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The Effect of Broad Money and Price Level on Growth in India: A VECM Estimation of the Causality

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Abstract: *This paper examines the long-run and short-run causal relationship among money supply, inflation and price level in India using a long series data from 1960 to 2016 using the ADF unit root test, Johansen cointegration test, Granger causality test and vector error correction method. The ADF test results show that the variables are non-stationary at levels but stationary at first difference without trend. The Johansen cointegration test shows cointegration among the variables. The Granger causality test reveals that a directional causality exists between money and output, and unidirectional causation between inflation and output. The results of cointegration test shows that there is one cointegrating equation at 5 percent level of significance, meaning that there is long-term stable relationship among the three variables - price level, output and inflation. The VECM results show short-run causality from money supply to price level. The speed of adjustment or correction of any short-run disequilibrium in money supply towards long-run equilibrium is 5.3 percent per year.*

Key words: *money supply, inflation, economic growth, causality, tests, VECM, disequilibrium, adjustment.*

1. INTRODUCTION

Economic growth, money supply and inflation are important macroeconomic parameters that play crucial role in aneconomy. An understanding of the nexus between the macroeconomic variables is important for to the policymaking in ensuring effective macroeconomic stabilisation policies. Over the past few decades, policy makers have become more aware of the socioeconomic costs of inflation, and thus, more concerned with the price level stability. Price stability is desirable because a rise in price level creates uncertainty in the economy and lowers economic growth (Fischer, 1993). However, the nature of the causal relationship between money supply and inflation is still an unsettled issue. In the macroeconomics literature,the classical economics says that an increase in money supply does not influence real output, but there will be proportionate increase in prices.Among the Keynesian and Monetarists schools,one of the most debated issues is the casual relationship between money supply, price level and GDP growth rate (Rami,2010).The Monetarists claim that money plays an important role in the economy and that the stock of money supply leads to changes in nominal income and prices. An increase in money supply will affect output changes in the short-run whereas only in the long-.run prices will increase proportionately the Keynesians, on the other hand, maintain that money supply does not play any active role in changing the income and prices. Instead, the GDP and price changes are mainly caused by changes aggregate demand and aggregate supply.

Numerous studies have been carried out to ascertain the impact of money supply on economic growth and inflation in developing and developed countries with mixed and varying results. Some empirical studies examine the causal relationship between money supply, GDP and prices in India (Rangarajan and Arif, 1990; Das, 2003; Rami, 2010). Das (2003) finds that money has a positive effect on price and there is a feedback between money and price and also between output and price in India.

The available few Indian empirical studies on the relationship between money supply, inflation and growth use short periods and weak empirical methods that are outdated. Therefore, this paper aims to provide an updated empirical evidence on the nature of causal relationship between growth rate, price level and money supplyusing the latest data and more rigorous empirical methodology. The main objectives of this paperare to examine the causal relationship among output (GDP) and broad money (M_3) and consumer price index (CPI) in India and to analyse the long-run relationship between GDP, CPI and M_3in India. This paper covers a long period, 56 years from 1960 to 2016for India. The annual data on the variables are collected from the RBI and World Bank databases. Empirically, this paper applies the causality test, cointegration test, and vector error correction mechanism (VECM) techniques.

2. A BRIEF REVIEW OF PAST STUDIES

Apart from theoretical literature, a lot of empirical work has been done by the researchers on the associationamong these macroeconomic variables in India. Monetary economics focuses on the behavior of prices, monetary aggregates, interest rates, and output. Classical economists say that an increase in money supply does not influence output and there will be proportionate increase in prices while monetarists were of the view that an increase in the money supply will effect the output in the short run whereas in the long run only prices will increase proportionately.The empirical literature broadly shows causal relationship among GDP, inflation and money supply in many countries and also in India.

Malik and Khawaja (2006) investigate the causality of inflation, outputgap and real money in Pakistan for the period 1975-2003 using the Near-VAR approach. The Granger causality test is applied to test the direction of causality between inflation, and reserve money and real GDP. It is observed that inflation is caused by reserve money and inflation responds positively to monetary shocks whereas reserve money is caused neither by output gap nor by inflation. Similarly, reserve money does not cause output gap. The results show that effect of monetary policy transmits into inflation with a lag of half a year and another year to reach to the peak. The reserve money doesnot respond to lagged values of both inflation and output gap. The paper therefore argues that in deciding the stock of money each year, the central bank need not consider the past state of the economy.

Ahmed and Suliman (2011) examinethe long-run relationships among real GDP, money supply and price level for Sudan using annual data over the period 1960 to 2005employing the unit root test, cointegration test and Granger causality test. The unit root test results indicate that GDP and CPI are trend-stationary. The Granger causality test shows that there is unidirectional causation between money and prices in Sudan, the direction running from money supply from money supply to price.There is no reverse causation from price movements to money supply andalso from prices to national income. The study also observes no causation between real GDP and money supply.

Hussain (2014) aims to assess the relative effectiveness of monetary and fiscal policy on aggregate output in the five SAARC countries (Bangladesh, India, Nepal, Pakistan and Sri Lanka). The standard unrestricted VAR model over the period of 1974-2007 to examine the relationship between fiscal-monetary policies and output. The results reveal that money supply, government expenditure, the real exchange rate and foreign interest rate are cointegrated in all the countries.The findings of the study show that the effectiveness of fiscal and monetary policy differs from country to country, depending upon the nature and the structure of the institutional factors in each country.

In the Indian context, Rangarajan and Arif (1990) examine the relationship between money supply, output and prices covering the period of 1961-62 to 1984-85, focusing on the determination of money supply and its link with fiscal operations. The study observes that an increase in credit leads to monetary expansion which gives rise to inflationary tendencies and this inflationary impact of monetary expansion is neutralised by additional output via transmission mechanism with partial adjustment over time.

Das (2003) study the nature of the relationship between price, money supply and output in India, using the annual data for the years 1992-2000 and employing the time series models ofvector autoregression (VAR) and vector autoregression moving average (VARMA)model. The VARMA model isalso used to determine the nature of causality i.e. unidirectional or bidirectionalrelationship. The cointegration test suggests that money, price and output are not cointegrated i.e. no long-run relationship among these three variables for the period under consideration, a result that is against the general belief of the existence of long-run equilibrium relationship. The analysis suggests that money hasa positive causal effect on price and price has a causal effect on money, while both money and price affect output. There is also feedback between money and price and also between output and price.

Rami (2010) analyses the causality among narrow money (M_1) and broad money (M_3), price level (WPI)and output (GDP at factor cost) in India over the period covering 1951-2005 using the Granger causality test. The pairwise Granger causality test shows that money supply does not Granger cause WPI, WPI does not Granger cause money supply, money supply does not Granger cause output (GDP) and output (GDP) does not Granger cause money supply. The study observes that monetary policy, especially with regard to money supply, has limited implication for controlling inflation, and in fact, increasing money supply in India is due to the increase in the rate of inflationin India. Hence, money supply affects both output and inflation.

3. DATA AND METHODOLOGY

As the main objective of this paper is to understand the nature of long-run causal relationship among output, money supply and inflation in India, the a long period, 56 years from 1960 to 2016The annual time series data have been collected from theReserve Bank of India and World Bank Indicators websites on the variables considered are GDP, broad money (M3) and consumer price index (CPI).

When using the OLS estimation with such a long time series data, the problem of spurious regression between totally unrelated variables occurs due to the non-stationary process. Further, if the variables are cointegrated, there will be some linear combination of variables in the model. Therefore, the series has to be tested for stationarity and cointegration.TheAugmented Dickey-Fuller (ADF) test examines the stationarity of the time seriesfor unit root. If all the variables are stationary at the first difference I(1), then the long-run relationship is tested using the Johansen cointegration test and then estimated by the Vector Error Correction Mechanism (VECM). The direction of causality between the variables is tested by the Granger causality test. The variance decomposition method is used to evaluate the proportion of forecast error variance.

Augmented Dickey-Fuller (ADF) test: The ADF test for stationarity of the variables takes the following forms:

With constant term: $\Delta y_t = \beta_0 + \alpha y_{t-1} + \Sigma_{i=1}^{n} y_{t-i} + u_t$ (1)

With constant and trend : $\Delta y_t = \beta_0 + \beta_1 t + \alpha y_{t-1} + \Sigma_{i=1}^{n} y_{t-i} + u_t$ (2)

With no constant and trend: $\Delta y_t = \alpha y_{t-1} + \Sigma_{i=1}^{n} y_{t-i} + u_t$ (3)

The null hypothesis and alternative hypothesis of the ADF test are: H_o: $\alpha = 1$ and H_1: $\alpha < 1$. The null hypothesis states the presence of unit root that is, the series is non-stationary against the alternative hypothesis that the series is stationary. If the p-value is less than 0.05 at 5 percent levels of significance, the null hypothesis is rejected indicating that the series is stationary.

Cointegration test: The time series that must be differenced in order to render them stationary are referred to as integrated or stochastically trending series. Typically, linear combination of integrated process is also integrated. The residual from a regression of the two variables will be stationary. However, if a group of integrated variables share a common stochastic trend the linear combination will be non-integrated. The phenomenon of the elimination of a stochastic trend by an appropriate linear function is known as cointegration. Engle and Granger (1987) introduced the notion of cointegration and tied it closely to the VAR model. Johansen (1988) developed a cointegration test of VAR approach based on the of maximum likelihood method. If the test indicates that the variables are cointegrated, Vector Error Correction Mechanism (VECM) is done to obtain the rate of adjustment by the variables in the short run to achieve equilibrium in the long run. However, if the variables are not cointegrated, Vector Autoregressive (VAR) model is used to capture the contemporaneous affect among the variables.

According to the Johansen cointegration test, a p-dimensional VAR model, involving k-lags, can be specific as:

$$z_t = \pi_1 z_{t-1} + \cdots + \pi_k z_{t-k} + \varepsilon_t \quad (4)$$

Where z_t is (p x 1) vector of p potential endogenous variables and each of π_t (pxp) is a matrix of parameters and ε_t is the white noise term. The equation (4) can be formed in an error correction model (ECM) form:

$$\Delta z_t = \pi_1 z_{t-k} + \Sigma_{i=1}^{k-1} \gamma_i z_{t-i} + \varepsilon_t \quad (5)$$

where Δ is the first difference operator, π and $\gamma$are (pxp) matrices of unknown parameters and k is the order of the VAR translated into a log of k-1 in the ECM and ε_t is the white noise term. Johansen and Juselius (1990) show that the rank of r of $\pi$is equal to the no of cointegrating vectors in the system. When the rank of π is reduced, even if all the variables are individually I(1), the level based long-run component would be stationary. In this case, there are (p-1) cointegrating vectors and vector error correction model (VECM) methodology is to be used.

Johansen and Juselius (1990) have developed two likelihood ratio tests. The likelihood ratio test based on the trace test tests the null hypothesis of 'r' cointegrating vector(s) against the alternative hypothesis of more than 'r' cointegrating vectors. The Trace statistic is specified as:

$$\text{Trace statistic: } \lambda_{Trace(r)} = -T\,\Sigma_{i=r+1}^{k} \ln[1-\lambda] \quad (6)$$

$$\text{Maximum eigen value statistic: } \lambda_{\max}(r, r+1) = -T\ln(1-\lambda) \quad (7)$$

H_0: No cointegration (r=0) and H_1: presence of cointegration(r>0)

where λ^1_{r+1},....., λ^1_k are (k-r) number of estimated eigen values.The null hypothesis is that there is no cointegration against the alternative hypothesis of cointegration between the variables.

Causality test: If the two variable are I(1) and cointegrated, the Granger causality test is applied in the framework of the error correction mechanism (ECM). The Granger causality is based on the concept of causal ordering and is in the prediction sense rather than in a structural sense. As Granger (1969) puts it, 'the future cannot cause the past'; if event y occurs after event x, then y cannot Granger cause x. The two variables may be contemporaneously correlated by chance but is unlikely that the past values ofx will be useful in predicting y, given all the past values of y, unless x does actually cause y. A variable x is said to Granger cause another variable y if past values of x help predict the current level of y given all other appropriate information. Similarly, if y in fact causes x, then given the past history of y, it is unlikely that information on x will help predict y. The Granger causality test requires estimating the following pair of regression equations:

$$y_t = \Sigma_{i=1}^{p} \beta_{1i} x_{t-i} + \Sigma_{j=1}^{p} \beta_{2p+j}\, y_{t-j} + \varepsilon_{1t} \tag{8}$$

$$x_t = \Sigma_{i=1}^{p} \gamma_{1i} x_{t-i} + \Sigma_{j=1}^{p} \gamma_{2p+j}\, y_{t-j} + \varepsilon_{2t} \tag{9}$$

where p is the number of lags that adequately models the dynamic and the error terms are white noise. The error terms may, however, be correlated across equations. If the p parameters β_{2p+j} are jointly significant then the null that x does not Granger cause y can be rejected. Similarly, if the parameters β_{1i} are jointly significant then the null that y does not Granger causex can be rejected.

If the sets of x and y coefficients are not statistically significant in both the regressions, then the test suggests independenceof the variables. Conversely, unidirectional causalityfrom x to y is indicated if the estimated coefficients on the lagged x are statistically different from zero as a group i.e. $\Sigma\beta_{1i}\neq 0$) and the set of estimated coefficients on the lagged y is not statistically different from zero i.e. $\Sigma\beta_{2j+p}= 0$. On the other hand, unidirectionalcausalityfromy to x exists if the set of lagged x coefficients is not statistically different from zero i.e. $\Sigma\gamma_{1i}= 0$) and the set of the lagged y coefficients is statistically different from zero i.e.$\gamma_{2j+p}\neq 0$.

Optimal Lag Length: The determination of optimal lag length of variables for further analysis like cointegration test, VAR and are to be chosen on the basis of any one of the criteria like the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQIC).

Akaike's Information Criterion: The AIC compares the quality of a set of statistical models ranking them from best to worst. The best model will be the one that neither under-fits nor over-fits. The AIC is calculated as:

$$AIC = -2(log - likelihood) + 2K \tag{10}$$

where K is the number of model parameters. The log-likelihood is a measure of model fit.

Schwarz Information Criterion: The SIC (also SBC, SBIC) is a criterion for model selection among a finite set of models where the likelihood increases by adding parameters. The SIC is given by:

$$SIC = kln(n) - 2(\hat{L}) \tag{11}$$

where the likelihood $\hat{L} = p(x \mid \hat{\theta}, M)$ where M is the model, x are the data, and $\hat{\theta}$ are the to-be-inferred parameters of the model.

Vector Error Correction Mechanism: If cointegration is found to existbetween the variables, then error correction mechanism to the model dynamics is required as a third step to indicate the speed of adjustment from the short-run equilibrium to the long-run equilibrium state.A vector error correction model (VECM) is a restricted VAR for using with non-stationary series that are known to be cointegrated. VECM explains the adjustments in each time period towards its long-run equilibrium state when the equilibrium conditions are enforced. The error correction term derived from the cointegrating vector points out an independent direction where a stable meaningful long-run equilibrium state exists. The VECM has cointegration error correction relationship while allowing for short-run adjustment dynamics. The cointegrating term is the error correction term because of the deviation from the long-run equilibrium corrected progressively through a series of partial short-run adjustments. The speed of adjustment of any disequilibrium in the direction of a long-run equilibrium state is given by the size of the error correction term.

The general VECM can be specified as:

$$\Delta M3_t = \alpha_1 + \delta_1 ECT_{t-1} + \gamma_{1i}\Sigma_{i=1}^{n}\,\Delta M3_{t-1} + \varphi_{1i}\Sigma_{i=1}^{n}\Delta GDP_{t-1} + \omega_{1i}\Sigma_{i=1}^{n}\,\Delta CPI_{t-1} + v_t \tag{12}$$

$$\Delta GDP_t = \alpha_2 + \delta_2 ECT_{t-1} + \gamma_{2i}\Sigma_{i=1}^{n}\,\Delta GDP_{t-1} + \varphi_{2i}\Sigma_{i=1}^{n}\Delta M3_{t-1} + \omega_{2i}\Sigma_{i=1}^{n}\,\Delta CPI_{t-1} + v_t \tag{13}$$

$$\Delta CPI_t = \alpha_3 + \delta_3 ECT_{t-1} + \gamma_{3i}\Sigma_{i=1}^{n}\,\Delta CPI_{t-1} + \varphi_{3i}\Sigma_{i=1}^{n}\Delta M3_{t-1} + \omega_{3i}\Sigma_{i=1}^{n}\,\Delta GDP_{t-1} + v_t \tag{14}$$

where Δ represents the first difference operator. ECT_{t-1} is the error correction term which stands for the long-run relationship. The long-run causal relationship is pointed out by the negative and significant coefficient of the error correction term. When both the coefficients are significant, it implies bidirectional causality. When only one coefficient δ_1 is negative and significant, it evokes a unidirectional causality from x to y indicating that x drives y in the direction of long-run equilibrium but on in the opposite direction, and correspondingly, when only δ_2 is negative and significant, it points out a unidirectional causality from y to x implying that y drives x in the direction of long-run equilibrium but not in the opposite direction. Further, the short-run cause and effect relationship between two variables is pointed out by the lagged terms of Δy and Δx as explanatory variables. Hence, it is meant that x causes y only when the lagged coefficients Δy, become significant in the regression of Δx.

Variance Decomposition: Variance decomposition is used to evaluate the proportion of forecast error variance in one variable elucidated by innovations in itself and that of other variables. The result helps to isolate the variation in yinto two parts, thepart of variation that is explained by the changes of x (independent variables) and another part that is completely due to chance i.e. unexplained.

4. EMPIRICAL ANALYSIS

The Table 1 presents the definition and descriptive statistics of the variables used in the causal relationship among money supply, growth and inflation in India. All variables are measured in logarithm form. The mean of lnM3is 28.23, lnCPI is 2.99, lnGDP30.86.

Table 1
Descriptive Statistics of Variables in the Analysis of Relationship between Money Supply, Inflation and Growth

Variable	*Definition*	*Mean*	*Std. dev.*
lnGDP	Gross domestic product (Rs.)	30.86	0.86
lnM3	Broad money (Rs.)	28.23	2.53
lnCPI	Consumer price index	2.99	1.25

The variables are tested for stationarity using the Augmented Dickey-Fuller (ADF) unit root test at levels and at first difference. The Table 2 presents the results of ADF unit root test showing that lnM3, lnCPI and lnGDP are non-stationary at levels as their probability values exceed 0.05 leading to the acceptance of the null hypothesis that the series are non-stationary. However, they become stationary after taking the first difference and therefore, are integrated of order 1, that is the variables are I(1).

Table 2
Augmented Dickey-Fuller Unit Root Test

Variable	*At levels*	*At first difference*		
	With intercept	*With intercept*	*With trend and intercept*	*None*
M3	-2.915 (0.92)	-2.915* (0.00)	-3.817* (0.00)	-0.430 (0.67)
CPI	-2.916 (0.901)	-2.916* (0.00)	-5.822* (0.00)	-2.395* (0.02)
GDP	-2.914 (1.00)	-2.915* (0.00)	-8.331 (0.00)	-0.726 (0.47)

Note: p-values in parentheses. *Rejection of null hypothesis at 5 percent level.

The existence of long-run relationships among the variables GDP, broad money and consumer price index are tested with the Johansen cointegration test. The Table 3 presents the test results of trace statistic, eigen value statistic and the probability valuesto determine the number of cointegrating equations. The trace test points out that the existence of one cointegrating equation at 5 percent level of significance. The maximum eigen value test also confirms this result. Therefore, there exists a long-run equilibrium relationship among the three variables and in the short-run there may exist likely deviations from this equilibrium.

Table 3
Johansen Cointegration Test

Hypothesised no. of cointegrationequations	*Trace statistic*			*Eigen value statistic*		
	Trace statistic	*0.05 critical value*	*Prob.*	*Maximum eigen statistic*	*0.05 critical value*	*Prob.*
None	53.995*	29.798	0.000	39.105	21.131	0.0001
At most1	14.890	15.495	0.061	11.096	14.265	0.149
At most2	3.7954	3.841	0.051	3.795	3.841	0.051

Note: * indicates significance at 5percent level.

The Table 4 shows the optimal lag length is 4 as indicated by LR, FPE, AIC criteria. This suggests that in the VAR estimation, each variable is lagged by 4 periods and the equation for each endogenous variable is regressed on 4 lags of itself and other endogenous variables in the system.

Table 4
Optimum Lag Order Selection

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	-13.915	-	0.0004	0.651	0.763	0.694
1	326.366	628.211	1.13E-09	-12.091	-11.641*	-11.918
2	342.628	28.147	8.56E-10	-12.370	-11.582	-12.068*
3	350.604	12.883	8.99E-10	-12.331	-11.205	-11.899
4	364.602	20.998*	7.55E-10*	-12.523*	-11.060	-11.962
5	369.174	6.331	9.22E-10	-12.353	-10.552	-11.662

Note: * indicates lag order selected by the criterionat 5percent level.

Therefore, there is a need to verify whether the disequilibrium relationship meets the long-run equilibrium or not with short-run adjustments.The estimated cointegration equation is:

$$\ln M3(-1) = -5.115 - 0.614 \ln GDP(-1) - 0.419 \ln CPI(-1) \quad (15)$$
$$\qquad\qquad\qquad (2.83) \qquad\qquad\qquad (9.46)$$

Note: Absolute t-values in parentheses. Both variables are significant at 5 percent level.

The cointegration regression shows that there exists a long-run relation between money supply and its determinants. If there is any deviation from long-run relation, within a short period of time, the system has a tendency to come back to the original level. That is, if there is a change in inflation as a result of these variables, inflation will adjust in the next period - this percentage of correction is called the error correction model. Therefore, the VAR model is estimated including the error correction term (ECT) and with the lag length of four, which is determined by the AIC, for each variable in the system. The VECM estimates are presented in Table 5.

The estimated coefficient of the error correction term (ECT) in the money supply equationis negative and statistically significantindicating the existence of long-run relationship between the variables. The relative value of -0.053 shows the speed of adjustment of any short-run disequilibrium in money supply towards long-run equilibrium is 5.3 percent per year. That is, about 5.3 percent in deviations is corrected each year. However, in the CPI and GDP estimates, the estimated coefficients of the error correction term are significantly positive, showing that the error correction term contributes to changes in general price level and output.

In addition, the existence of Granger causality at least in one direction is implied by the existence of cointegration. The results show that there exists unidirectional causality from money supply to output and money supply to general price level in the long-run. The coefficient of the first difference of the CPI lagged by one period in money supply equation is statistically significant indicating the existence of short-run causality from price to money supply.The coefficient of GDP lagged by one periodin CPI equation is statistically significant implying the existence of short-run causality from output to price level. The coefficient of the first difference of the money supply lagged by three period in GDP equation is statistically significant indicating the existence of short-run causality from money supply to output.

The Table 6presents the results of Granger causality test among the macroeconomic variables, showing that the null hypothesis of lnGDP does not Granger cause lnM3 and lnM3 does not Granger cause lnGDP are rejected. Hence in the short-run, a bidirectional causality exists between

Table 5
VECM Estimates of Broad Money, CPI and GDP

Variable	*D(lnM3)*	*D(lnCPI)*	*D(lnGDP)*
ECT	-0.053** (2.52)	0.084*** (2.58)	0.093*** (4.39)
D(lnM3 (-1))	0.309** (1.99)	0.479** (1.98)	-0.042 (0.26)
D(lnM3(-2))	0.515*** (3.33)	-0.146 (0.61)	0.190 (1.23)
D(lnM3(-3))	0.132 (0.86)	-0.382 (1.60)	-0.368** (2.38)
D(lnCPI(-1))	-0.197** (2.12)	0.372*** (2.58)	0.091 (0.97)
D(lnCPI(-2))	0.115 (1.19)	-0.135 (0.89)	0.014 (0.14)
D(lnCPI(-3))	-0.060 (0.73)	-0.029 (0.23)	0.285*** (3.50)
D(lnGDP(-1))	0.213* (1.74)	-0.699*** (3.66)	-0.082 (0.66)
D(lnGDP(-2))	0.056 (0.40)	-0.340 (1.56)	-0.240* (1.70)
D(lnGDP(-3))	0.193 (1.37)	-0.073 (0.33)	-0.133 (0.94)
Constant	-0.007 (0.24)	0.124*** (2.76)	0.078*** (2.69)
Adj. R-square	0.416	0.312	0.354
F-value	4.701	3.362	3.849
AIC	-4.399	-3.514	-4.381
SIC	-3.990	-3.105	-3.972

Note: Absolute t-values in parentheses. *** significant at 1 percent level ** significant at 5 percent level * significant at 10 percent level.

money and output. The null hypothesis of lnCPI does not Granger cause lnM3 and lnCPI does not Granger cause lnGDP are rejected, showing unidirectional causation between price level and money supplyand between money supply and output.

Table 6
Pair-wise Granger Causality Test

Null Hypothesis	*F-statistic*	*Probability*	*Decision*
lnCPIdoes not Granger cause lnM3	2.069	0.117	Accept null hypothesis
lnM3 does not Granger cause lnCPI	4.119*	0.011	Reject null hypothesis
lnGDP does not Granger cause lnM3	2.116	0.111	Accept null hypothesis
lnM3 does not Granger cause lnGDP	0.776	0.513	Accept null hypothesis
lnGDP does not Granger cause lnCPI	2.932*	0.043	Reject null hypothesis
lnCPI does not Granger cause lnGDP	0.533	0.662	Accept null hypothesis

Note: * indicates significance at 5 percent level.

The variance decomposition is used in the study to evaluate the proportion of forecast error variance in one variable elucidated by innovations in itself and that of other variables. The variance decomposition implies that the shocks in money supplyin year 1 accounted for 100 percent variation in itself, the shocks in fifth year lag accounts for 93.5 percent of variance in money supply, 0.6 percent of the variance in price level and 5.77 percent of variance in output. In the tenth lag period 92.83 percent of shocks in money supply has been explained by itself, by 1.9 percent of variance in price level and 5.2percent of variance in output. For the price level, the firstyear shock to itself account for 98 percent variation in itself while shocks to money supply accounts for 1.8 variation, and in 10th year, 85 percent of variation is observed in itself, while shocks money supply accounts for 3 percent of variation in CPI. In output growth variation, in first year 87 percent of variation is due to itself, in the 10th year, a shock in money supply accounts to 20 percent of variation in GDP and a shock to CPIaccounts to 31 percent variation in economic growth.

Table 7
Variance Decomposition

Period	*Standard error*	*lnM3*	*lnCPI*	*lnGDP*
Variance decomposition of lnM3				
1	0.0245	100.000	0.000	0.000
2	0.0415	95.661	2.453	1.886
3	0.062	94.748	1.467	3.786
4	0.085	93.605	1.016	5.379
5	0.108	93.595	0.629	5.775
6	0.131	93.666	0.538	5.796
7	0.154	93.559	0.743	5.697
8	0.176	93.422	1.079	5.498
9	0.198	93.194	1.460	5.345
10	0.218	92.839	1.921	5.240
Variance decomposition of lnCPI				
1	0.038	1.802	98.197	0.000
2	0.068	1.011	92.4212	6.567
3	0.087	1.675	85.885	12.439
4	0.098	1.345	85.520	13.134
5	0.105	1.619	85.867	12.514
6	0.109	2.428	85.517	12.055
7	0.114	2.836	85.653	11.511
8	0.120	3.166	86.019	10.814
9	0.128	3.607	85.987	10.406
10	0.135	3.995	85.763	10.243

contd. table 7

Variance decomposition of lnGDP				
1	0.45	2.406	9.809	87.785
2	0.033	3.411	11.615	84.973
3	0.039	10.228	16.371	73.400
4	0.0433	9.046	16.054	74.900
5	0.047	10.692	14.964	74.344
6	0.052	14.192	18.869	66.939
7	0.059	14.969	24.088	60.943
8	0.068	16.275	27.535	56.190
9	0.078	18.513	30.063	51.424
10	0.0873	20.982	31.558	47.460

5. CONCLUSION

This paper examines the causal relationship among money supply, inflation and price level in India using a long series data from 1960 to 2016. The study uses econometric methodology such as the ADF unit root test, Johansen cointegration test, Granger causality test and vector error correction techniques to investigate the long-run and short-run causality among the macroeconomic variables in India. The ADF test results show that the variables are non-stationary at levels but stationary at first difference without trend. The Johansen cointegration test shows cointegration among the variables. Therefore, this paper estimates the VECM model to analyse the long-run causality among the variables. The direction of causality is detected using the Granger causality test. The Granger causality test reveals that a directional causality exists between money and output, and unidirectional causation between inflation and output. The estimated empirical results of cointegration show that there is one cointegrating equation at 5percentlevel of significance meaning that there is long-term stable relationship among the three variables -price level, output and inflation. The VECM results show short-run causality from money supply to price level. The speed of adjustment or correction of any short-run disequilibrium in money supply towards long-run equilibrium is 5.3 percent per year.

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