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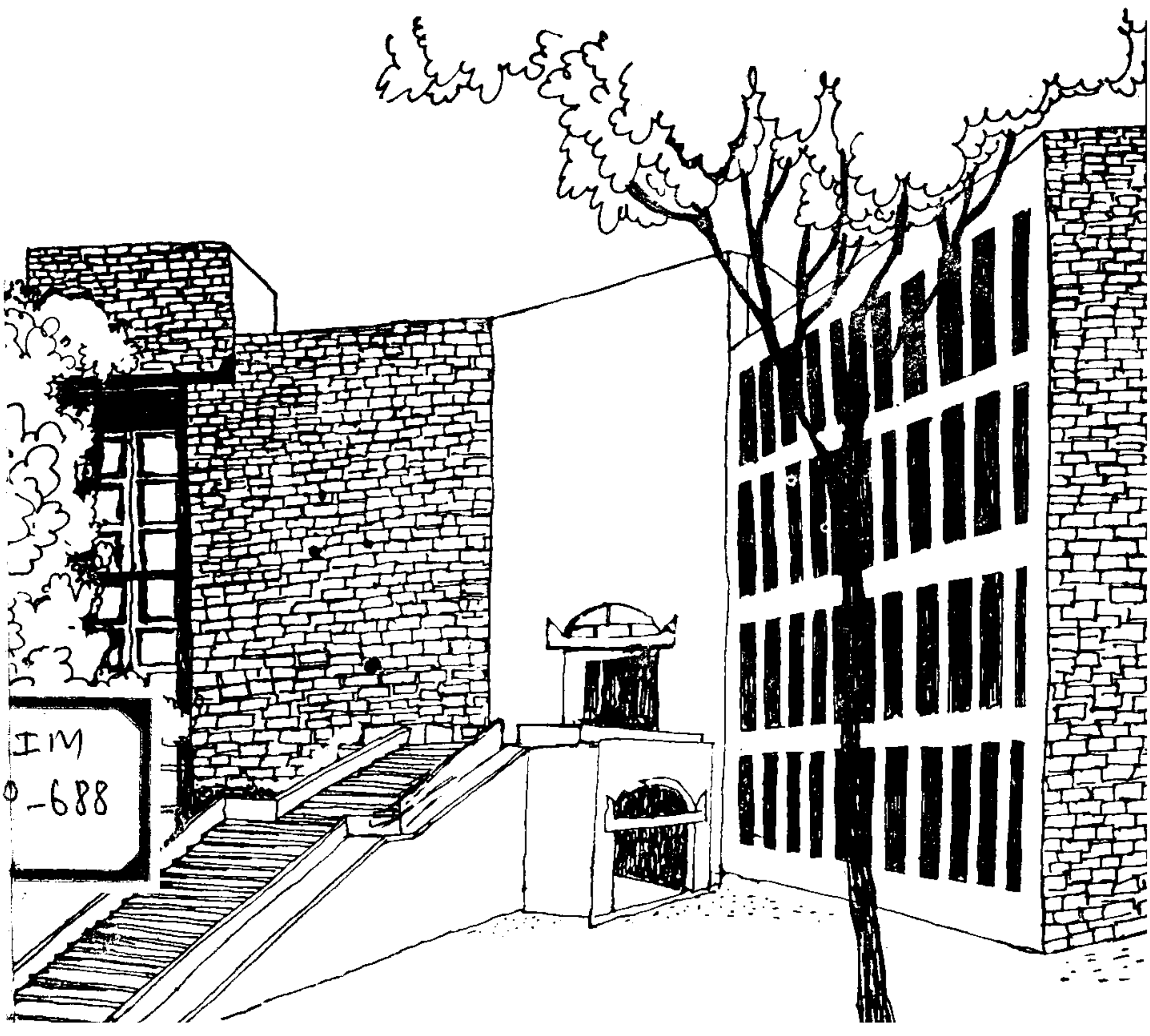

CAUSALITY BETWEEN MONEY AND PRICE LEVEL IN INDIA REVISITED

By

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CAUSALITY BETWEEN MONEY AND PRICE LEVEL IN INDIA REVISITED

Ram Lal Sharma*

Sharma (1985), while using Sims' methodology[1] to test causality between Money and Price level in India, concluded that: (i) 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 and (ii) Bidirectional causality existed between M_3 and P.

In this paper, we have reexamined the issue of causality between Money and Price level in India and have used only Granger's test for this purpose. We have found that there exists a 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 Sharma reported earlier.

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While working on this paper, I had many discussions with Prof. G.S.Gupta on various issues involved in the paper and I am therefore, grateful to him.

However, I am solely responsible for any errors that still remain.

1 Sims' methodology can be put very simply as if M causes P then,

(i) a regression of P on past, current and future values of M should exhibit significant coefficients for past and current values but insignificant coefficients on future values; (ii) and a regression of M on past, current and future values of P should exhibit significant coefficients on future values of P (and may or may not exhibit significant coefficient on present and past values). Thus Sims' test involves testing of two sided distributed lag relationship between M and P which should be jointly covariance stochastic processes with zero mean.

The sample period used in this study is from 1954 to 1985. There is nothing specific about the year 1954 as the beginning point. It could have been 1951 as well. But since some observations were lost in the process of deseasonalizing and second differencing we preferred to work from 1954 and onwards. We hope, choosing 1951 or 1954 does not affect our conclusions.

Both annual as well as quarterly data have been used for estimation of the parameters of regression equations. But the annual data did not provide us with conclusive results because of limited degrees of freedom. We therefore, concentrated more on the quarterly data.

Granger's method of testing causality[2] was originally proposed in terms of cross-spectrum analysis but Sims transformed the test to the conventional regression analysis.[3] So the Granger's test can be expressed as:

(i) M causes P if predictions of P based on all past information (including M) are better than those based on all past information excluding M.

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2 Granger,C.W.J. "Investing Causal Relations by Econometric Models and Cross-spectral Methods," Econometrica, 1969, 37, pp.424-38.

3 Sims,Christopher,A., (1972), "Money,Income and Causality" American Economic Review, Vol.62, pp.540-52.

(ii) Similarly P causes M if predictions of M based on all past information (including) P are better than those based on all past information excluding P.

Accordingly a testable form of Granger's causality may be shown as

$$M_{(t)} = \sum_{i=1}^{m} \hat{\alpha}(i) M_{(t-i)} + \hat{\beta} LT + \sum_{i=1}^{n} \hat{\delta}_{(i)} P_{(t-i)} \qquad \ldots \text{(A)}$$

$$P_{(t)} = \sum_{i=1}^{m} \hat{b}_{(i)} P_{(t-i)} + \hat{\beta} LT + \sum_{i=1}^{n} \hat{f}_{(i)} M_{(t-i)} \qquad \ldots \text{(B)}$$

Where $\hat{\alpha}$, $\hat{\beta}$, $\hat{\delta}$, $\hat{b}$ and $\hat{f}$ are least squares estimates and M is stock of money and P is price level, wholesale price level chosen mainly because of its quick responsiveness (necessary for testing instantaneous causality) to policy measures particularly monetary ones.

The null hypothesis is that if M does not cause P, the parameters $\hat{\delta}_{(i)}$ with i=1,....n are equal to zero. Similarly if P does not cause M, then the parameters f(i), i=1,....n should be equal to zero.

To begin with, we used the ratio to moving average method to deseasonalize the series on both sides of the regression equation. In order to stationarise the M and P dynamic series, the method of second differencing was used.[4] The latter became necessary because the M and P series after first differencing exhibited an upward trend so that means of the series were not constant over time,[5] though the autocorrelation function declined rapidly.[6] After second differencing the respective series, we again computed the sample means and auto-correlation functions. It was found that the mean of the series was not time-determined and the auto-correlation function dropped off rapidly as k, the number of lags became large. The values of autocorrelation functions were also examined to see if already deseasonalized series differenced twice, still possessed any residual seasonality. Since those values (of auticorrelation function) declined without any cycles, there was no scope for such seasonality.

In order to produce zero mean of the jointly covariance stationary process, a constant term was included in the regression equations.[7]

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4 Box and Jenkins (1970) p.85) show that a stochastic dynamic series can be stationarised by either first differencing or second differencing. Also see, Pindyck, R.S., and Rubinfeld, D.L. (1976 pp.431-458).

5 If the series Y_t is stationary, then the mean of the series defined as $\mu_y = E(y_t)$ must also be stationary, so that $E(y_t) = E(y_{t+m})$ for any t and m. Furthermore, the variance of the series must also be stationary so that $var(y_t) = Var(y_{t+m})$. See Pindyck and Rubinfeld, p.436.

6 the autocorrelation function provides us with a measure of how much correlation there is between neighbouring data points in the series y. It is necessary for a stationary series that the autocorrelation function declines as the lag k increasess.

The equations (A) and (B) were estimated with second differenced data (stationarised so that time trend is reduced to a constant). Because our experience of estimation of the equations used to test causality in Sim's sense shows that the estimates from the second differenced data and the ones from the second differenced data transformed in view of empirically determined filters to ensure whitenoise residuals are almost similar.[8]

First of all, we report the results for the whole sample period: 1954-85.

Table 1 (Quarterly data 1954 I - 1985 II)

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W. test value
(i) M_1 on 8 past M_1 and 4 past P	(12,103)	.8544	57.1997*	2.057[N]
(ii) M_1 on 8 past M_1	(8,107)	.8584	88.1140*	2.043[N]
(iii) P on 8 past P and 4 past M_1	(12,103)	.7296	26.8667*	2.012[N]
(iv) P on 8 past P	(8,107)	.6347	25.9794*	1.96[N]

*Significant at 5 percent level

N=No autocorrelation detected.

7 A constant in a regression equation is equal to $\bar{y} - \hat{\beta}\bar{X}$. Consider an equation $y = a + \beta X$ and substituting the value for a yields $(y-\bar{y}) = \hat{\beta}(X-\bar{X})$. Obviously $E(y-\bar{y})$ and $E(X-\bar{X}) = 0$ and hence the mean of $(y-\bar{y})$ and $(X-\bar{X})$ will also be equal to zero.

8 See Sharma (1985). We however, do not deny that the use of second differenced data duly transformed in view of empirically determined filters improve F values and makes them more reliable. What we want to emphasize is that (by and large) quantitatively and qualitatively, the conclusions remain the same.

Table 2 Estimated lag profiles (1954 I - 1985 II)

M_1 on 8 past M_1 and 4 Past P (1)		M_1 on 8 Past M_1 (2)		P on 8 past P and 4 Past M_1 (3)		P on 8 Past P. (4)	
M_{1t-1}	-0.8999*	M_{1t-1}	-0.8955*	P_{t-1}	-0.0229	P_{t-1}	-0.1302
M_{1t-2}	-0.8375*	M_{1t-2}	-0.8515*	P_{t-2}	-0.2317*	P_{t-2}	-0.3722*
M_{1t-3}	-0.8272*	M_{1t-3}	-0.8225*	P_{t-3}	0.0585	P_{t-3}	-0.0752
M_{1t-4}	-0.1959	M_{1t-4}	-0.1686	P_{t-4}	-0.0691	P_{t-4}	0.1144
M_{1t-5}	-0.0367	M_{1t-5}	-0.0419	P_{t-5}	-0.0065	P_{t-5}	-0.0885
M_{1t-6}	-0.0455	M_{1t-6}	-0.0485	P_{t-6}	-0.2380*	P_{t-6}	-0.2915*
M_{1t-7}	-0.0849	M_{1t-7}	-0.0641	P_{t-7}	-0.0161	P_{t-7}	-0.1305
M_{1t-8}	0.1832	M_{1t-8}	0.2094*	P_{t-8}	0.0581	P_{t-8}	0.1372
P_{t-1}	-0.0493			M_{1t-1}	0.2938*		
P_{t-2}	-0.0118			M_{1t-2}	.1842		
P_{t-3}	0.0146			M_{1t-3}	.0184		
P_{t-4}	-0.1021			M_{1t-4}	-.0602		

*Statistically significant at 5 percent level.

Table 3 (1954 I - 1985 II)

Regression	D.F.	$\bar{R}^2$	F ratio	D.W. test Value
(1) M_3 on 8 Past M_3 and 4 past P	(12,105)	.6916	22.87*	1.9942^N
(2) M_3 on 8 Past M_3	(8,109)	.6899	33.53*	1.9757^N
(3) P on 8 past P and 4 Past M_3	(12,105)	.6818	21.89*	2.03^N
(4) P on 8 Past P	(8,109)	.67	30.70*	2.016^N

*significant at 5 per cent level

N=No autocorrelation

Table 4 Estimated lag Profile (1954-I - 1985 II)

M_3 on 8 Past M_3 and 4 Past P (1)		M_3 on 8 Past M_3 (2)		P on 8 Past P and 4 Past M_3 (3)		P on 8 Past P (4)	
M_{3t-1}	-0.8145*	M_{3t-1}	-0.8090*	P_{t-1}	-0.0453	P_{t-1}	-0.1083
M_{3t-2}	-0.4540*	M_{3t-2}	-0.4782*	P_{t-2}	-0.3692*	P_{t-2}	-0.3464*
M_{3t-3}	-0.3422*	M_{3t-3}	-0.3570*	P_{t-3}	0.0397	P_{t-3}	-0.0076
M_{3t-4}	0.0908	M_{3t-4}	0.1167	P_{t-4}	0.1088	P_{t-4}	0.1622
M_{3t-5}	0.1381	M_{3t-5}	0.0998	P_{t-5}	-0.0338	P_{t-5}	-0.0878
M_{3t-6}	-0.0695	M_{3t-6}	-0.1208	P_{t-6}	-0.3341*	P_{t-6}	-0.3011*
M_{3t-7}	-0.1921	M_{3t-7}	-0.2313	P_{t-7}	-0.1198	P_{t-7}	-0.1666
M_{3t-8}	0.0845	M_{3t-8}	0.0887	P_{t-8}	0.0385	P_{t-8}	0.1043
P_{t-1}	-0.1008			M_{3t-1}	0.1501*		
P_{t-2}	-0.1347			M_{3t-2}	0.0051		
P_{t-3}	0.0091			M_{3t-3}	-0.0006		
P_{t-4}	-0.1426			M_{3t-4}	-0.0053		

*significant at 5 percent level.

Tables 1 to 4 give the F ratios, $\bar{R}^2$'s and estimated lag profiles pertinent for testing causality in Granger's sense. We carried out these tests for M_1 and P and M_3 and P.

An examination of table 1, reveals that all of the 4 equations have F ratios that are statistically significant and none of the equations exhibit autocorrelation.[9] Under the circumstance, it is $\bar{R}^2$ that can be the basis of inference about causality. The first equation (table 1) besides including 8 Past M_1 as explanatory variablesalso includes 4 Past P. The second equation (table 1) has only 8 Past M_1 as the explanatory variables. The objective is to find out whether equation 1 explains the behaviour of M_1 better than is done by equation 2. If equation 1 scores better our inference would be that P affects M_1 and therefore causes it. But, looking to the facts we find equation 2 has higher $\bar{R}^2$ and a higher F ratio when 4 Past P are excluded from the regression. Which implies that as far as changes in the behaviour of M_1 are concerned, 4 Past P donot have any explanatory power and therefore are redundant this establishes the fact that P does not cause M_1. But this conclusion is incomplete unless we show whether M_1 causes P.

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9 Although we are aware that when lagged dependent variables are entered as explanatory variables, use of D.W. test becomes a suspect. However for want of something better we have reported the D.W. test values.

We compare equations 3 and 4 (table 1) equation 4 has only 8 Past P to explain the changes in behaviour of P and has a value of $\bar{R}^2$ equal to .6347. Now, in equation 3, 4 Past M_1 have also been included as additional explanatory variables besides 8 past P (present in equation 4). As a result $\bar{R}^2$ increases to .7296 and the value of F also improves. In view of this, the inference is obvious. 4 Past M_1 are crucial in explaining the behaviour of P. But 4 Past P are not crucial in explaining the behaviour of M_1. In other words, M_1 causes P and we have already established above that vice-versa (P causes M_1) does not hold good.

Thus it can be said that there is a unidirectional causality running from M_1 to P.

If we examine the estimated lag profile (table 2), the same story is repeated. Col.1 of table 2 shows that as far as behaviour of M_1 is concerned it is markedly characterised by autoregressive property. In time series models this is to be expected. It simply says that this year's stock of money holding would be adjusted in view of the behaviour of money stock held during the preceding 3 quarters (a sort of partial adjustment hypothesis).

The Effect of P on M_1 (Col.1, table 2) is almost zero. None of the coefficients (on P_{t-1}, P_{t-2}, P_{t-3} and P_{t-4}) is significant and none of them is sizeable. As a contrast, if we examine the coefficients of M's (Col.3 table 2), we find that the preceding quarter's money stock affects P the most followed by two quarter's preceding money stock. This influence diminishes as we go back further in the past. Thus, the estimated lag profile also supports the conclusion that causality is unidirectional and it runs from M_1 to P.

As already mentioned, we have estimated equations to test causality between M_3 and P also, mainly due to find out whether the conclusions based on M_1 and P are reinforced.

In Table 3, are reported 4 equations concerning M_3 and P and in table 4 are reported their estimated lag profiles. It is clear that the conclusions drawn from the contents of these two tables (tables 3 and 4) are identical with those drawn from the contents of tables 1 and 2 with regard to M_1 and P. An examination of table 3 shows: (i) equations 1 and 2 are almost similar as far as $\bar{R}^2$ is concerned; which means that the behaviour of M_3 is auto-regressive (see Col.1 table 4) and that addition of 4 Past P as explanatory variables to equation 2 will be redundant (obvious from the coefficients of P_{t-i}'s in Col.1 Table 4). the inference to be drawn is that P does not cause M_3; (ii) if we add 4 Past M_3 to equation 4, $\bar{R}^2$ increases which means (other things given) that M_3 does explain a part of change in the behaviour of P.

Thus, in view of above, it may be said that causality is unidirectional and it runs from M_3 to P also which goes to confirm our earlier conclusion that it (causality) is unidirectional and runs from M_1 to P.

Sub-period results

the Monetary theory of balance of payments suggests that a country which is not a reserve centre will gain full control over its monetary conditions only when it floats its exchange rate (Johnson 1973), Frankel and Rodrique (1975)). Moreover, under a fixed exchange rate regime, the reserve centre can influence monetary conditions in a non-reserve centre by influencing worldwide monetary conditions.

Since two decades of our sample period (1954-1973) are characterised by the fixed exchange rate regime and since a non-reserve country (like India) is not supposed to have complete control over its monetary policy during such a regime it is likely that the exigencies of the fixed exchange rate may prevent full realization of the influence of monetary policy on price level.[10] It may therefore be argued that it is only under flexible exchange rate period that the true causality between

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10 Suppose a non reserve country decides to expand its money supply to accommodate the requirements of domestic origin, which is not in line with the monetary conditions in the reserve country, then the balance of payments situation may induce the monetary authorities to reverse their previous monetary policy with sufficient rapidity to prevent any causality from money to price level to materialize.

money and price level can be observed. In view of this the estimates of causality were obtained for 1954-1973 and 1974-85 sub periods which correspond with fixed and flexible exchange rates respectively.

Even if we were to disregard the influence of fixed and flexible exchange rates on money and price level in India (in the context of monetary approach to balance of payments), division of the total sample period into sub-periods would be useful as it will then enable us to say that causality of a particular type holds even in the sub-periods thereby lending support to the overall conclusion based on the whole sample period, we take the estimates of 1954 to 1973 first.

Table 5 (1954-I - 1973-IV) quarterly estimates

Regression	D.F.	$\bar{R}^2$	F Ratio	D.W. test value
(1) M_1 on 8 Past M_1	(8,61)	.9563	189.74*	2.07^N
(2) M_1 on 8 Past M_1 and 4 Past P.	(12,57)	.9544	121.49*	2.098^N
(3) P on 8 Past P	(8,61)	.7325	20.867*	1.919^N
(4) P on 8 Past P and 4 Past M_1	(12,57)	.7609	19.278*	1.9511^N

N = No autocorrelation

* significant at 5 percent level

Table 6 (1954 I - 1973 IV) quarterly estimates

Estimated lag profiles

M_1 on 8 Past M_1 and 4 Past P (1)		M_1 on 8 Past M_1 (2)		P on 8 Past P and 4 past M_1 (3)		P on 8 Past P (4)	
M_{1t-1}	-1.1111*	M_{1t-1}	-1.1015*	P_{t-1}	-0.0329	P_{t-1}	-0.1368
M_{1t-2}	-0.8536*	M_{1t-2}	-0.8524*	P_{t-2}	-0.3021*	P_{t-2}	-0.3887*
M_{1t-3}	-0.9339*	M_{1t-3}	-0.9255*	P_{t-3}	0.1623	P_{t-3}	0.0116
M_{1t-4}	-0.5226*	M_{1t-4}	-0.4725*	P_{t-4}	-0.1750	P_{t-4}	0.1408
M_{1t-5}	-0.3622	M_{1t-5}	-0.3095	P_{t-5}	-0.0321	P_{t-5}	-0.0985
M_{1t-6}	-0.6021*	M_{1t-6}	-0.5612*	P_{t-6}	-0.2216*	P_{t-6}	-0.1812
M_{1t-7}	-0.4922*	M_{1t-7}	-0.4812*	P_{t-7}	-0.0223	P_{t-7}	-0.2299
M_{1t-8}	0.0372	M_{1t-8}	0.0552	P_{t-8}	-0.0797	P_{t-8}	0.2345
P_{t-1}	0.0359			M_{1t-1}	0.2792*		
P_{t-2}	-0.0202			M_{1t-2}	0.1677		
P_{t-3}	0.1077			M_{1t-3}	-0.0287		
P_{t-4}	0.0101			M_{1t-4}	-0.2367		

* significant at 5 per cent level.

Table 7 (1954 I - 1973 IV)

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W.test value
(1) M_3 on 8 Past M_3	(8,61)	.913	91.065*	1.9433^N
(2) M_3 on 8 Past M_3 and 4 Past P	(12,57)	.917	65.25*	1.8745^N
(3) P on 8 Past P	(8,61)	.6871	19.94*	1.9941^N
(4) P on 8 Past P and 4 Past M_3	(12,57)	.7013	14.5*	2.01^N

* significant at 5 per cent level
N = No autocorrelation

Table 8 (1954 I - 1973 IV) Estimated lag profiles

M_3 on 8 Past M_3 and 4 Past P (1)		M_3 on 8 Past M_3 (2)		P on 8 Past P and 4 Past M_3 (3)		P on 8 Past P (4)	
M_{3t-1}	-0.9520*	M_{3t-1}	-0.9700*	P_{t-1}	-0.0633	P_{t-1}	-0.1155
M_{3t-2}	-0.8222*	M_{3t-2}	-0.9543*	P_{t-2}	-0.4434*	P_{t-2}	-0.4525*
M_{3t-3}	-0.7165*	M_{3t-3}	-0.9014*	P_{t-3}	0.1357	P_{t-3}	-0.0017
M_{3t-4}	-0.3826	M_{3t-4}	-0.5364*	P_{t-4}	-0.0189	P_{t-4}	0.1115
M_{3t-5}	-0.4614*	M_{3t-5}	-0.5107*	P_{t-5}	-0.0840	P_{t-5}	-0.1085
M_{3t-6}	-0.4335*	M_{3t-6}	-0.5218*	P_{t-6}	-0.2806	P_{t-6}	-0.1816
M_{3t-7}	-0.5024*	M_{3t-7}	-0.5695*	P_{t-7}	-0.0748	P_{t-7}	-0.2044
M_{3t-8}	0.0602	M_{3t-8}	0.0305	P_{t-8}	0.0741	P_{t-8}	0.1915
P_{t-1}	-0.1745			M_{3t-1}	00.2863*		
P_{t-2}	-0.0157			M_{3t-2}	0.2509		
P_{t-3}	-0.0647			M_{3t-3}	0.1787		
P_{t-4}	0.1259			M_{3t-4}	-0.0944		

*significant at 5 per cent level.

Table 9 (1974 I - 1985 IV)

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W. test value
(1) M_1 on 8 Past M_1	(8, 31)	.7376	13.99*	1.9437^N
(2) M_1 on 8 Past M_1 and 4 Past P	(12, 27)	.7025	8.2823*	1.9892^N
(3) P on 8 Past P	(8, 31)	.4350	4.5611*	1.9819^N
(4) P on 8 Past P and 4 Past M_1	(12, 27)	.6623	7.156*	1.8842^N

* significant at 5 percent level

N = No autocorrelation detected

Table 10 (1974 I - 1985 IV)

Estimated lag profiles

M_1 on 8 Past M_1 and 4 Past P (1)		M_1 on 8 Past M_1 (2)		P on 8 Past P and 4 Past M_1 (3)		P on 8 Past P (4)	
M_{1t-1}	-0.7843*	M_{1t-1}	-0.7599*	P_{t-1}	0.0031	P_{t-1}	-0.1221
M_{1t-2}	-0.7160*	M_{1t-2}	-0.7703*	P_{t-2}	0.0680	P_{t-2}	-0.4021
M_{1t-3}	-0.7095*	M_{1t-3}	-0.7072*	P_{t-3}	-0.0441	P_{t-3}	-0.1638
M_{1t-4}	-0.1393	M_{1t-4}	-0.0697	P_{t-4}	-0.1034	P_{t-4}	0.0368
M_{1t-5}	-0.1036	M_{1t-5}	-0.1031	P_{t-5}	0.0684	P_{t-5}	-0.0888
M_{1t-6}	0.0341	M_{1t-6}	0.0412	P_{t-6}	-0.2301	P_{t-6}	-0.4235
M_{1t-7}	-0.0320	M_{1t-7}	0.0174	P_{t-7}	0.0752	P_{t-7}	-0.0339
M_{1t-8}	0.1380	M_{1t-8}	0.1977	P_{t-8}	0.2279	P_{t-8}	-0.0232
P_{t-1}	-0.1623			M_{1t-1}	0.4285*		
P_{t-2}	-0.0100			M_{1t-2}	0.3023*		
P_{t-3}	-0.0164			M_{1t-3}	-0.0400		
P_{t-4}	-0.2023			M_{1t-4}	-0.0201		

* significant at 5 percent level.

Table 11 (1974 I - 1985 IV)

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W.Test Value
(1) M_3 on 8 Past M_3	(8, 31)	.6764	11.1901*	2.1731
(2) M_3 on 8 Past M_3 and 4 Past P	(12, 27)	.6640	7.4235*	2.13
(3) P on 8 Past P	(8, 31)	.4350	4.5611*	1.9819
(4) P on 8 Past P and 4 Past M_3	(12, 27)	.5904	5.6842*	1.8097

*significant at 5 per centlevel.

Table 12 (1974-1985) Estimated lag Profiles

M_3 on 8 Past M_3 and 4 Past P (1)		M_3 on 8 Past M_3 (2)		P on 8 Past P and 4 Past M_3 (3)		P on 8 Past P (4)	
M_{3t-1}	-1.0288*	M_{3t-1}	-1.0217*	P_{t-1}	-0.1810	P_{t-1}	-0.1583
M_{3t-2}	-0.4078*	M_{3t-2}	-0.4046*	P_{t-2}	-0.2462	P_{t-2}	-0.2645
M_{3t-3}	-0.0319	M_{3t-3}	-0.0632	P_{t-3}	-0.0551	P_{t-3}	-0.0492
M_{3t-4}	0.1627	M_{3t-4}	0.1711	P_{t-4}	0.1698	P_{t-4}	0.1968
M_{3t-5}	0.0190	M_{3t-5}	0.0073	P_{t-5}	-0.1116	P_{t-5}	-0.0945
M_{3t-6}	-0.0608	M_{3t-6}	-0.0388	P_{t-6}	-0.5631*	P_{t-6}	-0.4770
M_{3t-7}	0.0657	M_{3t-7}	0.0529	P_{t-7}	-0.1682	P_{t-7}	-0.1673
M_{3t-8}	0.1879	M_{3t-8}	0.1389	P_{t-8}	-0.0756	P_{t-8}	-0.0747
P_{t-1}	0.0476			M_{3t-1}	0.0264		
P_{t-2}	-0.0786			M_{3t-2}	-0.2014		
P_{t-3}	0.1632			M_{3t-3}	-0.1891		
P_{t-4}	-0.2218			M_{3t-4}	0.0012		

*significant at 5 percent level.

Table 13 (1977-85)

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W. test Value
(1) M_1 on 8 Past M_1	(8,17)	.7702	11.4756*	2.1139
(2) M_1 on 8 Past M_1 and 4 Past P	(12,13)	.7547	7.4102*	1.8768
(3) P on 8 Past P	(8,17)	.7942	13.0627*	2.6057
(4) P on 8 Past P and 4 Past M_1	(12,13)	.9195	24.7940*	2.3665

*Significant at 5 percent level.

Table 14 (1977–85) Estimated lag profiles

M_1 on 8 Past M_1 and 4 Past P (1)		M_1 on 8 Past M_1 (2)		P on 8 Past P and 4 Past M_1 (3)		P on 8 Past P (4)	
M_{1t-1}	-0.8802*	M_{1t-1}	-0.7265*	P_{t-1}	0.0235	P_{t-1}	-0.4438
M_{1t-2}	-0.4264	M_{1t-2}	-0.6274*	P_{t-2}	-0.6645*	P_{t-2}	-0.5122
M_{1t-3}	-0.3673	M_{1t-3}	-0.6509*	P_{t-3}	0.0097	P_{t-3}	-0.1146
M_{1t-4}	-0.1854	M_{1t-4}	-0.1210	P_{t-4}	0.0777	P_{t-4}	0.2997
M_{1t-5}	-0.1011	M_{1t-5}	0.1097	P_{t-5}	0.1497	P_{t-5}	0.0952
M_{1t-6}	0.1276	M_{1t-6}	0.0977	P_{t-6}	-0.1470	P_{t-6}	-0.2012
M_{1t-7}	0.2341	M_{1t-7}	0.1364	P_{t-7}	-0.0686	P_{t-7}	-0.2140
M_{1t-8}	0.3598	M_{1t-8}	0.4731*	P_{t-8}	0.0034	P_{t-8}	0.0085
P_{t-1}	-0.8407			M_{1t-1}	0.1631*		
P_{t-2}	-0.3907			M_{1t-2}	-0.0994		
P_{t-3}	0.2634			M_{1t-3}	-0.0227		
P_{t-4}	-0.0699			M_{1t-4}	-0.0009		

*significant at 5 per cent level.

Table 15 (1977 – 85)

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W.test value
(1) M_3 on 8 Past M_3	(8,17)	.7409	9.9366*	2.099
(2) M_3 on 8 Past M_3 and 4 past P	(12,13)	.7432	7.0303*	1.8632
(3) P on 8 Past P	(8,17)	.7942	13.0628*	2.6058
(4) P on 8 Past P and 4 Past M_3	(12,13)	.8622	14.039*	2.69

*significant at 5 percent level.

Table 16 (1977-85) Estimated lag profiles

M_3 on 8 Past M_3 and 4 Past P (1)		M_3 on 8 Past M_3 (2)		P on 8 Past P and 4 Past M_3 (3)		P on 8 Past P (4)	
M_{3t-1}	-1.4517*	M_{3t-1}	-1.5145*	P_{t-1}	-0.1961	P_{t-1}	-0.4438*
M_{3t-2}	-1.3022*	M_{3t-2}	-1.5001*	P_{t-2}	-0.6462*	P_{t-2}	-0.5122*
M_{3t-3}	-1.0564*	M_{3t-3}	-1.3838*	P_{t-3}	-0.0624	P_{t-3}	-0.1146
M_{3t-4}	-0.9052	M_{3t-4}	-1.0992*	P_{t-4}	0.2061*	P_{t-4}	0.2997*
M_{3t-5}	-0.8776	M_{3t-5}	-0.9986*	P_{t-5}	0.1342	P_{t-5}	0.0952
M_{3t-6}	-0.5981	M_{3t-6}	-0.7106	P_{t-6}	-0.3300*	P_{t-6}	-0.2012
M_{3t-7}	-0.2488	M_{3t-7}	-0.4649	P_{t-7}	0.0637	P_{t-7}	-0.2140
M_{3t-8}	-0.0241	M_{3t-8}	-0.1573	P_{t-8}	-0.1640	P_{t-8}	0.0086
P_{t-1}	0.1289			M_{3t-1}	-0.0656		
P_{t-2}	-0.08159			M_{3t-2}	-0.1893		
P_{t-3}	0.1127			M_{3t-3}	-0.0444		
P_{t-4}	-0.3768			M_{3t-4}	-0.0975		

*significant at 5 percent level.

Table 17 (1953-54 to 1984-85) Annual data

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W. test value
(1) M_1 on 8 Past M_1	(8,15)	.2855	2.1489	1.8816[N]
(2) M_1 on 8 Past M_1 and 4 Past P	(12,11)	.4019	2.2879	2.1697[N]
(3) P on 8 Past P	(8,15)	.3994	2.9117*	1.9991[N]
(4) P on 8 Past P and 4 Past M_1	(12,11)	.5213	3.0872*	1.8735[N]

* significant at 5 percent level

N = No autocorrelation.

Table 18 (1953-54 - 1984-85) Annual data

Estimated lag Profiles

M_1 on 8 Past M_1 and 4 Past P (1)		M_1 on 8 Past M_1 (2)		P on 8 Past P and 4 Past M_1 (3)		P on 8 Past P (4)	
M_{1t-1}	-0.6731*	M_{1t-1}	-0.6330*	P_{t-1}	-1.0320*	P_{t-1}	-0.8102*
M_{1t-2}	-0.5797	M_{1t-2}	-0.5809	P_{t-2}	-1.2560*	P_{t-2}	-1.1018*
M_{1t-3}	-0.9614*	M_{1t-3}	-1.0084*	P_{t-3}	-0.9740*	P_{t-3}	-0.8862*
M_{1t-4}	-0.5878	M_{1t-4}	-0.7929*	P_{t-4}	-1.0681*	P_{t-4}	-1.1316*
M_{1t-5}	-0.5720	M_{1t-5}	-0.6700	P_{t-5}	-1.2304*	P_{t-5}	-0.9778*
M_{1t-6}	-1.0909*	M_{1t-6}	-0.9149	P_{t-6}	-1.2999*	P_{t-6}	-0.8199*
M_{1t-7}	-0.5608	M_{1t-7}	-0.4152	P_{t-7}	-0.9342*	P_{t-7}	-0.3803
M_{1t-8}	-0.9307	M_{1t-8}	-1.0364*	P_{t-8}	-0.3378	P_{t-8}	-0.1591
P_{t-1}	-0.5386			M_{1t-1}	0.0719		
P_{t-2}	-0.6269			M_{1t-2}	0.4677*		
P_{t-3}	-0.2319			M_{1t-3}	0.5231*		
P_{t-4}	-0.0585			M_{1t-4}	0.2018		

*significant at 5 percent level.

Table 19 (1953-54 - 1984-85) Annual data

Regression	D.F.	$\bar{R}^2$	F-ratio	D.W. test value
(1) M_3 on 8 Past M_3	(8,15)	.1535	1.5214	2.0023^N
(2) M_3 on 8 Past M_3 and 4 Past P	(12,11)	.3671	2.1115	2.0112^N
(3) P on 8 Past P	(8,15)	.3994	2.9117*	1.9991^N
(4) P on 8 Past P and 4 Past M_3	(12,11)	.3930	2.2412	2.046^N

*significant at 5 percent level

N = No autocorrelation

Table 20 (1953-54 - 1984-85) Annual data

Estimated lag Profiles

M_3 on 8 Past M_3 and 4 Past P (1)		M_3 on 8 Past M_3 (2)		P on 8 Past P and 4 Past M_3 (3)		P on 8 Past P (4)	
M_{3t-1}	-0.6249*	M_{3t-1}	-0.4656*	P_{t-1}	-0.8366*	P_{t-1}	-0.8102*
M_{3t-2}	-0.3576*	M_{3t-2}	-0.4091	P_{t-2}	-1.1963*	P_{t-2}	-1.1018*
M_{3t-3}	-0.3574	M_{3t-3}	-0.5950*	P_{t-3}	-0.9762*	P_{t-3}	-0.8862*
M_{3t-4}	-0.0738	M_{3t-4}	-0.1988	P_{t-4}	-0.8621*	P_{t-4}	-1.1316*
M_{3t-5}	-0.4710	M_{3t-5}	-0.5330	P_{t-5}	-1.0138*	P_{t-5}	-0.9778*
M_{3t-6}	-0.5053	M_{3t-6}	-0.0646	P_{t-6}	-0.9105*	P_{t-6}	-0.8199*
M_{3t-7}	-0.6006*	M_{3t-7}	-0.4375*	P_{t-7}	-0.5262	P_{t-7}	-0.3803
M_{3t-8}	-0.1775	M_{3t-8}	0.1616	P_{t-8}	-0.0570	P_{t-8}	-0.1591
P_{t-1}	-0.3108*			M_{3t-1}	-0.1634		
P_{t-2}	-0.2978			M_{3t-2}	0.1998		
P_{t-3}	-0.2603			M_{3t-3}	0.9580*		
P_{t-4}	-0.0173			M_{3t-4}	-0.1369		

*significant at 5 percent level

The first sub period results (1954-I - 1973 IV) corresponding to the period of **fixed** exchange rates, amply show that M_1 causes P and P does not cause M_1. This conclusion emerges from a comparison of equation (1) with (2) and (3) with (4) in table 5. Addition of 4 Past P to equation (1) results in a fall in $\bar{R}^2$ showing that for explaining the behaviour of M_1, P is not important whereas addition of 4 past M_1 to equation (3) leads to an improvement in $\bar{R}^2$, which goes to demonstrate that M_1 does explain the behaviour of P. A look at table 6 Col.(1) corroborates this conclusion. Particularly examining the coefficients of P_{t-i}'s (Col.1) shows them to be insignificant and not sizeable, whereas Col.(3), reveals that the behaviour of preceding two quarters' M_1 is important for explaining the behaviour of P.

Information about causality running from M_3 to P for the sub period (1954 I - 1973 IV) is shown in table 7. Comparing equation (1) with (2) shows a negligible increase in $\bar{R}^2$ (equal to .004) while doing so for equation (3) with (4) (table 7) shows an increase of $\bar{R}^2$ from .6871 to .7013. This should not be taken to mean a case of bidirectional causality between M_3 and P. Because we have to see whether lag profiles support this inference.

First of all looking to Col.(1) of table 8 shows that M_3 is highly auto regressive and most of the coefficients on M_{3t-i}'s are significant and sizeable, the coefficient on M_{3t-8} being an exception. As far as coefficients on P_{t-1}'s (same Col. table 8) are concerned, they are incorrectly signed, statistically insignificant and not sizeable compared to the ones on M_{3t-i}'s. Therefore, on the basis of these coefficients we can't infer that they affect the behaviour of M_3. On the contrary, Col.(3) of table 8 makes it very clear: (i) that 3 of the 4 coefficients on M_{3t-i}'s are correctly signed; they affect P positively; (ii) they are sizeable compared to the ones on P_{t-i}'s and (iii) one coefficient on M_{3t-1} is statistically significant. This is sufficient information to say that causality running from M_3 to P (even in the sub-period) is unidirectional.

In view of this (causality running from M_1 to P and M_3 to P) two conclusions can be drawn. First, that fixed exchange rate regime has not affected causality in any way as is presumed and second that causality runs from M to P for the whole sample period as well as for the first sub-period.

The second subperiod (1974-I - 1985 IV) corresponds to the flexible exchange rate regime and that of managed float. Let us see whether this state improves the results for causality?

Tables 9 and 10 contain evidence on causality from M_1 to P. Examined from any angle (whether regressions or their estimated lag profiles), they are the best results so far obtained (for M_1 and P). Adding 4 Past P to equation (1) reduces $\bar{R}^2$ from .7376 to .7025. Looking to other statistics and lag profile (columns 1 and 3 of table 10), this strongly proves that the behaviour of M_1 can't be explained by P in any way. Addition of 4 Past P to equation (3).table (9) produces a dramatic increase in $\bar{R}^2$. It increases from .4330 to .6623. Read with lag profile, this proves that M_1 is the most important variable affecting the behaviour of P. As far as evidence on M_3 and P is concerned, it is almost of similar type. Although lag profile for M_3 and P is not as good as that for M_1 and P, (However, it does not, in any case suggest that there is bidirectional causality or causality runs from P to M_3), the results of table 11 leave little about about the fact that causality runs from M_3 to P.

In view of the estimates of the second sub-period it can be stated that: (i) flexible exchange rates probably make causality clearer as was mentioned at the beginning of the sub-period results. However, we can't be certain there might be other factors working to strengthen the causality during the second sub period like oil crisis and increase in world food prices; (2) unidirectional causality from M to P holds over all sub-periods.

The Reserve Bank of India began to publish a new series of money supply from January 1977 in the form of M_1, M_2, M_3 and M_4. Earlier money supply data are not available in this form. In order to make the earlier money supply data (i.e. M_1

and M_3 that we have used in this study) conform to the new money supply series we used the method of professor G.S.Gupta[11] so all our data before 1977 are based on a constructed series and how far they capture the spirit of new supply series is difficult to judge.

We therefore, used the actual money supply series published by the Reserve Bank of India for establishing causality to see whether our results are corroborated. Since some observations were lost in deseasonalizing and stationarizing, 1977-1985 formed a small sample. We did not expect this sample period to reveal all aspects of causality. However, it is surprising to note, that all our earlier conclusions are upheld by this new exercise. Equations 1 to 4 Table 13 establish unidirectional causality as far as M_1 and P are concerned. Even the lag profiles (table 14) show that though ecoefficients on P_{t-i}'s (Col.1, table 14) are sizeable, are negatively signed and insignificant, whereas in col.(3), coefficient on M_{3t-1} is significant. The only new development to be noted is that due to small sample D.W. value in equations (3) and (4)(table 13) have become inconclusive. But high F values and $\bar{R}^2$ support our conclusions. As far as M_3 and P are concerned, almost similar

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11 Gupta, G.S. (1984), "Monetary Target Setting" A Study sponsored by the Committee to Review the working of the monetary system set up by the RBI, pp.115-117.

type of results have been generated. Addition of 4 Past P to equation (1) table 15, increases $\bar{R}^2$ by .0023 which is almost equal to zero whereas when 4 Past M_3 are added to equation (3), $\bar{R}^2$ increases from .7942 to .8622 which is definitely not trivial and goes to show that M_3 causes P.

Thus our conclusion is that the actual new money supply series published by the Reserve Bank of India also establishes that causality is unidirectional from M to P.

We have used annual data also to find out whether they yield similar type of results. They are given in tables 17 to 20. It is strange the first two equations in table 17 do not have significant F ratios. Therefore, it is not possible to interpret results on the basis of values of $\bar{R}^2$. However, equations 3 and 4 (table 17) have significant F ratios and prove that M_1 causes P. This becomes very clear if we look at the coefficients on M_{t-i}'s (in col.3 of table 18).

As far as the results in tables 19 and 20 are concerned, it is difficult to infer the direction of causality. We suspect that such results as have been obtained reported in tables 17 to 18, are an outcome of a small sample and consequently small degrees of freedom.

Conclusion:

In this study we have used Grangers' test of causality as interpreted by Sims and found out that causality is unidirectional running from money to price level, this conclusion is independent of the type of definition of money used and is valid whether we choose time period characterized by fixed exchange rate regime or flexible exchange rate regime.

A note on Data

We have collected our data from the various issues of the RBI Bulletins. However, thereafter we constructed the M_1 and M_3 series (as already noted in the text) of money supply so as to make them conform to the new money supply series published by the Reserve Bank of India.

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