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CAUSALITY BETWEEN MONEY, PRICES AND OUTPUT IN INDIA (1951-2005): A GRANGER CAUSALITY APPROACH

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Abstract

The relationship between money, price and output is one of the most debated issues among different schools of thought of economics particularly between the Monetarists and Keynesians. The Monetarists argue that money influences the prices and the output, whereas the Keynesians argue that money does not influence the same. Direction of causality among these three and selection of appropriate lag length are widely debated issues in the literature. This study examines the relationship between money, price and output using pairwise Granger causality test on annual data of the Indian economy covering a period from 1951 to 2005. Lag length is selected using standard criteria – LR, FPE, AIC, SC and HQ through VAR estimation. The results strongly support the monetarists view and partially supports the Keynesian view. However, these relationships are sensitive to the lag length selections.

KEYWORDS: Granger causality, VAR, Stationarity, India

JEL Classification: C22, E31, E51

1. Introduction

The relationship between money, prices and output has been a debated issue among different schools of thought of economics particularly between the Monetarists and the Keynesians. The direction of causality and the selection of appropriate lag length are main issues of debate at empirical level. The Monetarists claim that changes in stock of money plays an important role and leads to changes in nominal income and prices. In other words, changes in nominal income and price in an economy are mainly caused by the changes in money stocks. Hence, the direction of causation runs from stock of money supply to nominal income and prices

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without any feedback; implying that nominal income and prices can be controlled through money supply. This is known as unidirectional causation. The Keynesians, on the other hand, argue that stock of money supply does not play an active role in changing nominal income and prices. In fact, changes in income cause changes in money stock via demand for money implying that the direction of causation runs from income to money without any feedback. According to them changes in prices are mainly caused by the structural factors.

The causal relationships between money and income and between money and prices have been an active area of investigation in Economics particularly after the seminal paper by Sims (1972). He devised a test of causality based on the work of Granger and applied it to the U.S. data to examine the causal relationship between money and income. He found the evidence of unidirectional causality from money to income as propounded by the Monetarists.

The existing literature on the empirical studies on the relationship between money, income and price is inconclusive. Moreover, the papers reviewed here investigated causality between two variables, i.e. between money and income and/or between money and prices. However, an economic variable is generally influenced by more than one variable; therefore, models involving more variables may be more useful.

In an attempt to understand money-output-price level inter-linkage, the issue of the relative effectiveness of monetary and fiscal policy in economic stabilization and growth has come under sharp focus. In this debate economists are divided into two distinct school of thought – the 'Monetarists' and the 'Neo-Keynesians'. Most empirical studies in this area have focused on the developed nations using St. Louis equation or some variants of it. Most of these studies show that monetary actions have a stronger and faster impact on economic activities than fiscal actions. The relative effectiveness of monetary and fiscal policies in India was examined by Chowdhary (1986), Upadhyay (1991) and Mehta and Kisero (1993). The results of these studies do not reveal any consistent pattern. Moreover, they do not support either the views of Monetarists or Keynesians.

Granger's (1969) notion of causality is perhaps widely accepted and empirically testable notion that has been extensively applied to economic relationships. This concept of causation, built on an earlier work by Weiner (1956), is essentially as Geweke (1984) has noted, 'an empirical rather than a logical or ontogological.' It rests on two crucial premises, viz.

1. direction of causation is only possible in case of stochastic (as opposed to any deterministic) processes
2. Since time is irreversible, it is the past and present that can only cause future

Granger's definition of causality is couched in terms of predictability. Granger defines simply causality as follows:

X causes **Y**, if knowledge of past **X** reduces the variance of the errors in forecasting **Y** as compared to the variance of the errors which would be made from knowledge of past **Y** alone.

2. Methodology and Data Sources

In the present paper, we have examined the issues of causality between money supply [both Narrow money (M_1) and Broad money (M_3) defined by RBI], price level (measured by

Wholesale Price Index), Output as measured by GDP at factor cost. We have taken annual data for M_1, M_3, GDP at factor cost and WPI for the time period covering 1951 to 2005.[2]

To begin with, we convert all the variables into natural logarithmic form for reducing variations in them. In the second step, the stationarity of variables included in the analysis was tested by a Unit Root test. In this context, the Augmented Dickey Fuller (ADF) test was used and three models were estimated. (i) Model I (without any constant and trend) (ii) Model II (with constant but no trend) (iii) Model III (with constant and trend). All three models were tested with test for Unit Root in (i) None (ii) First Difference and (iii) Second difference. A combination when value of ADF is statistically significant and AIC (Akaike Information Criterion) and SBC (Schwarz Information Criterion) become minimum such combination is considered as stationarity of series.

Then five different criteria viz. LR (Sequential modified Likelihood Ratio test statistic (each test at 5% level), FPE (Final Prediction Error), AIC, SC and HQ (Hannan-Quinn Information Criterion) have been used to select the appropriate lag order. For the lag order thus selected, pairwise Granger Causality test has been performed with a pair of Null Hypotheses viz.

(1) Money supply does not Granger cause WPI and WPI does not Granger cause Money supply

(2) Money supply does not Granger cause Output (GDP) and Output (GDP) does not Granger cause Money supply

Depending upon the values of F-statistic and the associated significance levels, appropriate conclusions are drawn.

The entire data analysis was done using the software 'E-views 4.0'

3. Review of Literature

Indian studies on causality between money, output and price, though a recent phenomenon, are quite large in number. Apart from sample periods and methodology adopted, the studies are varied in a number of technical details, the most important being the selection of appropriate lag structure and achieving stationarity in the data. A number of studies have ignored these technicalities. Not surprisingly, finding differs significantly. In fact, all the possibilities regarding the direction of causality between any two variables (i.e. two unidirectional and one bidirectional) have emerged as evidence from the studies in the Indian context.

In India, perhaps the earliest attempt in this respect is due to Ramchandra (1983). He used yearly data for the period 1951-71, to study the causality between money on one hand and both output (real and nominal) and prices on the other. The following variables were taken into consideration in studying the relationship.

1. NNP at current and at 1960-61 prices
2. Narrow money, M_1 as annual average monthly values
3. Implicit NNP deflator with base 1960-61

The study used Sims' test with independent variables involving past, present and one future lags. The methodology adopted for detecting causality was rather simplistic. If an equation

[2] Hand Book of Monetary Statistics of India (2006), Reserve Bank of India, Mumbai

was found to be satisfactory in terms of $\bar{R}^2$ and Durbin Watson [DW] statistic and the coefficient of $\mathbf{X_t}$ (and its differences) are found to be statistically significant individually, then the study concluded that **X** is causing **Y**. On the basis of regression results the study arrived at the following conclusions:

a) Money causes both real income and price level
b) Price level causes real income
c) Nominal income cause money

G S Gupta's (1984) analysis on money-income causality emerged as a peripheral to his study on monetary target setting. For the overall sample period 1954-55 to 1982-83, he tested both Granger's and Sims' causality on Money (M_3) nominal national income and real national income (1970-71=100). The same relationship was studied for various sub periods as well. The selection of lag structure and attainment of stationarity in data was somewhat ad-hoc. While for Granger's test uniformly three past lags were taken, for Sims' test three past and three future lags were considered. Stationarity was sought to be achieved by taking logarithms of the variables in the first difference form. The study concluded that 'causation is unidirectional and it runs from nominal national income to money supply as well as from real income to money supply'. In other words, the quantity of money is not an exogenous variable either in the nominal money equation or in the real income function.

The first elaborate causality study on money-output-prices in India seems to have done by Nachane and Nadkarni (1985). Their study presented an exhaustive theoretical survey of various causality tests. Spanning over the period 1960-61 to 1981-82 and based on quarterly data, they employed four tests viz.,

i. Sims
ii. Hsiao's Final Prediction Error (FPE)
iii. Cross-correlation test and
iv. Transfer function test

They measured output by GNP and price level by WPI. As far as the monetary variables are concerned, both M_1 and M_3 were taken into account. Stationarity of data and the related truncation process for selecting the lag structure was achieved through stepwise autoregression with the help of Box's Q-Statistic for the Sims' test. The results were reinforced by the use of Akaike's (1976) Information Criterion (AIC).

Their findings on the money-output-prices nexus turned out to be independent of the type of test adopted for detecting the direction of causation. All their test results demonstrate that money supply is a major determinant of nominal national income in India, though for M_3 the conclusion seems to be sensitive to the methods used to construct quarterly estimates of national income. There is uniformity among the test results in suggesting a unidirectional causality from money stock to prices; though in the case of M_3 the effect is evident only for longer lags (in excess of 16 quarters). On the other hand, as far as money supply affecting real output is concerned, their tests remained inconclusive.

Despite the technical finesse and the exhaustiveness of the test procedures Nachane and Nadkarni pointed out some limitations of the database. Their construction of quarterly estimates of national income should be treated with some caution, particularly in view of the fact that their conclusions often turn out to be sensitive to the type of estimate of national income used.

Joshi and Joshi (1985) have studied the relationship between M_1, M_3 and nominal income and used both Granger's and Sims' tests to examine causality. The time span of their sample period was 32 years. They uniformly used Sims' filter i.e. $(1\text{-}0.75\ L)^2$ for ensuring stationarity in data, the justification for which was not clear.

Their testing Granger's causality does not involve any statistical criterion for lag selection; they have arbitrarily selected 3 past lags. Moreover, after addition of the 'cause' variable, they did not deploy the F-Test; instead their inferences are based on improvements in the values or $\overline{R}^2$ and SEE. Their Granger causality results suggested that the direction of causation bidirectional, both between M_1 and nominal income and between M_3 and nominal income. Their results from Sims' test also reinforce the earlier findings of bidirectional causality between money and nominal income.

Sharma, Ram Lal (1985) while using the Sims methodology to test causality between Money and Price level in India observed that:

1. For the sample period 1962-80 the causality from M_1 to P was much stronger than the reverse causality from P to M_1.
2. Bidirectional causality existed between M_3 and P

However in his later study (1987) the author has re-examined the issue of causality between Money and Price level in India and has used only Granger's test for this purpose. Sharma has found the existence of unidirectional causality running from M_1 to P on the one hand and from M_3 to P on the other. These results are at sharp variance from those of Sharma reported earlier (1985).

Sample period used in this study is from 1954 to 1985. Both annual as well as quarterly data have been used for the estimation of the parameters of regression equations. The analysis based on annual data did not help him to get clear results because of limited degrees of freedom. He therefore concentrated on the quarterly data.

Biswas and Saunders (1990) have examined the relationship between the money supply and the price level in India, using quarterly data for two periods 1962-1980 and 1957 –1986. This study relies on the optimal lag selection causality technique outlined by Hsaio (1981). The results obtained by Hsiao's causality testing method are compared with the results of a similar study reported by Sharma (1985). The studies attempt to establish a causal flow between the stock of money and nominal income.

The study revealed that the lag selection in causality testing has a critical effect on the test result. An arbitrary lag selection determines the outcome of the tests. Consequently, it becomes crucially important to select an appropriate lag structure in causality testing. The minimum Final Prediction Error **(FPE)** causality testing technique used throughout the present study overcomes some of the difficulties associated with arbitrary lag selection methods. In particular, under the minimum FPE procedure the causality test results are no longer influenced by an arbitrary lag selection.

When the minimum FPE method is applied to Indian data, feedback is established between all the three measures of the money supply and wholesale prices for both test periods - 1962 to 1980 and 1957 to 1986. When M_1 is taken as the measure of the money supply, the results contradict Sharma's (1985) findings. Furthermore, the induction of a relatively high inflationary period does not affect the basic causality relationships under investigation. The results reported in this study are consistent with the situation where budget deficits are financed by creation of money, as is the case of India.

Jadhav, Narendra (1994) analysed the issue of causality between money and prices as well as between money and output in the Indian context using the Direct Granger test as well as the modified Sims test. He found that there is no strong support for the 'reverse' causality, i.e. from prices to money as the F-values corresponding to both tests are not statistically significant even at 10 percent level of significance. Fairly large F-values, however, heuristically indicate that a weak reverse causation in not entirely ruled out.

In this case, the proposition that money causes output is supported by both the tests, though somewhat weakly. One the other hand, there is no support for the reverse causation from output to money as suggested by extremely low F-statistic value.

Since no definite conclusions have been arrived at by the earlier studies cited above, we made a modest attempt to contribute to the ongoing debate.

For this purpose, we have tried to determine the interrelationships between money, income and price by using various estimation methods. Our basic data are

1. Wholesale Price Index [WPI] Base year : 1993-94
2. Narrow Money Supply (M_1) as defined by Reserve Bank of India
3. Broad Money Supply (M_3) as defined by Reserve Bank of India
4. Gross Domestic Product (GDP) at factor cost

In order to establish the relationship among these important macroeconomic variables, it is necessary to examine stationarity of the time series.

(A) Stationarity of W.P.I Annual Series: 1951-2005 (Base – 1993-94 = 100)

We have used ADF test for stationarity along with AIC and SBC criteria.

Table 1.1 gives values of various test statistics used for testing stationarity of the W.P.I series.

As can be seen from this table, the Augmented Dicky-Fuller (ADF) test statistics in level (logarithmic) shows presence of unit root in WPI (level). Here intercept coefficient is not statistically significant. However, intercept and trend coefficient taken together are significant. But ADF is not significant. Therefore, it may be concluded that the series in not stationary.

For the W.P.I (first difference) series, it is found that ADF statistic is statistically significant indicating absence of unit root. In this case, both intercept coefficients alone is statistically significant but intercept along with trend coefficient are not statistically significant.

When the W.P.I (second difference) series is considered, one finds that there is absence of unit root and both the criteria AIC as well as SBC – are minimized, which suggest that W.P.I (second difference) without intercept and intercept with trend is statistically significant. In this case, the series is found stationary.

These results are depicted graphically in **Graph 1.1 and 1.2**.

(B) Stationarity of Narrow Money (M_1) and Broad Money (M_3) Annual series, 1951-2005

Both M_1 and M_3 series, become stationary when second differences are considered without including intercept and intercept with trend. The relevant results of the test statistics are provided in **Table 1.2 and 1.3**.

It should be noted here that in the case of M_1 series, intercept coefficient and coefficient of intercept with trend are not statistically significant, whereas in the case of M_3 series intercept alone is not statistically significant but intercept is statistically significant when trend is included.

Graph 1.3 and 1.4 (for M_1) and **Graph 1.5 and 1.6** (for M_3) represent graphically non stationatiry of first difference and the stationarity of second difference of these series.

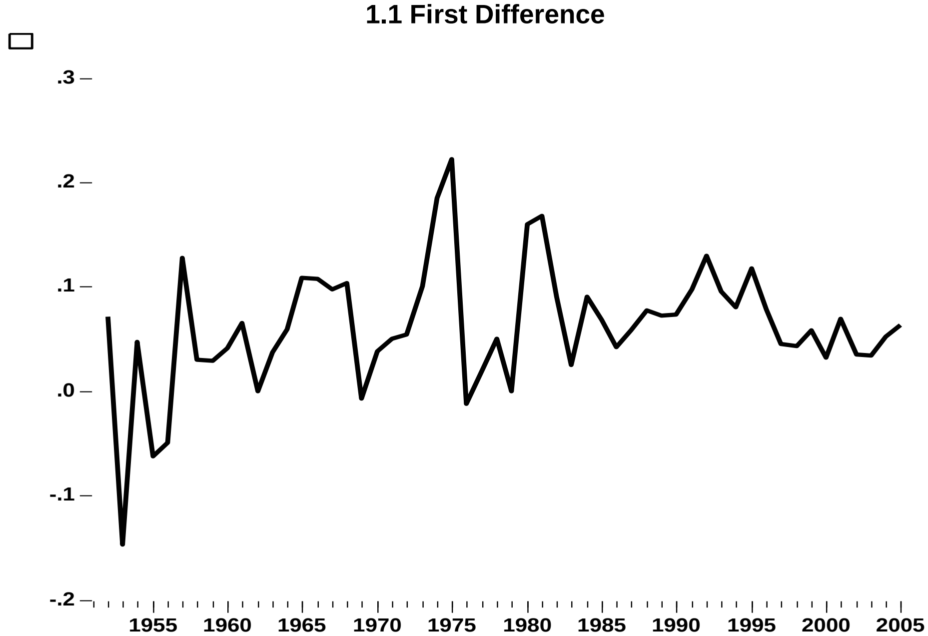
(C) Stationarity of GDP Annual series: 1951-2005

GDP series become stationary when second differences are taken, without including intercept and intercept with trend. The relevant results are given in **Tables 1.4**

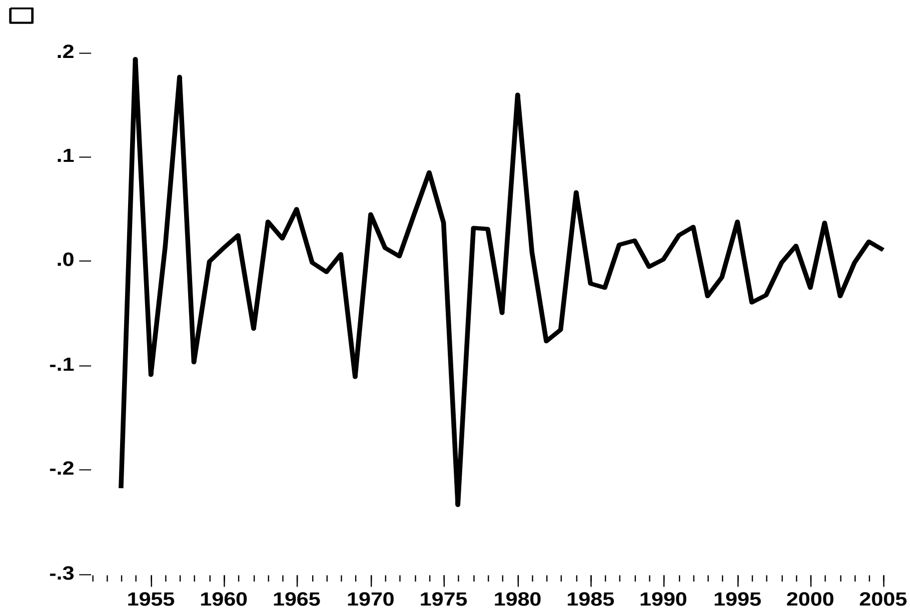
The first difference becomes stationary when intercept alone and intercept with trend are included. However, in case of the second difference, the values of both AIC and SBC are found to be minimized. So it may be concluded that GDP (second difference) without intercept and intercept with trend is stationary.

The non-stationarity of first difference and stationarity of second difference are shown in **Graph 1.7 and 1.8** for GDP.

1.1 First Difference



1.2 Second Difference



Graph 1.1. & 1.2. Stationarity of Wholesale Price Index (WPI) Annual Series from 1951-2005 (Base 1993-94 = 100)

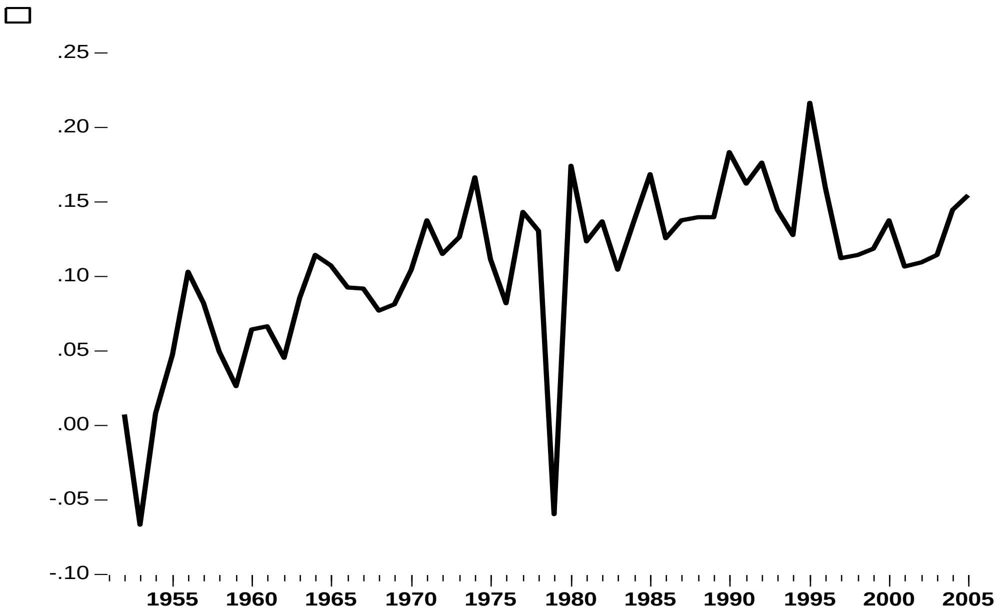
Table 1.1. Values of Various Test Statistics

Wholesale Price Index (WPI) Annual Series (Base: 1993-94=100)				
WPI (Level)	ADF	AIC	SBC	Remark
None	7.5954	-2.7874	-2.7506	
Intercept	1.2833	-2.7783	-2.7047	Intercept coefficient is not statistically significant
Intercept with Trend	-3.8082	-3.0176	-2.9071	Intercept and trend coefficient statistically significant
WPI (First Difference)				
None	-3.4369*	-2.5546	-2.5174	
Intercept	-5.5768*	-2.7882	-2.7139	Intercept coefficient statistically significant
Intercept with Trend	-5.8208*	-2.7918	-2.6803	Intercept and trend coefficient is not statistically significant
WPI (Second Difference)				
None	-11.7957*	-2.6976	-2.6601	
Intercept	-11.7008*	-2.6632	-2.5881	Intercept coefficient is not statistically significant
Intercept with Trend	-11.6592*	-2.6378	-2.5252	Intercept and trend coefficient is not statistically significant

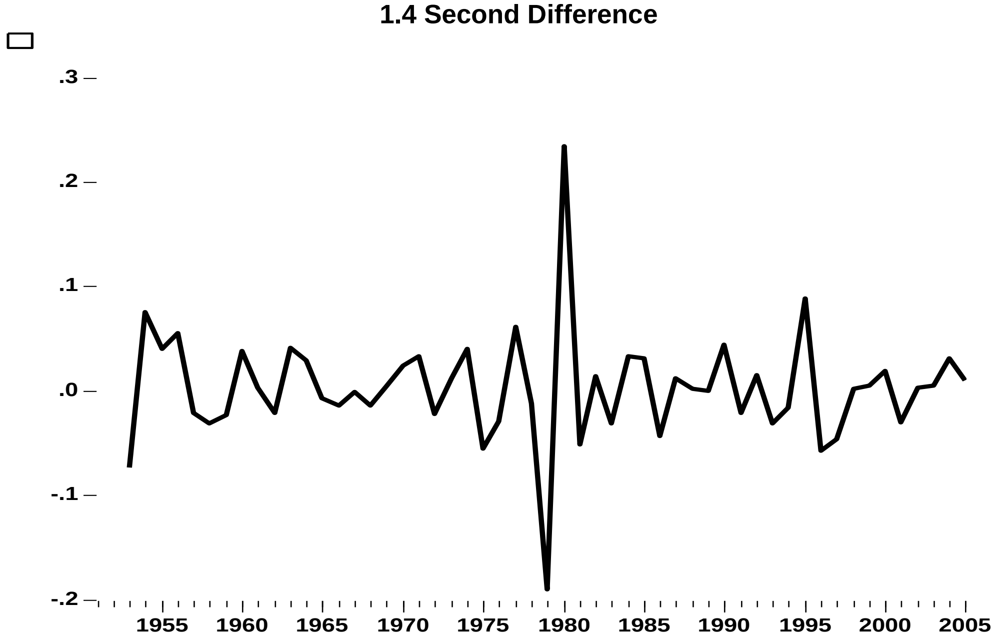
*Significant at 1 percent

Result: Wholesale Price Index (WPI) stationary at Second Difference without Intercept and Intercept with Trend

1.3 First Difference



1.4 Second Difference



Graph 1.3 and 1.4. Stationarity of Narrow Money Supply (M_1) Annual Series from 1951-2005

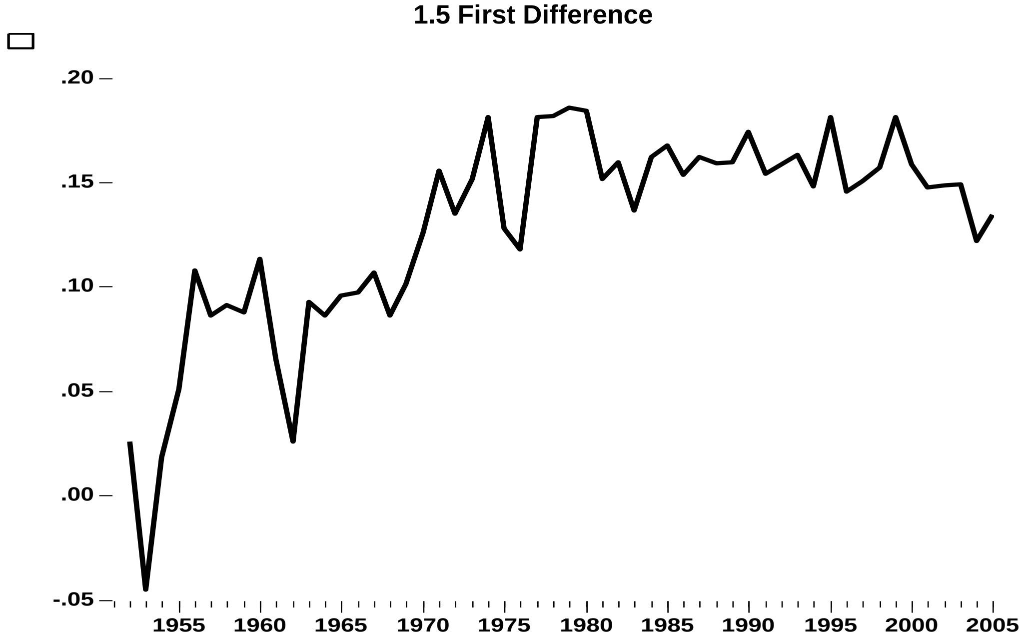
Table No 1.2. Values of Various Test Statistics

Narrow Money Supply (M_1) Annual Series				
M_1 (Level)	ADF	AIC	SBC	Remark
None	17.62	-3.2935	-3.2567	
Intercept	5.0253	-3.3183	-3.2447	Intercept coefficient statistically significant at 90 percent
Intercept with Trend	-4.0694	-3.6762	-3.5657	Intercept and trend coefficient statistically significant
M_1 (First Difference)				
None	-1.3997	-3.0107	-2.9735	
Intercept	-4.3557*	-3.1850	-3.1406	Intercept coefficient statistically significant
Intercept with Trend	-5.9068*	-3.1914	-3.1599	Intercept and trend coefficient statistically significant
M_1 (Second Difference)				
None	-11.6048*	-3.2061	-3.1686	
Intercept	-11.5902*	-3.1806	-3.1055	Intercept coefficient is not statistically significant
Intercept with Trend	-11.5703*	-3.1550	-3.0424	Intercept and trend coefficient is not statistically significant

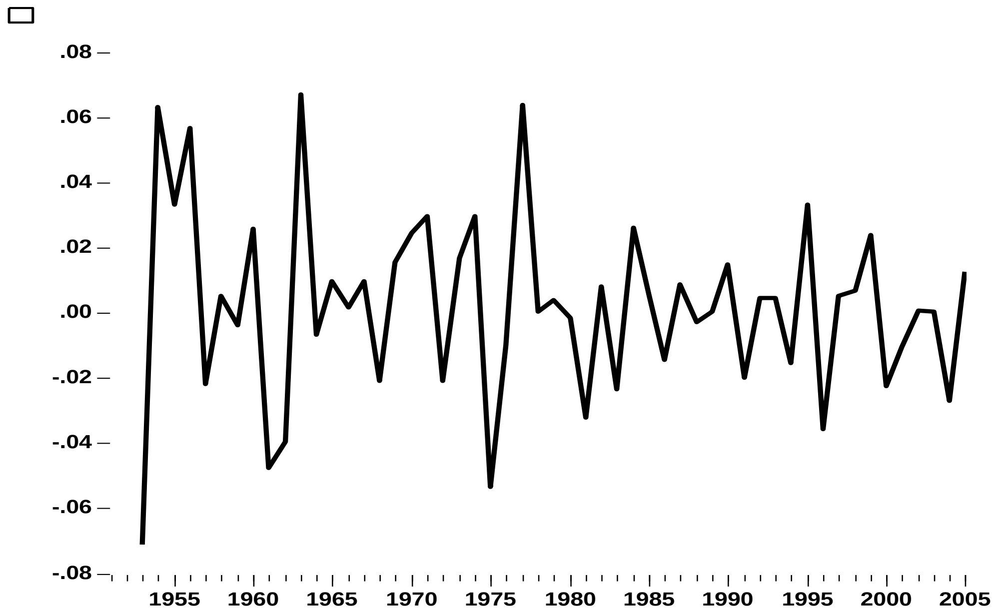
*Significant at 1 percent

Result: Narrow Money Supply (M_1) stationary at Second Difference without Intercept and Intercept with Trend

1.5 First Difference



1.6 Second Difference



Graph 1.5. and 1.6. Stationarity of Broad Money Supply (M_3) Annual Series from 1951-2005

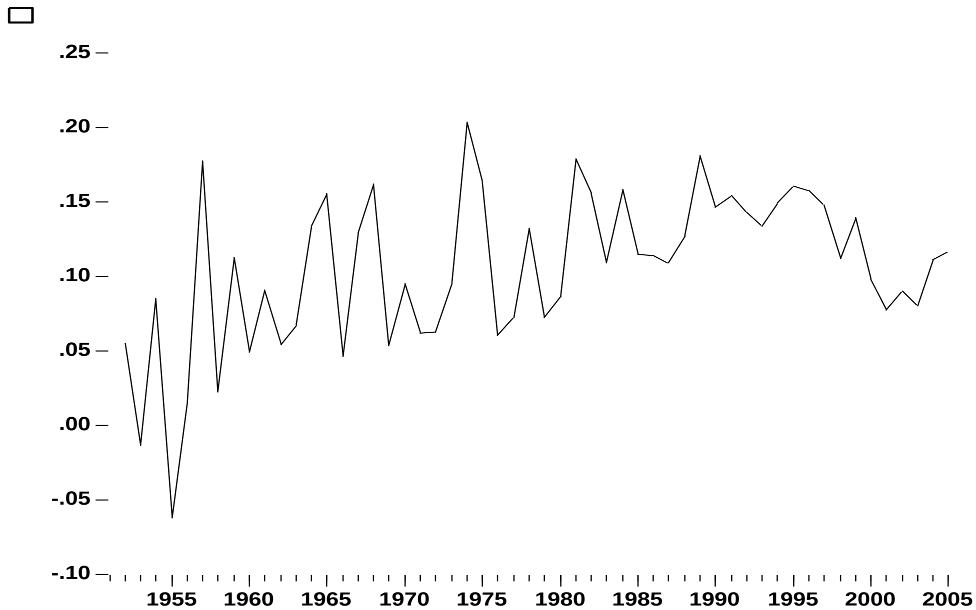
Table 1.3. Values of Various Test Statistics

Broad Money Supply (M_3) Annual Series				
M_3 (Level)	ADF	AIC	SBC	Remark
None	25.8845	-3.7192	-3.6823	
Intercept	6.1652	-3.7001	-3.6265	Intercept coefficient is not statistically significant
Intercept with Trend	-6.8647*	-4.4126	-4.3821	Intercept and trend coefficient statistically significant
M_3 (First Difference)				
None	-0.4347	-4.2693	-4.2321	
Intercept	-2.7657	-4.3730	-4.2987	Intercept coefficient statistically significant
Intercept with Trend	-3.1971*	-4.3944	-4.2829	Intercept coefficient is statistically significant but trend coefficient is not statistically significant
M_3 (Second Difference)				
None	-9.7066*	-4.4393	-4.4017	
Intercept	-9.7227*	-4.4239	-4.3489	Intercept coefficient is not statistically significant
Intercept with Trend	-10.1941*	-4.4578	-4.3452	Intercept coefficient is statistically significant but trend coefficient is not statistically significant

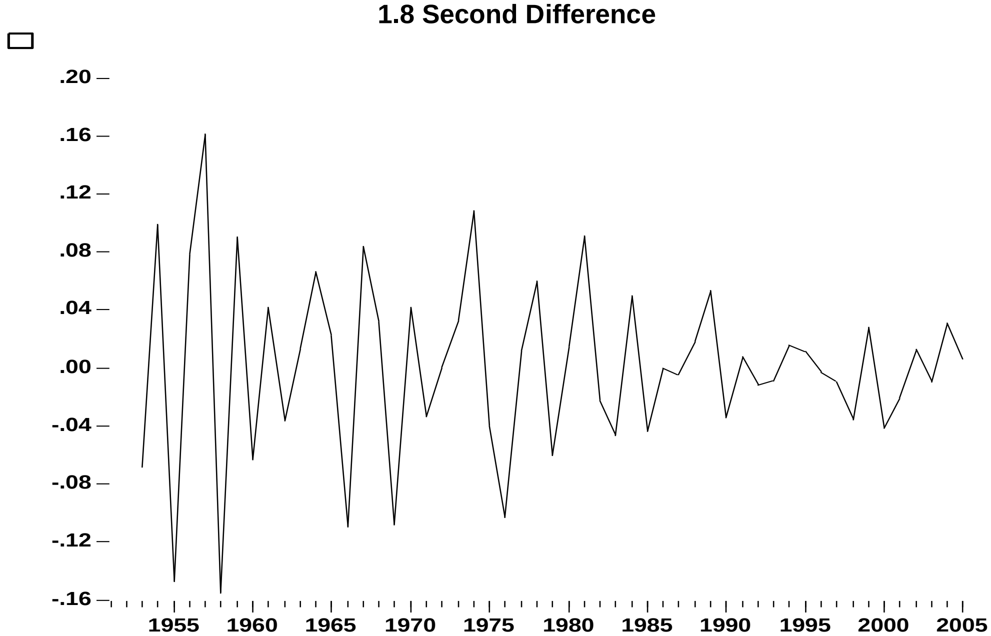
*Significant at 1 percent

Result: Broad Money Supply (M_3) stationary at Second Difference without Intercept and Intercept with Trend

1.7 First Difference



1.8 Second Difference



Graph 1.7. and 1.8. Stationarity of Gross Domestic Product (GDP) Annual Series from 1951-2005

Table No 1.4. Values of Various Test Statistics

Gross Domestic Product (GDP) Annual Series				
GDP (Level)	ADF	AIC	SBC	Remark
None	16.4566	-3.2196	-3.1827	
Intercept	3.1821	-3.1922	-3.1186	Intercept coefficient is not statistically significant
Intercept with Trend	-3.5432	-3.4256	-3.3151	Intercept and trend coefficient statistically significant
GDP (First Difference)				
None	-1.8755	-2.7412	-2.7041	
Intercept	-5.42618*	-2.0941	-2.0198	Intercept coefficient statistically significant
Intercept with Trend	-6.3745*	-2.1954	-2.0844	Intercept and trend coefficient statistically significant
GDP (Second Difference)				
None	-11.8565*	-2.9183	-2.8808	
Intercept	-11.7620*	-2.8828	-2.8078	Intercept coefficient is not statistically significant
Intercept with Trend	-11.6923*	-2.8509	-2.7383	Intercept and trend coefficient is not statistically significant

*Significant at 1 percent

Result: Gross Domestic Product (GDP) stationary at Second Difference without Intercept and Intercept with Trend

IV) Granger Causality: (Annual data)

The most important limitation of the OLS (Ordinary Least Square) method is that even a highly significant regression does not imply causation. Statistically it is possible in a limited sense to test whether the independent (explanatory) variable cause the dependent variable or not. The Granger Test, developed by Nobel Laureate econometrician C W J Granger (1969) is applicable only to econometric models where there is a lead-lag relationship between two variables. In terms of the St. Louis equation, we are to test whether M_1 (Narrow Money) Granger-causes Inflation measured by WPI in India and whether M_3 (Broad Money) Granger causes Inflation measured by WPI in India.

Case 1: Causality between M_1 and WPI

According to Granger, the time series M_{1t} (Narrow Money) fails to Granger cause WPI_t if in a regression of WPI_t on lagged WPI values and lagged Money supply, the estimated coefficients of the latter are not statistically significant from zero. Similarly the dependent variable M_{1t} is regressed on the lagged values of M_{1t} as well as the lagged values of WPI and if the estimated coefficients of the lagged values of WPI are found to be statistically insignificant then it may be concluded that WPI does not Granger cause M_1. The Granger Test for the St. Louis equation involves the estimation of the following pairs of equations:

$$WPI_t = \sum_{i=0}^{p} \alpha_i M_{1t-i} + \sum_{j=0}^{q} \beta_j WPI_{t-j} + u_{1t} \qquad \text{... (1)}$$

$$M_{1t} = \sum_{i=0}^{p} \gamma_i M_{1t-i} + \sum_{j=0}^{q} \delta_j WPI_{t-j} + u_{2t} \qquad \text{... (2)}$$

We assume further that the disturbance u_{1t} and u_{2t} are uncorrelated.

Equation 1 is used to test whether Narrow Money Granger Causes WPI, while equation 2 test its contrary. In model 1 we are to test the null hypothesis that the lagged M_1 terms do not belong to the regression. Analogously, in model 2 we test whether the lagged WPI terms belong to the regression or not. Unidirectional causality from M_1 to WPI is indicated when the null hypothesis only in equation 1 is rejected. The converse is true if only the null hypothesis in equation 2 is rejected. Bi-directional causality is indicated if in both equations 1 and 2 the respective null hypotheses are rejected.

Case 2: Causality between M_3 and WPI

Here also, the test for Granger causality (unidirectional of bidirectional) is done exactly in the same way as in case (1), only replacing M_1 by M_3.

$$WPI_t = \sum_{i=0}^{p} \alpha_i M_{3t-i} + \sum_{j=0}^{q} \beta_j WPI_{t-j} + u_{1t} \qquad \text{... (3)}$$

$$M_{3t} = \sum_{i=0}^{p} \gamma_i M_{3t-i} + \sum_{j=0}^{q} \delta_j WPI_{t-j} + u_{2t} \qquad \text{... (4)}$$

We assume further that the disturbance u_{1t} and u_{2t} are uncorrelated.

Case 3: Causality between GDP and M_1

The test for Granger causality is on the similar line in which we estimate the following equations:

$$GDP_t = \sum_{i=0}^{p} \alpha_i M_{1t-i} + \sum_{j=0}^{q} \beta_j GDP_{t-j} + u_{1t} \qquad \text{... (5)}$$

$$M_{1t} = \sum_{i=0}^{p} \gamma_i M_{1t-i} + \sum_{j=0}^{q} \delta_j GDP_{t-j} + u_{2t} \qquad \text{... (6)}$$

We assume further that the disturbance terms u_{1t} and u_{2t} are uncorrelated.

Case 4: Causality between GDP and M_3

The test for Granger causality is done in exactly similar manner, by replacing M_1 by M_3 in the equations given in case (3).

$$GDP_t = \sum_{i=0}^{p} \alpha_i M_{3t-i} + \sum_{j=0}^{q} \beta_j GDP_{t-j} + u_{1t} \qquad \text{... (7)}$$

$$M_{3t} = \sum_{i=0}^{p} \gamma_i M_{3t-i} + \sum_{j=0}^{q} \delta_j GDP_{t-j} + u_{2t} \qquad \text{... (8)}$$

We assume further that the disturbance terms u_{1t} and u_{2t} are uncorrelated.

Here one must keep in mind that causality and its direction depend on:

1. Time period under study

2. Methodology of testing causality
3. Definitions of the variables and
4. Model specification

LAG ORDER SELECTION:

In order to determine the significant lag values, we have used five different criteria viz.

(1) LR : sequential modified LR test statistic (each test at 5% level)

(2) FPE : Final prediction error

(3) AIC : Akaike information criterion

(4) SC : Schwarz information criterion

(5) HQ : Hannan-Quinn information criterion

(1) Causality between M_1 and WPI:

The relevant results for case (1) are provided in **Table 1.5** As per the results given in Table 1.6 out of 5, 4 criteria (LR, FPE, AIC and HQ) indicate that lag order 4 is significant.

Table 1.5. VAR Lag Order Selection Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	133.8922	NA	7.43E-06	-6.134522	-6.052606	-6.104314
1	148.8722	27.86975	4.46E-06	-6.645219	-6.399470*	-6.554595
2	154.3816	9.737605	4.16E-06	-6.715425	-6.305844	-6.564384
3	156.6609	3.816449	4.53E-06	-6.635391	-6.061977	-6.423934
4	171.1522	22.91639*	2.80E-06*	-7.123356*	-6.386110	-6.851483*
5	174.0933	4.377546	2.97E-06	-7.074108	-6.173029	-6.741818
6	174.1750	0.114019	3.62E-06	-6.891862	-5.826951	-6.499156
7	178.7133	5.910286	3.61E-06	-6.916898	-5.688153	-6.463775
8	179.0653	0.425643	4.41E-06	-6.747222	-5.354645	-6.233683
9	180.3951	1.484507	5.19E-06	-6.623030	-5.066620	-6.049074
10	181.3637	0.991117	6.30E-06	-6.482034	-4.761792	-5.847662

* indicates lag order selected by the criterion

Using this selected lag order, the results of the Granger causality test were obtained and are presented in **Table 1.5.1**

Table 1.5.1. Pairwise Granger Causality Tests: Lags: 4

Null Hypothesis:	*Obs*	*F-Statistic*	*Probability*
M_1 does not Granger Cause WPI	49	0.77491	0.54805
WPI does not Granger Cause M_1		3.07790	0.02665

M_1 stationary at Second Difference without Intercept and Intercept with Trend

WPI stationary at Second Difference without Intercept and Intercept with Trend

Results presented above in **Table 1.5.1** show that there is unidirectional granger causality running from WPI to M_1.

The SC criterion suggested the selection of lag order 2. Taking this lag order, the results are presented in **Table 1.5.2** the results indicate that there is almost unidirectional granger causality running from WPI to M_1. Here it should be noted that the significance level is slightly more (0.06) than the standard significance level of 0.05.

Table 1.5.2. Pairwise Granger Causality Tests: Lags: 2

Null Hypothesis:	*Obs*	*F-Statistic*	*Probability*
M_1 does not Granger Cause WPI	51	0.39781	0.67408
WPI does not Granger Cause M_1		2.96096	0.06171

M_1 stationary at Second Difference without Intercept and Intercept with Trend
WPI stationary at Second Difference without Intercept and Intercept with Trend

(2) Causality between M_3 and WPI:

The values of the test statistics and the significance of various criteria are provided in **Table 1.6**

Table 1.6. VAR Lag Order Selection Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	171.3105	NA	1.30E-06	-7.874908	-7.792992	-7.844700
1	185.3552	26.12972	8.17E-07	-8.342104	**-8.096355***	**-8.251480***
2	189.2244	6.838476	8.24E-07	-8.336018	-7.926436	-8.184977
3	190.9249	2.847309	9.20E-07	-8.229063	-7.655649	-8.017606
4	198.5481	**12.05533***	**7.82E-07***	**-8.397585***	-7.660339	-8.125711
5	200.4148	2.778365	8.73E-07	-8.298362	-7.397283	-7.966072
6	201.6373	1.705786	1.01E-06	-8.169176	-7.104264	-7.776469
7	203.8861	2.928732	1.12E-06	-8.087727	-6.858982	-7.634604
8	208.0822	5.074348	1.14E-06	-8.096847	-6.704270	-7.583308
9	210.2958	2.470982	1.29E-06	-8.013758	-6.457349	-7.439803
10	211.9979	1.741683	1.51E-06	-7.906879	-6.186637	-7.272507

* indicates lag order selected by the criterion

It can be seen from this table that 3 out of 5 criteria (viz. LR, FPE and AIC) indicate selection of lag order 4 and SC and HQ criteria suggest selection lag order 1.

The results of granger causality test are given in **Table 1.6.1** and **Table. 1.6.2**; according to which there is unidirectional causality running from WPI to M_3 for both the sets of criteria.

Table 1.6.1. Pairwise Granger Causality Tests: Lags: 4

Null Hypothesis:	Obs	F-Statistic	Probability
M_3 does not Granger Cause WPI	49	1.17284	0.33730
WPI does not Granger Cause M_3		3.85380	**0.00968**

M_3 stationary at Second Difference without Intercept and Intercept with Trend
WPI stationary at Second Difference without Intercept and Intercept with Trend

Table 1.6.2. Pairwise Granger Causality Tests: Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
M_3 does not Granger Cause WPI	51	0.98383	0.38161
WPI does not Granger Cause M_3		7.67135	**0.00133**

M_3 stationary at Second Difference without Intercept and Intercept with Trend
WPI stationary at Second Difference without Intercept and Intercept with Trend

Thus we find in both these cases that there seems to be unidirectional Granger causality running from WPI to M_1 as well as M_3.

(3) Causality between GDP and M_1:

The values of various lag order selection criteria are shown in **Table 1.7** bellow

Table 1.7. VAR Lag Order Selection Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	134.0738	NA	7.37E-06	-6.142966	-6.061049	-6.112757
1	146.9355	23.92885	4.88E-06	-6.555140	-6.309391	-6.464516
2	157.7799	19.16685	3.56E-06	-6.873484	**-6.463903***	**-6.722443***
3	159.7096	3.231137	3.93E-06	-6.777192	-6.203778	-6.565734
4	167.3979	**12.15826***	3.33E-06	-6.948741	-6.211495	-6.676867
5	173.3098	8.799107	**3.08E-06***	**-7.037667***	-6.136588	-6.705377
6	176.5271	4.489196	3.25E-06	-7.001260	-5.936348	-6.608554
7	177.7475	1.589433	3.78E-06	-6.871979	-5.643235	-6.418856
8	182.5791	5.842759	3.74E-06	-6.910654	-5.518077	-6.397115
9	184.6987	2.366086	4.25E-06	-6.823194	-5.266785	-6.249239
10	188.2509	3.634865	4.57E-06	-6.802369	-5.082127	-6.167997

* indicates lag order selected by the criterion

2 out of 5 criteria (FPE and AIC) indicate lag order of 5, other 2 criteria (SC and HQ) indicate lag order 2 and 1 criteria (LR) indicate lag order 4.

The results of granger causality test between narrow money supply (M_1) and GDP are given in **Table 1.7.1, 1.7.2** and **Table 1.7.3**.

Table 1.7.1. Pairwise Granger Causality Tests: Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
M_1 does not Granger Cause GDP	51	2.96667	**0.06140**
GDP does not Granger Cause M_1		1.24097	0.29860

M_1 stationary at Second Difference without Intercept and Intercept with Trend
GDP stationary at Second Difference without Intercept and Intercept with Trend

Table 1.7.2. Pairwise Granger Causality Tests: Lags: 4

Null Hypothesis:	Obs	F-Statistic	Probability
M_1 does not Granger Cause GDP	49	2.71054	**0.04346**
GDP does not Granger Cause M_1		0.69685	0.59863

M_1 stationary at Second Difference without Intercept and Intercept with Trend
GDP stationary at Second Difference without Intercept and Intercept with Trend

Table 1.7.3. Pairwise Granger Causality Tests: Lags: 5

Null Hypothesis:	Obs	F-Statistic	Probability
M_1 does not Granger Cause GDP	48	3.90699	**0.00606**
GDP does not Granger Cause M_1		1.31319	0.27972

M_1 stationary at Second Difference without Intercept and Intercept with Trend
GDP stationary at Second Difference without Intercept and Intercept with Trend

In all the cases, there is unidirectional causality running from M_1 to GDP, as argued by the monetarists. Analysis further suggests one way causation from narrow money to GDP indicating that probably narrow money supply rather than real factors has played major role in the growth of National Income of India.

(4) Causality between GDP and M_3:

Table 1.8 shows the values of various lag order selection criteria.

Table 1.8. VAR Lag Order Selection Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	170.7161	NA	1.34E-06	-7.847260	-7.765344	-7.817052
1	178.7310	14.91141	1.11E-06	-8.033999	-7.788250	-7.943375
2	189.6281	19.26003	8.08E-07	-8.354796	**-7.945214***	-8.203755
3	192.0820	4.108886	8.72E-07	-8.282885	-7.709471	-8.071428
4	198.9150	10.80558	7.69E-07	-8.414650	-7.677403	-8.142776
5	207.8894	13.35732	6.17E-07	-8.646019	-7.744940	-8.313729
6	217.3083	13.14265	4.87E-07	-8.898061	-7.833149	**-8.505355***
7	219.0628	2.284862	5.53E-07	-8.793617	-7.564873	-8.340494
8	222.8274	4.552529	5.76E-07	-8.782668	-7.390091	-8.269128
9	227.8864	5.647297	5.70E-07	-8.831925	-7.275516	-8.257969
10	237.7061	**10.04811***	**4.58E-07***	**-9.102611***	-7.382369	-8.468239

* indicates lag order selected by the criterion

Table 1.8 shows that according SC criterion, 2^{nd} lag order is significant and it shows unidirectional granger causality from M_3 to GDP. Other criteria (HQ) suggest lag order 6; and LR, FPE, AIC criteria suggest lag order 10.

The results of granger causality test between broad money supply (M_3) and GDP are given in **Table 1.8.1, 1.8.2**, and **1.8.3**.

Table 1.8.1. Pairwise Granger Causality Tests: Lags: 2

Null Hypothesis:	*Obs*	*F-Statistic*	*Probability*
GDP does not Granger Cause M_3	51	1.60284	0.21236
M_3 does not Granger Cause GDP		3.17304	**0.05118**

M_3 stationary at Second Difference without Intercept and Intercept with Trend
GDP stationary at Second Difference without Intercept and Intercept with Trend

Table 1.8.2. Pairwise Granger Causality Tests: Lags: 6

Null Hypothesis:	*Obs*	*F-Statistic*	*Probability*
GDP does not Granger Cause M_3	47	3.00888	**0.01814**
M_3 does not Granger Cause GDP		4.66039	**0.00148**

M_3 stationary at Second Difference without Intercept and Intercept with Trend
GDP stationary at Second Difference without Intercept and Intercept with Trend

Table 1.8.3. Pairwise Granger Causality Tests: Lags: 10

Null Hypothesis:	*Obs*	*F-Statistic*	*Probability*
GDP does not Granger Cause M_3	43	2.31391	**0.04852**
M_3 does not Granger Cause GDP		2.87872	**0.01853**

M_3 stationary at Second Difference without Intercept and Intercept with Trend
GDP stationary at Second Difference without Intercept and Intercept with Trend

In 2 cases out of 3 cases bidirectional causality and in one case unidirectional causality from M_3 to GDP is indicated. This means that growth of GDP is caused by increase in broad money supply as well as it causes increase in broad money. Thus, the near money (or credit money) seems to be all important factor in causing growth in Gross Domestic Product in India during the reference period.

As far as the direction of causality between Income and Money supply is concerned, the findings of some important studies done earlier are as follows:

1. Ramchandra (1983) found that money causes income (both nominal and real) and also that Nominal income causes money. He used yearly data from 1951 to 1971 and had applied Sims test to determine the causality.
2. Gupta G S (1984) considering the sample period of 1954-55 to 1982-83 and using both Granger and Sims test concluded that the causation is unidirectional and runs from Nominal income to money supply as well as real income to money supply.
3. Nachne & Nadkarni (1985) using the annual data from 1960-61 to 1981-82 had found that money supply was a major determinant of nominal national income in India.
4. Joshi and Joshi (1985) who tested the causality between M_1, M_3 and nominal income using both Sims and Granger's tests have arrived at the conclusion that the direction of causation is bidirectional between M_1 and Nominal income as well as between M_3 and nominal income.

5. Jadhav Narendara (1994) Using both Sims test and Granger Causality test that money causes income is supported by both these tests, though somewhat weakly (10% level of significance), but the reverse causality is not found. He used annual data of 34 years from 1955-56 to 1987-88.
6. Adhikari and Mazumdar (2006) using the appropriate data from Indian economy over the period 1970-2002 had concluded that there was Granger causality running from GDP to M_1.

Thus with one exception, the results obtained by this study are in conformity with the results obtained by the researchers cited above.

Thus a majority of studies (including ours) found existence of reverse causality i.e from Price to Money supply in India during the reference period; so main conclusions may be summarized as follows as far as concern Granger causality between price and money supply in India:

1. Money is endogenous as it is partially determined by the price level
2. Selection of definition of money supply does not affect the direction of causality between WPI and money supply as the results are similar for M_1 and M_3.
3. Monetary policy especially regarding money supply has limited implication for controlling inflation in India.
4. Increasing money supply in India is mainly due to increase in the rate of inflation.

Conclusion

The Keynesian views that money does not play an active role in changing income and price is partially supported by our results. However, the monetarist view that money (Narrow Money) plays an active role and leads to change in income in India emerges very clear in our findings.

Thus we may say that money supply affects both output and inflation. Which effect of money supply on price level and output will be dominated depends upon the lag structure under consideration. While arriving at these conclusions, however, one has to be careful in using Granger causality because it is quite sensitive to the length of lag used in the model (Sims, 1972). We have used statistically significant lagged terms as suggested by various lag order selection criteria but it may be altered if the length of lag is changed.

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