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MACROECONOMIC RELATIONSHIP IN INDIA: ARDL EVIDENCE ON COINTEGRATION AND CAUSALITY

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Abstract

The main objective of the paper is to estimate the dynamic interrelation among the macroeconomic variables viz., real output, money, price, interest rate and exchange rate using monthly data for India covering the period from 1991:1 to 2007:12 using ARDL approach to cointegration.

The bounds test revealed that there exists a long-run relation between real output, money supply, interest rate and exchange rate when the price variable was the dependent variable. Also, a long-run relationship between real output, money supply, price and interest rate was found when exchange rate was the dependent variable. However, reverse cointegration relationships were not noticed when the real output, money supply and interest rate were the dependent variables.

The short-run causality found no evidence of causality between real output and money and a unidirectional causality running from price and interest rate to real output was found. The exchange rate was found independent to the changes in real output. The exchange rate and price were found to be independent to changes in money. Further, it was noticed that the price is caused by output, money, interest rate and exchange rate. The causality was found to be neutral from output, money, price, and exchange rate on interest rate. Finally, it was found that output, money, price and interest rate has no effect on exchange rate in the short-run.

Keywords: Real Output, Money, Price, Interest Rate, Exchange Rate, ARDL

JEL Classifications: E41, E52, C22

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1. Background

The empirical study on cointegration and the dynamic interrelation among the macroeconomic variables is very important especially in the era of economic and financial liberalization. In liberalized economy, important macroeconomic variables such as money, income, the level of prices, interest rate and exchange rate are expected to cause each other and share a long-run relationship. In view of existence of interrelationship and causality between these macroeconomic variables different schools of thought, such as the Classical, the Keynesians, the New Growth Theorists have propounded different explanations for the relationship among these variables.

In general, income and money are considered as important macroeconomic variables which play a crucial role particularly in determining the level of prices, interest rates and exchange rates in a liberalized economy. For example, the monetarist view mainly headed by Friedman proposed that an expansion in the quantity of money at any period of time may generally expected to result in a rise in general price level and in turn impacts the level of national income. As noted, price stability is an essential condition for stability in economic life as well as economic growth. Fluctuations in prices, on the contrary, create an atmosphere of uncertainty which is not conducive to development activity. Further, if prices rise steadily over a long period, redistribution of national income and wealth takes place to the disadvantage of the poor, which eventually influences the aggregate demand pattern and in turn impacts the level of economic activity in an economy.

Thus, the supply of money or stock of money at any period of time has a tendency to impact prices and income levels in the economy and is one of the important active macroeconomic variables which the policy makers have to keep a check on it. Thus, according to monetarists view, the direction of causation runs from money to income and prices without any feedback. However, the emphasis of the Keynesian theory was that the effective demand determines the level of income. Thus, essentially Keynesians argue that money does not play an active role in changing income and prices. In fact income plays the leading role in changing money stocks via demand for money implying that the direction of causation runs from income to money without any feedback. Similarly, changes in prices are mainly caused by the structural factors.

Traditionally, the differing propositions of Monetarists and Keynesians mainly dealt with three issues. First, the effectiveness of monetary policy against fiscal policy, second the Phillips curve and finally the role of policy. In view of this debate Keynesians stressed that fiscal rather than monetary policy is crucial for the economy.

In light of this contradiction, Friedman and Schwarz (1963) examined the relationship between money supply and output in USA over a period of 1867-1960. The most relevant determinant of output was found to be monetary policy which could solely explain most of the fluctuations in output. Similarly, Sims (1972) tested the causal relationship between money and nominal GNP in the bivariate framework. His study found that causality is unidirectional running from money to income in the post-war quarterly data for USA as claimed by the Monetarists. However, he rejected the hypothesis that causality is unidirectional from income to money as claimed by the Keynesians.

However, the subsequent studies on the issue did not support Sims' findings. For instance, Fiege and Pearce (1979), using similar data, have found little or no causal relationship between money supply and GNP. Likewise, Pierce (1977) draws the conclusion that independence or lack of causal relationship characterizes important economic variables.

To examine the generality of Sims' results (1972), Williams, Goodhart, and Gowland (1976) undertook a similar study using UK data. They find that neither the causal relationship from money to income nor the reverse causality from income to money is significant. Rejection of the first hypothesis that causality is unidirectional from money to income was found to be decisive, but rejection of the second hypothesis that causality is unidirectional from income to money was found to be marginal at the 5 percent significance level.

On the other hand, Barth and Bennett (1974) replicating Sims test in Canadian economy, Lee and Li (1983) investigating causality among money, income, and prices in Singapore, Joshi and Joshi (1985) examining causality between money and income in India, Dyreyes, Starleaf, and Wang (1980), examining the pattern of causality between money and income for six industrialized countries, found a bidirectional causality contrary to Sims (1972).

Further, Karras (1994, 1999) concluded that money supply affects not only the output but also increases its influence on inflation. Studies such as Masih and Masih (1995, 1996), Hondroyannis (2000) examining the nature and direction of causality between money supply and other macroeconomic variables for different countries and time periods found differing results which complicates further the nature of true relationship between these macroeconomic variables in a globalized world.

The empirical examination of direction and causality between money, income and other macroeconomic variables in India also stand inconclusive. Ramachandra (1983, 1986) for India by adopting Sim's technique during 1951-1971 and 1951 to 1980 found that money causes real income and price and price causes real income and finally nominal income causes money. Gupta (1984) using Granger and Sim's framework concluded that both nominal and real income cause money. Nachane and Nadkarni (1985) using quarterly data and Sim's methodology found that money caused the changes in price and nominal income. Singh (1989) found a bidirectional causality between money and prices for the period of 1970-71 to 1986-87. Similarly, Biswas and Saunders (1990) found a bidirectional causality between money and prices. And recently, Khundrakpam and Goyal (2008) using annual data found that money and real output cause price both in short as well as in the long-run while money is neutral to output.

Also, along with the direction of causality, the existence of long-run equilibrium relationship among money and income represented by a money demand function also has significant implications for monetary policy. For instance, the existence of the long-run equilibrium relationship between money and income implies that a monetary policy, using money as a policy instrument can influence fluctuations in income and prices otherwise, it is impossible for the central bank to use money as a policy instrument, and to control prices and income by controlling money.

The above discussion clearly indicates first, that the empirical evidence regarding the direction of causation between money and income remain inconclusive, and second, the directions of causation assumes importance especially for an emerging economy like India, for effective implementation of its monetary policy and achieve the desired target of growth keeping stability of prices and exchange rates. To add to this, the current debate on the causal relationship between money and income in India is certainly, inconclusive especially since India adopted new economic and financial sector reforms in 1991 where exchange rate and interest rate are mainly determined by the free market forces.

Thus, in an emerging economy like India, one of the important tasks of the central bank in framing its monetary policy is to understand the causal relationship between money, income and other macroeconomic variables and understand the dynamics of future movements of some relevant aspects of the real economy. Also, since liberalization hardly any study exist in India which had examined the macroeconomic relationship between the selected five variables in a single study using monthly data and ARDL approach to cointegration.

Detecting the true causal directions among macroeconomic variables between money, income and other macroeconomic variables therefore assumes importance and is essential for effectiveness of its monetary policy and design of an appropriate policy. Therefore, this study attempts to investigate the causal relationship specifically between money, income, price, interest rate and the exchange rates in India during post-liberalization period using monthly data.

The paper is organized as follows. Section 2 presents the data used and the methodology adopted. Section 3 presents empirical results and discussion and Section 4 provides concluding remarks of the paper.

2. Data and Research Strategy

The Data

The macroeconomic monthly data under examination consist of Index of Industrial Production (IIP), Money Supply (MS), Price (P), Interest Rate (INT) and Nominal Effective Exchange Rate (NEER) from 1991:1 to 2007:12. Monthly time series data on IIP a proxy to measure real Income or Output (RY), WPI a measure of price and interest rate were collected from International Financial Statistics CD-ROM, 2008, where as macroeconomic series such as Money Supply, NEER were culled from Handbook of Statistics on Indian Economy, 2007, RBI. All the selected variables have been seasonally adjusted.

The component of money supply used in the study is Broad Money (M_3), which consists Narrow money i.e., currency with public, other deposits with RBI and demand deposits of banks (M_1) plus time deposits.

The Research Strategy

In a regression of two or more underlying time series, one often finds a high R^2 even though there may not be any meaningful relationship between the underlying variables. In some of the time series variable(s) one expect no relationship between them, yet a regression of one on the other variable(s) often shows a significant relationship. This situation exemplifies the problem of spurious regression (Gujarati, 2004). Thus, the regression of a non-stationary time series variable on another non-stationary time series variable(s) may produce a spurious regression. Therefore, much of the empirical work based on time series data assumes that the underlying time series is stationary. In the empirical literature most of the macroeconomic time series exhibit stationarity in first-differencing.

The application of cointegration technique requires the determination of the order of cointegration of each of the time series which is done by checking the stationarity of the variables. If a time series variable has a unit root, the first differences of such time series are stationary and they are known to be integrated of order I or I(1). However, if a time series variable exhibits stationarity at levels then it is known to be integrated of order zero or I(0). In cointegration analysis, after establishing a cointegration relationship between the underlying time series variables, one is mainly interested in estimation of long-run coefficients of the cointegrated variables. But using the method of first-differencing usually confiscates the existing long-run relationship between the underlying time series and such model ends up in providing short-run causal relationship between the variables which may not be the main objective of investigation.

As noted in the literature, depending on the power of the unit root tests, different tests yield different results (Bahmani-Oskooee, 1998). In view of this problem, Pesaran and Shin (1995) and Pesaran et al. (1996, 2001) introduced a new alternative method known as Autoregressive Distributed Lag (ARDL) modeling of testing for cointegration. ARDL method has the advantage of avoiding the classification of variables into I(1) or I(0) and unlike standard cointegration tests, there is no need for unit root pre-testing. Further, Pesaran and Shin (1999) showed that estimates based on ARDL are super-consistent, and valid inferences on the long-run parameters can be drawn using the standard normal asymptotic theory. Further, this method not only provides evidence on long-run cointegration but also provides long-run coefficients. Also, this method not only solves the problem of residual serial correlation and but also solves the problem of endogenous regressors (for example present in two-step cointegration method like Engle and Granger (1987).

The first step of ARDL estimation requires the establishment of the existence of the long-run relationship between the underlying time series variables. This is tested first, by using F-test on the joint null hypothesis that the coefficients of the lag levels of the variables are jointly equal to zero, against the alternative that they are jointly different from zero. Second, by using t-test on the lag level of the dependent variable that it is individually different from zero.

For the purpose, Pesaran et al. (1996) formulated two sets of appropriate critical values for (K) number of regressors, and whether the model contains an intercept and/or trend. One set assumes that all variables are I(0) and another set assumes that they are all I(1). This provides a band covering all possible classifications of the variables into I(0) and I(1). If the calculated F-value lies above the upper level of the band, the null of no cointegration is rejected, demonstrating the presence of cointegration. If the calculated F-value falls below the lower level of the band, the null of no cointegration cannot be rejected. This implies that there is no cointegration among the variables in the underlying model of ARDL.

The second step involves the estimation of the ARDL equation determined by a optimal lag structure on the basis of lag selection criterion like Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC). On the basis of appropriate lag length decided by AIC and/or SBC, the next step, involves the estimation of ARDL equation to obtain long-run coefficients of the variables included in the model. Finally, the error correction mechanism of ARDL equation is estimated in order to decide and determine how quickly the long-run equilibrium is restored between the underlying ARDL variables.

To determine the long-run macroeconomic relationship between the selected variables the following ARDL version of error-correction model is specified.

$$\Delta \log A_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \log A_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \log B_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \log C_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta \log D_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta \log E_{t-i} + \gamma_1 \log A_{t-1} + \gamma_2 \log B_{t-1} + \gamma_3 \log C_{t-1} + \gamma_4 \log D_{t-1} + \gamma_5 \log E_{t-1} + \varepsilon_{1t} \quad \text{... (1)}$$

$$\Delta \log B_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \log B_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \log A_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \log C_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta \log D_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta \log E_{t-i} + \gamma_1 \log B_{t-1} + \gamma_2 \log A_{t-1} + \gamma_3 \log C_{t-1} + \gamma_4 \log D_{t-1} + \gamma_5 \log E_{t-1} + \varepsilon_{2t} \quad \text{... (2)}$$

$$\Delta \log C_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \log C_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \log A_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \log B_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta \log D_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta \log E_{t-i} + \gamma_1 \log C_{t-1} + \gamma_2 \log A_{t-1} + \gamma_3 \log B_{t-1} + \gamma_4 \log D_{t-1} + \gamma_5 \log E_{t-1} + \varepsilon_{3t} \quad \text{... (3)}$$

$$\Delta \log D_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \log D_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \log A_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \log B_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta \log C_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta \log E_{t-i} + \gamma_1 \log D_{t-1} + \gamma_2 \log A_{t-1} + \gamma_3 \log B_{t-1} + \gamma_4 \log C_{t-1} + \gamma_5 \log E_{t-1} + \varepsilon_{4t} \quad \text{... (4)}$$

$$\Delta \log E_t = \alpha_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \log E_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \log A_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \log B_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta \log C_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta \log D_{t-i} + \gamma_1 \log E_{t-1} + \gamma_2 \log A_{t-1} + \gamma_3 \log B_{t-1} + \gamma_4 \log C_{t-1} + \gamma_5 \log D_{t-1} + \varepsilon_{5t} \quad \text{... (5)}$$

In the above models Δ is the first-difference operator, and 'A', 'B', 'C', 'D' and 'E' are the five macroeconomic variables selected in the study. In (1), where 'A' is the dependent variable, with 'B', 'C', 'D' and 'E' as the long-run regressors, the null of no cointegration defined by $H_0 : \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$ is tested against the alternative of $H_1 : \gamma_1 \neq 0, \gamma_2 \neq 0, \gamma_3 \neq 0, \gamma_4 \neq 0, \gamma_5 \neq 0$, denoted by F(A/B,C,D,E) by means of F-test. The t-test is $\gamma_1 \neq 0$. Similarly, in (2), (3), (4), (5), where 'B', 'C', 'D' and 'E' are the dependent variables, the similar null hypothesis, with 'A', 'C', 'D' and 'E' (denoted by F(B/A,C,D,E), 'A', 'B', 'D' and 'E' (denoted by F(C/A,B,D,E), 'A', 'B', 'C' and 'E'(denoted by F(D/A,B,C,E), 'A', 'B', 'C' and 'D'(denoted by F(E/A,B,C,D) is respectively applicable. The terms ε_{1t}, ε_{2t}, ε_{3t}, ε_{4t}, and ε_{5t} are mutually uncorrelated white noise error terms.

Once the specified equation suggests a cointegrating relationship, the conditional long-run relationship is estimated by the reduced form solution of the following ARDL equation. For example, if 'A' is the explained variable the specification takes the following form:

$$A_t = \alpha_0 + \sum_{i=1}^{n} \beta_1 A_{t-i} + \sum_{i=0}^{n} \beta_2 B_{t-i} + \sum_{i=0}^{n} \beta_3 C_{t-i} + \sum_{i=0}^{n} \beta_4 D_{t-i} + \sum_{i=0}^{n} \beta_5 E_{t-i} + \varepsilon_{6t} \quad \text{... (6)}$$

Following (6), the short-run causality is determined from the following ARDL model:

$$\Delta A_t = \alpha_0 + \sum_{i=1}^{n} \lambda_1 \Delta A_{t-i} + \sum_{i=0}^{n} \lambda_2 \Delta B_{t-i} + \sum_{i=0}^{n} \lambda_3 \Delta C_{t-i} + \sum_{i=0}^{n} \lambda_4 \Delta D_{t-i} + \sum_{i=0}^{n} \lambda_5 \Delta E_{t-i} + EC_{t-1} + \varepsilon_{7t} \quad \text{... (7)}$$

where, Δ is the difference operator, EC representing the error-correction (EC) term derived from the long-run cointegrating relation using the above specified ARDL model (6).

Using (7) the Granger-causality test is performed. It has been noted by Engle-Granger (1987) that if the Granger causality test is conducted at first-difference through vector auto regression (VAR) modeling, than it will be misleading in the presence of cointegration. Therefore, by adding the lag EC terms not only the direction of causality is determined but also one can differentiate between the short-run and long-run causality. The long-run causality is confirmed by the negative sign and the statistical significance of the lag EC terms included in the ARDL model.

3. Empirical Results and Discussion

ARDL Bounds Test for Cointegration

Table 1 reports ARDL bounds test for cointegration of the selected macroeconomic variables. As noted earlier, the presence of cointegration between the variables is confirmed if the F-test of joint significance of lagged levels of the variables and the t-test on lag level of the dependent variable included in the model rejects the null hypothesis of no cointegration.

In the present study, the maximum lag length was fixed to twelve (being monthly data) and the optimal lag length to be employed in the estimation of ARDL model was decided by AIC. Examination of Table 1 shows that when price (lnP, model 3) is the dependent variable, the calculated F-statistics is found to be higher at 99% of level of significance than the upper critical bound values of Pesaran et al. (1996). Also, the lag level of the dependent variable is found to be significant at 95% level as indicated by t-statistics. This supports the assertion that there exists a long-run cointegration relation between real output, money supply, interest rate and exchange rate when the price variable is the dependent variable.

Similarly, when exchange rate (lnNEER, model 5) is the dependent variable, the calculated F-statistics is found to be higher at 99% of level of significance than the upper critical bound values of Pesaran et al. (1996). The lag level of exchange rate is found to be significant at 99%. Thus, real output, money supply, price and interest rate share a long-run relationship with exchange rate, with the latter as the dependent variable.

As evidenced from Table 1, reverse cointegration relationships is not found when the real output, money supply and interest rate are the dependent variables as the F-statistics and t-statistics are lower at 95% upper critical bound values.

Based on the existence of cointegration relationship for model 3 and model 5, the following long-run coefficients are estimated using ARDL model (6) (Table 2). The resulting underlying ARDL equation was also verified with all its statistical diagnostic properties in order to get unbiased and consistent/efficient estimates.

Table 1. ARDL Bounds Test for Cointegration

Model No.	*Variables*	*F-statistics*	*t-statistics*	*Cointegration*
1	F(lnRY/lnMS, lnP, lnINT, lnNEER)	2.76	-2.19	No Cointegration
2	F(lnMS/lnRY, lnP, lnINT, lnNEER)	0.77	-0.51	No Cointegration
3	F(lnP/lnMS, lnRY, lnINT, lnNEER)	6.47***	-5.05**	Cointegration
4	F(lnRINT/lnMS, lnP, lnRY, lnNEER)	2.00	-1.45	No Cointegration
5	F(lnNEER/lnMS, lnP, lnINT, lnRY)	6.78***	-5.38***	Cointegration

Notes: 1. The estimated F-values and t-values are compared with the critical bound values reported in Pesaran et al. (1996)

2. At 99% and 95% level of significance with constant and no trend, the critical values of the upper bound as per Pesaran et al. (1996) are 5.122, 4.049 respectively.

3. ***, ** denote rejection of the null hypothesis of no cointegration at 99% and 95% level of significance respectively

Table 2. ARDL Estimates of Long-Run Coefficients

Regressors/Dependent Variable	*lnP*	*lnNEER*
Constant	3.64 (8.61)***	6.06 (6.01)***
lnRY	-0.28 (-2.73)**	0.74 (2.53)**
lnMS	0.18 (3.83)***	0.07 (0.51)
lnINT	-0.06 (-4.10)***	0.01 (0.08)
lnNEER	-0.50 (-8.80)***	---
LnP	---	-1.19 (-4.09)***

Notes: 1. ***, ** denote significance level at 99%, 95% respectively

2. Figures in parentheses are the estimated t-values

From Table 2, which brings out the precise nature of the long-run relationship when price is the dependent variable (column 1, Table 2), the following inferences can be drawn: first, the coefficient of real output in the price equation is found to be negative and statistically significant indicating any increases in real output in the long-run lowers or decreases price or inflation in India during the study period. The long-run negative coefficient of real output shows the fact that the supply factors play a crucial role in controlling inflation in India i.e., as and when supply of output increases in the economy it has the tendency to lower the level of price.

Second, the long-run coefficient of money supply is found to be positive and significant supporting the premise that any increases in the money supply leads to long-run inflation in India. Friedman (1956) in his essay maintained that a change in the supply of money causes a proportionate change in the price level. That is, in the long run, an increase in the quantity of money brings an equal percentage increase in the price level in India

Third, the estimated long-run coefficient of interest rate is found to be negative and significant indicating that any increases in the interest rate in the economy leads to fall in the price level. Since interest rate is the opportunity cost of holding wealth in the form of money rather than an interest-bearing asset, a rise in the interest rate decreases the quantity of money that people plan to hold. Therefore, the reduced quantity of money does not assert inflationary pressure in the economy.

Fourth, like interest rate, the estimated coefficient of exchange rate is also found to be negative and significant indicating that any appreciation in exchange rate has a tendency to decrease the level of prices in the domestic economy via reduction in import prices of goods and services.

From the estimated long-run coefficients when exchange rate is the dependent variable (column 2, Table 2), the following inferences can be drawn: money and interest rate are found to insignificant determinant of exchange rate where as real output and price are found to be significant determinants of exchange rates in India. Also, it can be observed that the value of price coefficient is high (1.19) indicating a greater role of inflation in influencing the exchange rate of India.

The Dynamics of Short-Run Causality

To estimate short-run dynamics and causal correlation between the selected macroeconomic variables, F-test has been employed on the joint significance of the lagged variables. Specifically, model (7) has been estimated to determine the nature and direction of short-run dynamics of the selected macroeconomic variables. Table 3 presents the estimated results that are as follows:

As ARDL bounds test showed that there exists no cointegrating relationship for real output on money supply, price, interest rate and exchange rate and they are neutral to real output in the long-run. However, in the short-run, the real output equation suggests that price and interest rate are non-neutral to real output and cause the changes in real output (row 3). Money Supply and exchange rate are found to be neutral to the changes in real output.

Similarly, the ARDL bounds test showed that there exists no cointegrating relationship for money on output, price, interest rate and exchange rate and they are neutral to money in the long-run. However, the short-run causality in the money equation shows that interest rate leads to changes in money supply (row 4). Nominal effective exchange rate, prices and real output remain neutral to changes in money supply in the short-run.

From these two equations it is confirmed that there exists no causality between real output and money supply in the short-run during the post liberalization period.

This may be due to the impact of liberalization on changes in money supply and real output which operate in an open economy on the basis of market forces unlike pre-liberalization phase. These findings suggest that changes in money supply and real output in post liberalization period depend on interest rate and price level in India.

The EC term included in the price equation is negative and statistically significant confirming the results obtained under the ARDL bounds test of cointegration that price is caused by real output, money supply, interest rate and real exchange rate (row 5). Significantly in the short-run also, show the evidence that all the chosen macroeconomic variables cause the changes in the level of prices.

The ARDL bounds test showed that there exists no cointegrating relationship for interest rate on output, money, price, and exchange rate and they are neutral to interest rate in the long-run. In the short-run also the causality seems to be neutral from output, money, price, and exchange rate on interest rate (row 6). This suggests that the changes in interest rates in India is neutral to changes in money, output, price and exchange rate both in the short and the long-run.

Similar to the price equation, the lagged EC term included in the exchange rate equation is negative and statistically significant confirming the results obtained under the ARDL bounds test of cointegration that exchange rate is caused by real output, money supply, price and interest rate (row 7). However, in the short-run real output, money, price and interest rate has no effect on NEER (row 7) as suggested by low calculated F-values.

Table 3. Granger Causality Test using VECM (1991:1 to 2007:12)

Dependent Variable/ Regressors	$\sum_{j=1}^{p} \Delta \ln RY_{t-j}$	$\sum_{j=1}^{p} \Delta \ln MS_{t-j}$	$\sum_{j=1}^{p} \Delta \ln P_{t-j}$	$\sum_{j=1}^{p} \Delta \ln INT_{t-j}$	$\sum_{j=1}^{p} \Delta \ln NEER_{t-j}$	EC_{t-1} (t-statistics)
	$\Sigma\beta_i = 0$ F-stat (p-value)	$\Sigma\beta_i = 0$ F-stat (p-value)	$\Sigma\beta_i = 0$ F-stat (p-value)	$\Sigma\beta_i = 0$ F-stat (p-value)	$\Sigma\beta_i = 0$ F-stat (p-value)	$\varepsilon = 0$: t-stat (p-value)
$\Delta \ln RY_t$	---	0.96 [0.39]	6.95*** [0.00]	5.53*** [0.00]	0.25 [0.78]	-1.98 [0.12]
$\Delta \ln MS_t$	0.32 [0.21]	---	0.02 [0.98]	2.62* [0.08]	0.44 [0.65]	-0.47 [0.64]
$\Delta \ln P_t$	4.13*** [0.007]	2.69** [0.05]	---	5.93*** [0.00]	3.64** [0.03]	-2.28** [0.02]
$\Delta \ln INT_t$	0.20 [0.82]	0.62 [0.54]	0.97 [0.38]	---	0.25 [0.78]	-0.56 [0.39]
$\Delta \ln NEER_t$	0.19 [0.82]	0.18 [0.84]	1.61 [0.20]	0.50 [0.61]	---	-3.16*** [0.002]

Notes: 1. ***, **. * denotes significance at 99%, 95% and 90% respectively
2. The lag length was selected on the basis of AIC criterion.

4. Conclusion and Policy Implications

The present paper attempted to examine the long-run cointegration between real output, money, price, interest rate and nominal effective exchange rate in India for post-liberalization period viz., 1991:1 to 2007:12. For the purpose, necessary macroeconomic variables, such as IIP a proxy to measure real Income or Output (RY), WPI, a measure of price and interest rate were collected from International Financial Statistics, CD-ROM, 2008. The other macroeconomic series such as Money Supply, NEER were obtained from Handbook of Statistics on Indian Economy, RBI.

To investigate the long-run cointegration between the selected macroeconomic variables ARDL bounds test for cointegration was adopted. Further, the dynamics of short-run causality between the selected variables was also examined to determine the nature and direction of causality between these selected variables.

The bounds test revealed that there exists a long-run relation between real output, money supply, interest rate and exchange rate when price was the dependent variable. However, reverse cointegration relationships is not found when the real output, money supply and interest rate were the dependent variables. Also, existence of long-run relationship was observed between real output, money supply, price and interest rate when exchange rate was the dependent variable.

The short-run causality results revealed some interesting evidence. Price and interest rate were found to be causing the changes in real output. The money and exchange rate were found independent to the changes in real output. Also, in the short-run, interest rates were found to be causing money supply where as real output, price and exchange rate were found to be independent to changes in money supply. Further, no causality between real output and money supply in the short-run was found in the post liberalization period.

The price equation confirmed that price is caused by real output, money, interest rate and exchange rate. The causality seems to be neutral from output, money, price, and exchange rate on interest rate. Finally, it was found that real output, money, price and interest rate has no effect on NEER in the short-run.

Thus, due to the mixed direction of causation found between money, output, price, interest rate and exchange rate one finds it difficult either to accept or reject the monetarists or the Keynesians view in India for the post liberalization period. However, there are some definite policy implications for Indian policy makers. The thrust of the RBI's monetary policy stance has been designed at providing ample rupee liquidity, maintaining continued credit flow to productive sectors along with ensuring sustained growth and price stability in the economy.

The present study found that there exists a long-run relationship between real output, money supply, interest rate and exchange rate when the price variable is the dependent variable. Also, the examination of short-run causality confirmed that real output, money, interest rate and exchange rate cause the changes in price level. In the short-run it was also found that price as well as interest rates cause the real output. Therefore, in order to maintain price stability and avoid inflationary pressures in the economy, the central bank should design its monetary policy by targeting interest rates. The existence of cointegration between real output, money, price, and interest rates when exchange rate is dependent variable suggests that in post liberalization a greater role is played by exchange rates. Also, evidence shows that there is a unidirectional causality running from exchange rate to the level of prices in India. Therefore, exchange rate can be used to serve as an efficient intermediate target for the monetary policy through effective intervention of RBI in foreign exchange market.

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