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DYNAMICS OF INFLATION, ECONOMIC GROWTH, MONEY SUPPLY AND EXCHANGE RATE IN INDIA: EVIDENCE FROM MULTIVARIATE ANALYSIS

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ABSTRACT

The present study investigates the dynamics of inflation, GDP and exchange rate and money supply in India for the period 1975-2012. The data source is cumulated from the Reserve Bank of India (RBI) Handbook of Statistics 2012. The empirical findings of the study show that there is a long-run equilibrium relationship exist among the variables. The result also suggest that money supply has a positive effect on GDP growth in India. The result of error correction indicates that correct and negative sign for Gross Domestic Product and exchange rate. The behavior of GDP implies there is no problem of adjustment in the long run in case of shocks in the short run. The VECM Granger causality confirms that unidirectional causality from GDP to inflation and exchange rate to inflation. The result also found that exchange rate Granger causes both GDP and money supply at 10 percent level of significance. The impulse response result shows that GDP has a positive response to money supply from the occurrence to the end of the period. Whereas the response of exchange rate to money supply negative in the whole lag period. The variance decomposition result explainss that no significant part of variance is caused by money supply. The result also reveals that cyclical variance of GDP caused by money supply, exchange rate, and inflation.

Keywords: Inflation, Economic growth, Cointegration, Vector error correction, Causality, India.

JEL Classification: E4, E6.

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Contribution/ Originality

This study is one of very few studies which has investigated the growth inflation relationship in the context of India in a new approach using VAR model.

1. INTRODUCTION

The relationship between inflation and growth has been debated much (Barro, 1995; Ghosh and Phillips, 1998; Gillman *et al.*, 2004). High economic growth and low inflation is the objective of every economy. Like many countries in the world, India also focuses on sustaining high growth with low inflation. The common objective of the macroeconomic policy is a low inflation rate, which usually creates an environment conducive to economic growth (Fischer, 1993). Various economists are recommending that macroeconomic stability, particularly defined as the low rate of inflation is positively related to economic growth. Both high and persistent inflation imposes negative spillover effects on the smooth functioning of the economy. The negative externality of inflation comes into the picture in the way on economy's efficiency. Inflation creates more burdens on the cost of living which severely affect the life of common man. The Inflationary situation leads to uncertainty of investment which has a long gestation period. The increase in price variation induces the cost of production, as a result of which it affects the profit rate negatively. Inflation also affects the international competitiveness at the time of increases in the cost structure and the price level. High inflation undermines the confidence of domestic and foreign investors about the future monetary policy. Moreover, inflation also highly affects the other determinants of growth, investment, and vitality of the country.

By the above discussion, this study briefly examines several economic theories and empirical studies to assess the effects of inflation on economic growth, and then it verifies whether a long-run relationship exists between the macroeconomic variables in India. They are like Classical, Keynesian, New Keynesian, and Monetarist, neoclassical and endogenous theories, Structuralist theories, cost-push theories, open economy models and the Phillips curve. The classical economist gave more importance to the supply side theories. The importance of the supply side theory is the need for incentives to save and invest if the economy is to grow to deal with different factors of production such as land, labor and capital. Keynesian and neo-Keynesian theories have developed a significant relation for linking inflation to growth the aggregate demand (AD) and aggregate supply (AS) model. The monetarist theory emphasized that the role of monetary growth in determining the rate of inflation. While, neoclassical and endogenous growth theories emphasize the effect of inflation on economic growth through its impact on investment and capital accumulation, structuralists theory deals with the structure of the economy which can lead to certain bottlenecks in the process of growth which leads to inflationary price rise. The important determinant of this inflation is that institutional features and the structure of the economy. The cost-push model explains that the impact of cost-push factors which generates inflationary situations. The open economy models suggest that the increase in the money supply for an individual country leads to an increase in world money stock, which then it transmitted to world prices. This model also shows that any increase in world prices of the tradable for a given rate of productivity will affect the prices of non-tradable, through a hike in wage costs. Phillips (1958) defines the relationship between inflation and unemployment, which indicates that there is a negative relationship between inflation and unemployment. Traditional economic thoughts account the behavior of monetary policy makers as an exogenous factor. The present scenario of inflation states as a monetary phenomenon which indicates that there would be no inflation without a continuous increase in money supply. It concluded that long run price stability could be achieved by reducing the growth rate of money to the long-run growth rate of the economy. Besides this, to maintain higher economic growth, it is necessary and sufficient to reduce the rate of inflation for price stability and achieving high economic growth.

The structure of this study is presented in the following manner. Section 2 presents Literature review, Section 3 presents the econometric models and the data, section 4 deals with the results and discussion, and in the last section 5, we have explained the conclusion and policy implications of the study.

2. REVIEW OF LITERATURE

Barro (1995) investigates the relationship between inflation and economic growth in a sample of 100 countries over the period 1960 to 1990. Using the instrumental variables method, he finds that there is a negative and significant impact of long-term inflation on the economic performance of these countries and because of a higher level of persistent inflation, the pace of economic growth and investment reduces. Sarel (1995) examines a nonlinear effect of inflation on economic growth in 87 countries during the period 1970 to 1990 and concludes that there is no significant and negative impact of inflation on growth while inflation is low, but higher inflation causes a negative impact on economic growth. Applying OLS, he also estimates that during structural breaks in the economy, the impact of inflation increases by a factor of three. Andres and Ignacio (1999) examine the correlation between growth and inflation of the OECD countries and to discuss whether this correlation withstands. The main empirical finding of this paper is that current inflation has never been found to be positively correlated with income per capita over the long run. Overall, this result indicates that the long-run costs of inflation are non-negligible and that efforts to keep inflation under control will sooner or later payoff regarding better long run performance and highest per capita income. Following cointegration and error correction. Shitundu and Luvarda (2000) investigated the relationship between inflation and economic growth in the context of Tanzania. By employing the Least Trimmed Squares (LTS) method, the study found that inflation has been harmful and negatively affect the economic growth in Tanzania. Boyd (2001) finds a negative relationship between inflation and financial performance in 97 countries over the period 1960 to 1995. The OLS results suggest a negative and significant association between financial sector reform and inflation in these 97 countries. Gylfason (2001) investigates inflation and economic growth in 170 developing and developed countries for the period 1960 to 1992. The results of the study find a statistically and robust relationship between inflation and growth in both the countries. Applying OLS technique they confirm the earlier studies of the negative and significant association between inflation and economic growth in such countries. Mashiri and Sepehri (2004) examined the inflation-growth relationship comparing the data set for 54 countries 26 lower middle-income countries and 28 low-income countries. The empirical findings of the study suggest that there is a negative relationship exist between inflation and economic growth. Gokul and Hanif (2004) studied the relationship between inflation and economic growth in the context of Fiji. The empirical result suggests that there is a weak and negative correlation exists between inflation and economic growth. Saaed (2007) examined the inflation-growth relationship in the context of Kuwait covering the period from 1985 to 2005. The result found that there is a long run and a strong inverse relationship exist between inflation and economic growth. Khan and Senhadji (2001) examine the threshold level inflation in the context of India taking both annual and quarterly data for the period of 1971 to 2009 and 1996: Q1 to 2009: Q3. The empirical findings of the study suggest that the threshold level inflation in India is 6 percent beyond which inflation affects growth negatively. Bhaduri (2013) analyzed the nexus between inflation and economic growth in the context of Indian economy. The used the wavelet analysis with varying time scale decomposition suggests a strong and persistent negative relationship between growth and inflation for a short time scale. Eaboyka and Okuyan (2008) explored the relationship between inflation and economic growth in Turkey. By using the ARDL method, the study found that there is a unidirectional causal relationship running from inflation to economic growth. The result also shows that there is no long-run relationship, but a negative statistical significant short-run relationship has been found. Behera (2014a) investigated the relationship between inflation and economic growth in the context of South Asian countries for the period of 1980-2012. By employing the cointegration technique, the study found that there is a long-run relationship exist in the context of Malaysia. However, the rest of the country fails to establish the long-run relationship between inflation and economic growth. Behera (2014b) examined the relationship between inflation and GDP growth in seven South Asian countries for the period of 1980-2013. By using the Pedroni panel cointegration methodology, the study found that there is a long-run equilibrium relationship between inflation and GDP growth in all the South Asian countries. The result also reveals that there is a unidirectional causality between CPI and GDP in the context of all South Asian countries. Behera and Mishra (2016) examined the inflation growth nexus in BRICS. By employing the ARDL econometric technique, the study found that there is a unidirectional causality from inflation to economic growth in the context of India and bidirectional causality in the context of China. The result also reveals that a long run positive relationship between inflation and economic growth only for China and South Africa.

3. DATA AND PERIOD OF THE STUDY

This study used the annual time series data covering the period from 1975-2012. The variables like Wholesale Price Index (WPI), real effective exchange rate (REER), money supply (M_3) and real Gross Domestic Product (GDP) are collected from RBI (Reserve Bank of India) Handbook Book of Statistics on Indian Economy 2012-13.

All the variables are adjusted 2004-05 base year. To find out the relationship between inflation and economic growth the study has employed various econometric techniques like unit root test, Granger causality, cointegration, vector error correction model, impulse response function and variance decomposition analysis.

4. MODEL SPECIFICATION

To investigate the long-run relationship between the variables the study used the following econometric model.

$$lnGDP_t = \alpha_1 + \beta_1 lnMS_t + \beta_2 lnINF_t + \beta_3 lnER_t + \varepsilon_t \quad (1)$$

Where, GDP is Gross Domestic Product; MS, INF, and ER denote, respectively, annual money supply (M_3), inflation and real effective exchange rate. ε is the disturbance term in the model.

4.1. Model Specification

4.1.1. Unit Root Test

Stationary test plays a significant role in the time series analysis. In this study to examine the stationary properties of the time series data the study employed both Augmented Dickey-Fuller and Phillip Perron test. The stationary test helps to avoid bias and the spurious result which leads to misleading conclusions. To eliminate this problem, the study conducted the unit root test.

$$\Delta Y_t = \alpha + \alpha_2 Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + \varepsilon_t \quad (2)$$

Where Y is the choice variable; Δ is the first difference operator; αi (for i= 1& 2) and β_i (for i=1, 2….p) are constant parameters; and ε_t is a non-stochastic error term. The lags have been chosen by Akaie Information Criteria (AIC). To determine the order of integration of a particular series, the equation has to be modified and include the second difference on lagged first and p lags of second differences which follow

$$\Delta^2 Y_t = \theta_1 \Delta Y_{t-1} + \sum_{i=1}^{p} \theta_i \ \Delta^2 Y_{t-1} + \epsilon_t \quad (3)$$

Where, Δ^2 is the second difference operator; $\theta_1$and $\theta_1$are constant parameters; ϵ_t is a stationary stochastic process. Due to inclusion of difference lagged term, i.e. 'p' the error term (ε_t and ϵ_t) in the respective equations is serially independent. Test stationarity The Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1981; Phillips and Perron, 1988) test are applied to equations 2 and 3. The null hypothesis are H_0: $\alpha_2 = 0$ against H_0: $\alpha_2 \neq 0$ and H_0: θ_1=0 against H_0: $\theta_1 \neq 0$ respectively, which signifies non-stationary of both Y_{t-1} and ΔY_{t-1}. In order to understand the time series properties of the variables in the study, we have carried out the unit root test analysis proposed by Dickey and Fuller (1981). We have applied both ADF +and PP test to estimate the order of integration of the variables.

4.2. Lag Length Selection Criteria

The lag length selection for the VAR (P) model may be determined using model selection criteria. The general approach is to fit VAR (P) models with orders P=0, …, 0_{max} and choose the value of P which minimizes some model selection criteria. Model selection criteria for VAR (P) models have the form.

$$\ln(p) = \ln\left|\widetilde{\sum(p)}\right| + C_r.\varphi\ (n,p)$$

$\widetilde{\Sigma(p)} = T^{-1} \sum_{T=1}^{T} \hat{\varepsilon_t} \hat{\varepsilon_t}$ is the residual covariance matrix without a degree of freedom correction from a VAR (p) model, T is a sequence indexed by the sample size T, and (n, p) is a penalty function which penalizes large VAR (P) models.

The three most common information criteria are the Akaike (AIC), Schwarz-Bayesian (BIC) and Hannan-Quinn (HQ);

$$AIC\ (p) = \ln\left|\widetilde{\sum(p)}\right| + \frac{2}{T}\ pn^2$$

$$BIC(p) = \ln\left|\widetilde{\sum(p)}\right| + \frac{lnT}{T}\ pn^2$$

$$HQ\ (p) = \ln\left|\widetilde{\sum(p)}\right| + \frac{2\ln lnT}{T}\ pn^2$$

Where AIC overestimates the order with positive probability asymptotically, the BIC and HQ criteria estimate the order consistently under fairly general conditions if the true order p is less than or equal to p_{max}.

4.3. The Cointegration Approach

The next step in our model selection is to test for cointegration. If the variables are considered to be I (1), the cointegration method is appropriate to estimate the long run equilibrium relationship between GDP growth and other variables. The concept of cointegration is that non-stationary time series are cointegrated if a linear combination of these variables is stationary. The coinetgration requires the error term in the long run relation to be stationary.

Assume that in case of two variables Y_t and X_t and both Y_t and X_t follows I (1) process. The linear commination $U_t = Y_t - \alpha X_t$ is I (0). If so, both Y_t and X_t are said to be cointegraed and α is the cointegrated parameter. The maximum likelihood approach to test for cointegration is based on the equation given below.

$$\Delta y_t = \pi X_{t-1} + \sum_{i=1}^{p-1} \pi_i\ \Delta X_{t-1} + \varepsilon_t \qquad (4)$$

In the above equation the number of independent cointegrating vectors is equal to the rank of matrix π, if $\pi = 0$, then π is a null matrix and equation turns out to be a VAR model where as if rank of $\pi = 1$, there is a one cointegrating vector and πX_{t-1} is an error correction term, Johansen suggest that it can be done by testing the significance of characterized roots of π. Let rank $\pi = 0$, then $\lambda_i = 0$; hence, ln $(1-\lambda) = 0$ whereas, if rank of π =unity then $0 < \lambda_1 < 1$ and ln $(1-\lambda_1)$ will be negative and the rest ln $(1-\lambda_2) = 0$. Johansen suggests two test statistics to test the null hypothesis that number of characteristics roots is significantly different from unity.

$$\lambda_{trace}\ (\pi) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right)$$

$$\lambda_{max}\ (r, r+1) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_{r+1}\right)$$

λ_i= estimated characteristics roots are Eigen values.

T= the number of usable observations

λ_{trace} test the null hypothesis, r=0 against the alternative of r>0

λ_{max} test the null hypothesis r=0, against the alternative of r=1

The theory expressed in equation (1) asserts that there exists a linear combination of this no stationary that is stationary. Solving the error term, we can rewrite the equation (1) as

$$\hat{\varepsilon_t} = lnGDP_t - \alpha - \hat{\beta}_0 lnMS_t - \hat{\beta}_1 lnINF_t - \hat{\beta}_2 lnER_t \qquad (5)$$

Where, $\hat{\varepsilon_t}$ is estimates error term from the original equation 1.

4.4. VECM approach to Granger Causality Approach

The co-integration result indicates the presence of Error Correction Model (ECM). Thus, the VECM is tested. This indicates short-run dynamics of the model. The ECM combines the short-run and the long run relationship between variables. The dynamic relationship can estimate through the inclusion of lagged values of residuals from cointegrating regression (t-1) in addition to the first difference of the variables which appears on the right-hand side of the long run relationship (GDP, MS, INF, ER). Variables included from the long run relationship would capture short-run dynamics.

The ECM can be defined as

$$= \begin{pmatrix} \Delta LNGDP_t \\ \Delta LNIFN_t \\ \Delta LNMS_t \\ \Delta LNER_t \end{pmatrix} \begin{pmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{pmatrix} + \sum_{J=1}^{P} \begin{pmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \end{pmatrix} \begin{pmatrix} \Delta LNGDP_{t-1}\ \Delta LNINF_{t-1}\ \Delta LNMS_{t-1}\ \Delta LNER_{t-1} \\ \Delta LNINF_{t-1}\ \Delta LNGDP_{t-1}\ \Delta LNMS_{t-1}\ \Delta LNER_{t-1} \\ \Delta LNMS_{t-1}\ \Delta LNGDP_{t-1} \Delta LNINF_{t-1} \Delta LNER_{t-1} \\ \Delta LNER_{t-1}\ \Delta LNGDP_{t-1} \Delta LNINF_{t-1} \Delta LNMS_{t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} \emptyset_1 \\ \emptyset_2 \\ \emptyset_3 \\ \emptyset_4 \end{pmatrix} \begin{pmatrix} \varepsilon_{1t-1} \\ \varepsilon_{2t-1} \\ \varepsilon_{3t-1} \\ \varepsilon_{4t-1} \end{pmatrix} \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \\ \epsilon_4 \end{pmatrix}$$

Where, ξt s are white noise errors and λs are the speed of adjustment parameters. α, β, ψ and Φ are short-run parameters. In the ECM all the above variables are stationary. Hence ECM is free from spurious regression problem.

4.5. Impulse Response Function

Impulse response function (IRF) of a dynamic system is its output when presented with a brief input signal, called an impulse, more generally, an impulse response refers to the reaction of any dynamic system in response to any external change. A VAR was written in vector MA infinite from as.

$$Y_t = \mu + \varepsilon_t + \psi_1 \varepsilon_{t-1} + \psi_1 \varepsilon_{t-2} + \qquad (6)$$

Thus, the matrix ψ_s has the interpretation $dy_{t+s}/d\varepsilon_t = \psi_t$that's the row 1th column J element of ψ_s identifies the consequences of 1 unit increase in the jth variables. Innovation of data t (ε_{jt}) for the value of the ith variable time t+s (y_{it+s}) holding all other innovations at all data's constant. $dy_i t + s/d\varepsilon^1 jt$ as a function 's' is called an impulse response function. It describes the response j_{it+s} for a one time impulse in y_{jt} with all other variables dated t or earlier held constant.

Impulse response traces out the response of current and future values of each of the variables to one unit increase in the current value of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero. Specifically, an impulse response function refers to the reaction of any dynamic system in response to some external change. The impulse response function of a dynamic system is its output when presented with the brief input signal, called impulse. More specifically, an impulse response refers to the reaction of any dynamic system in response to some external change. In both cases, the impulse response describes the reaction of the system as a function of time.

5. RESULTS AND DISCUSSIONS

Table -1. Unit Root Test

Variables	ADF Test		PP Test	
	Level	First Difference	Level	First Difference
LNGDP	4.94 (1.00)	-5.65* (0.00)	-3.08 (1.00)	4.77* (0.00)
LNINF	-1.28 (0.62)	-4.21* (0.00)	-0.93 (0.76)	-4.23* (0.00)
LNER	-1.54 (0.49)	-4.75* (0.00)	-1.55 (0.49)	-4.77* (0.00)
LNMS	-1.22 (0.65)	-5.48* (0.00)	-1.22 (0.65)	-5.50* (0.00)

Note: The ADF and PP test is based on critical 't' statistics. ( ) Parenthesis indicates P-values. '*' indicates variables are significant at the 1% level of significance.

The reported result in Table 1 shows that the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) test. The result of the unit root test shows that the null hypothesis of the unit root can't be rejected in all variables in the level. However, the hypothesis of unit root is rejected in the first difference at the convenient significant level. Which indicates that all variables are integrated of degree one I (1). That means the variables have achieved stationary after first difference.

The resulting lag structure is reported in the following table 2. Here the optimal lag is taken into consideration for the analysis.

Table-2. Lag Order Selection Criteria

Lag	LR	FPE	AIC	SBC
0	NA	2. 19	-10.89	-10.71
1	364.31	1.98	-22.51	-21.61*
2	28.68*	1.68*	-22.71	-21.10
3	20.01	1.96	-22.73*	-20.39

Note: '*' denotes lag order selected by the criterion

LR: Sequential Modified LR Test Statistics (each test at 5% level)

FPE: Final Prediction Error

AIC: Akaike Information Criteria

SBC: Schwarz Besiayan Criteria

Table-3. Cointegration Analysis

Unrestricted Cointegration Rank Test (Trace)				
Null Hypothesis	**Eigen value**	**Trace Statistics**	**0.05 C.V.**	**Prob. *** **
r = 0*	0.53	55.50	47.85	0.00
r ≤ 1	0.48	29.54	29.79	0.23
r ≤ 2	0.18	6.97	15.49	0.58
r ≤ 3	0.00	0.15	3.84	0.68
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Null Hypothesis	**Eigen value**	**Max-Eigen Statistics**	**0.05 C.V.**	**Prob. *** **
r = 0	0.53	25.96	27.58	0.25
r ≤ 1**	0.48	22.57	21.13	0.03
r ≤ 2	0.18	6.81	14.26	0.51
r ≤ 3	0.00	0.15	3.84	0.68

Note: * and ** denotes the rejection of the null hypothesis at the 1% and 5% level of significance respectively, and *** indicates Mackinnon –Haug-Michelis (1999) p-values.

The above table 5 reported the cointegration result, the result of the table shows that the null hypothesis of no cointegration is rejected at the conventional level of significance at 1% and 5% and conclude that there is a long-run equilibrium relationship exist among the variables. Where the trace statistics and Eigen value indicate strong evidence of one cointegrating vector in the variables of our study.

Table -4. Normalized Cointegration Coefficients

Variables	Coefficients	Standard errors	t-statistics
LNGDP	1.00	-----	----
LNIFN	-5.87	(1.77)	[-3.30]
LNER	-3.36	(0.96)	[-3.49]
LNMS	1.59	(0.69)	[2.28]

Source: Authors estimation

The long-run regression results of is shown in Table 4. From the Table 4, it is evident that there is negative and significant negative relationship between GDP, inflation, and exchange rate. Both exchange rate and inflation have a negative impact on GDP. One percent changes (increase) in inflation lead to 58 percent decrease in economic growth (GDP) and one percent in increase in the exchange rate will have 33 percent decline in economic growth. Money supply has a positive and significant impact on GDP. Here the long-run relationship cannot speak mush about the dynamics of the variables both in short-run and long-run.

Table-5. Error Correction Mechanism

	LNGDP	LNIFN	LNER	LNMS
	-0.04	0.03	-0.00	0.00
CointE	(0.01)	(0.01)	(0.03)	(0.01)
	[-4.46]	[2.63]	[-0.17]	[0.35]

Note: p is in parenthesis and t values in brackets

Table 5 reported the error correction result which confirms the cointegration results and indicates the presence of error correction term for Gross Domestic Product and inflation. The error correction result shows that correct negative sign for Gross Domestic Product and Exchange rate. The values of Gross Domestic Product and inflation is significant where the exchange rate is not significant. However, money supply and inflation show no significance for adjustment as their coefficients are not negative. The behavior of the variables of GDP implies there is no problem for adjustment in the long run in case of shock in the short run, that is, considerable high-speed adjustment to long run equilibrium every year after short run shock. It presents that 0.04 previous disequilibrium of GDP has been removed in the present period which needs adjustment to bring back to the equilibrium path.

Table-6. Granger Causality Using VECM

	LNGDP	LNIFN	LNER	LNMS
ΔLNGDP (-1)	-0.111234	-0.146857	-0.439148	0.080698
	(0.19593)	(0.24640)	(0.62385)	(0.21622)
	[-0.56771]	[-0.59601]	[-0.70394]	[0.37322]
ΔLNGDP (-2)	-0.200362	0.454417	-0.140673	0.113997
	(0.16792)	(0.21117)	(0.53466)	(0.18531)
	[-1.19311]	[2.15186] ***	[-0.26311]	[0.37322]
ΔLNIFN (-1)	0.184151	0.316096	-0.618800	-0.153711
	(0.15518)	(0.19515)	(0.49409)	(0.17125)
	[1.18670]	[1.61976]	[-1.25242]	[-0.17125]
ΔLNIFN (-2)	-0.156494	0.319088	0.328634	0.017431

	(0.13469)	(0.16938)	(0.42885)	(0.14864)
	[-1.16187]	[0.82114]	[0.76631]	[0.11727]
LNER (-1)	-0.071044	0.155666	0.287571	0.040448
	(0.06826)	(0.08585)	(0.21735)	(0.07533)
	[-1.04073]	[1.81332] ***	[1.32309]	[0.53693]
LNER (-2)	-0.135926	-0.137665	-0.216559	-0.154941
	(0.07092)	(0.08919)	(0.22582)	(0.07827)
	[-1.91653] ***	[-1.54349]	[-0.95900]	[-1.97964]***
ΔLNMS (-1)	0.146294	0.187468	0.012249	0.027022
	(0.19948)	(0.25087}	(0.63515)	(0.22014)
	[0.73336]	[0.74729]	[0.01929]	[0.12275]
ΔLNMS (-2)	0.182531	-0.281589	-0.000451	0.107773
	(0.17635)	(0.22177)	(0.56148)	(0.19461)
	[1.03507]	[-1.26975]	[-0.00080]	[0.55380]
Constant	0.007162	0.016361	0.017519	0.058183
	(0.01855)	(0.02333)	(0.05906)	(0.02047)
	[0.38610]	[0.70135]	[0.29663]	[2.84229]

The standard error is in parenthesis and t-value in brackets. *, ** and *** presents significance level at 10%, 5% and 1%.

The reported result in table 6 observes that there is unidirectional causality running from GDP to inflation and exchange rate to inflation. The result also reveals exchange rate Granger causes both GDP and money supply at the 10% level of significance.

Table-7. Diagnostic Test of the VECM

Statistics	1	2	3	4
Serial Correlation	6.22	10.63	24.49	37.07
X^2 (LN)	16.56	16.32	13.67	11.94
Normality Test (Jarque Bera)	0.90	4.19	0.95	0.22
R^2	0.56	0.57	0.14	0.27
F	3.53	3.65	0.46	1.00

Source: Authors estimation

The diagnostic test of the VECM model presented in Table 7 presents structural stability of the model, no specification errors, the normality of the residuals and homoscedasticity. The model is free from all errors and hence explores all the dynamics of the variables without delay.

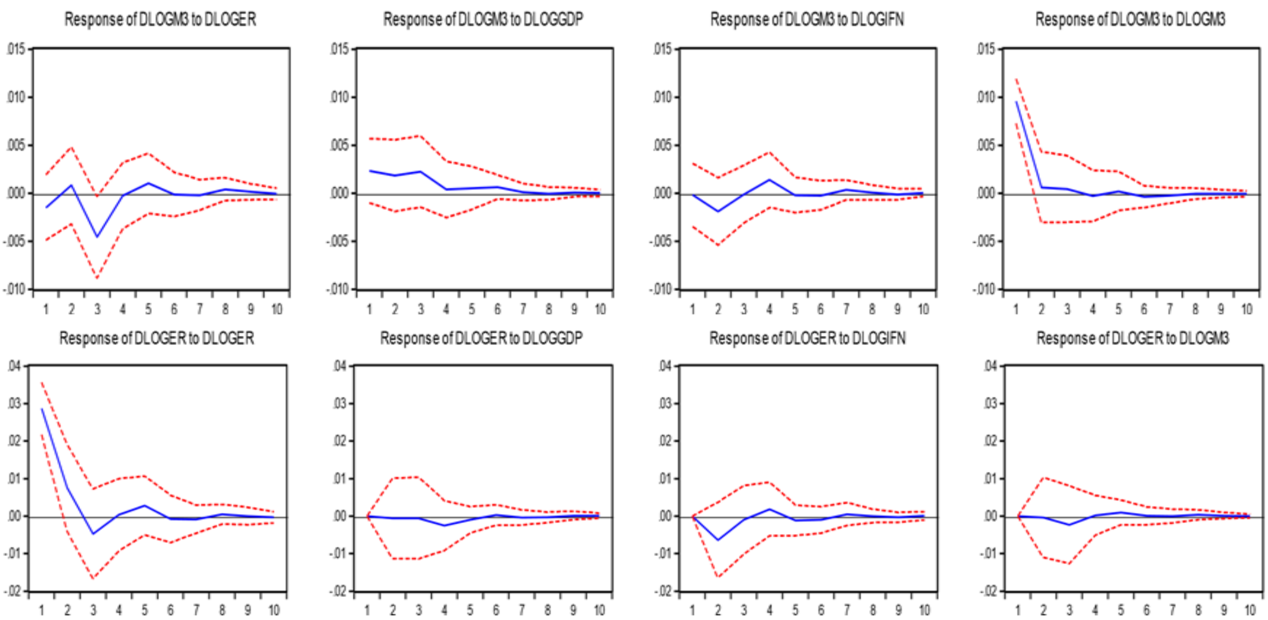
Table-8. Variance Decomposition

		VDC of GDP				VDC of INF				VDC of ER				VDC of MS		
	GDP	IFN	ER	MS	GDP	IFN	ER	MS	GDP	IFN	ER	MS	GDP	IFN	ER	MS
1	97.27	0.00	2.72	0.00	28.39	71.43	0.16	0.00	0.00	0.00	100	0.00	5.30	80.03	2.24	92.33
2	80.30	11.85	4.50	3.34	35.91	53.95	0.45	9.72	0.04	4.44	95.49	0.01	8.05	3.44	2.68	85.81
3	79.34	11.69	5.53	3.41	30.22	45.86	14.54	9.36	0.07	4.41	94.92	0.58	10.25	2.77	17.88	69.08
4	78.33	11.44	5.90	74.24	26.47	42.32	22.59	8.60	0.06	4.72	93.93	0.58	10.18	4.13	17.65	68.03
5	77.73	11.98	5.92	4.35	26.21	42.21	22.33	9.23	0.85	4.81	93.65	0.66	10.17	4.11	18.22	67.37
6	77.29	11.91	6.45	4.33	26.32	42.05	22.35	9.29	0.86	4.91	93.55	0.66	10.51	4.14	18.16	67.17
7	77.26	11.94	6.45	4.34	26.22	41.70	22.86	9.20	0.87	4.93	93.52	0.66	10.50	4.21	18.25	67.11
8	77.22	11.95	6.47	4.35	36.19	41.70	22.84	9.20	0.88	4.93	93.50	0.67	10.49	4.21	18.25	67.03
9	77.20	11.95	6.49	4.35	26.20	41.70	22.85	9.19	0.88	4.94	93.49	0.67	10.49	4.22	18.25	67.02
10	77.20	11.95	6.49	4.35	26.21	41.72	22.85	9.19	0.88	4.94	93.49	0.67	10.49	4.22	18.26	67.01

Source: Authors estimation

The Variance Decomposition test indicates the amount of information each variable contributes to other variables in the autoregression. It determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. The forecast error decomposition is the percentage of the variance of the error made in forecasting a variable due to a specific shock a given horizon. This method is used to know the forecast error rate of inflation explained by exogenous shocks to GDP growth rate and vice versa.

Table 8 shows the variance decomposition result; from this table, we found that with a lag of ten periods the variance decomposition result from GDP for inflation is 11.44 percent and 11.59 percent in the lag period 8. This is also indicated that the same variance has occurred in the lag period of 10. The variance decomposition from GDP to the exchange rate is more significant after the fourth lag period, and the forecast error variance is remaining same up to the lag period ten. The variance decomposition from GDP to money supply reveals that in the lag period four there is high forecast variance takes place, i.e. 74.24 but the forecast variance continuously, declines and remain stagnate in the lag period ten. The variance decomposition from inflation to exchange rate in the fourth lag period is 42.32 and 41.45 in the lag period eight. Again, by the end of ten periods, the forecast variance remains same that is 41.72. It is also observed that variance decomposition from inflation of the money supply is absent during the lag period one. For the lag period two onwards the error forecast increases and in the lag period four it is 8.60 percent. However, the decomposition variance remains same up to the lag period ten that is 9.19. On the other hand, the variance decomposition shock from inflation to GDP is not significant. Again the table depicts that variance decomposition from exchange rate of GDP and money is not significant, whereas, the decomposition result less significant to inflation in the lag period 4.72. Further, the decomposition result marginally increased up to the lag period that is fluctuating around 4.93 and 4.94 in the lag period eight and ten respectively. The above table also represents the variance decomposition effect from money supply to GDP is 10.18 in the lag period four, and the decomposition result marginally increased up to the lag period seven then started declining to 10.49 in the lag period eight which remains same for the ten-period lag. The error decomposition result from money supply inflation is very high in the lag period one, and then it sharply declines in decreasing proportion after an external shock given in the lag period four that is 4.13. However, the error variance remains same up to the lag period ten that is 4.22. Further, the variance decomposition from money supply to the exchange rate is very low for the lag period one, and it is 17.65 in the lag period four. The error variance is increasing at a decreasing rate up to the lag period ten that is 18.25 and 18.26 in the lag period eight and ten respectively.



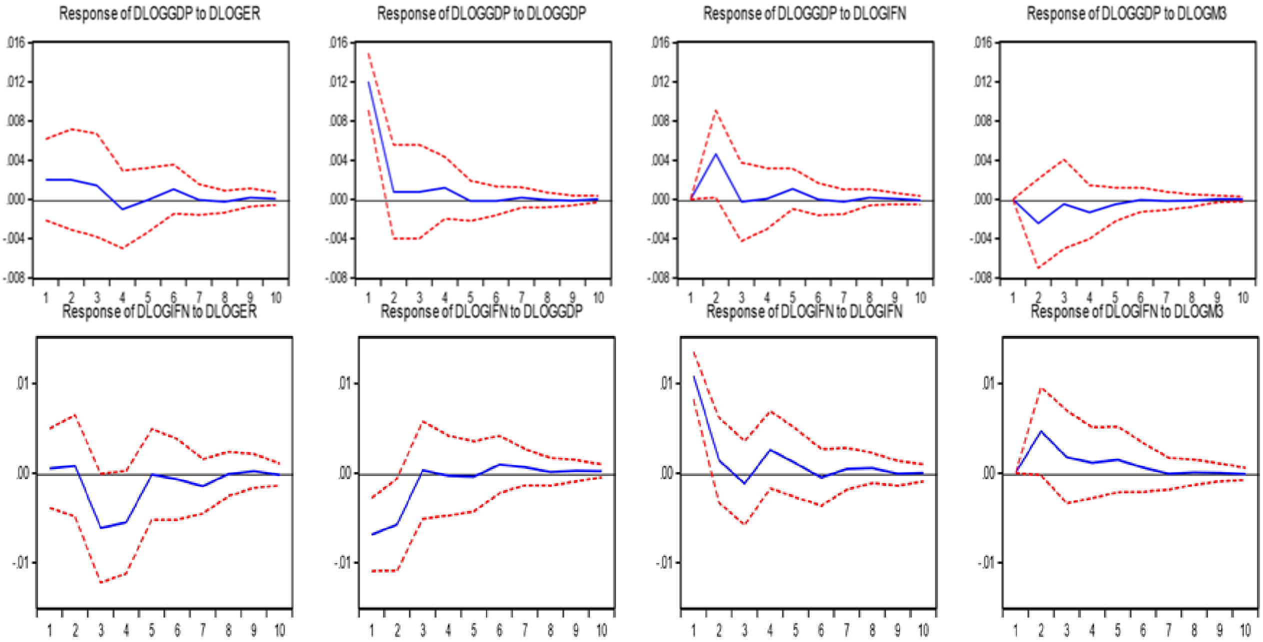


Figure-1. Response to Cholesky One S.D. Innovations ± 2 S.E

Source: Authors estimation

The Cholesky Impulse Response Result reveals (Fig.1) that one standard deviation shock to exchange rate have a very low positive effect on GDP growth rate in the short run, but it has a positive effect in the long run. At the same time, the shock has a negative effect on the inflation rate and money supply in the lag period ten. Similarly, one standard deviation shock to GDP has a significant positive effect in the short run, but in the long run, the effect remains to stagnate in the lag period ten. However, the shock has a positive impact on the inflation rate in the short run, but in the long run, the impact has declined till the end of the ten-period lag. At the same time, in the case of money supply, it has a low positive effect which is not significant until the end of the lag period ten. In the same way, one standard deviation shock to inflation has a negative impact on the exchange rate in the short run, but after a lag period one, it is converging towards zero in the ten lag period. The Same case is occurring in the case of GDP, whereas; in the case of money supply, it has a significant positive effect up to the lag period ten. On the other hand, one standard deviation shock to money supply has no significant effect to exchange rate in the short-run as well as in the long run in the lag period ten. But in the case of GDP, the shock has a significant positive effect of GDP up to the lag period ten. Likewise, the shock has a positive effect of inflation up to certain lag periodically then it decays towards zero from the lag period two onwards it has a positive impact up to the lag period ten.

5. CONCLUSION

In this paper, attempts were made to investigate the dynamics of inflation, GDP, exchange rate and money supply in India for the period 1975 to 2012 in a multivariate autoregressive framework. All the variables are stationary only after first order difference and hence confirming the long run equilibrium relationship among the variables. The cointegration test also suggests a long run equilibrium relationship which motivates towards knowing the dynamics of the variables in the study. The co-integration result shows that there is at least one linear combination in the long run and hence there is a long run equilibrium relationship between variables in the model, which suggest that money supply and the exchange rate has a positive effect on the GDP growth in the economy. The error correction results indicate that correct and negative sign for gross domestic product and exchange rate. The values for GDP and inflation are highly significant. However, money supply and inflation show no short-run impact. The behavior of GDP implies that there is no problem of adjustment in the long run in case of shock in the short run, that is, considerable high-speed adjustment to long run equilibrium among year after short run shock. The result of Granger causality reveals that there is a unidirectional causality running from GDP to inflation and exchange rate to inflation. The result also found that exchange rate Granger causes both GDP and money supply at the 10 percent level of significance. The study used to estimate the strength of the explanatory variables as well as the inter-temporal response pattern of economic growth through VDC and impulse response function. This allows knowing the explanatory variables respond to a long run shock in the economy over time. The VDC result shows that no significant part of the variance is caused by money supply, whereas money supply results in the weak variability in the exchange rate. It also reveals that cyclical variance GDP caused by money supply, exchange rate, and inflation. The impulse response result shows that GDP has a positive response to money supply from the occurrence to the end of the period. Whereas the response of exchange rate to money supply negative in the whole lag period. The response of the other variable is not so significant and cyclical within the lag periods.

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