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Variations in Prices due to Anticipated and Unanticipated Money

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Abstract

The relation between money and price has unique relevance in price stability. Rational expectations theorists hold that both anticipated and unanticipated money supply affect price level. This paper addresses this issue and enquires if anticipated and unanticipated money supplies have any role in the variations in whole sale and consumer prices (WPI & CPI) in India over the period 1992:Q1 to 2010:Q3. It is found that both anticipated and unanticipated money supply shocks cause rise in WPI and CPI inflation and justifying the rational expectations proposition. Price level, therefore, can be stabilized through appropriate monetary management.

Introduction

Economic theory viewed that money supply is one of the important causative factors behind the variations in general price level. Accordingly, monetary management of most of the countries is directed towards maintaining price stability. The issue of price stability has burgeoning importance particularly in the globalized regime where external economic shocks get freely transmitted affecting small economies. Maintenance of price stability, therefore, becomes a challenging task for policy makers, and in this area monetary management assumes a significant role to play especially when price instability is related to different types of monetary shocks.

Plethora of empirical studies has established significant role of money supply behind the variations in price level in countries concerned. In the context of Indian economy a few of empirical studies have also been done. Among these studies, Ramachandra (1983, 1986), Sharma (1985), Nachane and Nadkarni (1985), Singh (1990), Biswas and Saunders (1990), Masih and Masih (1994), Ashra, Chattopadhyay and Chaudhuri (2004) explore the causal

relation between different monetary aggregates and general price level. However, the direction and potency of such relation as reported by these studies are mixed and ambiguous in many cases.

Rational expectations theorists (Sargent 1975, Lucas 1976, Wallace 1975), in this regard, hold that both anticipated money supply and unanticipated money supply affect price level. Empirically the issue has not been enlightened adequately, particularly in the context of Indian economy. This paper addresses this issue under rational expectation proposition and examines if anticipated and/or unanticipated money supplies have any role in generating variations in price level in India over the period 1992 to 2010. The economy of India experienced transitory supply shocks which led instability in general price level. Thus the task to maintaining price stability becomes a complicated issue where monetary policy may be expected to play a significant role.

Study period starting from early 1990s derives justification from the fact that affluent monetary policy entails well developed financial sector. Before 1990's, the financial sector of the

economy was not strong. Edge of monetary policy was narrow. Higher degree of control and restrictions were operative. Financial sector of the economy experienced a drastic change with adoption of economic reforms in early 1990s. With the passage of time, the economy gradually becomes a market based open economy and accordingly the price mechanism gradually becomes market driven. Further, since early 1990s, the market based exchange rate system has been introduced where proficiency of the monetary policy is expected to hold.

Review of Theoretical Propositions

In the classical set-up money is neutral. The quantity theory of money postulates that change in money supply leads to rise in general price level while output level remains fixed at full employment level. According to Fishers equation of exchange:

$$M_t V_t = P_t Y_t \quad (1)$$

Where, M_t = money supply, V_t = velocity of money supply, P_t = price level and Y_t = real national income. Taking log in both sides,

$$\log(M_t) + \log(V_t) = \log(P_t) + \log(Y_t)$$

$$\text{or, } m_t + v_t = p_t + y_t \quad (2)$$

$$\text{or, } p_t = m_t + v_t - y_t \quad (3)$$

$$\text{Therefore, } p_t = f(m_t, v_t, y_t) \quad (4)$$

[where, $\log(M_t) = m_t$, $\log(V_t) = v_t$ (assumed constant¹), $\log(P_t) = p_t$, $\log(Y_t) = y_t$]

Equation (3) states that price level is positive function of money supply and velocity of circulation of money but negative function of real output level. Monetary authority often seeks to stabilize the rate of change of price level through the other macroeconomic

variables. To show this, if we differentiate Equation (3) with respect to 't',

$$\frac{1}{p_t} \frac{dp_t}{dt} = \frac{1}{m_t} \frac{dm_t}{dt} + \frac{1}{v_t} \frac{dv_t}{dt} + \frac{1}{y_t} \frac{dy_t}{dt}$$

$$\dot{p}_t = \dot{m}_t + \dot{v}_t - \dot{y}_t \quad (5)$$

Equation (5) asserts that rate of change of price level (inflation) is positively related to the rate of change of money supply, rate of change of velocity of money and negatively related to the output growth. Similar expression can be derived from the Cambridge version of the quantity theory of money.

Keynesians do believe in an indirect link between money supply and price level. However, the relationship is not proportional. They support the tradeoff between inflation and unemployment. Increase in money supply leads to rise in price level along with an increase in output and employment. Friedman holds that money supply variation entails output effect, inflation effect and liquidity effect. Friedman and other monetarists, in this regard, made an important distinction between the short-run and long-run effect of change in money. They argued that in the long-run money is more or less neutral. Prices are mainly affected by the growth rate in money, while having no real effect on income growth. If the growth in money supply is higher than the output level, price level goes up and inflation result in. In the short-run, changes in money supply can have important real effect. Rational expectation proposition, in this regard, is already stated in the section 1 which is modeled below.

We have found that,

$$m_t + v_t = p_t + y_t$$

The aggregate supply curve is given by the Lucas supply equation as:

$$y_t = y_p + \beta(p_t - {}_{t-1}^e p_t) \quad (6)$$

where, y_p = log of full employment output, ${}_{t-1}^e p_t$ = log of the price level that the public expects to occur in time t viewed from period t-1. Let the monetary rule used by the policy authorities be

¹ Keynes and many other economists have challenged the classical assumption of constant velocity of money, 'v'. Notionally it is well documented that 'v' may affect output, price or other macro-economic variables. In the theoretical discussion 'v' is assumed constant. Inferences drawn from the theoretical exposition remain unaltered if datasets deny this assumption.

$$m_t = \alpha_1 y_{t-1} + \varepsilon_t \quad (7)$$

where, $E(\varepsilon_t) = 0$

Under rational expectations, the price expectations are determined within the model in the light of past and present developments of the money supply. This can be expressed as

$${}_{t-1}p_t = E({}_t P_t / I_{t-1}) \quad (8)$$

This equation asserts that people's subjective and psychological expectation of the price level (${}_{t-1}p_t$) equals the mathematical expectation of the price level, given both the structure of the model and the information available at time 't-1'. From (2) and (6) we have

$$m_t + v_t - p_t = y_p + \beta(p_t - {}_{t-1}p_t) \quad (9)$$

$$\text{or, } \alpha_1 y_{t-1} + \varepsilon_t + \bar{v} - p_t = y_p + \beta(p_t - {}_{t-1}p_t) \quad (10)$$

where \bar{v} represents constancy of 'v'.

Taking mathematical expectations, we have

$$\alpha_1 y_{t-1} + E(\varepsilon_t) + \bar{v} - E(p_t) = y_p + \beta(E(p_t) - {}_{t-1}p_t)$$

$$\text{or, } \alpha_1 y_{t-1} + \bar{v} - {}_{t-1}p_t = y_p + \beta({}_{t-1}p_t - {}_{t-1}p_t)$$

$$\text{or, } \alpha_1 y_{t-1} + \bar{v} - {}_{t-1}p_t = y_p$$

$$\text{or, } {}_{t-1}p_t = \alpha_1 y_{t-1} + \bar{v} - y_p$$

From (10) and (11)

$$p_t = \alpha_1 y_{t-1} + \bar{v} + \beta(p_t - {}_{t-1}p_t) + \varepsilon_t - y_p$$

$$\text{or, } p_t + \beta p_t = \alpha_1 y_{t-1} + \bar{v} + \beta({}_{t-1}p_t) + \varepsilon_t - y_p$$

or,

$$(1 + \beta)p_t = (\alpha_1 y_{t-1} - y_p + \bar{v}) + \beta(\alpha_1 y_{t-1} + \bar{v} - y_p) + \varepsilon_t$$

$$\text{or, } (1 + \beta)p_t = (1 + \beta)(\alpha_1 y_{t-1} + \bar{v} - y_p) + \varepsilon_t$$

$$\text{or, } p_t = \alpha_1 y_{t-1} + \bar{v} - y_p + \frac{\varepsilon_t}{1+\beta} \quad (12)$$

Therefore, the gap between the actual price and the expected price is

$$p_t - {}_{t-1}p_t = \frac{\varepsilon_t}{1+\beta} \quad (13)$$

Using the Lucas supply equation, we find that output will equal

$$y_t = y_p + \frac{\beta \varepsilon_t}{1+\beta} \quad (14)$$

Equations (12) and (14) indicate that both the anticipated and unanticipated parts of money supply affect price level but not output level.

Variables, Data and Methodological Issues

Study involves money supply and price level dataset, which are quarterly time series for the period 1992:Q1 to 2010:Q3. The datasets have been taken from International Financial Statistics (IFS), published by the International Monetary Fund (IMF). Two types of monetary aggregates, namely, M1 and M2 has been taken, where M1 money consists of currency in circulation and demand deposits of banks. M2 money includes narrow money M1 and quasi money. Logarithms of monetary aggregates M1 and M2 is denoted by m_{1t} and m_{2t} respectively. First difference of which are denoted by Δm_{1t} and Δm_{2t} respectively. Consumer Price Index (CPI) and Wholesale Price Index (WPI) time series (base year 2000) are considered for measuring general price level and are (logarithm of CPI and WPI) are denoted by cpi_t and wpi_t respectively. First difference of logarithmic prices implies inflation which are denoted by Δcpi_t and Δwpi_t respectively. Time plots of prices and inflations are shown in Figure A1 and A2 (Appendix).

Study requires anticipated and unanticipated components of money supply. Using Box-Jenkins (BJ) methodology, minimum mean squared error forecast series of money supplies have been generated. These forecasts series are anticipated parts of money supplies. On the other hand, forecast residuals (white noise residuals) imply unanticipated money. It is found that M1 money supply follows ARCH (1) based ARIMA (1, 1, 0) structure which is

estimated by the Maximum Likelihood method and is depicted in Table A1 shown in Appendix. Components of anticipated and unanticipated M1 money supply are denoted by m_{1t}^a and m_{1t}^u respectively. M2 money supply series, on the other hand, identifies GARCH (1,2) based ARIMA (1, 1, 0) stochastic process (shown in Table A2, Appendix). Accordingly, anticipated and unanticipated components of M2 money have been generated and are represented by m_{2t}^a and m_{2t}^u respectively. Time plots of actual, anticipated and unanticipated components of M1 and M2 money are visualized in terms of Figure A3 to Figure A6 (Appendix).

Before enquiring the relation between money and price involving time series dataset, it is essential to specify stationarity and order of integrability of variable concerned. Nonstationary variables can be made stationary by appropriate differencing and/or de-trending. Stationarity of dataset has been studied through the Augmented Dickey-Fuller (ADF, 1981) unit-root tests. The ADF unit-root tests necessitate running a regression of the first difference of the series concerned against the series lagged once, lagged difference terms and specified deterministic components like constant (intercept) and a time trend. Thus in ADF test, following equation is to be estimated.

$$\Delta m_t = a_0 + a_1 t + a_2 m_{t-1} + \sum_{i=2}^k \beta_i \Delta m_{t-i+1} + \varepsilon_t \quad (15)$$

where ε_t represents a sequence of uncorrelated stationary error terms having zero mean and constant variance. k is the optimum lag which should be chosen in such a way that ε_t will be free from autocorrelation. Here the test for unit-root is conducted on the coefficient of m_{t-1} in the regression. If the coefficient is significantly different from zero, i.e., $H_0: a_2 = 0$ is accepted, the equation is entirely in first differences and has a unit root. Alternatively, rejection of $H_0: a_2 = 0$ implies stationarity. $H_0: a_2 = 0$ is examined by the Dickey-Fuller statistic, where appropriate test statistic and corresponding critical values (McKinnon's values) vary with the specified deterministic components in the ADF test equation.

If all the time series concerned contain unit root, the next step is to examine whether there exists a long-run equilibrium relationship among them. This can be done through the study of cointegration. Study of cointegration identifies if the long run movement of the variables is associated. Our study follows VAR-based cointegration tests using the methodology developed in Johansen (1991, 1995a). Under this method, a VAR of order p as shown below needs to be estimated.

$$cpi_t = A_1 cpi_{t-1} + \dots + A_p cpi_{t-p} + Bm_{1t} + \varepsilon_t$$

where cpi_t is a k -vector of nonstationary I(1) series, m_{1t} is a d -vector of deterministic variables, and ε_t is a vector of innovations. We can rewrite this VAR as:

$$\Delta cpi_t = \Pi cpi_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta cpi_{t-i} + Bm_{1t} + \varepsilon_t$$

$$\text{where, } \Pi = \sum_{i=1}^p A_i - I, \Gamma_i = -\sum_{j=i+1}^p A_j$$

Granger's representation theorem states that if the coefficient matrix Π has reduced rank $r < k$ then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' cpi_t$ is I(0). Where, r is the number of cointegrating relation (i.e., cointegration rank) and each column of β is the cointegrating vector. The Johansen approach to cointegration test is based on two test statistics: the trace test statistic, and the maximum eigen value test statistic. The trace statistic can be specified as:

$$\lambda_{\text{trace}} = -T \sum_{i=r+1}^k \log(1 - \lambda_i),$$

where, λ_i is the i th largest eigen value of matrix Π and T is the number of observations. In the trace test, the null hypothesis is that the number of distinct cointegrating vectors is less than or equal to the number of cointegration rank. The maximum eigenvalue test statistic can be calculated as:

$$\lambda_{\text{max}} = -T \log(1 - \lambda_{r+1})$$

where λ_{r+1} is the $(r + 1)^{th}$ largest squared eigen value. In the trace test $H_0: r = 0$ is tested against $H_A: r = r + 1$ cointegrating vectors.

Absence of cointegrating relation does not reject the possibility of having non-linear relation between the variables. In such a case, footing. There should not be any *a priori* distinction between endogenous and exogenous variables. For the two stationary variables of Δcpi_t and Δm_{1t} , VAR model can be stated in terms of the following equations:

$$\Delta cpi_t = \alpha_1 + \sum_{i=1}^k \beta_{1i} \Delta cpi_{t-i} + \sum_{i=1}^k \gamma_{1i} \Delta m_{1t-i} + u_t \quad (16)$$

$$\Delta m_{1t} = \alpha_2 + \sum_{i=1}^k \beta_{2i} \Delta m_{1t} + \sum_{i=1}^k \gamma_{2i} \Delta cpi_{t-i} + v_t \quad (17)$$

where, Δcpi_{t-i} and Δm_{1t-i} ($i=1, 2, \dots, k$) are lagged series of Δcpi_t and Δm_{1t} respectively. u_t and v_t represent vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged and with all of the right-hand side variables. For ascertain the optimum lag length (k), lag selection criterion can be used.

Empirical Relation Between Money and Prices in India

To establish appropriate relation among the macroeconomic time series, it is essential to specify stationarity and integrability of the time series. Stationarity and integrability of selected time series have been examined through the ADF unit-root tests. Results of ADF tests are summarized in Table 1.

ADF unit-root tests on money supplies (m_{1t} , m_{2t}) and prices fail to reject the null hypothesis of unit-root even at 10 percent level. When first differences of these series are used (i.e., CPI and WPI inflations), ADF tests reject the null hypothesis of unit-root even at 1 percent level.

causal relation (if, any) can be studied through the estimation of vector autoregression (VAR) model involving (differenced) stationary dataset. In the VAR estimation, true simultaneity among a set of variables necessitates that these are to be treated on equal

Therefore, each of money supplies (m_{1t} , m_{2t}) and prices (cpi_t , wpi_t) are found to be I(1) stationary series over the period of the study. ADF tests also indicate that anticipated money supplies (m_{1t}^a , m_{2t}^a) are I(1) series. On the other hand, ADF tests reject unit-root for unanticipated money supply m_{1t}^u and m_{2t}^u even at one percent level and, therefore, unanticipated money supplies are I(0) stationary series. As both the money supplies and prices are I(1) series, it is pertinent to enquire into cointegrating relation between them. Johansen (1991, 1995a) method of cointegration tests have been applied for this purpose.

Table 2 depicts results of Johansen (1991, 1995a) cointegration tests involving four sets of money and price variables. In making inferences about the number of cointegrating relations between each sets of variables, trace test (λ_{trace} rank statistics) and maximal eigenvalue test (λ_{max} rank statistics) have been used. Trace test designed the null hypothesis that there is at most r cointegrating vector against the alternative hypothesis of r or more cointegrating vectors. Under the maximum eigenvalue test, null hypotheses of r cointegrating vectors are tested against the alternative of $r + 1$ cointegrating vectors. For making inferences regarding the number of cointegrating relationships, calculated λ_{trace} and λ_{max} rank values are compared with the critical values tabulated in Osterwald-Lenum (1992). Both λ_{trace} and λ_{max} statistics accept null hypothesis of no cointegrating relation ($r = 0$) for all four sets of variables under this test. Therefore, valid inference is that there does not exist any cointegrating relation between money and price datasets.

Table 1: Results of ADF Unit-Root Tests

Null Hypothesis: Series Has Unit-Root									
Series	τ_{μ} statistic	Prob.	τ_{τ} statistic	Prob.	Series	τ_{μ} statistic	Prob.	τ_{τ} statistic	Prob.
m_{1t}	0.324 (4)	0.97	-1.676 (4)	0.75	Δm_{1t}	-4.284(3)	0.00	-4.268 (3)	0.00
m_{2t}	0.544 (3)	0.98	-0.07 (0)	0.54	Δm_{2t}	-3.892(4)	0.00	-3.919 (3)	0.01
cpi_t	0.101 (4)	0.96	-1.471 (3)	0.83	Δcpi_t	-3.320(3)	0.01	-3.142 (3)	0.10
wpi_t	-1.95 (2)	0.30	-2.856 (2)	0.18	Δwpi_t	-7.415(1)	0.00	-7.655 (1)	0.00
m_{1t}^a	0.076 (6)	0.96	-2.303 (5)	0.42	Δwpi_t^a	-4.11(5)	0.00	-4.08 (5)	0.01
m_{1t}^a	0.730 (0)	0.99	-1.898 (0)	0.64	Δm_{1t}^a	-10.24(0)	0.00	-10.24 (0)	0.00
m_{2t}^a	-9.167 (0)	0.00	-9.109 (0)	0.00	Δm_{2t}^a				
m_{1t}^u	-9.167 (0)	.00	-9.109 (0)	0.00					

Note: lag(s) are selected on the basis of Schwartz Information Criterion (SIC)

Table 2: Results of Johansen Cointegration Tests

Variables	λ_{trace} rank test				λ_{max} rank test			
	H_0	H_A	λ_{trace} rank value	critical value 95 %	H_0	H_A	λ_{max} rank value	critical value 95%
m_{1t}, cpi_t	$r = 0$	$r > 0$	5.28	15.4	$r = 0$	$r = 1$	4.98	14.07
	$r \leq 1$	$r > 1$	0.29	3.76	$r = 1$	$r = 2$	0.29	3.76
m_{1t}, wpi_t	$r = 0$	$r > 0$	11.84	15.4	$r = 0$	$r = 1$	11.15	14.07
	$r \leq 1$	$r > 1$	0.68	3.76	$r = 1$	$r = 2$	0.68	3.76
m_{2t}, cpi_t	$r = 0$	$r > 0$	5.638	15.4	$r = 0$	$r = 1$	4.64	14.07
	$r \leq 1$	$r > 1$	0.995	3.76	$r = 1$	$r = 2$	0.99	3.76
m_{2t}, wpi_t	$r = 0$	$r > 0$	11.88	15.4	$r = 0$	$r = 1$	11.22	14.07
	$r \leq 1$	$r > 1$	0.65	3.76	$r = 1$	$r = 2$	0.65	3.76

Notes: (i) Critical Values are taken from Osterwald-Lenum (1992), (ii) The assumption 'linear deterministic trend with intercept' is considered for the test.

Rejection of cointegrating relation between the pairs of money-price datasets does not discard the possibility of having any causal relation between them. Macroeconomic theory recognized the justification of *money growth* in the *variations in prices and inflation*. This possibility can be encompassed through the estimation of vector autoregression (VAR) model. Hence, we have estimated VAR model [presented through the Equations (16) and (17)] involving first differenced series of money supplies and prices. The results are presented in Table 3 and Table 4.

Table 3 depicts causal relation between consumer price inflation and money growth (M1, M2). From the estimated VAR model involving consumer price inflation and M1 money growth, it is evident that the estimate of

Δm_{1t-2} is positive and statistically significant at 1 percent level. It implies two quarter lagged M1 money growth leads to rise in consumer price inflation. The estimates of lagged CPI inflation in the second equation of VAR (equation of M1 money growth) indicate that CPI inflation has some causal impact on M1 money growth. Specifically, the estimate of first lag of inflation is negative and that of second lag is found positive which can be explained as, if price level rises in the previous quarter, monetary authority reduce M1 money growth and tries to stabilize price rise. However, this money growth cannot be reduced constantly for the following periods as money supply has other import role for the economy and, as a result, higher price of higher lag fails to influence money growth.

Table 3: Causal Relation Between Money Growth and CPI Inflation

Dependent Variable Δcpi_t		Dependent Variable Δm_{1t}		Dependent Variable Δcpi_t		Dependent Variable	
Parameters	Estimates	Parameters	Estimates	Parameters	Estimates	Parameters	Estimates
constant	0.008 [2.04]	constant	0.048 [5.03]	constant	-0.001 [-0.18]	constant	0.049 [6.21]
Δcpi_{t-1}	0.223 [2.18]	Δm_{1t-1}	-0.29 [-2.79]	Δcpi_{t-1}	0.141 [1.34]	Δm_{2t-1}	-0.094 [-0.83]
Δcpi_{t-2}	-0.263 [-2.64]	Δm_{1t-2}	-0.28 [-2.67]	Δcpi_{t-2}	-0.273 [-2.72]	Δm_{2t-2}	-0.189 [-1.60]
Δm_{1t-1}	0.059 [1.25]	Δcpi_{t-1}	-0.42 [1.85]	Δm_{2t-1}	0.233 [2.57]	Δcpi_{t-1}	-0.219 [-1.67]
Δm_{1t-2}	0.192 [4.07]	Δcpi_{t-2}	0.824 [3.75]	Δm_{2t-2}	0.286 [2.99]	Δcpi_{t-2}	-0.094 [-0.83]
$R^2 = 0.33$, Adjusted $R^2 = 0.29$		$R^2 = 0.32$, Adjusted $R^2 = 0.29$		$R^2 = 0.314$, Adjusted $R^2 = 0.275$		$R^2 = 0.17$, Adjusted $R^2 = 0.12$	

Table 4: Causal Relation Between Money Growth and WPI Inflation

Dependent Variable Δwpi_t		Dependent Variable Δm_{1t}		Dependent Variable Δwpi_t		Dependent Variable Δm_{2t}	
Parameters	Estimates	Parameters	Estimates	Parameters	Estimates	Parameters	Estimates
Constant	0.004 [1.53]	Constant	0.055 [6.08]	Constant	0.002 [0.73]	Constant	0.048 [8.87]
Δwpi_{t-1}	0.144 [1.39]	Δm_{1t-1}	-0.228 [-2.15]	Δwpi_{t-1}	0.176 [1.62]	Δm_{2t-1}	-0.08 [-0.74]
Δwpi_{t-2}	-0.151 [-1.57]	Δm_{1t-2}	-0.313 [-2.87]	Δwpi_{t-2}		Δm_{2t-2}	
Δm_{1t-1}	0.118 [3.16]	Δwpi_{t-1}	-0.558 [-1.91]	Δm_{2t-1}	0.233 [2.9]	Δwpi_{t-1}	-0.39 [-2.54]
Δm_{1t-2}	0.161 [4.19]	Δwpi_{t-2}	0.48 [1.76]	Δm_{2t-2}		Δwpi_{t-2}	
$R^2 = 0.326$, Adjusted $R^2 = 0.288$		$R^2 = 0.238$, Adjusted $R^2 = 0.194$		$R^2 = 0.13$, Adjusted $R^2 = 0.10$		$R^2 = 0.08$, Adjusted $R^2 = 0.06$	

Table 5: Results of Johansen Cointegration Tests Between Anticipated Money and Prices

Variables	Trace Test				Max-Eigen Test			
	H_0	H_A	λ_{trace} rank value	critical value 95%	H_0	H_A	λ_{max} rank value	critical value 95%
m_{1t}^a, cpi_t	$r = 0$	$r > 0$	5.21	15.4	$r = 0$	$r = 1$	4.67	14.07
	$r \leq 1$	$r > 1$	0.54	3.76	$r = 1$	$r = 2$	0.54	3.76
m_{1t}^a, wpi_t	$r = 0$	$r > 0$	11.71	15.4	$r = 0$	$r = 1$	10.85	14.07
	$r \leq 1$	$r > 1$	0.86	3.76	$r = 1$	$r = 2$	0.86	3.76
m_{2t}^a, cpi_t	$r = 0$	$r > 0$	5.42	15.4	$r = 0$	$r = 1$	4.06	14.07
	$r \leq 1$	$r > 1$	1.35	3.76	$r = 1$	$r = 2$	1.35	3.76
m_{2t}^a, wpi_t	$r = 0$	$r > 0$	10.64	15.4	$r = 0$	$r = 1$	9.65	14.07
	$r \leq 1$	$r > 1$	0.98	3.76	$r = 1$	$r = 2$	0.98	3.76

Notes: (i) critical values are taken from Osterwald-Lenum (1992), (ii) The assumption ‘linear deterministic trend with intercept’ is considered for the test.

Estimated VAR model involving CPI inflation and M2 money growth shows that, (lagged) money growth has significant role on CPI inflation. M2 money growth of the past two quarter causes rise in CPI inflation. However, the estimates of lagged CPI inflation of the M2 money growth equation are statistically insignificant which implies higher CPI inflation of previous periods fail to affect M2 money growth. This observation is quite logical in the sense that M2 money consists of M1 money and quasi money (savings deposit, fixed deposit, etc), where quasi money growth generally related to interest rates and other factors which may not be affected by CPI inflation.

Table 4 depicts the results of VAR estimation involving two sets of variables namely, WPI inflation, M1 money growth and WPI inflation, M2 money growth. In both the cases significant role of money growth in the variations in WPI inflation have been established. M1 money growth of past quarters Granger causes WPI inflation. M2 money growth of immediate past quarter also Grange causes WPI inflation over the period of the study.

Anticipated Money and Price Variations

Invariance proposition uphold the role of anticipated and unanticipated money supplies in the variations of price level which has been justified mathematically in Section 2. In this endeavor we enquire into this proposition involving Indian dataset over the period of the study. The role of anticipated money supply in this regard has been analyzed. Keeping in view this objective, we attempt to testify if anticipated money and price datasets are cointegrated² through Johansen cointegration tests. Results are summarized in Table 5.

Table 5 summarizes results of Johansen cointegration tests involving anticipated parts of money supplies and prices. Calculated λ_{trace} and λ_{max} rank statistics accepts null hypothesis of no cointegration ($r = 0$) at 95 percent level

²As it is found that both the anticipated money supplies and prices are nonstationary and integrated of same order.

between all four pairs of anticipated money and price. These findings confirm the absence of any cointegrating relation between sets of anticipated money supplies and prices. However, rejection of cointegrating relation enraged us to study the causal relation (if, any) between anticipated money growth and inflations (measured by CPI and WPI). This has been done through the estimation of VAR equations and Table 6 presents the results of estimations.

Table 6 justifies:

- a) two quarter lagged anticipated M1 money growth Granger causes the variations in CPI inflation. An increase in M1 money growth set forth rise in CPI inflation in two quarter time lag.
- b) M1 money growth also Granger causes WPI inflation. WPI inflation is provoked by the anticipated M1 money growth of previous quarter.
- c) growth of anticipated M2 money supply Granger causes CPI inflation. Here time lag is one quarter.
- d) growth of M2 money supply also Granger causes WPI inflation with two quarter time lag. However, estimate of this lagged anticipated money growth is found negative which implies this money growth helps to stabilize WPI inflation. This finding is not in conformity with the macroeconomic theory.

It is, therefore, confirmed that anticipated money growth leads variations in CPI and WPI inflation in India over the period of the study. This finding upholds the theoretical proposition that anticipated money supply has significant role in the variations in price level as propounded by the rational expectation school of macroeconomics which is also painted mathematically in this paper.

Unanticipated Money and Price Variations

This section is an attempt to enquire into the proposition that if unanticipated M1 and M2 money supply affect price level (measured by CPI and WPI) in India over the period of the

study. We have found that unanticipated parts of M1 and M2 money supplies are I(0) stationary. On the other hand, both CPI and WPI series are I(1) stationary. Therefore, study of cointegration cannot be applied on these

datasets. Under this situation, we attempt to testify if unanticipated money supply has any causal role in the variations in CPI and WPI inflations.

Table 6: Variations of CPI, WPI due to Anticipated M1 and M2 Money

Variations of CPI inflation due to anticipated M1 money growth		Variations of WPI inflation due to anticipated M1 money growth		Variations of CPI inflation due to anticipated M2 money growth		Variations of WPI inflation due to anticipated M2 money growth	
Parameters	Estimates [t-stat]	Parameters	Estimates [t-stat]	Parameters	Estimates [t-stat]	Parameters	Estimates [t-stat]
constant	0.013 [2.85*]	constant	0.012 [3.63*]	constant	0.009 [1.36]	constant	0.019 [3.51]
Δcpi_{t-1}	0.205 [1.85]	Δwpi_{t-1}	0.240 [2.06]	Δcpi_{t-1}	0.154 [1.33]	Δwpi_{t-1}	0.248 [2.15*]
Δcpi_{t-2}	-0.338 [-3.018]	Δwpi_{t-2}	-0.273 [-2.51]	Δcpi_{t-2}	-0.359 [-3.21*]	Δwpi_{t-2}	-0.251 [-2.25*]
Δm_{1t-1}^a	0.078 [1.153]	Δm_{1t-1}^a	0.112 [2.67*]	Δm_{2t-1}^a	0.202 [1.99#]	Δm_{2t-1}^a	0.071 [0.84]
Δm_{1t-2}^a	0.101 [1.939*]	Δm_{1t-2}^a	-0.03 [-0.68]	Δm_{2t-2}^a	0.082 [0.79]	Δm_{2t-2}^a	-0.185 [-2.17*]

For enquiring such causal role, it is rational to assume unanticipated part of money supplies as exogenous variable and, accordingly, VAR model is not used (as estimations of VAR model necessitate true simultaneity of a set of variables which are treated as equal footing). Instead, following equations have been taken.

$$\Delta cpi_t = \alpha_1 + \beta_{1t}cpi_{t-1} + \gamma_{1i} \sum_{i=1}^n m_{1t-i}^u + \varepsilon_{1t} \tag{18}$$

$$\Delta wpi_t = \alpha_2 + \beta_{2t}wpi_{t-1} + \gamma_{2i} \sum_{i=1}^n m_{1t-i}^u + \varepsilon_{2t} \tag{19}$$

$$\Delta cpi_t = \alpha_3 + \beta_{3t}cpi_{t-1} + \gamma_{3i} \sum_{i=1}^n m_{2t-i}^u + \varepsilon_{3t} \tag{20}$$

$$\Delta wpi_t = \alpha_4 + \beta_{4t}wpi_{t-1} + \gamma_{4i} \sum_{i=1}^n m_{2t-i}^u + \varepsilon_{4t} \tag{21}$$

Where, ε_{1t} , ε_{2t} , ε_{3t} and ε_{4t} are stochastic error terms. ‘n’ is the optimum lag length which ensures the presence of white noise residuals. We need to test if $\hat{\gamma}_{1i} \neq 0$, $\hat{\gamma}_{2i}$

$\neq 0$, $\hat{\gamma}_{3i} \neq 0$ and $\hat{\gamma}_{4i} \neq 0$. If this be the case, the proposition ‘unanticipated money supply

Granger causes prices’ will be testified. Accordingly, we have estimated these equations (OLS regression) and results are depicted below:

$$\begin{aligned} \Delta cpi_t &= 0.015 + 0.155 cpi_{t-1} \\ [t] \quad [5.37] \quad [1.32] \\ &+ 0.07 m_{1t-1}^u + 0.126 m_{1t-2}^u \end{aligned} \tag{22}$$

[1.09] [1.97]

$$\begin{aligned} \Delta wpi_t &= 0.011 + 0.189 wpi_{t-1} \\ [t] \quad [5.02] \quad [1.61] \\ &+ 0.088 m_{1t-1}^u + 0.13 m_{1t-2}^u - 0.116 m_{1t-3}^u \\ [1.79] \quad [2.54] \quad [-2.17] \end{aligned} \tag{23}$$

$$\begin{aligned} \Delta cpi_t &= 0.014 + 0.012 cpi_{t-1} \\ [t] \quad [5.30] \quad [1.08] \end{aligned}$$

$$+0.241 m_{2t-1}^u + 0.233 m_{2t-2}^u$$

[2.22] [2.09]

(24)

$$\Delta wpi_t = 0.011 + 0.181 wpi_{t-1}$$

[t] [5.33] [1.59]

$$+ 0.153 m_{2t-1}^u + 0.064 m_{2t-2}^u - 0.253 m_{2t-3}^u$$

[1.72] [0.71] [-2.85]

(25)

The estimate of m_{1t-2}^u in Equation (22) is found statistically significant (at 5 percent level), which implies two quarter lagged unanticipated M1 money supply leads variation in consumer price inflation. Specifically, this lagged unanticipated M1 money causes rise in consumer price inflation. Affects of this money in the variations in wholesale price, on the other hand, has been depicted through the estimated Equation (23), where it is found that up to three quarter lagged unanticipated M1 money also has significant role in the variations of whole sale price inflation. Specifically, statistically significant positive estimates of first two quarters lagged money reveal that these money leads to rise in wholesale price inflation. However, statistically significant negative estimate of lagged third quarter money implies (m_{1t-3}^u) that this lagged money assists to lower and stabilizes whole sale price inflation. This findings can be explained in the way that when unanticipated or surprise money increase in the first two quarter, liquidity effect of money operates and pushes price level up. This higher price reduces the real balance, intern, helps to stabilize whole sale price in the next period.

On the other hand, affects of unanticipated M2 money on consumer and whole sale prices inflation have been enquired and represented through the Equations (24) and (25) respectively. Equation (24) depicts lag 1 and lag 2 of unanticipated M2 money are statistically significant even at 5 percent level (at the presence of autoregressive lag of consumer price inflation) which testifies unanticipated M2 money Granger causes consumer price inflation. Finally, estimated

Equation (25) shows that unanticipated M2 money of immediate past quarter has positive impact on wholesale price inflation and that of lagged three quarter helps to stabilize wholesale price inflation, which is similar with the affects of unanticipated M1 money on whole sale inflation. Therefore, study uphold the proposition laid down by the rational expectation theorists that the unanticipated part of money supply also has significant role in the variations of price level.

Concluding Remarks and Policy Implications

Study of the paper examines the role of anticipated and unanticipated money supply in the variations in price level in India over the period 1992:Q1 to 2010:Q3. Theoretical propositions in this regard are reviewed and highlighted mathematically. Empirical analysis involved M1, M2 money supplies, consumer price and wholesale price indices dataset. Anticipated and unanticipated parts of monetary aggregates are decomposed by Box-Jenkins methodology. Stationarity and integrability of time series are studied through Augmented Dickey Fuller unit-root tests. To confirm co-movements of nonstationary series having same order of integrability, Johansen cointegration tests are performed. However, Johansen cointegration tests fail to establish any cointegrating relation between monetary aggregates and prices. Vector Autoregression estimations testified that lagged money growth led to rise in CPI and WPI inflations. Anticipated money growth also causes CPI and WPI inflation with time lag. Role of unanticipated money in the variations in CPI and WPI inflation is also established.

These findings have some policy implications. As price level is sensitive with money growth, it may be possible to stabilize price level, if necessary, by appropriate monetary management. It is the fact that for the economy like India, particularly in the present globalized regime, it is very difficult to prevent the transmission of external shocks. However, a sovereign monetary policy may protect the domestic economy through neutralizing prolonged detrimental effects of such external shocks. Appropriate monetary

and fiscal management may execute pivot role. Monetary policy in India is found effective to maintain price stability.

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Appendix

Table A1: Estimation of Anticipated Component of M1 Money (Maximum Likelihood – ARCH)

Parameters	Estimates	z-Statistic	Prob.
Δm_{1t-1}	0.579	6.893	0.00
α	0.016	3.793	0.00
Variance Equation			
C	0.0006	4.423	0.00
ARCH (1)	0.3861	2.173	0.02

Table A2: Estimation of Anticipated Component of M2 Money (Maximum Likelihood – ARCH)

Parameters	Estimates	z-Statistic	Prob.
Δm_{2t-4}	0.4678	11.1904	0.00
α	0.0198	8.2509	0.00
Variance Equation			
C	8.83E-05	3.6444	0.00.0
ARCH (1)	0.28569	2.5883	.00
GARCH(1)	1.00577	6.7326	0.00
GARCH(2)	-0.58605	-5.1074	0.00

Figure A1: Time Plots of CPI and WPI Series

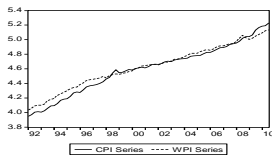


Figure A2: Time Plots of CPI and WPI Inflation

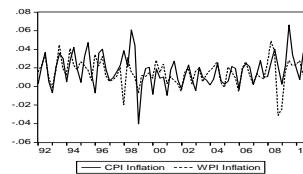


Figure A3: Time Plots of Actual and Anticipated M1 Money

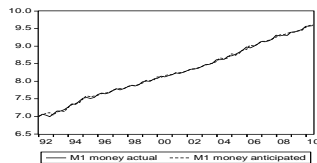


Figure A4: Time Plot of Unanticipated M1 Money

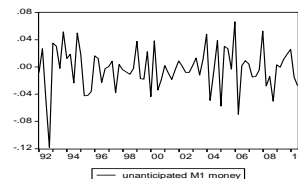


Figure A5: Time Plots of Actual and Anticipated M2 Money

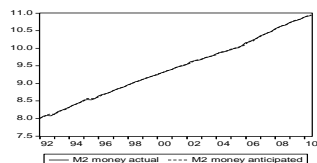


Figure A6: Time Plot of Unanticipated M2 Money

