An Empirical Evidence of Dynamic Interaction among price level, interest rate, money supply and real income: The case of the Indian Economy

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An Empirical Evidence of Dynamic Interaction among price level, interest rate, money supply and real income: The case of the Indian Economy

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Abstract

Monetary policy approaches in India has changed from simple monetary targeting framework in the mid-1980s to multiple indicator approach in the late 1990s and to the current flexible inflation targeting framework. The aim of this study is to investigate the relationship among selected macroeconomic variables such as, money supply, real income, price level and interest rate for period 1998 to 2014 in case of India; a period when the Multiple Indicator Approach (MIA) was implemented. The study employs vector autoregression (VAR) approach to examine the dynamics of the relationship between variables. The result shows that lags of all dependent variables are significant except real income. The Granger causality via VAR framework suggests that four pairs of Granger causality exist, in particular, bi-directional causality exists between money supply and price level. Interest rate Granger causes both income and price level, and lastly money supply causes the rate of interest. However, the study could not find any causal relationship between real income and money supply in either direction. The findings of Impulse response functions and Variance decomposition reinforce causality results. Finally, the estimated result supports the arguments which are made in favour of policy move from MIA to inflation targeting framework.

Keywords: Multiple Indicator Approach, VAR, Granger causality, IRF and VD.

JEL Classification Codes: C5, E31, E43, E51, E52.

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1. Introduction

The preamble to the Reserve Bank of India Act, 1934 outlines the basic functions of the Reserve Bank as "*to regulate the issue of Bank notes and keeping of reserves with a view to securing monetary stability in India and generally to operate the currency and credit system of the country to its advantage; to have a modern monetary policy framework to meet the challenge of an increasingly complex economy, to maintain price stability while keeping in mind the objective of growth*". The objectives of monetary policy evolve from this broad guideline as maintaining price stability and ensuring adequate flow of credit to the productive sectors of the economy. In practice, monetary policy strived to maintain a judicious balance between economic growth and price stability. The Reserve Bank of India (RBI) interprets the objective of monetary policy as, "maintaining price stability and ensuring adequate flow of credit to productive sectors". Alternatively, Rangarajan (2001) one of the chief architects of economic reforms in India defines its functions as "to maintain a reasonable degree of price stability and to help to accelerate the rate of economic growth".

The monetary policy framework in India has undergone significant shifts since the beginning of economic planning in 1951. At the beginning of the planning period, the monetary policy framework could be best described as 'controlled expansion' of the money supply and was determined mainly by a fiscal stance that was formulated against the backdrop of large budget deficits (Mishra and Mishra, 2010). The main task of the RBI at that time was to contain the adverse effects of monetization. In short, monetary policy in India during this period was completely subservient to the fiscal stance of the central government (Bhattacharya, 2012).

In the mid-1980s, India switched to a "monetary targeting framework" on the recommendations of Chakravarty committee (1985) set up by the Reserve Bank of India. Under this approach, a monetary projection is made consistent with the expected real GDP growth and a tolerable level of inflation. The committee also recommended for limiting monetary expansion through the process of monetisation of fiscal deficit by an agreement between the Reserve Bank and the Government. Thus broad money (M3) was set as the nominal anchor during this regime. The framework was, however, a flexible one allowing for various feedback effects (Mohanty, 2010). Moreover, money supply target was relatively well understood by the public at large (Rangarajan, 1997). The setting of monetary policy during the early 1980s, more often than not, used to be in the backdrop of an uncomfortably high growth of liquidity (M3) and a higher than the desired rise in wholesale prices (Mohanty and Mitra, 1999).

After a balance of payment crisis in 1991, India adopted economic reforms which led to a distinct change in the early 1990s in the policy environment, framework and strategies. The monetary policy then had to deal with traditional issues besides those new issues, which is brought about by the changed economic policy environment. Indeed, deregulation and liberalization of financial markets started casting doubt on the appropriateness of exclusive reliance on money as the only intermediate target in the late 1990s. In 1998–1999, the monetary policy framework in India changed from 'pure monetary targeting strategy' to a 'multiple indicator approach' (MIA). A particularly noteworthy step during this period was the historic accord between the government and the RBI for phasing out the issue of ad hoc treasury bills, thereby eliminating automatic monetization of the budget deficit. This, in turn, reinforced monetary policy autonomy and enhanced central bank credibility. Although the basic objectives of monetary policy of ensuring price stability and availability of credit to productive sectors remained intact, the underlying operating procedures underwent significant changes. Abandonment of the monetary targeting (MT) framework implied the loss of broad money (M3) as the nominal anchor. By changing the policy framework, the RBI has not categorically mentioned its nominal anchor. Nevertheless, broad money remained an informative variable with a host of quantity variables (including rate of interest, exchange rate, inflation rate, real GDP and others), are analysed for drawing monetary policy perspectives. Also, emphasis shifted from direct instruments of monetary policy (interest rate regulations, selective credit controls and cash reserve ratio (CRR)) to indirect instruments (repo operations under liquidity adjustment facility (LAF) and open market operations (OMO)). Therefore, from 1998-99 to till about 2014-15, most of the focus has been on inflation and growth with multiple intermediate targets.

On the eve of the financial crisis, some observers question on this strategy, suggesting a gradual move towards a framework keener to the inflation targeting adopted in other emerging economies (Rajan, 2008). Therefore, it was in 2015 when former governor Raghuram Rajan adopted flexible inflation targeting approach in its monetary framework particularly after the 'Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework' under the Chairmanship of Dr. Urjit R. Patel in 2014. Under this framework a new nominal anchor is announced by the RBI, that is inflation targeting. On 20th February 2015, the RBI and Government of India signed a Monetary Policy Framework Agreement, which is focussed upon the inflation targeting. While considering the objective of growth, the objective of the inflation targeting would be primarily to maintain price stability. And RBI maintains the monetary policy framework. Henceforth, RBI focuses to contain consumer price inflation within 4 percent with a band of (+/-) 2 percent. Thus in India, the monetary policy framework has changed from simple monetary targeting framework in the mid-1980s to multiple indicator approach in the late 1990s to the current inflation targeting framework.

The main purpose of this study is to look at the dynamic relationship among prices, real income, money supply, and interest rate by employing the vector autoregression (VAR) model during the Multiple Indicator Approach (MIA) regime, i.e. from April 1998 to 2014. Since present study focusses on the contemporaneous relationship among the variables under consideration, hence VAR framework is adapted to know the policy impact of the variables. The VAR-based Granger causality test in the present study indicates bi-direction causality between money and prices. The findings also evince that rate of interest causes real income and prices, and finally unidirectional causality running from money to rate of interest. However study does not find any relationship between money and income, which is against the theoretical predictions but are consistent with the findings of *Nachane and Nadkarni (1985)* for India who also concludes that relationship between income and money is inconclusive. Further for the lead relationship among variables and to know the forecast error variance decomposition of variables study employs impulse response function and variance decomposition respectively.

2. Analytical Framework

The causal interactions among money supply, output, interest rate and price level has been a matter of great dispute among different economists. Different schools of thought have postulated the interrelations in different ways, giving rise to different economic paradigms such as the Classical, the Keynesian, the Monetarists, the New Classical and the New Keynesians. The common belief among various doctrines with the exception of classical economists (who argue that monetary expansion in the long-run, leads to only corresponding rise in price level without affecting output, M→P) was that an aggregate demand shock such as monetary shocks has a positive impact on real economic variables, i.e. M→ Y. The issues among various economists were not whether monetary shocks have a positive impact on output but the nature and transmissions mechanism of these positive shocks.

Keynesians believe that a positive monetary shock would affect both price and output by influencing interest rate and investment variables, M→R→I→P→Y, i.e they advocate non-neutrality of money on real output. The Monetarists led by Friedman integrated Keynes' short run theory with Classical's long run theory. They agreed with Keynesian transmission mechanism in the short run, M→Y but if the monetary expansion persists in the long-term, they agreed with the classical notion of neutrality of money on real output, M→Y→R→P. According to them, this monetary expansion would then be dissipated in the form of higher interest rate and prices rather than output which would be restored to "natural level" as soon as inflationary expectations have been fully adapted. Hence, according to them, the expectation-augmented supply curve will be fully vertical in the long-run, although in the short run it could be upward sloping as claimed by Keynesian. The new classical economists led by Lucas, Sargent and others decomposed monetary effect into output and price effect, not on the basis of the short run and long run, but on whether monetary expansion is "anticipated" or "unanticipated". Based on the assumptions of rational expectations and equilibrium efficient market hypothesis, they stated that money expansion will cause an increase in output only if it is unanticipated and in case of an anticipated increase in money supply would be dissipated in inflation. Therefore, the expectation-augmented supply curve is vertical both in the short-run and long-run. The New Keynesian, based on the hypotheses of rational expectations but disequilibrium inefficient market, postulated non-neutrality of money at least in the short run because of rigidities in prices and wages, and market imperfections.

Henceforth, the causal chain between money and other macroeconomic activities such as output, interest rates and price level implied by the existing macroeconomic paradigms still remains ambiguous. The issue, therefore, as per the dynamic causal relationships remain unresolved and is a matter of an empirical observation. These competing theoretical constructs suggest that relationships between money, income and prices could exist through different channels. Further, country-specific conditions could have an impact on the relationship. Thus, the relationship among money, income and price in India too is considered to be an empirical issue; on which the present study focusses.

Section I provided a brief introduction to the different monetary policy scenarios along with their rationale over a period of time in case of India followed by the analytical framework in section II. In section III, study focusses on previous studies in case of India and foreign countries. The details of data and empirical framework are discussed in section IV. Section V presents results and discussion. And finally study ends up with the summary and concluding remarks in section VI.

3. Review of Literature

The causal relationship among money and the other two variables, i.e., income and prices have been an issue among researchers particularly after the seminal paper by *Sims (1972).* Using post-war quarterly data for the U.S. in a bivariate framework, he found evidence of unidirectional causality from money to income as claimed by the monetarists. However, this result was not supported by subsequent studies. Replicating Sims' test in the Canadian economy, *Barth & Bannett (1974)* presents evidence of bidirectional causality between money and income. *Williams et al. (1976)* employing a similar approach found evidence of unidirectional causality from income to money in case of U.K., i.e. opposite to Sims' findings. However, Dyreyes et al. (1980) showed evidence of bidirectional and unidirectional causality between money and income in U.S. and Canada respectively.

Investigation of linkages between nominal interest rate and inflation was also studied by *Gul and Ekinci (2006)* with respect to the Turkish economy. The authors employed Johansen's cointegration technique and Granger causality test to explore this relationship. They found the causal unidirectional relationship between nominal interest rate and inflation with causality running from interest rate to prices. The close relationship was also proved by *Booth and Canir (2001)* by the application of cointegrating methods in case of European countries and in the US economy. *Favara and Giordani (2009)* determine the role of broad money on output, prices and interest rates by the application of vector autoregression (VAR) model by using the quarterly U.S data for the period 1966Q1 to 2001Q3. Contrary to the theoretical predictions, the findings suggest that shocks to monetary aggregates have substantial and persistent effects on the future path of output levels, prices and interest rates. *Urbanovsky (2016),* by using the quarterly data from 1996Q1 to 2015Q3 for the Czech Republic investigated the causal interactions between price level, interest rate, money supply and real income. By applying VAR (1) framework study indicates three types of one-way causalities among selected macroeconomic variables, in particular, real income cause both interest rate and prices. Also price level granger causes the rate of interest and none of these causalities flows the other way.

In case of India, similar issue is discussed by *Ramachandra (1983, 1986)* for the period 1951-1971 and 1951-1980 who concluded that money causes both real income and price, price causes real income and nominal income causes money. Using Granger's and Sims' causality test on money (M3) and income (both real and nominal) for the period 1954–1955 to 1982–1983, *Gupta (1984)* concluded that quantity of money is not an exogenous variable either in nominal money equation or in the real income equation for India. *Nachane and Nadkarni (1985)* using causality framework, studied the relationship among money, output and prices. Spanning over the period 1960–1961 to 1981–1982 using quarterly data, their results suggest the presence of unidirectional causality from money stock to prices, but the relationship between money and real output is inconclusive. Both *Singh (1989)*, based on quarterly averages of monthly data for the period 1970-71 to 1986-87, and *Biswas and Saunders (1990)*, on quarterly data for two sub-periods of 1962-1980 and 1957-1986, find bi-directional causality between money and prices. Jadhav (1994) for the period 1955-56 to 1987-88 finds that money causes both prices and output.

Moosa (1997) by employing a seasonal cointegration framework shows long-run neutrality of money on output in India. On the hand, Rangarajan and Mohanty (1998) for the period 1970-71 to 1996-97 finds that money is non-neutral to output. Ashra *et al.,* (2004) by using the cointegration and causality tests for the period 1950-51 to 200 0-01 also find that narrow money (M1), but not broad money (M3), is non-neutral to output. They also find that broad money (M3) and prices have a bi-directional causality. *Khundrakpam and Goyal (2008)* in case of India revisited linkages between inflation, output and money supply by using the annual time series data for the period 1951-52 to 2006-07. The findings based on vector error correction VECM causality test indicates that changes in money and output level can explain changes in price level both in the shortrun and the longrun while money supply is found neutral to output. *Yadav and Lagash (2011)* by implementing autoregressive distributed lag model (ARDL) cointegration and VECM causality tests attempt to estimate the dynamic interconnections among real output, price level, money and interest rate for the period 1991to 2007. The findings evince the longrun causality running from the interest rate, money and income towards price level and no other reverse causality was found. The shortrun dynamics indicate that changes in price level and interest rate can cause real output while as money and output are neutral to each other. Further, it was noticed that price level is caused by output, interest rate and money.

From the above studies, it is clear that relationship among macroeconomic indicators is divergent and inconsistent in case of developed and developing countries in general and India in particular. This inconsistency may be attributed to differences in selected economies, sample periods, the frequency of observations, adopted methodological framework. Unlike the literature mentioned above the present paper investigates the linkages among variables by using Vector Autoregressive (VAR) model. VAR models are useful for policy analysis and forecasting (Sims, 1980). The VAR system of equations is able to ascertain whether the past values of an endogenous variable are capable of explaining their current values. Consequently, the present study investigates the relationship among variables by utilising the time series data for the period 1998 and 2014 in case of India, a period when the Multiple Indicator Approach (MIA) was followed as a monetary policy approach. To the authors' best of knowledge there is no such study which has studied the causal relationship among money, income, money, prices and interest rate during this regime.

4. Database and Empirical Framework

4.1 Data

The main objective of our study is to discern the dynamic interconnection between price level, rate of interest, money supply and real GDP during the MIA regime in India. The dataset on all the variables is acquired from the *Handbook of Statistics on Indian Economy* published by RBI except for wholesale price index (WPI). We take data on WPI from the *Labour Bureau of Statistics*. All the dataset are extracted on monthly basis except GDP. With due care, all monthly series are converted into quarterly series. Importantly, the concept of stock and flow of the variables have been taken in account while converting dataset from monthly to quarterly. In literature, earlier studies did not focus on this issue. While converting series they simply take three-month average to make data at quarterly frequency while it should not have been the case. Ultimately, we get 67 number of observations, covering the period from 1998:Q2 to 2014:Q4 calendar year. Further, noting that above mentioned studies in the literature did not consider the issue of seasonality while dealing with quarterly or monthly dataset. It is common to believe that seasonality must be there in case of the monthly or quarterly dataset (*Franses, 1998).* Hence keeping in mind the seasonality issue this study utilises the seasonally adjusted quarterly GDP data by using *X-13 ARIMA* filter.

Abbreviation and description of variables

Money Supply (M): Nominal broad money (M3) is defined as the addition of the following quasi money such as currency with the public, others' deposits with the RBI, demand deposits, and time deposits. M3 has been used in the study to reflect money supply in the economy.

Real Income (Y): Gross Domestic Prices (GDP) at market prices (at constant prices, base year: 2004-05) is considered as the proxy for real income.

Interest Rate (R): Study take weighted average overnight *Call Money Rate* (CMR) into account as a proxy for the interest rate. As mentioned by Ray (2013), the operating target of monetary policy of the RBI is the weighted average overnight call money rate. Therefore, study takes CMR as an instrument of monetary policy.

Price Level (P): Price level is measured by a rate of change in wholesale price index (WPI). The WPI based inflation was chosen for the study because during the study period (Q2: 1998–1997 to Q4: 2014) the RBI was primarily focusing on WPI based inflation as the main inflation measure, in absence of a nation-wide representative Consumer Price Index (CPI); although currently inflation is measured by the CPI.

Lastly, in line with Das (2003), all variables are considered in logarithmic scale as logarithmic transformation has some advantages when transforming data that is near symmetric and homoscedastic (but we maintain the abbreviation mentioned above).

4.2 Methodological Framework

The primary step in the present time series analysis is to determine, whether variables under study are stationary or non-stationary. The main feature of non-stationary time series is a presence of unit root. To test for a unit root, Augmented Dickey-Fuller (ADF) test given by Dickey and Fuller (1979) has been utilised. The ADF test consists of estimating the following equation.

$$\Delta X_t = \alpha + \rho X_{t-1} + \sum_{i=1}^{p} \beta_i \Delta X_{t-i} + \delta t + v_t \quad (1)$$

Where ΔX_t is a detrended logarithmic variable, v_t is a white noise error term and $\Delta X_t = (X_t - X_{t-1})$, $\Delta X_{t-1} = (X_{t-1} - X_{t-2})$ and so on. The value of coefficient p is very critical. If p=0, it indicates that original time series $X_t$contains unit root and is non-stationary. It is often difficult to distinguish between non-stationary variable, which contains the stochastic trend, and trend stationary variable which contains the deterministic trend. For this purpose, it was decided to include time element *t* into Equation (1).

The appropriate number of lags (*p*) of the dependent variable is determined by Schwarz Bayesian criterion (SBC). Else it is not possible to perform ADF tests properly. In our present analysis, we are dealing with quarterly data, so it is quite reasonable to suspect that value of the variable from the same period year ago can help explain value in the current period i.e. value in the first quarter in 2013 can explain the value in first quarter 2014. For this reason, the highest number of lags is set at four and use of sequential testing procedure ensures that insignificant lags are dropped from regressions.

4.3 Vector Autoregression Approach and Granger Causality test

To analyse the dynamic interconnections among price level, interest rate, money supply and real GDP, this study proposes to use unrestricted vector autoregression (VAR) approach and Granger causality test. The

Vector Auto Regression Models (VAR) introduced and popularised by Sims (1980) is a system of regression models considered to be a kind of hybrid between univariate time series models and simultaneous equation models. The autoregressive term in VAR models is due to the presence of lagged value of the dependent variable on the right-hand side of the equation and the term vector is due to the fact that we are dealing with a vector of two or more variables. The VAR system of equations is able to ascertain whether the past values of an endogenous variable are capable of explaining their current values. VAR is a typical econometric model which is used to detect the direction of causality in case of stationary time series (*Urbanovsky, 2016)*.

It is a system of equations where the number of equations matches the number of variables under study. In each equation we have different dependent variable i.e. it is always one of the variables under study. Each equation uses lags of all variables as its explanatory variables. The basic form of VAR model with p-lag (*VAR (p)*) can be defined as:

$$Y_t = C + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} \dots + \phi_p Y_{t-p} + v_t \qquad ; \quad t = 1, 2, 3, \dots, T \qquad (2)$$

Where $Y_t = (Y_{1t}, Y_{2t}, Y_{3t}, \dots Y_{nt})$ is a vector of $(n \times 1)$ time series variables, C is a k-vector of intercepts, ϕ_i are $(n \times n)$ coefficients matrices *with all eigenvalues of* ϕ *having moduli* less than one to satisfy the stationary property of time series, and v_t is an $(n \times 1)$ *i.i.d* zero-mean white noise error vector process with time-invariant covariance matrices. The selection of VAR lag length is based on the lag selection criteria. We use *Schwartz Bayesian Criterion (SBC).* The resulting model will be known as a VAR (p) model with *p* representing the number of included lags.

In the next step, granger causality test is applied to identify the direction of causality between the variables. It is expressed as follows:

$$\Delta P_t = a_3 + \sum_{i=1}^{p} \gamma_{3i} \Delta P_{t-i} + \sum_{i=1}^{p} \phi_{3i} R_{t-i} + \sum_{i=1}^{p} \psi_{3i} \Delta M_{t-i} + \sum_{i=1}^{p} \varphi_{3i} \Delta Y_{t-i} + \varepsilon_{Pt} \qquad (3)$$

$$R_t = a_4 + \sum_{i=1}^{p} \phi_{4i} R_{t-i} + \sum_{i=1}^{p} \gamma_{4i} \Delta P_{t-i} + \sum_{i=1}^{p} \psi_{4i} \Delta M_{t-i} + \sum_{i=1}^{p} \varphi_{4i} \Delta Y_{t-i} + \varepsilon_{Rt} \qquad (4)$$

$$\Delta M_t = a_5 + \sum_{i=1}^{p} \psi_{5i} \Delta M_{t-i} + \sum_{i=1}^{p} \phi_{5i} R_{t-i} + \sum_{i=1}^{p} \gamma_{5i} \Delta P_{t-i} + \sum_{i=1}^{p} \varphi_{5i} \Delta Y_{t-i} + \varepsilon_{Mt} \qquad (5)$$

$$\Delta Y_t = a_6 + \sum_{i=1}^{p} \varphi_{6i} \Delta Y_{t-i} + \sum_{i=1}^{p} \psi_{6i} \Delta M_{t-i} + \sum_{i=1}^{p} \phi_{6i} R_{t-i} + \sum_{i=1}^{p} \gamma_{6i} \Delta P_{t-i} + \varepsilon_{Yt} \qquad (6)$$

Where Δ is first difference operator; P_t, R_t, M_t, and Y_t represents price level, interest rate, money supply and real GDP at time t respectively; a_3, a_4, a_5 and a_6 are the intercepts; $\gamma, \psi, \phi,$ and φ are the parameters to be estimated; ε_{Pt}, ε_{Rt}, ε_{Mt}, ε_{Yt} are the white noise error terms and finally p indicates the lag lengths.

In Equation (3) interest rate granger causes inflation if either $\emptyset_{1i}$ are jointly significant by testing the null hypothesis of $H_0 : \phi_{31} = \phi_{32} = \phi_{33} = \dots = \phi_{3p} = 0$. Likewise, causality from money supply and real GDP to price level exists if either ψ_{3i} or φ_{3i} are jointly significant. The causality analysis for equation (4), (5), and (6) are tested in the similar fashion.

4.5 Impulse response functions and Variance Decomposition Analysis

The study has also used impulse response functions (IRF) and variance decomposition (VD) analysis. IRF and VD are very useful to study the extent to which shocks to certain variables are explained by other variables in the system. IRF shows the effects of shocks on adjustment path of a variable whereas the forecast error variance decomposition measures the contribution of each type of shock to the forecast error variance. Both these methods explain how shocks to various economic variables reverberate through a system.

5. Empirical Results and Discussion

5.1 Stationarity, Lag selection and VAR Results

By utilising the sequential testing procedure unit root test via ADF tests were performed on each variable under study. Parameters of executed regressions are reported in table 1.

Table 1. ADF tests on variables under study

Dependent var. ($\Delta \boldsymbol{X_t}$)	Explanatory var. ($\Delta \boldsymbol{X_{t-1}}$)	Coefficient ($\boldsymbol{\rho}$)	S.E	t-ratio	p-value
$\Delta \boldsymbol{P_t}$	ΔP_{t-1}	-0.002309	0.007253	-0.318	0.7513
$\Delta \boldsymbol{R_t}$	ΔR_{t-1}	-0.313558*	0.110933	**-2.826**	**0.0063**
$\Delta \boldsymbol{M_t}$	ΔM_{t-1}	-0.002672	0.002905	-0.919	0.3614
$\Delta \boldsymbol{Y_t}$	ΔY_{t-1}	-0.000815	0.005432	-0.150	0.8812

Source: authors calculations.
Note: * denotes significant at 1% level.

It is clearly indicated from the t-ratios and p-values that the coefficients are statistically insignificant in case of variables such as, ΔP_t, ΔM_t and ΔY_t. In other words we are not able to reject the hypothesis that they are equal to zero. Hence, we can conclude that the original time series P, M and Y evinces the presence of unit roots and exhibits non-stationary behaviour. However, the variable ΔR_t shows opposite results i.e. variable R does not have a unit root and we are able to conclude that this series is stationary.

On the basis of unit root test results, we cannot perform cointegration analysis as it is conditioned by the non-stationary of every variable under study. It is also not plausible to run simple OLS regression for variables showing non-stationary property since the presence of trend component in time series is likely lead to spurious results and conclusions. Therefore we need to remove the trend from variables. Variables ΔP_t, ΔM_t and ΔY_t contain stochastic trend and this can be removed by differencing them and the variables we get are called difference stationary variables. Results of differencing stationary variables are not reported here but the graphical representation in *Appendix B* can provide an initial proof about their stationarity. In case of *R,* there is no such trend (stochastic) as is apparent from the *Appendix A*. From now onwards, we are going to label variables *P, M* and *Y* with symbol Δ (which stands for first difference).

Table 2. Lag length determinants

Criterion	Lags 1	Lags 2	Lags 3	Lags 4
AIC	-16.10748	-16.11468	-16.05916	**-16.24464**
SBC	**-15.40937**	-14.85807	-14.524406	-13.87105
HQC	**-15.83441**	-15.62315	-15.34917	-15.31620

Source: Authors calculations.
Note: Bold numbers shows lag length selected

Stationarity of the variables fulfils the requirements and allow us to look at policy impact of the variable under VAR framework. The first step in our VAR analysis is to find the appropriate number of lags for each variable. The decision of most appropriate number is based on information criteria- Akaike information criterion (AIC), Schwarz Bayesian criterion (SBC) and Hannah-Quinn criterion (HQC). The best value of each criterion is always the lowest one. The best option appears to be with 1 lag (results reported in table 2) as two out of three criterion suggests 1 lag. Therefore regression takes the form of VAR (1).

Table 3 presents the results from OLS estimation of a VAR (1). Since there are four variables under study, there are four equations to estimate. Each equation regresses a dependent variable on one lag of all the variables in the VAR, (statistically significant coefficients are in bold).

Table 3. The VAR (1) results using ΔP, ΔR, ΔM and ΔY as dependent variables

Explanatory variable	**dependent variable** ΔP		**dependent variable** R		**dependent Variable** ΔM		**dependent variable** ΔY	
	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
Constant	**0.0215**	0.0658	**0.8392**	0.0001	**0.0580**	0.0000	**0.0403**	0.0007
ΔP_{t-1}	**0.2147**	0.0916	3.0680	0.1740	**-0.3909**	0.0090	-0.0344	0.7804
R_{t-1}	**-0.0125**	0.0256	**0.6342**	0.0000	-0.0001	0.9808	**-0.0129**	0.0186
ΔM_{t-1}	**0.2978**	0.0034	**-4.9861**	0.0056	**-0.4257**	0.0004	0.0126	0.8951
ΔY_{t-1}	0.0521	0.6876	-0.3026	0.8956	0.0615	0.6809	0.0125	0.9212
R^2	0.2229		0.4607		0.2508		0.4824	
F-test	4.3028		12.8188		5.0216		10.0921	
(p-value)	(0.0039)		(0.0000)		(0.0014)		(0.0000)	
DW stat.	1.8532		2.2965		1.7961		2.1086	

Source: Authors calculations.

The first interesting finding is that lags of the dependent variable are statistically significant in all the cases with exception of ΔY, where it has no explanatory power. This means current changes in the concerned variable can be explained by its own previous value.

In the first model with price level as the dependent variable, the coefficient of interest rate with one-quarter lag indicates that current price level is negatively related to the interest rate. This implies that monetary tightening has a significant impact on mitigating inflation. Past money supply changes affect current price level positively which states that any rise in money supply results in a rise in prices. Thus, both results are in accordance with economic theory. The coefficient of real income with one-quarter lag is insignificant but it is important to take note of its sign which helps to explain whether it confirms with the theoretical expectations. The positive value of real income indicates that with the increase in purchasing power, prices will go up via increase in aggregate demand which holds true as per the economic theory.

In the second model interest rate is positively related to its own lag while lagged money supply has the negative relationship with the interest rate which also supports economic theory. And the coefficients of the price level is positive and real income is negative but both turns out to be insignificant. The positive coefficient of prices reflects the Fisher's (1930) hypothesis, which states that there is a positive one-to-one relationship between nominal interest rates and expected inflation rates where causality runs from inflation rates to interest rates.

In case of the money supply, it is negatively associated with its own lag and price level. The results state that previous rise in price level leads to fall in current money supply. This findings also holds true as during inflationary times money supply is reduced in order to reduce purchasing power.

In the last model real income is negatively influenced by previous interest rate while all other variables turn out to be insignificant in the model. The negative coefficient of interest as expected demonstrates that with the increase in interest rate real income falls via fall in investment due to higher costs of borrowings.

Values of coefficients of determination (R^2) suggest that model with R and ΔY as dependent variable are more accurate in explaining changes in these variables than the models with dependent variable as ΔM and ΔP. Thus, we can say that included variables explain 46.07% and 48.24% variability in variable R and ΔY respectively. However models with dependent variable ΔP and ΔM have low explanation power, in particular, the R^2 value (22%) of model with dependent variable as ΔP and R^2 value (25%) of the model with dependent variable as ΔM are low, implying the capacity of explanatory variables to explain the changes in price level and money supply is least.

The F-test for the joint statistical significance of explanatory variables provides a very small p-value in all the cases. As a result we can reject the null hypothesis that all coefficients are equal to zero or the model has no predictive capability. Consequently we can conclude that independent variables together have high explanatory power. Further values of Durbin-Watson statistics (originally designed to test the presence of the first-order autocorrelation in the residuals) in the last row of the table indicates that all values are very close to 2, which reflects the desirable property of regression i.e. there is no autocorrelation of residuals.

5.2 Direction of Relationship

The results of Granger causality or Block Exogeneity test based on VAR framework is presented in table 4. The value of the Chi-square statistic suggests, whether the "causing" variable Granger causes the "caused" variable. This is the test of the joint hypothesis that all coefficients of the causing variables in regressions with the caused variables as dependent variables are zero. A significance level of 0.05 or less than this indicates that Granger-causation exists, otherwise not.

The results indicate a bi-directional causality between money supply and price level i.e. there is feedback relationship between two. This finding is consistent with the studies of Singh (1989), Bishwas and Saunders (1990) and Ashra *et al.* (2004), who also finds bi-directional causality between money and prices in case of India. Further, One-way causation exists from rate of interest to price level i.e. changes in interest rate explains price level. Thus our results support Wicksell theory (1898), which posits a negative association between real interest rates and inflation rates with causality running from interest rates to inflation rates. The Wicksell price level effect plays an important role in modern monetary policy. This concept is used by central banks to control inflation by changing the interest rate. This result is in line with *Yadav and Lagash (2011)* for India and *Gul and Ekinci (2006)* for Turkey. The rate of interest also granger causes real income. Interest rate can impact income via changes in investment. This finding is also prior to theoretical expectations. Finally, it is money supply which causes the rate of interest with no reverse causality. The study could not find any causality between money and income in either way which is against the findings of *Sims (1972)* for U.S, *Ramchandra (1986), Jadhav (1994)* for India but in line with *Nachane and Nadkarni (1985)* who also concluded that money and income are neutral to each other. The findings also demonstrate that money supply does not granger causes real income thus indicates money is neutral to income and supports the proposition of classical dichotomy (Patinkin, 1965).

Table 4. VAR Granger Causality/ Block Exogeneity Wald Tests

Dependent Variable= ΔP				**Dependent Variable=** R			
Excluded	Chi-sq	df	P-value	Excluded	Chi-sq	df	P-value
R	5.2442	1	**0.0220**	ΔP	1.8930	1	0.1689
ΔM	9.3358	1	**0.0022**	ΔM	8.2553	1	**0.0041**
ΔY	0.1633	1	0.6861	ΔY	0.0173	1	0.8952
All	14.4163	3	**0.0024**	All	10.9718	3	**0.0119**
Dependent Variable= ΔM				**Dependent Variable= ΔY**			
ΔP	7.3000	1	**0.0069**	ΔP	0.0784	1	0.7794
R	0.0005	1	0.9807	R	5.8575	1	**0.0155**
ΔY	0.1707	1	0.6794	ΔM	0.017	1	0.8947
All	7,3673	3	**0.0611**	All	5.8884	3	0.1172

Source: Authors calculations.

5.3 Explanation of Impulse Response functions and. variance Decomposition model

Lastly, to look at the relationship among economic variables, the study utilises the impulse response function (IRF) and the Variance Decomposition (VD). In *Appendix C*, generalised impulse response functions (GIRF) show the impact of one standard deviation shock to each variables' innovation on rest of the other variables in the VAR framework. The dark line in the middle of the critical bands represents the estimates of impulse responses whereas dotted lines around impulse response represent two standard deviation critical bands. Noting that effect would be significant if the bands exclude zero axis (*Thiripalraju et al., 2011*).

The explanation of the impulse response functions are as follows. The impact of one standard deviation shock to innovation in interest rate has a negative and significant impact on inflation. The impact lasts till seventh quarter and ultimately it converges towards zero axis which also confirms the stability of the system. The impact of one standard deviation shock to innovations in money supply is significant and positively related to inflation. The impact lasts till third quarter and then converges, which shows that system is stable. Finally, the impact of one standard deviation shock to innovation in real income is observed. It shows that real income has a positive impact on inflation till third quarter. Again by converging towards zero axes it confirms the stability of the system. Likewise, rest of the graphs can be interpreted.

Thus, it is clear that the response in inflation due to one standard deviation shock in the explanatory variables, such as, *R, M, Y* and lagged values of *lnP* have desired results as per their theory and also consistent with the coefficients in the VAR model.

While IRF traces the effect of a shock to one endogenous variable on to the other variables, Variance Decomposition separates the variation of an endogenous variable into components shock in the VAR framework. The results of VD based on VAR for the four macroeconomic variables over a ten-quarter horizon is presented in the *Appendix D*. The VD of inflation shows that major proportion of its shock is explained by none other than its own innovation. By the end of the quarter 10, the forecast error variance for inflation is

82.861 percent. While for the rest of the variables such as, R, DM, and DY the forecast error variance at the 10^{th} quarter are 7.881, 8.973, and 0.282 percent respectively. Thus, the VD of inflation confirms that inflation is the most exogenous variable in the VAR system. Since inflation (percentage change in the price level) is the most exogenous variable in the system, hence most of the disturbances are created by prices. Therefore, to reduce the vulnerability of the system one can target the price level. Likewise, the VD for other variables can also be interpreted.

6. Summary and Concluding Remarks

The main purpose of the present paper is to investigate the causal interactions among four macroeconomic variables viz., money supply, price level, real income and interest rate during the Multiple Indicator Approach. The study covers the quarterly data from 1998:Q2 to 2014:Q4, a period when MIA was followed as monetary policy approach. The ADF test is used to check the time series properties before applying unrestricted vector autoregression (VAR) model followed by Granger causality test. The study also utilises IRF and VD to test the causality among variables.

The findings of ADF test indicates that variable P, M, Y exhibit unit root while series R shows stationary behaviour at level. Consequently, variables were converted at first difference in order to achieve stationary property among series so as to fulfil the requirement of VAR approach. With the help of lag selection criterion i.e. SBC, VAR (1) is employed to examine to relationship among the variables. The empirical findings show that lags of all dependent variables are significant except real income. Granger causality results show four types of causality, in particular, bi-directional causality exists between price level and money supply i.e., there exists feedback relation between these two variables. This is in consistent with the findings of Das (2013) who also established bi-directional causality between money and price in India. One-way causality is also noticed running from interest rate to price level and not the other way. Also, un-directional causality from interest rate to real income exists. And finally changes in money supply also explains changes in interest rate. However, there is no causal relationship between money supply and real income and this finding is inclined with the results of *Nachane and Nadkarni (1985)* in case of India. Here the non-causal relation between these two supports the classical dichotomy i.e. neutrality of money on real income Further non-causal relation between money and income probably shows the failure of MIA from 1998 to 2014. Therefore, this result reinforces those arguments which favour the changing of monetary policy approach from multiple indicator approach to inflation targeting approach.

This finding is further confirmed by the IRF and VD analysis. The results of VD for inflation indicates that inflation is most exogenous variable to the system, which is vulnerable to the system. Hence in order to curtail the effect of the price level one should bother about the reduction of price level. And exactly this is what the inflation target approach does. Therefore, the study supports the views which are in favour of targeting inflation framework, hence the adoption of inflation targeting in case of India is something desirable.

However, the above results regarding the direction of causality should be interpreted keeping in mind the following usual facts for such study. First, all variables except R are not stationary at level; they have been transformed to fulfil some statistical criteria needed for estimation. Second, results could be different for other frequencies (say weekly, monthly, and yearly) of the data. Thirdly results corresponding to seasonally adjusted and non-adjusted data may be different. Finally, variation in the result is also subject to the econometric technique, inclusion of some other variables, and time span under consideration.

References

Ashra, S., Chattopadhyay, S., & Chaudhuri, K. (2004). Deficit, money and price: The Indian experience. *Journal of policy Modeling*, *26*(3), 289-299.

Barth, J. R., & Bennett, J. T. (1974). The role of money in the Canadian economy: An empirical test. *The Canadian Journal of Economics, 7*(2), 306-311.

Biswas, B., & Saunders, P. J. (1990). Money and price level in India: an empirical analysis. *Indian Economic Journal*, *38*(1), 103.

Booth, G. G., & Ciner, C. (2001). The relationship between nominal interest rates and inflation: international evidence. *Journal of Multinational Financial Management*, *11*(3), 269-280.

Chakravarty, S. C. (1985). Report of the Committee to Review the Working of the Monetary System.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, *74*(366a), 427-431.

Dyreyes, F. R., Starleaf, D. R., & Wang, G. H. (1980). Tests of the direction of causation between money and income in six countries. *Southern Economic Journal*, 477-487.

Das, S. (2003). Modelling money, price and output in India: a vector autoregressive and moving average (VARMA) approach. *Applied Economics*, *35(10),* 1219-1225.

Fisher, I. (1930). The theory of interest. *New York*, *43*.

Franses, P. H. (1998). Time series models for business and economic forecasting. *Cambridge university press*.

Favara, G., & Giordani, P. (2009). Reconsidering the role of money for output, prices and interest rates. *Journal of Monetary Economics*, *56*(3), 419-430.

Gupta, G. S. (1984). Monetary target setting [Mimeo]. Ahmedabad: Indian Institute of Management.

Gul, E., & Ekinci, A. (2006). The causal relationship between nominal interest rates and inflation: The case of Turkey. *Scientific journal of administrative development*, *4*(21), 54-69.

Jain, A. K., & Gupta, S. (1987). Some evidence on" herding" behaviour of US banks. *Journal of Money, Credit and Banking*, 19(1), 78-89.

Jadhav, N. (1994). Monetary economics for India. Delhi: Macmillan India Limited.

Khundrakpam, J. K., & Goyal, R. (2009). Is the Government Deficit in India Still Relevant for Stabilisation? (No. 50905). *University Library of Munich, Germany.*

Mohanty, D., & Mitra, A. K. (1999). Experience with monetary targeting in India. *Economic and Political Weekly*, 123-132.

Moosa, I. A. (1997). Testing the long-run neutrality of money in a developing economy: the case of India. *Journal of Development Economics*, *53*(1), 139-155.

Mohanty, D. (2010). Monetary policy framework in India–experience with multiple-indicators approach. *Speech at the Orissa Economic Association, Orissa*, *21*.

Mishra, A., & Mishra, V. (2012). Inflation targeting in India: A comparison with the multiple indicator approach. *Journal of Asian Economics*, *23*(1), 86-98.

Nachane, D. M., & Nadkarni, R. M. (1985). Empirical testing of certain monetarist propositions via causality theory: The Indian case. *Indian Economic Journal*, *33(1),* 13.

Patinkin, D. (1965). Money, interest, and prices; an integration of monetary and value theory (No. 04; HG221, P3 1965.).

Patel, U. R., Chinoy, S., Darbha, G., Ghate, C., Montiel, P., Mohanty, D., & Patra, M. (2014). Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework. *Reserve Bank of India, Mumbai.*

Ramachandra, V. S. (1983). Direction of causality between monetary and real variables in India-An empirical result. *Indian Economic Journal*, *31*(1), 65-76.

Ramachandra, V. S. (1986). Direction of causation between monetary and real variable in India: an extended result. *Indian Economic Journal*, *34*(1), 98.

Rangarajan, C. (1997). Role of monetary policy. *Economic and Political Weekly*, 3325-3328.

Rangarajan, C. and Mohanty M.S. (1998). Fiscal Deficit, External Balance and Monetary Growth. *Reserve Bank of India Occasional Papers, 18,* 635-653.

Rangarajan, C. (2001). Some critical issues in monetary policy. *Economic and Political Weekly*, 2139-2146.

Rajan, R. (2008). Committee for Financial Sector Reforms. *Committee report, Planning Commission, Government of India*.

Ray, P. (2013). Monetary Policy. *Oxford University Press.*

Sabade, S. (2014). Is money supply the cause of inflation in India? An alternative postulate to understand inflation. *Procedia-Social and Behavioral Sciences*, *133*, 379-382.

Sims, C. A. (1972). Money, income, and causality. *The American economic review*, 540-552.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica: Journal of the Econometric Society*, 1-48.
Singh, B. (1989). Money Supply-Prices: Causality Revisited. *Economic and Political Weekly*, 2613-2615.

Thiripalraju, M., & Acharya, R. (2011). Dynamic interaction between institutional investment and stock returns in India: A case of FIIs and MFs. *Indian Institute of Capital Markets*.

Urbanovský, T. (2016). Interconnection of interest rate, price level, money supply and real GDP: The case of the Czech Republic. *Procedia-Social and Behavioural Sciences*, *220*, 531-540.

Wicksell, K., 1898. Interest and Prices: A Study of the Causes of Regulating the Value of Money. In: Kahn, R.F. (Ed.), .MacMillan, London, UK, 1936.

Williams, D., Goodhart, C. A., & Gowland, D. H. (1976). Money, income, and causality: the UK experience. *The American Economic Review*, *66(3),* 417-423.

Yadav, I. S., & Lagesh, M. A. (2011). Macroeconomic relationship in India: ARDL evidence on cointegration and causality. *Journal of Quantitative Economics*, *9(1),* 156-168.

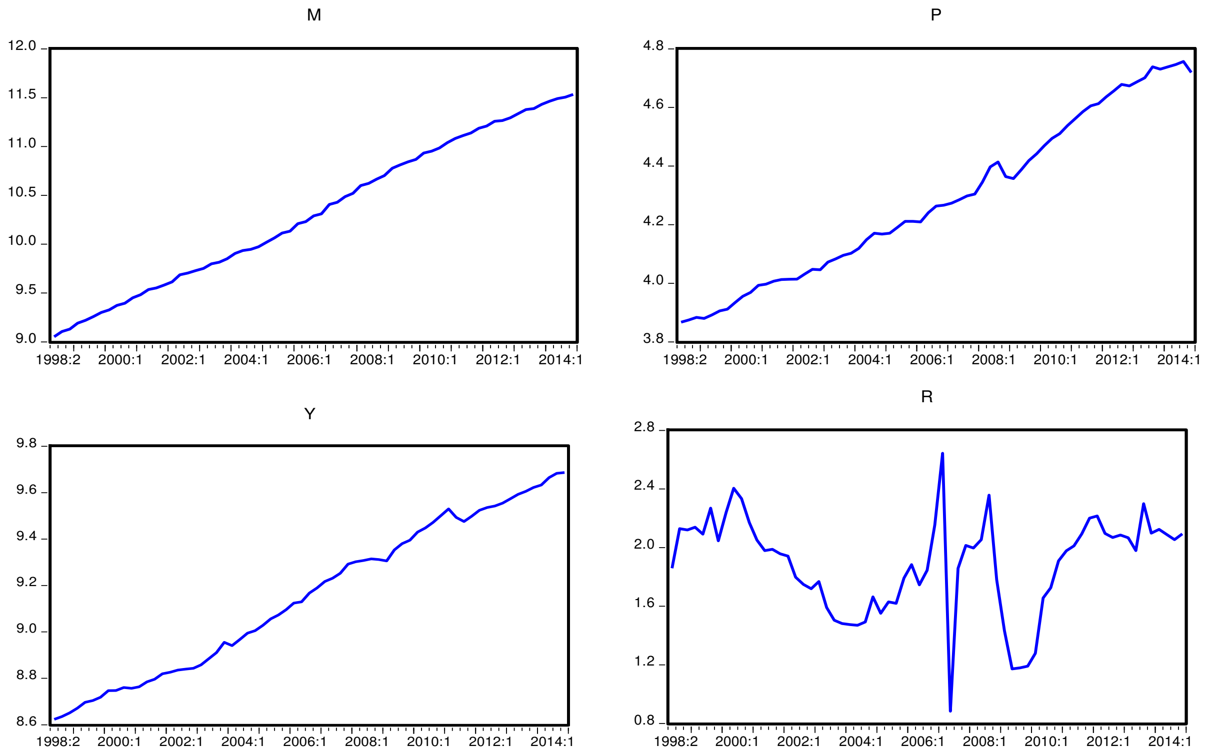
Links

https://www.rbi.org.in/scripts/aboutusdisplay.aspx.

https://dbie.rbi.org.in/DBIE/dbie.rbi?site=home.

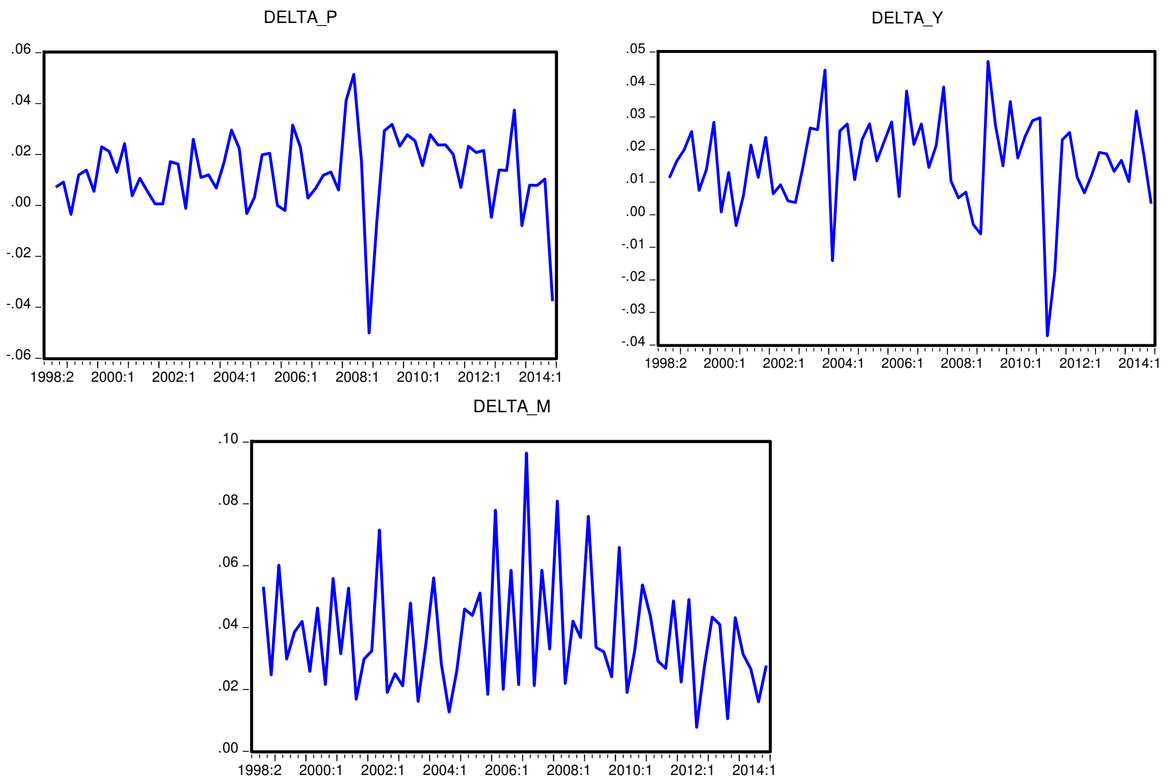
http://labourbureau.nic.in.

Appendix A. time series of natural logarithms of variables of variables under study.



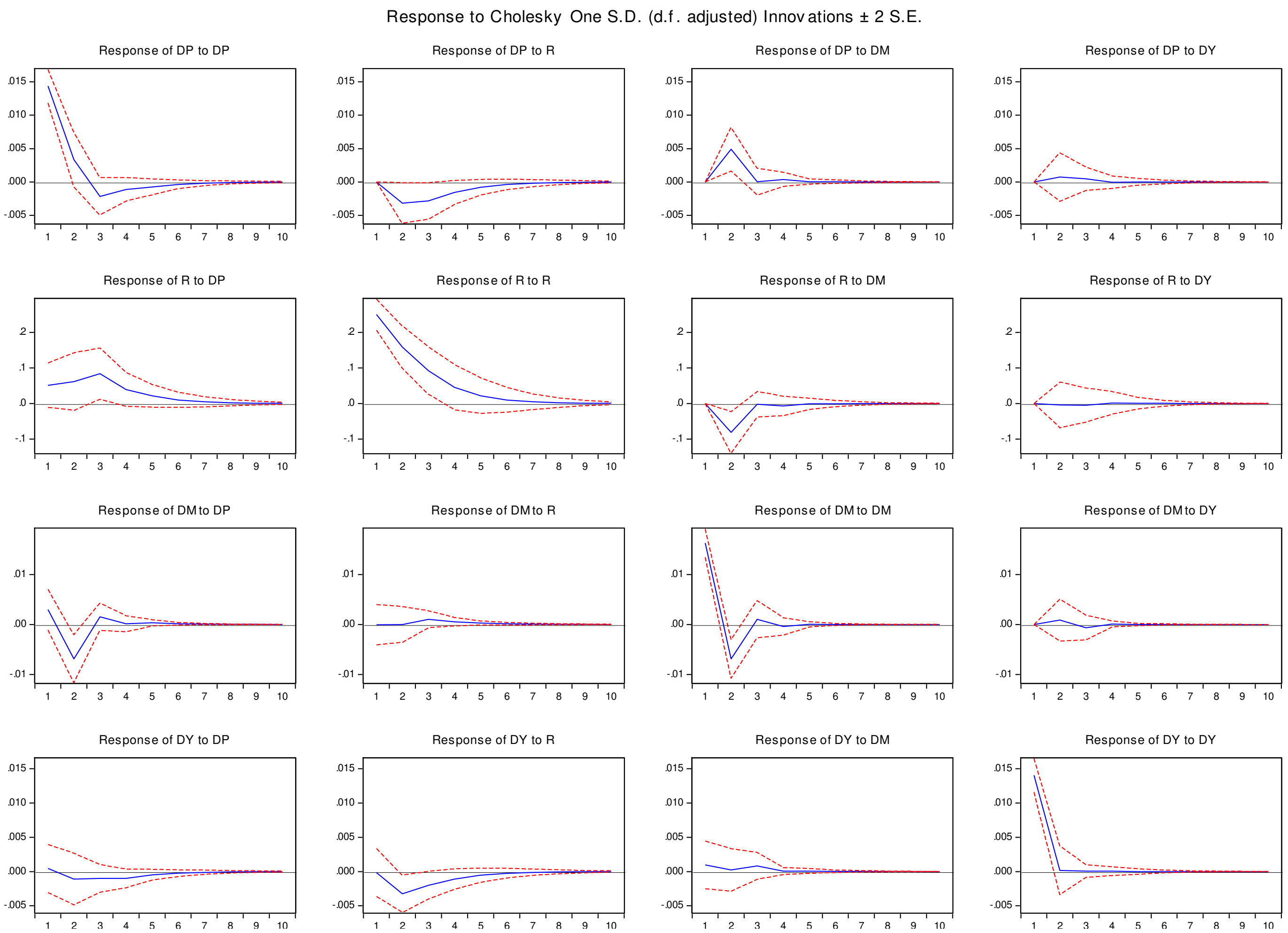
Source: Authors Calculations

Appendix B. Time series of differenced variables under study



Source: Authors calculations

Appendix C. Impulse Response Function's (IRF's)



Source: Authors calculations

Appendix D. Variance Decompositions

Variance Decomposition of Price Level

Horizon	1	2	3	4	5	6	7	8	9	10
ΔP	100.000	86.276	83.809	83.071	82.908	82.871	82.864	82.862	82.861	82.861
R	0.000	3.946	6.805	7.620	7.824	7.869	7.879	7.7881	7.881	7.881
ΔM	0.000	9.564	9.097	9.024	8.985	8.976	8.974	8.974	8.973	8.973
ΔY	0.000	0.212	0.288	0.284	0.283	0.282	0.282	0.282	0.282	0.282

Variance Decomposition of Interest Rate

Horizon	1	2	3	4	5	6	7	8	9	10
ΔP	4.016	6.334	11.515	12.446	12.724	12.782	12.795	12.798	12.798	12.798
R	95.983	87.057	82.734	81.936	81.699	81.650	81.639	81.637	81.636	81.636
ΔM	0.000	6.589	5.714	5.580	5.539	5.530	5.528	5.528	5.528	5.528
ΔY	0.000	0.017	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036

Variance Decomposition of Money Supply

Horizon	1	2	3	4	5	6	7	8	9	10
ΔP	3.251	15.144	15.573	15.557	15.575	15.578	15.579	15.579	15.579	15.579
R	0.000	0.000	0.277	0.355	0.379	0.385	0.386	0.387	0.387	0.387
ΔM	96.747	84.653	83.839	83.776	83.732	83.732	83.724	83.722	83.722	83.722
ΔY	0.000	0.201	0.309	0.311	0.311	0.311	0.311	0.311	0.311	0.311

Variance Decomposition of Real GDP

Horizon	1	2	3	4	5	6	7	8	9	10
ΔP	0.099	0.684	1.142	1.594	1.696	1.724	1.730	1.731	1.732	1.732
R	0.011	5.028	6.740	7.236	7.353	7.378	7.384	7.385	7.385	7.385
ΔM	0.472	0.468	0.756	0.749	0.750	0.749	0.749	0.749	0.749	0.749
ΔY	99.417	93.818	91.361	90.419	90.199	90.146	90.135	90.133	90.132	90.132