificant financial innovations, in the presence of narrow array of financial assets and highly restricted cross border capital flows over a long period. Accordingly, a number of recent studies such as Rao and Bajpai (1995), Arif (1996), Das and Mandal (2000), and Rao and Ramachandran (2003) reported that the demand for money is fairly stable with respect to income and prices despite some significant changes induced by financial market deregulation, innovation and functional diversification in recent years.
[6] Because of the data availability the sample period runs from 1957-2001.
[7] Interested readers are referred to Judge *et al* (1988), and Sims (1980b) for detailed derivation of the moving average representation and the calculation of VDCs.
[8] To test the sensitivity of the VDC results, we have also used the following ordering option: *(r m y p e)*. In the second ordering the interest rate variable is placed before money stock to account for the fact that the official authorities also pursued interest rate targeting over a long period of time. However, no significant changes were observed as a result of such reordering.

APPENDIX

TABLE A1. SUMMARY OF DIAGNOSTIC TESTS FOR EQUATIONS USED IN CASUALITY TESTS REPORTED IN TABLE 4

M1 system	*Serial Correlation*	*Heteroskedasticity*	*Normality'*
Equation	LM(1)	ARCH	JB
Δy	0.116	0.042	0.063
Δm	0.016	0.921	0.780
Δr	0.447	0.157	0.130
Δp	2.320	0.036	0.560
Δe	0.078	0.718	22.34
M2 system	*Serial Correlation*	*Heteroskedasticity*	*Normality*
Equation	LM(1)	ARCH	JB
Δy	0.378	0.030	0.963
Δm	0.449	0.062	0.614
Δr	0.484	0.002	0.209
Δp	2.730	0.573	1.714
Δe	0.265	0.592	13.54

Notes: Distributional properties of diagnostics are respectively: LM(1) as $\chi^2(1)$ testing for the null of no first order serial correlation amongst the residuals; Het: a $\chi^2(1)$ test for first-order ARCH effects; and the Jarque-Bera $\chi^2(2)$ LM test for normality of residuals.

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