Research Report

A Study on the Effectiveness of Transmission of Monetary Policy Rates in India

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Dr. Vighneswara Swamy*

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*Dr. Vighneswara Swamy is currently with IBS-Hyderabad, as Professor. He is reachable at vswamypm@gmail.com or vighneswar@ibsindia.org Mobile: +91 9705096919.

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-: Preface :-

Lower interest rates assume greater significance to spur consumption and investment, and consequently economic growth. On the other hand, Indian banks are seen raising their lending rates quicker after a policy rate hike as most of the loans are at variable rates and can be re-priced faster. Even as the Reserve Bank of India has effected considerable monetary policy rate cuts, its transmission remains a matter of concern. The challenge with monetary policy transmission in India continues to be the efficiency of the bank lending channel and interest rate channel in transmitting the change in policy rates into the real economy.

Monetary policy rates influence the real economic indicators – output and inflation, through the transmission process that conventionally operates through five channels: the interest rate channel, the exchange rate channel, the credit channel, the asset price channel, and the expectations channel.The effectiveness of monetary policy actions lies in the speed and magnitude of the transmission process. The interest rate channel of monetary policy transmission has become the cornerstone of monetary policy in most economies. Amidst the changes to the monetary policy framework, there is a need for empirical evidence on the effects of monetary policy in India. This study revisits the widely relevant questions on monetary policy, overshooting, inflationary puzzle and weak monetary transmission mechanism in the Indian context.

This study provides answers to some pertinent questions like; How is the efficiency of the transmission of monetary policy rates to the real economy? How is the co-integrating relationship of monetary policy interest rate movements with rates across financial markets? How is the co-integrating relationship of monetary policy interest rate movements with credit growth, the lending rate in the bank lending channel? and How is the pass-through to call money rate from monetary policy and then how is the pass-through to bank interest rates from call money rate?

This research report on "A Study on the Effectiveness of Transmission of Monetary Policy Rates in India" provides useful insights about the speed and magnitude of transmission based on a comprehensive analysis of existing latest literature on monetary policy transmission and with the use of appropriate econometric techniques. The report, besides making some notable observations, provides useful policy implications. The ineffective monetary policy transmission is perhaps due to the weaknesses in the domestic financial system and poor integration of financial markets and the presence of a large and segmented informal sector.

Dr. Vighneswara Swamy

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Dr. Vighneswara Swamy

A Study on the Effectiveness of Transmission of Monetary Policy Rates in India

Abstract

This study provides new evidence on the effectiveness of monetary policy transmission in India. Considering the impeding factors in the transmission of monetary policy, it estimates a series of vector autoregression models to examine the effects on the real sector. Using stepwise estimation of vector error correction models, the study estimates the pass-through of policy rate changes to bank interest rates. The study also examines the co-integrating relationship of monetary policy interest rate movements with rates across financial markets as well as the co-integrating relationship of monetary policy interest rate movements with credit growth, lending rates in the bank lending channel.

The effectiveness of monetary policy actions lies in the speed and magnitude of the transmission process. Estimations of the impulse responses of macroeconomic indicators show that the time lag for complete transmission of the pass-through from Repo Rate to Commodity Price Inflation is about 8 quarters; from Repo Rate to Short-Term Lending Rate is about 4 quarters; from Repo Rate to Exchange Rate is 9 quarters. However, for the transmission from Repo Rate to Output Growth is 3 quarters. Examination of the co-integrating relationship of monetary policy interest rate movements with rates across financial markets shows that the time lag for the transmission from Call Money Rate to Lending Rate is 2.82 quarters; from Call Money Rate to Asset Prices it is 8-10 quarters, and from Call Money Rate to Bond Market, it is 9 quarters.

The bank lending channel remains a principal means of transmission of monetary policy in India in the post-LAF period. Estimation of the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel shows that the transmission lag for the complete pass-through from Repo Rate to Call Money Rate is about 5 quarters; and from Call Money Rate to Lending Rate (alternate specification) is about 2.7 quarters; from Call Money Rate to Bank Deposit Rate it is 2.9 quarters. Assessing the pass-through to call money rate from monetary policy the study finds that the time lag in complete transmission from Repo Rate to Call Money Rate is 3.17 quarters; from Repo Rate to Call Money Rate (alternate Specification) is 2.76 quarters.

Assessing the pass-through to Bank Interest Rates from Call Money Rate shows that the time lag in the transmission from Repo Rate to Lending Rate is about 2.58 quarters and from Repo Rate to Bank Deposit Rate it is 1.49 quarters. Examining the co-integrating relationship of monetary policy rates movements with Call Money Rate, the study shows that the time lag in the transmission from Cash Reserve Ratio to Call Money Rate is1.46 quarters; from Statutory Liquidity Ratio to Call Money Rate it is 1.69 quarters; from Bank Rate to Call Money Rate, it is 1.8 quarters; and from Reverse Repo Rate to Call Money Rate, it is 9 quarters.

JEL Classification: E43, E52, E58

Key words: Monetary Policy, Monetary Transmission, Interest Rate Channel, Bank Lending Channel, Structural VAR

Executive Summary

This study provides a comprehensive analysis of the efficiency of the monetary policy transmission. This study sheds more light on the timely questions such as: (i) What are the extent and speed of pass-through from monetary policy to inter-bank money market rate and short-term market rate? (ii) What are the extent and speed of pass-through from monetary policy rate to deposit and lending rates, and the real credit to the private sector? (iii) What are the impacts of policy repo rate change in inflation, investment, and gross domestic product? (iv) Is pass-through symmetric? Or do the episodes of monetary contraction and expansion have different influences on bank interest rates? (v) What are the perspectives of the Indian bankers on the efficacy of the transmission of monetary policy rates with changes to the operating framework?

Monetary policy is transmitted to the real sector through several methods and these mechanisms differ from country to country depending upon their legal and financial structures. The effectiveness of monetary policy actions lies in the speed and magnitude of the transmission process. Like other empirical studies in emerging countries have established the importance of the bank lending channel and the interest rate channel, this study finds the predominance of the banking channel in the transmission of the monetary policy in India.

The study analysed the different models of monetary policy transmission models and underscore the importance of lending model in the context of banking dominated financial system of an economy. The efficacy of monetary policy largely depends on the channels of its transmission. The study analysed six channels of monetary policy transmission: (i) the interest rate channel, (ii) exchange rate channel, (iii) bank lending channel, (iv) balance sheet channel, (v) asset price channel, and (vi) expectation channel. Though all of these channels are active in advanced economies, only a few are prominent in the developing countries. The effectiveness of these channels mostly depends on the stage of development of the economy and the structure of its financial system. A sound and stable financial system is indispensable for an objective and efficient implementation of monetary policy. A fragmented and fragile financial sector poses several challenges in the smooth conduct of monetary policy, as the interest rate channel may not have the targeted outcome. Thus, a country’s financial structure has a strong influence on the monetary policy transmission.

Understanding the dynamics of inflation is essential to an efficient monetary policy formulation. Till the unfolding of the global financial crisis, inflation was low, both in advanced countries as well as in emerging and developing economies. As the global economy recovered from the severe effects of the global financial crisis, inflation picked up in emerging and developing economies as the global commodity prices rebounded given the higher level of commodity intensity of growth in these emerging economies. A review of the cross-country inflation dynamics shows that India has a distinct pattern of inflation behavior due to its distinctive features. In addressing the inflation dynamics in the Indian context, there is a need for an India specific approach instead of the plain workbook approach.

The principal objective of the monetary policy has been ‘price stability’ while keeping in mind the objective of growth − though not necessarily the sole objective. Essentially, it is aimed at low and stable levels of inflation as price stability is a necessary precondition to sustainable growth. RBI employs several direct and indirect instruments in implementing its monetary policy, such as *Repo Rate*, *Reverse Repo Rate*, *The LAF*, *Marginal Standing Facility (MSF)*, *Bank Rate*, *Cash Reserve Ratio* (CRR), *Statutory Liquidity Ratio* (SLR), *Open Market Operations* (OMOs), and *Market Stabilization Scheme* (MSS). Monetary policy instruments in India have undergone frequent changes in tune with set objectives of the policy changes. Monetary policy framework in India has evolved in response to and in consequence of financial developments, openness, and shifts in the underlying transmission mechanism. The evolution of monetary policy framework in India can be envisaged in phases such as (i) *Formative Phase*, (ii) *Foundation Phase*, (iii) *Monetary Targeting Phase*, (iv) *Multiple Indicator Approach (MIA) Phase*, and (v) *Disinflation and a New Framework Phase.* Impediments to Monetary Policy Transmission in India are found to be in the persistent fiscal dominance and the development of the financial sector.

This study estimates the efficiency of monetary policy transmission in India in five separate sub-studies. Study 1 reports the estimation of the impulse responses of macroeconomic indicators to the policy repo rate shocks in India:

Transmission to Commodity Price Inflation:

The analysis shows that commodity price inflation experiences a negative impact for the first shock in monetary policy repo rate in the 4th quarter by 3 percent. In response to the first shock, the maximum decline in CPI occurs with a lag of eight quarters with the overall impact continuing through 4–10 quarters.

Transmission to Short Term Lending Rate:

The impulse response functions imply that increase in the policy repo rate is associated with a decline in STLR by 0.11 for the first shock in the 4th quarter. In response to the first shock, the maximum decline in STLR (-5.26) occurs with a lag of ten quarters with the overall impact continuing through 4 – 10 quarters.

Transmission to Exchange Rates:

The analysis shows that a hike in the monetary policy repo rate is associated with an appreciation of the exchange rate by 0.17 for the first shock in the 3rd quarter. In response to the first shock, the maximum decline (appreciation) in the exchange rate (-7.09) occurs with a lag of nine quarters with the overall impact continuing through 3–9 quarters. The possible reason could be that the exchange rate channel is rather weak due to the fact that India remained characterised by a low degree of de facto capital mobility during the sample period, at least when compared to other emerging markets. Further, a possibility is that the RBI's intervention in the foreign exchange market has tended to mute the exchange rate response to monetary policy. This explains the possibly weak exchange rate channel.

Transmission to Output growth:

The estimation of the impact of monetary policy shocks on the economic growth reveals that a hike in policy rate is associated with a decline in real GDP growth rate by -1.06 for the first shock in the 6th quarter. In response to the first shock, the maximum decline in GDP growth (-4.3) occurs with a lag of eight quarters with the overall impact continuing through 6–8 quarters. The real GDP growth responds to the policy repo rate shock with a lag of three-quarters.

Study 2 reports the estimation of the cointegrating relationship of the monetary policy repo rate movements with the rates across the financial markets in India.

Transmission from Call Money Rate to Lending Rate:

The analysis shows that the transmission to lending rate from the call money rate has a feedback effect of 8.85 percent from a weighted average lending rate of the previous quarter and the transmission of call money rate to the lending rate is to the extent of 35.4 percent. It requires 2.82 quarters to achieve complete pass-through.

Transmission to asset prices:

A positive weighted average call money rate shock creates a -4.28 percent rise in SENSEX in the first year. At the end of the second year, about 12 percent of the effects of monetary policy tightening pass through the asset prices. After a period of 10 quarters, only 16 percent of the effects of monetary policy tightening pass through the asset prices.

Transmission to Bond Market:

An unexpected rise in the call money rate is associated with a rise in 10-year bond yield by around 0.29 in the first period and reaches a peak of 0.33 in the 3rd period. Considering the accumulated responses, a positive call money rate shock creates a 1.17 percent rise in BOND 10Y yield in the first year. At the end of the second year, only 2.35 percent of the effects of monetary policy tightening pass through the bond market. After a period of 10 quarters, only 2.95 percent of the effects of monetary policy tightening pass through the long-term bond market. In the case of 5-year bonds, an unexpected rise in the call money rate is associated with a rise in 5-year bond yield by around 1.09 percent in the first year. At the end of the second year, only 2.20 percent of the effects of monetary policy tightening pass through the bond market. After a period of 10 quarters, only 2.75 percent of the effects of monetary policy tightening pass through the long-term bond market.

Study 3 reports the examination of the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel.

Transmission to the Inter-Bank Market Rate:

The analysis suggests that about 20 percent of disequilibrium is “corrected” in each quarter by changes in call money rate. Accordingly, it requires 5 quarters to achieve complete pass-through. An unexpected 1 percentage point increase in repo rate is associated with a rise in call money rate by around 2.04 in the 1st quarter and settles in the range of 0.99 to 1.03 during the 4th to the 10th quarters. The results show that there is significant, albeit slow, pass-through of policy changes to inter-bank call money rate.

Transmission from Call Money Rate to the Lending Rate:

The analysis suggests that about 37 percent of disequilibrium is “corrected” in each quarter by changes in the call money rate, resulting in 2.7 quarters to achieve the complete pass-through from a change in the call money rate. The impulse responses reveal that an unexpected rise in the call money rate is associated with a rise in lending rate by around 0.42 in the 1st quarter.

Transmission from Call Money Rate to the Deposit Rate

The results reveal a long run coefficient of -0.3431 which indicates the speed of adjustment of deposit rate with call money rate at a level of 34.31% per quarter. It requires 2.91 quarters to achieve the complete pass-through from the call money rate. An unexpected one percentage point rise in the call money rate is associated with a rise in deposit rate by around 0.04 in the 2nd quarter. The extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate.

Study 4 reports the estimation of the pass-through to call money rate from monetary policy.

Transmission from Repo Rate to Call Money Rate:

The results indicate that the call money rate adjusts by 31.5 percent per quarter towards the repo rate to re-establish equilibrium suggesting that it takes 3.16 quarters for the complete pass-through from the policy repo rate to call money rate. At this rate, it would take 1.58 quarter to achieve fifty percent of the pass-through from an increase in the repo rate. In the alternate specification, the results suggest that it takes 2.76 quarters for the complete pass-through from the policy repo rate to call money rate. At this rate, it would take 4.16 months to achieve fifty percent of the pass-through from an increase in the repo rate. The results also suggest that the complete transmission of the monetary policy through REPO and REVERSEREPO happens in around 8 to 9months. Thus, the repo rate appears to sufficiently capture the monetary policy stance.

Study 5 reports the estimation of the pass-through to bank interest rates from call money rate.

Pass-through from Repo Rate to Bank Lending Rate:

The results indicate a feedback of about 38.77% of the repo rate of the previous quarter’s disequilibrium from the long run elasticity, resulting in 2.58 quarters to achieve the complete pass-through from repo rate.

Pass-through from Repo Rate to Bank Deposit Rate:

The results indicate a feedback of about 67% of the repo rate of the previous quarter's disequilibrium from the long run elasticity, resulting in 1.49 quarters to achieve the complete pass-through from repo rate.

Finally, Study 6 reports the estimation of the cointegrating relationship of monetary policy rate movements with call money rate.

Pass-through from Cash Reserve Ratio to Call Money Rate:

The results indicate a feedback of about 68% of the cash reserve ratio of the previous quarter's disequilibrium from the long run elasticity, resulting in 1.46 quarters to achieve the complete pass-through from cash reserve ratio.

Pass-through from Statutory Liquidity Ratio to Call Money Rate:

The results indicate a feedback of about 59% of the statutory liquidity ratio of the previous quarter's disequilibrium from the long run elasticity, resulting in 1.69 quarters to achieve the complete pass-through from statutory liquidity ratio.

Pass-through from Bank Rate to Call Money Rate:

The results indicate a feedback of about 55% of the bank rate of the previous quarter's disequilibrium from the long run elasticity, resulting in 1.8 quarters to achieve the complete pass-through from bank rate.

Pass-through from Reverse Repo Rate to Call Money Rate:

The results indicate a feedback of about 5.5% of the reverse repo rate of the previous quarter's disequilibrium from the long run elasticity, resulting in 9 quarters to achieve 50 percent of the complete pass-through from reverse repo rate.

Results at a Glance

	Transmission	*Complete Pass-through*
Study 1: *Estimating Impulse Responses of macroeconomic Indicators*		
1	From Repo Rate to Commodity Price Inflation	8 quarters
2	From Repo Rate to Short-Term Lending Rate	4 quarters
3	From Repo Rate to Exchange Rate	9 quarters
4	From Repo Rate to Output Growth	3 quarters
Study 2: *Examining the Co-integrating Relationship of Monetary Policy Interest Rate Movements with Rates across Financial Markets*		
5	From Call Money Rate to Lending Rate	2.82 quarters
6	From Call Money Rate to Asset Prices	8-10 quarters
7	From Call Money Rate to Bond Market	9 quarters
Study 3: *Examining the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel*		
8	From Repo Rate to Call Money Rate	5 quarters
9	From Call Money Rate to Lending Rate (alternate specification)	2.7 quarters
10	From Call Money Rate to Bank Deposit Rate	2.9 quarters
Study 4: *Assessing the Pass-through to call money rate from Monetary Policy*		
11	From Repo Rate to Call Money Rate	3.17 quarters
12	From Repo Rate to Call Money Rate (alternate Spwcification)	2.76 quarters
Study 5: *Assessing the Pass-through to Bank Interest Rates from Call Money Rate*		
13	From Repo Rate to Lending Rate	2.58 quarters
14	From Repo Rate to Bank Deposit Rate	1.49 quarters
Study 6: *Examining the co-integrating relationship of monetary policy rates movements with Call Money Rate*		
15	From Cash Reserve Ratio to Call Money Rate	1.46 quarter
16	From Statutory Liquidity Ratio to Call Money Rate	1.69 quarter
17	From Bank Rate to Call Money Rate	1.8 quarter
18	From Reverse Repo Rate to Call Money Rate	9 quarters

Notable Observations:

1. The unidirectional causation running from monetary policy action through call money rate to asset prices through stock market index seems to be weaker as this process looks just coincidental, not targeted. This is because the magnitude of the increase in the call money rate is not large enough to effectively pop up asset price bubbles.

2. The response of stock exchange index to credit market shocks evidences the presumed role of credit expansion in contributing to the asset price bubbles.

The monetary policy tightening leads to a moderation in credit demand over the medium-term, given the usual lags in the impact of monetary policy. The tightening of policy interest rates, which causes the call money rate to rise, impacts the stock prices, as financing the leverage in the markets turns higher and costlier. The impact of the credit market channel on the asset price channel can also work through changes in market perception. As the credit conditions tighten, the perception about the overheating of the economy may get strengthened and accordingly the stock prices would adversely be affected.

3. There is strong bidirectional causality between the policy rate and the call money rate. However, there is significant, albeit slow, pass-through of policy changes to inter-bank call money rate. Similarly, there is a weak pass-through of monetary policy to the lending rate from the inter-bank call money rate.

4. Though there exists a unidirectional causality running from the call money rate at the deposit rate, there is a weaker feedback from deposit (liquidity) channel of monetary policy transmission. The unidirectional causation running from monetary policy action through call money rate to deposit rate seems to be weaker as this process looks just coincidental, not targeted. Further, the extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate.

5. There is a unidirectional causality running from the change in the repo rate to the change in lending rate; from the change in the call money rate to the change in the ratio of loans to assets; and from the change in the ratio of loans

to assets to the change in the lending rate. The direction of causality evidences the dominant presence of the bank lending channel of monetary policy transmission in India.

6. There is a unidirectional causality running from the cash reserve rate to the call money rate; from the bank rate to call money rate; from the reverse repo rate to call money rate. The direction of causality evidences the predominance of the bank lending channel of monetary policy transmission in India.

7. The transmission from reverse repo rate to call money rate is relatively weaker compared that from repo rate to call money rate. The repo rate appears to sufficiently capture the monetary policy stance.

Policy Implications

It is important to note that since food and fuel account for more than 57 percent of the CPI on which the immediate impact of monetary policy is limited, the commitment to the nominal anchor needs to be established by the timely monetary policy response to risks from second round effects and inflation expectations in response to shocks to food and fuel. Administered prices, wages, and directed interest rates continue to be the significant impediments to monetary policy transmission and the achievement of the price stability objective.

The real GDP growth responds to the policy repo rate shock with a lag of three-quarters. The biggest impediment to monetary targeting is the lack of control over RBI’s credit to the central government, which accounts for the bulk of reserve money creation. Persistent fiscal dominance continues to interrupt monetary policy efficacy as open market operations are intermittently employed to ‘manage yields’ in the context of large government borrowings. Further, there is a need to delink the open market operations from fiscal operations and instead linked solely to liquidity management.

In view of the implementation of Basel III framework, it is desirable to reduce the SLR to a level in consonance with the liquidity coverage ratio (LCR).

The transmission of monetary policy to deposit and lending rates is sensitive to liquidity conditions prevailing at the time of a policy rate change and during the period thereafter. There is a need to fine tune RBI’s liquidity management operations in order to ensure consistency with the monetary policy stance. Every increase in the policy rate (conveying an anti-inflation policy stance) should be accompanied by liquidity tightening measures through the liquidity management operations to enable efficient transmission.

In the transmission of the monetary policy to the lending rate, continued time-lags are also due to the imperfectness in the financial system structures and incompletely integrated market segments.

There is a need to develop a more competitive and dynamic banking structure that can facilitate faster re-pricing of deposit and lending rates, in response to RBI’s monetary policy actions.

The higher cost of funds for the banks and related banking system inefficiencies cause a significant impediment in the efficient transmission of the monetary policy through the banking channel.

Asset quality of the banks affects their margins and impedes the efficient transmission of the reduction in the policy rates to the real sector. Banks’ reluctance to pass on the benefits of the favourable monetary policy measures to the real sector are perhaps due to the attempt by the banks to cover their shrinking margins due to the deteriorating asset quality.

Monetary policy transmission mechanism in India, an emerging economy, is found to be weaker compared to the advanced economies. The possible reasons could be: first that the small size of the formal financial sector in India would tend to undermine the effects on bank lending rates on aggregate demand. With the expansion of domestic financial markets and gradual deregulation of interest rates, monetary policy operating procedure in India in the recent years has evolved towards greater reliance on interest rates to signal the stance of monetary policy. This process is bolstered by significant evidence that policy rate changes transmit through the term structure of interest rates, though the intensity of transmission differs across markets. The monetary policy transmission mechanism in India is felt to be weak.

-: List of Select Abbreviations :-	
BRICS	Brazil, Russia, India, China, South Africa
CDR	Credit Deposit Ratio
CPI	Commodity Price Inflation
CRR	Cash Reserve Ratio
DSGE	Dynamic Stochastic General Equilibrium
EME	Emerging Market Economies
FAVAR	Factor-Augmented Vector Autoregressive
FIT	Flexible-Inflation Targeting
FMOD	Financial Markets Operations Department
FMC	Financial Markets Committee
GDP	Gross Domestic Product
GFC	Global Financial Crisis
IRF	Impulse Response Functions
IS-LM	Investment Savings – Liquidity preference/Money supply
LCR	Liquidity Coverage Ratio
LAF	Liquidity Adjustment Facility
MIA	Multiple Indicator Approach
MPC	Monetary Policy Committee
MSF	Marginal Standing Facility
MSS	Market Stabilisation Scheme
NPA	Non-Performing Assets
NDTL	Net Demand And Time Liabilities
OBS	Off-Balance Sheet
OECD	Organisation for Economic Co-operation and Development
OMO	Open Market Operations
PSBs	Public Sector Banks
RBI	Reserve Bank of India
SCBs	Scheduled Commercial Banks
SVAR	Structural Vector AutoRegression
SLR	Statutory Liquidity Ratio
UMPs	Unconventional Monetary Policies
VAR	Vector Autoregression
WACMR	Weighted Average Call Money Rate
WPI	Wholesale Price Index

Chapter 1

Introduction

Monetary policy framework in India has undergone several transformations reflecting underlying macroeconomic and financial conditions. The efficacy of monetary policy actions depends on the speed and magnitude with which they achieve the final objectives. Monetary transmission in advanced economies is found to be relatively robust and efficient in normal times as the pass through happens through alternative channels. On the other hand, in emerging market economies, the transmission is dominant in the credit channel.

In the recent years, more particularly, in the post-global financial crisis scenario, there has been considerable debate around the monetary policy framework, especially on the efficiency of the transmission through the banking channel in India. Even as the Reserve Bank of India has effected considerable monetary policy rate cuts, its transmission remains a matter of concern. Nevertheless, Indian banks have mostly refrained from passing this rate cut benefit on to their borrowers. Since January 2014 until January 2016, there have been five instances of policy rate cuts resulting in the reduction of repo rate from 8.00 percent (28.01.2014) to 6.75 percent (29.09.2015) yielding a net reduction by 1.25 percent (Table 1). Against this reduction of 1.25 percent in policy repo rate, the banks have reduced their lending rates by 0.25 to 0.40 percent.

Lower interest rates assume greater significance to spur consumption and investment, and consequently economic growth. On the other hand, Indian banks are seen raising their lending rates quicker after a policy rate hike as most of the loans are at variable rates and can be re-priced faster. Some of the reasons for the very slow pace of adjustments to the rate cuts by the banks are; the cost of deposits can’t be reduced in the short term, with competition from small savings instruments it is challenging for the banks to cut the deposit rates. Another challenge for the banks in reducing the lending rates is that the credit off-take is low when business is tepid. For example, the credit growth has slowed to 11 percent in 2014-15, down from 15 percent the previous year. Further, banks are experiencing a severe stress on their balance sheets due to a soaring level of stressed assets. Their severely stressed balance sheets obviously instigate banks to instantly pass on the rate cuts in deposit rates and limit the pass-through into lending rates, so as to increase their net interest margins. This is believed to cause the monetary transmission process slower. Thus, the challenge with monetary policy transmission in India continues to be the efficiency of the bank lending channel and interest rate channel in transmitting the change in policy rates in the real economy.

The conduct of monetary policy in a globalized environment complicated by spillovers from monetary policies of advanced economies faces the challenge of managing the impossible trinity: (i) a stable foreign exchange rate, (ii) free capital movement, and (iii) an independent monetary policy, at the same time. The exit from the unconventional monetary policies (UMPs) of systemically important central banks has indeed exposed the limits of the effectiveness of monetary policy in spillovers-sync economies. Gaining from the lessons of the global financial crisis, there is a growing consensus that monetary policy should move away from its narrow focus on inflation towards a multiple target-multiple instrument approach without swerving from a commitment to price stability over the medium term.

The effectiveness of monetary policy actions lies in the speed and magnitude of the transmission process. The interest rate channel of monetary policy transmission has become the cornerstone of monetary policy in most economies. This channel operates through expectations of future interest rates and thereby influences the behavior of economic agents in a forward-looking economy. As the financial systems and markets grow in sophistication, central banks are increasingly employing indirect instruments such as policy interest rates and open market operations rather than direct measures of credit allocation. The policy repo rates directly affect the short-term money market rates which in turn transmit the policy impulse to the financial system through the deposit and lending rates, which in turn affect consumption, saving and investment decisions of economic agents and eventually aggregate demand, output, and inflation. The transmission mechanism is often typified by long, variable and uncertain time lags, rendering it intricate to forecast the precise effect of monetary policy actions on the economy. Comprehending the effects of monetary policy on the economy is essential to the study of macroeconomics and practice of policy makers.

The bank lending channel remains a principal means of transmission of monetary policy in India in the post-LAF period. The interest rate and asset price channels have turned out to be stronger and the exchange rate channel, even though imperceptible, shows a moderate improvement in the post-LAF period. The path to strengthening the monetary policy operating framework of India's was laid out recently in the Patel Committee[1] Report to the Reserve Bank of India (RBI) with the aim of improving transmission. Quite often, the RBI has voiced its concern over a lack of policy rate pass-through to lending rates and deposit rates. Concerns about transmission are not unique to India, as the strength of monetary policy transmission in developing countries as a whole has come into question (Mishra and Montiel 2013; and Mishra et al. 2014). Amidst the changes to the monetary

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[1] Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework, Jan 21, 2014, www.rbi.in/scripts/PublicationReportDetails.aspx?UrlPage=&ID=743

policy framework, there is a need for empirical evidence on the effects of monetary policy in India (IMF 2015a, 2015b).

Previous empirical studies in emerging countries have established the importance of the bank lending channel and the interest rate channel. It is essential to assess in the Indian context, the efficacy of the effects of monetary transmission pass through in the bank lending channel and the interest channel. Though Mishra and Montiel (2013) review the reasons why the credit (bank lending) channel is likely to be the dominant one for developing countries and previous studies of the different channels in India have found this to be the case (Sengupta 2014). In the light of the foregoing motivation, this study proposes to examine the efficacy of the bank lending (credit) channel, and interest rate channel in smoothing the pass-through from the policy rate.

The general consensus based on most of the empirical literature is that monetary policy affects the real economy at least in the short run. Monetary policy is transmitted to the real sector through different mechanisms and these mechanisms differ from country to country depending upon their legal and financial structures. However, the debate is about how and through which channel monetary policy affects output and prices are still an open and unresolved issue. Monetary policy transmission continues to be a ‘black box’ in terms of understanding as to which sector of the real economy is affected the most.

Mostly in response to the challenges and opportunities due to the structural changes in the economy and financial liberalization measures, the conduct of monetary policy has gone through the conduct of monetary policy has undergone key changes and regime shifts across the world. With the fast-evolving financial liberalization and globalization, monetary policy formulation has gained increased market orientation than ever before.

In the context of the above debate on the efficacy of monetary policy transmission in India, this study addresses the following questions: (i) what are the extent and speed of pass-through from monetary policy to inter-bank money market rate and short-term market rate? (ii) What are the extent and speed of pass-through from monetary policy rate to deposit and lending rates, and the real credit to the private sector? (iii) What are the impacts of policy repo rate change in inflation, investment, and gross domestic product? (iv) Is pass-through symmetric? Or do the episodes of monetary contraction and expansion have different influences on bank interest rates?

This report is organised in six chapters: Chapter 2 presents a brief on monetary policy transmission. Chapter 3 presents a discussion on inflation dynamics and monetary policy as understanding inflation dynamics is very important in the context of monetary policy and its transmission. Chapter 4 describes the monetary policy in India and its approaches. Chapter 5 provides the assessment of the efficiency of monetary policy transmission in India under six sub-studies. Chapter 6 provides the conclusion and policy implications based on the results of the study.

Chapter 2

Monetary Policy Transmission

A transmission process is specific to a class of hypotheses. Real business cycle hypotheses do not allow any monetary effects on real variables, so the transmission of monetary impulses is limited and uninteresting. For other classes of hypotheses— classical, Keynesian, monetarist, neo-Keynesian, neoclassical, eclectic—monetary impulses have at least temporary real effects. The source of these real effects differs according to the model. In these models, the conduct of monetary policy influences the real variables through several channels.

In a '*money-in-utility function model*' with flexible prices, an inflationary growth in money supply determines the spending decisions in the economy through real balances, while in a '*cash–in–advance model*', the impact is transmitted by raising the cost of the purchases. In a sluggish wage-price regime, the IS-LM model depicts the impact of monetary policy on real variables. In a closed economy, the key variable in the process of transmission is the interest rate, while in an open economy this role is played by the exchange rate. In a 'money view' framework of the transmission mechanism, credit markets stay inactive. In an aggregate analytical model like IS-LM, the bonds and money are the only two assets. As suggested by Bernanke and Blinder (1988).

The transmission of monetary policy affects the real economy is influenced by the degree of integration of financial institutions with the global economy, increased exchange rate flexibility, macroeconomic conditions of the real economy, and the level of central bank autonomy. The field of international macroeconomics has postulated the 'Trilemma': with free capital mobility, independent monetary policies are feasible if and only if exchange rates are floating. As the conduct of monetary policy in a globalized environment confronts the challenge of managing the impossible trinity, the global financial cycle transforms the ‘trilemma’[2] into a ‘dilemma’ or an ‘irreconcilable duo’: independent monetary policies are possible if and only if the capital account is managed.

Monetary policy rates influence the real economy indicators – output and inflation, through the transmission process that conventionally operates through five channels: the interest rate channel (Taylor, 1995), the exchange rate channel (Obstfeld and Rogoff, 1995), the credit channel (Bernanke and Gertler, 1995), the asset price channel (Meltzer, 1995), and the expectations channel (Mishkin, 1996). These channels are not mutually exclusive as the effect of one channel could amplify or moderate the effect of another channel as they evolve alongside changes in the overall economic and financial conditions. The lack of a consensus on the channels of monetary transmission is evident from the debate in a Symposium on ‘The Monetary Policy Transmission’ published in the Journal of Economic Perspectives in 1995. Further, Mishkin (1995, 1996 and 2001) provide a helicopter view on the working of various channels for a better understanding of monetary policy transmission.

Economies have considerable differences among their financial structures, even among the advanced ones. However, these differences are even more systematically pronounced in the case of developing economies. Developing countries tend to be relatively less integrated with International financial markets as their central banks generally intervene quite often in the foreign exchange markets to protect their domestic macroeconomic environment that is often unstable (Mishra, Montiel, and Spilimbergo (MMS), 2013). Consequently, the exchange rate, the interest rate, and the asset channels are constrained in

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[2] India’s Trilemma: Financial Liberalization, Exchange Rates and Monetary Policy Hutchison et al. (2012).

properly implementing their functions within the system. On the contrary, banks being the dominant financial institutions in these economies make the bank lending channel to be the most dominant channel. These characteristics, according to (MMS, 2013), suggest that the bank lending channel should dominate monetary transmission in low-income countries. However, it is also noticed that the financial structures of developing countries tend to undermine the effectiveness of the bank lending channel as they suffer from a fallible domestic institutional environment, ineffective legal systems, weak accounting and disclosure standards, poorly stated property rights, relatively small and illiquid securities markets, and poorly capitalized and public owned banking systems.

The efficacy of monetary policy largely depends on the channels of its transmission. A country's financial structure has a strong influence on the monetary policy transmission. Literature features the monetary policy transmission through two sets of broad channels: (i) neoclassical channels and (ii) non-classical channels. The neoclassical channels emphasize on how interest rate changes operate through investment, consumption, and trade to achieve the policy objectives. The non-classical channels focus on how the policy rates operate primarily through a change in credit supply and influence the behaviour of banks and their balance sheets. In general, six channels of transmissions are observed: (i) the interest rate channel (Taylor, 1995), (ii) exchange rate channel (Obstfeld and Rogoff, 1995; Boivin, Kiley and Mishkin, 2011), (iii) bank lending channel (Bernanke and Blinder, 1988; Bernanke and Gertler, 1995), (iv) balance sheet channel (Boivin *et al.*, 2011), (v) asset price channel (Meltzer, 1995), and (vi) expectation channel (Yellen, 2011). Most of these channels are found to be active in advanced economies. However, only a few are instrumental in the case of developing countries. The effectiveness of these channels in a given economy largely depends on the stage of development of the economy and the structure of its financial system.

Interestingly, Bernanke and Gertler (1995) refer to the channels of monetary transmission as a ‘black box’ – implying that ‘we know’ that monetary policy does influence output and inflation but ‘we do not know’ for certain how precisely it does so. Is it because not only different channels of monetary transmission tend to operate simultaneously but also they change over time. Therefore, some questions persist: does monetary policy affect the real economy? If yes, how does the transmission mechanism effects the changes to take place?

In the ensuing section, I compare the above models of monetary policy transmission models and underscore the importance of lending model in the context of banking dominated financial system of an economy.

I begin the discussion with the workhorse model of most textbooks and much policy discussion – IS-LM model introduced by Hicks (1937) that relates money and interest rate to aggregate income or output. The model hypothesizes the transmission of the monetary policy through the changes in the interest rate as a reduction in the money stock increases the cost of borrowing. The rising borrowing costs shrink the spending by producers on investment in inventories and capital goods or consumers on durable goods, consequently, aggregate spending decreases in response to a monetary contraction and rise following a monetary expansion. As spending, output and aggregate income are equivalent in a closed economy, the output and the spending alter together.

The IS-LM model left open whether it is a model of real output with fixed prices or a model of nominal output that does not distinguish between real and nominal values (Meltzer, 1995). The Phillips curve later resolved the issue by introducing a simple dynamics relating inflation to some measure of aggregate excess demand for output. A positive monetary impulse initially increases the real money stock and decreases the interest rate, indicating the opportunity cost of holding money. The Phillips curve delineates the distribution of the increased spending between inflation and an output; the higher the increase in inflation, the lower is the rise in real money stock and real output. A monetary impulse that alters the nominal and real stocks of money does more than the change in single short-term interest rate or borrowing cost. In effect, monetary policy impulses change actual and anticipated prices for a variety of domestic and foreign assets. In the process, the term structure of interest rates, borrowing and lending, and exchange rates respond.

The question – why does an unanticipated change in the nominal money stock affect the relative price level and the real variables, finds its answer in the ‘liquidity effect’ enunciated by (Christiano and Eichenbaum, 1992). A change in money stock changes liquidity and hence the short-term interest rate is a measure of this liquidity effect. From a monetarist perspective, to capture some of the interplay of relative prices, the transmission model should have: (i) money stock that provides the real services as a medium of exchange; (ii) bonds or securities that yield a nominal return (i.e. rate of interest); and (iii) the stock of real capital, or claims to real capital, yields a real return—a unit of real capital has a price *P*.

However, according to Meltzer (1995), the following five monetarist propositions are of importance in the conduct of the monetary policy. First, neither the central bank nor private forecasters can predict output, employment, inflation, or other variables with sufficient accuracy to damp fluctuations on average. Second, lags are not constant; neither the government nor private forecasters can distinguish between permanent and transitory disturbances to levels and growth rates until sometime after they occur. Third, the response of particular relative prices to monetary and other impulses in any cycle may differ from previous cycles depending on initial conditions, the nature of shocks and the policy rule that is followed. Fourth, the private sector damps fluctuations and returns to stability if undisturbed by unanticipated policy impulses. Fifth, rules that are easily monitored to reduce costs of information.

2.1 Interest Rate Channel

The conventional interest rate channel operates in the following way: An increase/decrease in a monetary policy interest rate (specifically the repo rate in the Indian context) leads first to an increase/decrease in interest rates on the interbank market. This, in turn, triggers the banks to raise/lower their rates on credits and deposits resulting in contraction/expansion of investment activity and aggregate demand and ultimately a weakening/strengthening of inflationary pressures.

The interest rate channel of transmission of monetary policy has been a typical feature in the economics literature since last five decades. It has been the basic Keynesian textbook model on the transmission of monetary policy. The conventional Keynesian view of monetary policy transmission to the real economy is characterized as below:

$$\boldsymbol{M} \downarrow \Longrightarrow \boldsymbol{i} \uparrow \Rightarrow \boldsymbol{I} \downarrow \Rightarrow \boldsymbol{Y} \uparrow$$

where $\boldsymbol{M} \downarrow$ denotes a contractionary monetary policy causing a rise in real interest rates ($\boldsymbol{i} \uparrow$). In turn, it causes rise in the cost of capital, thereby triggering a decline in investment spending ($\boldsymbol{I} \downarrow$), and further causing a decline in aggregate demand and a drop in output ($\boldsymbol{Y} \uparrow$). The interest rate channel of monetary policy transmission as summarized above applies equally to consumer spending in which I denote residential housing and consumer durable expenditure.

Taylor (1995) argues that the interest rate channel is a key component of how monetary policy effects are transmitted to the real economy. In Taylor's model, contractionary monetary policy increases the short-term nominal interest rate and then through a combination of sticky prices and rational expectations, the real long-term interest rate rises as well, at least for a time. The higher real interest rates lead to a drop in business fixed investment, residential housing investment, consumer durable expenditure, and inventory investment, which in turn reduces the aggregate output. Interest rate effects on consumer spending and investments and hence there is a strong interest rate channel of monetary transmission. However, Bernanke and Gertler (1995) state that they have great difficulty in identifying quantitatively important effects of interest rates through the cost of capital. Indeed, they imply that there is a lack of support for a strong interest rate channel as having provided the stimulus for the search for other transmission mechanisms of monetary policy, especially the credit channel.

The interest rate channel is considered to impact the cost of capital. In the case of advanced economies, the interest channel is observed to be strong and has exhibited good information content about the future movement of real macroeconomic variables (Bernanke and Blinder, 1992). However, in the case of developing countries where there is a lack of well-functioning matured capital markets for debt and equities, and in which real estate markets are fragmented and illiquid, monetary transmission through the interest rate is found to be weak. However, the interest rate channel is blunted during surges in capital inflows (Jain-Chandra and Unsal, 2012).

Using cointegrated VAR approach, Singh and Kalirajan (2007) corroborate the importance of interest rate as the major policy variable for conducting monetary policy in the post-liberalised Indian economy, with CRR playing a complementary role. Using VECM approach, Ramey (1993) observe that the money channel was much more important than credit channel in explaining the direct transmission of monetary policy shock in the US. Transmission of monetary policy through money market rates and retail lending rates is observed to be strong but rather weak in the case of longer maturity rates (Égert and MacDonald, 2009). However, owing to the reduced fiscal dominance, flexible exchange rates, and growing market effectiveness in the developing and emerging markets, the interest rate channel is found to be strengthening (Gumata et al., 2013).

In the euro area countries, Smets and Wouters (2002) observe that monetary policy shock via the interest rate channel affects real output, consumption, and investment demand. Similarly, Angeloni et al., (2003) also notice the complete dominance of interest rate channel monetary transmission in a few euro area countries, while being an important channel in almost all of them.

In their study on emerging market economies (EMEs), Mohanty and Turner (2008) argue that credible monetary policy frameworks put in place across EMEs in recent years have strengthened the interest rate channel of monetary policy transmission. Mukherjee and Bhattacharya (2011) observe that the interest rate channel impact private consumption and investment in EMEs, with and without inflation targeting.

2.2 Credit Channel

The credit channel of monetary policy transmission operates by affecting the external finance premium through both the bank lending channel and the balance sheet channel. It is found to impact through the bank lending channel by decreasing the supply of bank loans in response to the contractionary monetary policy. On the other hand, it is observed to operate through the balance sheet channel when the contractionary monetary policy decreases the collateral valuation and net worth of firms and raises the agency costs affecting the firm's activity levels through the financial accelerator. Literature suggests that bank lending channel is found to be more pronounced in the case of firms, and the balance sheet channel is manifest in the case of households (Cicarrelli, et al., 2010)

The credit channel ascribes a dynamic role to the supply of loans in the monetary policy transmission process. It captures the bank lending and balance sheet effects of policy-induced changes in short-term nominal interest rates. The traditional cost-of-capital channel (i.e., interest rate channel) is amplified and propagated by how changes in policy rates affect the availability and cost of credit. Research on the credit channel has picked up since the 1990s when concerns about credit crunch were widespread.

Aleem (2010) studied the credit channel, asset price channel and exchange rate channel of monetary policy transmission using VAR models for the period 1996 – 2007 found credit channel to be the only important channel of monetary transmission in India. Bhaumik *et al.,* (2010) emphasize the importance of bank ownership in monetary policy transmission through the credit channel.

2.3 Exchange Rate Channel

The exchange rate channel has assumed significance given the greater integration of commodities, services and financial markets alongside greater exchange rate flexibility. A flexible exchange rate regime in emerging economies that aims at stabilizing the exchange rates resembles a *de facto* peg[3]. As explained by the hypothesis of ''*fear of floating*'', the

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[3] Quite often, countries implement an exchange rate regime that differs from the officially declared regime. When a government makes a *de jure* public commitment to a fixed exchange rate, it communicates its monetary policy priorities to the domestic and international markets. On the other

emerging economies are characterized by underdeveloped financial markets, their central banks are required to intervene in foreign exchange markets to stabilize exchange rates (Calvo and Reinhart, 2002).

With the fast growing globalization and the advent of flexible exchange rates, the transmission of monetary policy through exchange rate channel has been a standard feature in the leading textbooks of macroeconomics. The exchange rate channel involves the interest rate effects. As the domestic real interest rates rise, the higher value of domestic currency causes the domestic goods expensive thereby triggering the fall of exports ($\boldsymbol{X} \downarrow$) and rise in exchange rate ($\boldsymbol{E} \uparrow$) leading to the decline in aggregate output. The conventional view of monetary policy transmission to the real economy through the exchange rate channel is characterised as below:

$$\boldsymbol{M} \downarrow \Longrightarrow \boldsymbol{i} \uparrow \Rightarrow \boldsymbol{E} \uparrow \Rightarrow \boldsymbol{X} \downarrow \Rightarrow \boldsymbol{Y} \downarrow$$

Obstfeld and Rogoff (1995) and Taylor (1995) emphasize the importance of the exchange rate channel of monetary transmission. Monetary transmission through the exchange rate is either directly influenced by the central bank or impacted by its actions. Typically the exchange rate channel of monetary transmission works through the expenditure switching between domestic and foreign goods. An appreciation of the domestic currency makes foreign goods less expensive inducing demand for the domestic goods and net exports to plunge. At the same time, this may also shrink minimize the external debt in domestic currency terms. Thus the exchange rate effects transmit to aggregate demand and the price level.

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hand, when a government proclaims a floating exchange rate it signals a desire to retain discretion over monetary policy, even if it has implemented a *de facto* fixed rate.

Extant research indicates the exchange rate channel of monetary transmission is substantive in economies with a free float of exchange rates, but its impact is weakened with central bank intervention. For example, in the case of Latin American countries lower exchange rate flexibility relative to that of the peers in Asia appears to have ensued weaker transmission of policy rates. For India, Al-Mashat (2003) used a structural VECM model for the period 1980–2002 found interest rate and exchange rate channels to be important in the transmission of monetary policy shocks on key macroeconomic variables.

2.4 Balance Sheet Channel

The balance-sheet channel of monetary policy transmission operates through the net worth of business firms. Bernanke and Gertler (1995) argue that there is no reason to contemplate that this channel has become less significant of late. As the monetary policy reduces the net worth of the individuals, the quality of collateral declines leading to adverse selection and higher losses. The lower net-worth of business firms also heightens the moral hazard problem as owners with a lower equity stake in their firms tend to engage in risky investment projects. Thus, a decrease in net worth of businesses and individuals causes a drop in lending which in turn causes a reduction in investments.

Monetary policy can impact the firms' balance sheets in many ways. A contractionary monetary policy $\boldsymbol{M} \downarrow$ causes a drop in equity prices $\boldsymbol{P_e} \downarrow$ leading to the decline in the net-worth of firms which in turn leads to low investment spending $\boldsymbol{I} \downarrow$ and reduced aggregate output $\boldsymbol{Y} \downarrow$ in view of the adverse selection and moral hazard problems. This balance-sheet channel of monetary transmission can be characterised as below:

$$M \downarrow \Longrightarrow P_e \downarrow \Rightarrow adverse\ selection\ \uparrow \Rightarrow moral\ hazard\ \uparrow \Rightarrow lending \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

The balance sheet channel, thus provides a rationale for the asset price effects emphasized in the monetarist literature. As the contractionary monetary policy raises the interest rates, it causes deterioration in firms' balance sheets and reduces the cash flows as well. This phenomenon in the balance sheet channel of monetary policy can be represented as below:

$$\boldsymbol{M\downarrow \Longrightarrow i\uparrow \Rightarrow Cash\,flow\downarrow \Rightarrow adverse\ selection\ \uparrow \Rightarrow moral\,hazard\ \uparrow}$$
$$\boldsymbol{\Rightarrow lending\downarrow \Rightarrow I\downarrow \Rightarrow Y\downarrow}$$

2.5 Asset Price Channel

The transmission of monetary policy begins in the asset market. Meltzer (1995) observes that the costs of information and transactions are lower for many assets than the costs of changing production or adjusting consumption or investment in durables. The asset markets respond relatively more quickly, specifically when there is uncertainty about whether monetary policy impulses are either persistent or transient. An open market operation by the central bank causes the following: (i) Simultaneous, opposite change in the stocks of base money and securities; (ii) Purchase increases the base and reduces the stock of debt held by banks or the public; (iii) Sale reduces the base and increases the public's debt holdings. In a monetarist analysis, changes on the securities market affect the interest rate as well. A central bank that sets an interest rate target would increase the money stock following any disturbance that changes in interest rate.

Another way of looking at how the balance-sheet channel may operate through consumers is in its impact through the liquidity effects on consumer expenditures on durable goods and housing, which have been found to be an important factor during the Great Depression (Mishkin, 1978). In the 'liquidity-effects' view, balance-sheet channel works through its impact on consumers' desire to spend rather than on lenders' desire to lend. In this model, if consumers expect a higher likelihood of finding themselves in financial distress, they would rather be holding fewer illiquid assets like consumer durables or housing and more liquid financial assets. The underlying logic is that if consumers sought to sell their consumer durables or housing to raise money, they would expect to suffer large losses, because they may not get their full value in a distress sale. On the contrary, financial assets like bank deposits, stocks or bonds can more easily be realized at full market value to raise cash.

The monetary transmission through the asset price channel operates through the link between money and equity prices. The declining stock prices lower the value of financial assets, consumer expenditures on housing or consumer durables will also plunge, as consumers have a less secure financial position and a higher estimate of the likelihood of suffering financial distress. This phenomenon in the asset price channel can be expressed in schematic form as below:

$$\boldsymbol{M} \downarrow \Longrightarrow \boldsymbol{P} \downarrow \Rightarrow \boldsymbol{financial\ assets} \downarrow \Rightarrow \boldsymbol{likelihood\ of\ financial\ distress} \uparrow \\ \Rightarrow \boldsymbol{consumer\ durable}\ \&\ housing\ expenditure\ \downarrow \Rightarrow Y \downarrow$$

A contractionary monetary policy $\boldsymbol{M} \downarrow$ causes a drop in equity prices $\boldsymbol{P_e} \downarrow$ leading to the decline in the value of financial assets. This causes the rise in the likelihood of financial distress and decline in the consumer and housing expenditure which in turn causes decline in the aggregate output $\boldsymbol{Y} \downarrow$ in the economy.

The asset price channel affects consumption and spending in the economy. A higher interest rate lowers wealth holdings, thus discouraging current consumption and investment, leading to a dampening effect on the aggregate demand. With an expansionary monetary policy, changes in asset prices also affect aggregate demand through the valuation of equities (Tobin's q). A higher value of 'q' indicates the market price of firms is high relative to the replacement cost of capital. As the new plant equipment is cheap relative to the market value of business firms, investment spending increases. On the other hand, with contractionary monetary policy, bonds become more attractive than equities causing the price of equities to drop. Thus, a lower 'q' causes lower investment spending.

It is important to note that changes in asset prices such as the equities and real estate prices also impact the inflation and economic growth. Contractionary monetary policy dampens the equity prices and the resultant wealth effects and the collateral valuation changes feed through to consumption and investment. The asset price channel is found to be weak in emerging economies where equity markets are modest and illiquid, but relatively strong in those economies that have mature open equity markets. Similarly, monetary transmission is also noticed to be limited in countries with weak property price regimes and inadequately developed illiquid real estate markets.

For instance, in countries like the US and Australia, where the mortgage market is well integrated with capital markets, the asset price channel is observed to be quite substantial. In general, stock prices are observed to respond quicker to contractionary monetary policy, though liquidity in the stock markets impacts the intensity and lags of monetary transmission. Examining the impact of quantitative easing adopted during the recent global financial crisis on the UK economy, Joyce *et al.* (2011) have highlighted the importance of the different transmission channels, particularly asset prices which were expected to have conventional effects on output and inflation.

2.6 Bank Lending Channel

The bank lending channel is premised on the construct that banks play a unique and central role in the financial system since they are well suited to solve asymmetric information problems in credit markets. The broad credit channel focuses on all forms of external finance that firms can tap but at a cost premium. This external finance premium compensates lenders for the monitoring and evaluation of loans and is affected by the stance of monetary policy. Monetary tightening raises the external finance premium of all funds. While the higher interest rates raise interest expense, reducing the borrower's net cash flow and weakening its financing position[4], they also shrink the value of the borrower's collateral, thus leading to the decline in the borrower's net worth leads to a fall in investment and aggregate demand (Bernanke and Blinder, 1992).

The bank lending channel postulates that besides the marginal costs and earning considerations, the availability of funds is an important factor in investment and funding decisions. Accordingly, interest rate alone could be an inadequate indicator of the effects of monetary policy. The strength of the bank lending channel depends on other factors like propensity to supply funds, the degree of substitution among different forms of financing, and degree of substitution among different financial institutions (Worms, 2001). Under this channel, the policy-induced reduction or increase in reserve rates affects the banks' supply of loans. Consequently, as not all the firms can shift to other sources of funding without any costs, investment spending will be subsequently affected.

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[4] It is the nominal interest rate that affects the firm's cash flow. This effect differs from the conventional interest rate mechanism in which it is the real rather than the nominal interest rate that affects investment.

The bank lending channel is based on the view that banks play a special role in the financial system because they are especially well suited for financial intermediation and aid in overcoming the problem of asymmetric information. A contractionary monetary policy that reduces the bank reserves and bank deposits will impact through the borrowers. This phenomenon in the bank lending price channel can be expressed in schematic form as below:

$$\boldsymbol{M \downarrow \Longrightarrow bank\ deposits\ \downarrow \Rightarrow bank\ loans\ \downarrow \Rightarrow I\ \downarrow \Rightarrow Y \downarrow}$$

A contractionary monetary policy $\boldsymbol{M} \downarrow$ causes a drop in bank deposits leading to the decline in bank loans. This causes low investment spending $\boldsymbol{I} \downarrow$ and reduced aggregate output $\boldsymbol{Y} \downarrow$.

Questions about the importance of the bank lending channel have been raised in the literature (Edwards and Mishkin, 1995). However, in the evolving periods of globalization, the importance of the bank lending channel has been growing in multitude. In particular, Bernanke (1983) and others emphasize the role of the bank loan market as part of the transmission process. Recent evidence from the euro area suggests that the bank lending channel was more pronounced than the balance sheet channel in the case of firms, while for households, it was the another way round (Cicarrelli, et al., 2010). Bank intermediation is considered to be particularly important in a state of asymmetric information and moral hazard since only banks specialize in monitoring their borrowers. During the state of asymmetric information, since publicly-issued bonds and bank-intermediated loans are not close substitutes, quite a large number of borrowing firms would turn out to be bank-dependent. Under these circumstances, monetary policy has a reason to operate not only through the conventional money channel but also and more importantly through the bank lending channel. To the extent monetary policy shocks influence credit supply independent of influencing credit demand, theoretical considerations make it imperative for monetary policymakers to pay attention to the bank lending channel (Bernanke and Blinder, 1988). However, Pandit and Vashisht (2011) observe that policy rate channel of the transmission mechanism, a hybrid of the traditional interest rate channel and credit channel, works in India, as in other six EMEs in their study.

2.7 Monetary Policy in Developing Countries

The monetary transmission has been through diverse channels in the countries across the globe. In the case of advanced economies, it happens through several alternative channels, which is often found to be robust and efficient in normal times. In contrast, in EMEs, it is the credit channel that dominates transmission. Monetary policies in emerging economies are constructed by the central banks of the advanced economies. However, it is felt that a monetary policy pass-through happens through the traditional money channel.

The challenges for the efficient conduct of monetary policy in emerging economies can be looked at from three specific dimensions. First, the policy and institutional environment face the problem of several constraints in addition to the large and persistent shocks. Second, the ambit and ability for the implementation of economic policies are constrained by legacy structures and absence of analytical and practical tools. Third, keeping in view the reality of funding the investment needs from external financing the conduct of monetary policy cannot be wished away.

The efficacy of monetary policy and the channels for its transmission are considerably influenced by a country’s financial structure (Modigliani and Papademos, 1982). The financial structures of the low-income economies to advanced and emerging ones differ substantially. As the low-income economies tend to be poorly integrated with international financial markets, their central banks generally intervene heavily in foreign exchange markets in order to provide stability to their domestic macroeconomic environment (Mishra, Montiel, and Spilimbergo, 2013). Accordingly, the bank lending channel tends to dominate the monetary transmission in low-income economies.

Analysis of the monetary transmission mechanisms in emerging economies has gained considerable importance due to structural and economic reforms and consequent transitions to new policy regimes. Monetary policies in emerging economies are affected by the policies of world's major central banks, i.e., the Federal Reserve Bank, the European Central Bank and the Bank of Japan. Therefore, the study of monetary transmissions in emerging economies necessitates a model specification unlike that of developed countries.

Central banks in emerging economies always aim at stabilizing exchange rates. As explained by the hypothesis of ‘‘fear of floating’’ (Calvo and Reinhart, 2000), the central banks in the EMEs intervene in the foreign exchange market to stabilize the exchange rates. A flexible exchange rate regime in the EMEs appears like a de facto peg. Disyatat and Vongsinsirikul (2003) used a VAR framework to assess the monetary policy transmission in Thailand and observe that in addition to the traditional interest rate channel, banks play an important role in monetary policy transmission mechanism, while exchange rate and asset price channels were relatively less significant. For Sri Lanka, Amarasekara (2008) in his study observed the interest rate channel to be more important for monetary policy transmission. For the Philippines, Bayangos (2010) noticed the credit channel of monetary transmission to be important.

In the case of South Africa, Kabundi and Nonhlanhla (2011) assess the monetary policy transmission using an FAVAR framework and conclude that monetary policy shock had a short-lived impact on both the real economy and prices and, in addition to interest rate channel, found confidence channel to be important in monetary policy transmission. However, Ncube and Ndou (2011) showed that monetary policy tightening in South Africa can marginally weaken inflationary pressures through household wealth and the credit channel.

On the other hand, some studies reveal a weaker transmission of monetary policy in low-income countries and emerging economies. Particularly, in the low incomes countries, Mishra et al., (2010) observes that weak institutional mechanism impaired the efficacy of traditional monetary transmission channels namely, interest rate, bank lending, and asset price. Bhattacharya et al., (2011) also found a similar weaker transmission for a group of emerging economies and observe that the weakness in the domestic financial system and the presence of a large and segmented informal sector led to ineffective monetary policy transmission.

The literature undoubtedly emphasizes a sound and stable financial system is indispensable for an objective and efficient implementation of monetary policy. A fragmented and fragile financial sector poses several challenges in the smooth conduct of monetary policy, as the interest rate channel may not have the targeted outcome. Thus, these problems arise due to the segmented financial system and highlight the financial sector dominance.

Chapter 3

Inflation Dynamics and Monetary Policy

"*Inflation is always and everywhere a monetary phenomenon*." Milton Friedman

Understanding inflation dynamics is very important in the context of monetary policy and its transmission. According to Mishkin (2007), a discussion on inflation dynamics is required to see: (1) what is the available evidence on changes in inflation persistence in recent years? (2) What is the available evidence on changes in the slope of the Phillips curve? (3) What role do other variables play in the inflation process? It is interesting that monetary policy can account for a large proportion of the reduction in aggregate demand volatility; a reduction in aggregate supply volatility would be required to account for the remaining reduction in the volatility of output growth. Further, the monetary policy changes considered predict large declines in the slope of the reduced-form relationship between the change in inflation and the unemployment rate.

In the presence of price adjustment costs (price adjustment is not completely costless), inflation causes uneconomical expenses for the firms and gives rise to changes in the distribution of relative prices that do not reflect changes in productivity. Imperfect competition and costly price adjustment combined with sticky prices cause significant changes in the money supply on output. Thus inflation dynamics and price adjustment can determine the effects of monetary policy on output and welfare (Blanchard and Kiyotaki, 1987). Inflation affects the real value of nominal assets, including money which in turn can affect aggregate demand. As negative inflation or deflation increases the real value of money, holding money then gives a positive real return.

The distribution of relative prices and the real value of nominal assets in a market economy affect the allocation of the society's resources to consumption, leisure and investment. Inflation affects the aggregate economy and economic welfare by generating real wealth redistributions across agents, more particularly among the debtors and creditors (Doepke and Schneider, 2006). In the New Keynesian model, with a monetary policy shock, as the nominal interest rate increases, inflation, consumption, investment and output persistently fall. Output decreases after a tightening of monetary policy. Prices do not react much, or even increase slightly in the short run (Christiano et al., 1999).

High inflation has profound consequences. In the post global financial crisis years, persistently high inflation has caused the real interest rates turn negative for savers, leading to a slowdown in the growth of domestic savings. In addition, high inflation levels have a negative impact on the country's competitiveness in the external sector thereby undermining the macroeconomic stability. Further, the rise in demand for gold as a hedge against inflation has also aggravated the drop in financial savings leading to the widening of current account deficit and subsequent vulnerability to external shocks.

In the words of Samuelson (2009), "today's most perplexing economic debate", inflation developments continue to pose a daunting dilemma to monetary policy authorities across the world. Low headline inflation across the world with the threats of deflation persisting in some economies and consequent slack in the economic growth offers the rationale for continuation of accommodative monetary policy. At the same time, the growing fears of future inflation in view of the persistent abundant liquidity has formed the raison d'être for the advocacy for coordinated exit strategies from the accommodation. However, the past history tells us that expectations shape how economic agents behave and if they fear inflation, they act in ways that bring it about.

The "persistent and lagged" inflation (with respect to output) has been a worldwide phenomenon in that these short-run inflation dynamics are highly synchronized across countries. Persistent inflation and its lead-lag relationship with output is a common feature of developed economies. Such inflation dynamics are majorly synchronized across countries with the cross-country correlations in inflation and consistently stronger than those in output. However, changes in money stocks are not significantly correlated across countries (Wang and Wen, 2007). The nature of short-run inflation dynamics is one of the most eminent issues in macroeconomics (Phillips, 1958). According to the "sticky-information" model in which information diffuses slowly throughout the population, the slower diffusion happens due to costs of acquiring information or costs of reoptimization (Mankiw and Reis, 2002).

3.1 Cross-country Inflation Comparison

World’s average inflation level during the sample period is 3.93 percent. India’s average inflation during the period is 6.81 percent quite well above the world inflation level. The advanced economies experienced inflation levels less than that of the world. Table 3.1 reports the cross-country inflation comparisons for India, other BRICS countries, and selected advanced economies. France is found to have experienced low levels of inflation during the sample period with an average level at 1.52 percent. On the other hand, Russia has experienced higher levels of inflation during the period with an average level at 11.8 percent.

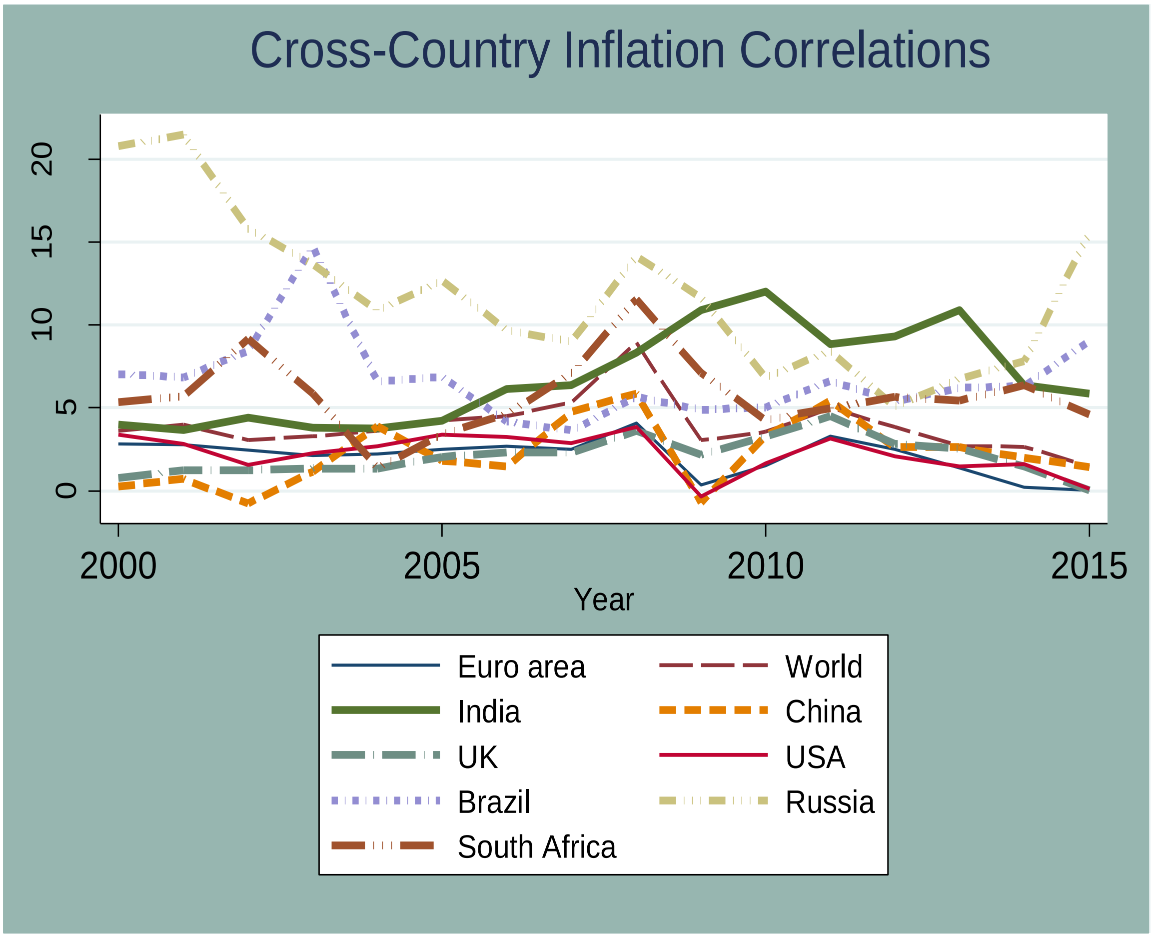
Table 3.1: Cross-country Inflation Comparison

	Mean	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Brazil	2.09	6.87	4.18	3.64	5.66	4.89	5.04	6.64	5.40	6.20	6.33	9.03
China	2.24	1.82	1.46	4.75	5.86	-0.70	3.31	5.41	2.62	2.63	2.00	1.44
France	1.52	1.74	1.68	1.49	2.81	0.09	1.53	2.12	1.96	0.86	0.51	0.04
Germany	1.49	1.55	1.58	2.30	2.63	0.31	1.10	2.08	2.01	1.50	0.91	0.23
India	6.81	4.25	6.15	6.37	8.35	10.8	11.9	8.86	9.31	10.9	6.35	5.87
Russia	11.8	12.6	9.69	8.99	14.1	11.6	6.84	8.43	5.08	6.78	7.81	15.5
SA	5.79	3.40	4.64	7.10	11.5	7.13	4.26	5.00	5.65	5.45	6.38	4.59
U.K	2.07	2.05	2.33	2.32	3.61	2.17	3.29	4.48	2.82	2.55	1.46	0.05
USA	2.24	3.39	3.23	2.85	3.84	-0.36	1.64	3.16	2.07	1.46	1.62	0.12
Euro area	2.09	2.49	2.68	2.51	4.08	0.37	1.53	3.29	2.49	1.37	0.24	0.04
World	3.93	4.25	4.49	5.34	8.95	3.04	3.55	5.00	3.85	2.70	2.66	1.44

Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent year-on-year

Figure 3.1 presents the graphical description of the inflation levels in the countries in the sample during the period of review. There is a strong comovement in inflation among countries and is striking. Perhaps oil shocks are largely responsible for the cross-country inflation comovements. What causes the international synchronization in inflation? Of course, an obvious reason to a large extent is the coordinated monetary policies among the developed countries.

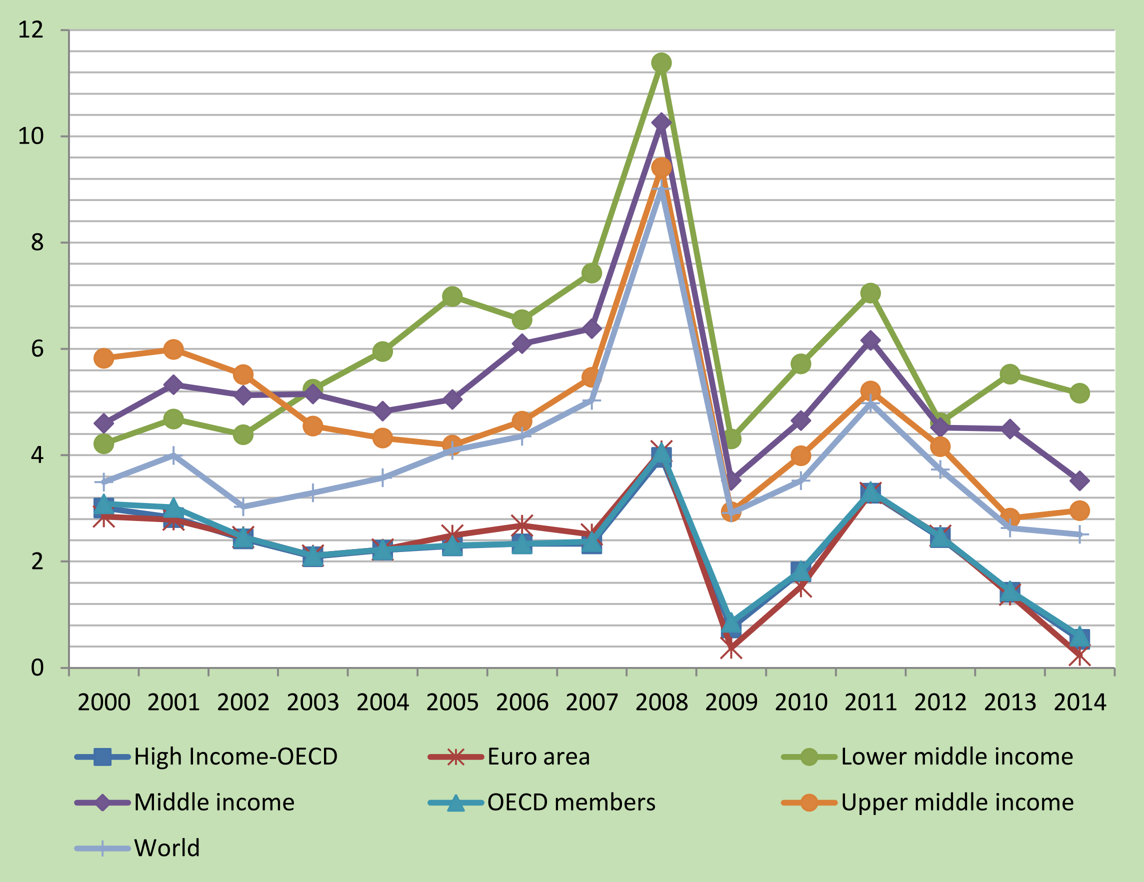
Figure 3.1: Cross-country inflation correlations



Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent year-on-year

Cross–regional inflation comparison (Figure 3.2) indicates similar pattern in regional groupings such as Lower middle income, Middle income, Upper middle income, OECD members, High income–OECD, Euro area, and World. In all the regions under comparison, the average inflation levels have spiked up during the global financial crisis period. Lower middle income countries experience higher levels of inflation and Euro area experience very low levels of inflation. High–income OECD countries also experience lower levels of inflation compared to that of other regions. It is noticeable that the advanced economies that are of high income levels experience lower levels of inflation and the low income countries experience higher levels of inflation.

Figure 3.2: Cross–regional inflation comparison



Source: World Development Indicators, August 2015 of World Bank Database

The inflation rates between most of the country pairs are positively correlated. The average cross-country correlation of inflation is significantly and systematically stronger in the case of the euro area and the USA, Germany, and World, Germany, and USA (Table 3.2). Brazil has a negative correlation with inflation levels in China, Germany, India, South Africa, U.K, and the USA. However, India does not have a significant correlation with any of the developed and BRICS countries. India has a negative correlation with inflation levels in Russia (-0.66), USA (-0.38), Euro area (-0.22), Brazil (-0.47), France (-0.25) and Germany (-0.07). India's inflation correlation with that of World average is the lowest at 0.08.

Table 3.2: Cross-country Inflation Correlations

	Euro area	World	Brazil	China	France	Germany	India	Russia	SA	UK	USA
Euro area	1										
World	**0.79***	1									
Brazil	-0.09	-0.32	1								
China	0.43	0.65	-0.31	1							
France	**0.91***	0.70	0.10	0.45	1						
Germany	**0.88***	**0.79***	-0.33	0.64	**0.79***	1					
India	-0.22	0.08	-0.47	0.30	-0.25	-0.07	1				
Russia	0.21	0.01	0.37	-0.47	0.08	-0.05	-0.66	1			
SA	0.25	0.51	-0.04	0.03	0.16	0.26	0.17	0.17	1		
UK	0.45	0.62	-0.43	0.67	0.42	0.53	0.67	-0.59	0.21	1	
USA	**0.87***	0.70	-0.11	0.48	**0.82***	**0.82***	-0.38	0.16	0.01	0.32	1

Note: * indicates significance at 5 percent level

Inflation in BRICS

The descriptive statistics of Inflation in BRICS reveal some interesting facts. All the BRICS countries except China have mean inflation level higher than the World mean inflation (Table 3.3). Russia has the highest mean and median inflation (11.89%, 11.27%) and China has the lowest mean and median inflation (2.24%, 1.91%). China experienced lowest inflation level in the range of -0.77% to 5.86%. The Indian inflation was in the range of 3.68% to 11.99%. Among the BRICS countries, Russia experienced the highest mean inflation (11.89 percent) and China with the lowest inflation of 2.24 percent

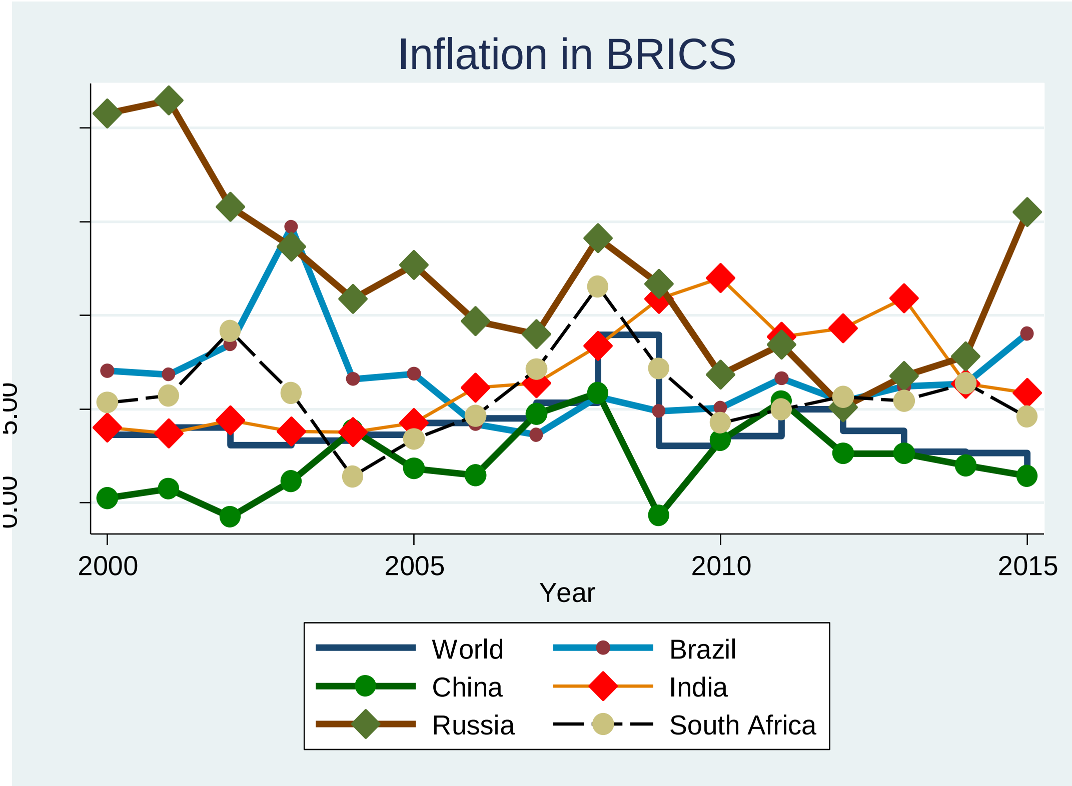
Table 3.3: Descriptive Statistics of Inflation in BRICS

Stats	World	Brazil	China	India	Russia	South Africa
Mean	3.93	6.72	2.24	6.81	11.89	5.79
Max	8.95	14.72	5.86	11.99	21.46	11.54
Min	1.44	3.64	-0.77	3.68	5.08	1.39
Median	3.63	6.47	1.91	6.25	11.27	5.55
Standard Deviation	1.64	2.55	2.00	2.86	4.82	2.30

Note: Inflation figures in percent year-on-year

Figure 3.3 presents the graphical description of the inflation in BRICS countries. Individual country-wise graphical presentation of inflation in BRICS countries is presented in Figure 3.6 at the end of this section. Figure 3.7 captures the graphical comparison of India inflation with advanced economies. Figure 3.8 presents the country-wise inflation and GDP growth in BRICS group. Figure 3.9 presents the country-wise comparison of India inflation and GDP growth with that of advanced economies. There is a noticeable comovement in inflation among countries and is prominent. Oil shocks are mostly responsible for the cross-country inflation comovements. Further, the synchronization in inflation is largely due to the comparable monetary policies among these countries.

Figure 3.3: Inflation in BRICS Countries



Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent year-on-year

What is more interesting about the output-inflation dynamics is that the dynamic movements in inflation are highly synchronized across individual countries. Namely, a high rate of inflation in one country following an output boom is also associated at the same time with a high rate of inflation in another country. Table 3.4 presents the correlations of inflation in BRICS countries. We notice positive correlations in the case of Brazil with Russia (0.37), South Africa with India (0.17), India with China (0.30), and South Africa with Russia (0.17). Negative correlations are observed in the case of China with Brazil (-0.31), India with Brazil (-0.47), Russia with China (-0.47), and Russia with India (-0.66). Amongst the BRICS group, all countries, except Brazil, have a positive correlation with the World inflation. The minimum value of correlation is -0.66 between Russia and India and the maximum is 0.37 between Russia and Brazil. This strong comovement in inflation between Brazil and Russia, and between India and China is striking (Figure 3.2). It could be associated with the long-standing riddle that output is positively correlated among countries.

Table 3.4: Correlations of Inflation in BRICS Countries

	World	Brazil	China	India	Russia	South Africa
World	1					
Brazil	-0.32	1				
China	0.65	-0.31	1			
India	0.08	-0.47	0.30	1		
Russia	0.01	0.37	-0.47	-0.66	1	
South Africa	0.51	-0.04	0.03	0.17	0.17	1

Cross-country output comparison indicates interesting insights in understanding the inflation dynamics (Table 3.5). Amongst the advanced economies, France has the least mean GDP growth rate of 0.82 percent and among the BRICS group, China has the highest mean growth rate of 9.71 percent. India has a mean growth rate of 7.59 percent with the least growth of 5.62 percent in 2012.

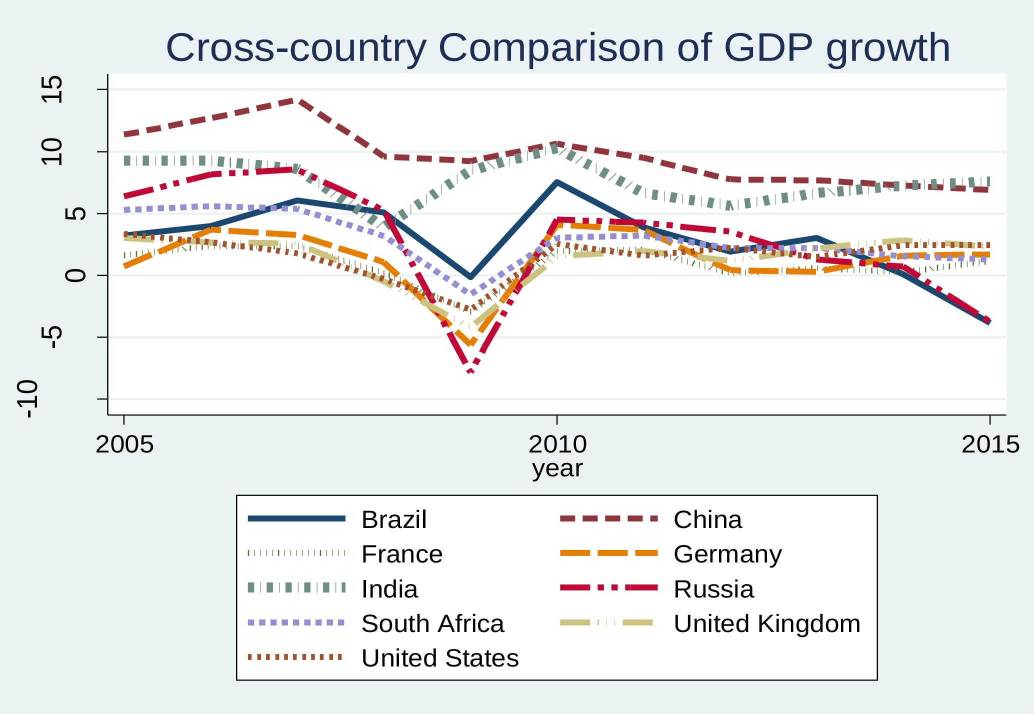
Table 3.5: Cross-country GDP growth Comparison

	Mean	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Brazil	2.80	3.20	3.96	6.07	5.09	-0.13	7.53	3.91	1.92	3.02	0.10	-3.85
China	9.71	11.3	12.6	14.1	9.62	9.23	10.6	9.48	7.75	7.68	7.27	6.90
France	0.89	1.61	2.37	2.36	0.20	-2.94	1.97	2.08	0.18	0.58	0.26	1.16
Germany	1.35	0.71	3.70	3.26	1.08	-5.62	4.08	3.66	0.41	0.30	1.60	1.69
India	7.59	9.28	9.26	8.61	3.89	8.48	10.26	6.64	5.62	6.64	7.24	7.57
Russia	2.82	6.38	8.15	8.54	5.25	-7.82	4.50	4.26	3.52	1.28	0.71	-3.73
SA	2.85	5.28	5.59	5.36	3.19	-1.54	3.04	3.21	2.22	2.21	1.55	1.28
UK	1.42	3.00	2.66	2.59	-0.47	-4.19	1.54	1.97	1.18	2.16	2.85	2.33
USA	1.58	3.35	2.67	1.78	-0.29	-2.78	2.53	1.60	2.22	1.49	2.43	2.43
Euro area	0.82	1.70	3.25	3.06	0.48	-4.54	2.07	1.59	-0.88	-0.32	0.90	1.66
World	2.74	3.82	4.38	4.31	1.84	-1.68	4.35	3.13	2.48	2.40	2.63	2.47

Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent year-on-year

Figure 3.4 presents the graphical description of the cross-country comparison of GDP growth of the countries. There is a noticeable comovement of growth rates in the countries excluding China and India.

Figure 3.4: Cross-country comparison of GDP growth



Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent year-on-year

The cross-country correlations of GDP growth are presented in Table 6. Two important patterns are worth noticing: First, country pairs with higher cross-country correlations in inflation also tend to have higher correlations in GDP growth (Table 3.6). Second and more importantly, the output correlations are stronger than inflation correlations for most of the country pairs.

Table 3.6: Cross-country Correlations of GDP growth

	Brazil	China	France	Germany	India	Russia	SA	UK	USA	Euro area	World
Brazil	1										
China	**0.68**	1									
France	0.48	0.49	1								
Germany	0.48	0.35	**0.95**	1							
India	0.15	0.50	0.28	0.15	1						
Russia	**0.76**	**0.68**	**0.80**	**0.75**	0.07	1					
SA	**0.62**	**0.73**	**0.86**	**0.74**	0.22	**0.95**	1				
UK	0.14	0.15	**0.85**	**0.80**	0.18	**0.62**	**0.70**	1			
USA	0.13	0.12	**0.81**	**0.76**	**0.29**	**0.58**	**0.65**	**0.95**	1		
Euro area	0.40	0.50	**0.96**	**0.93**	**0.28**	**0.77**	**0.84**	**0.84**	**0.79**	1	
World	0.52	0.48	**0.96**	**0.92**	0.33	**0.84**	**0.87**	**0.88**	**0.88**	**0.94**	1

Among the BRICS countries, Brazil – Russia have a positive correlation in both inflation and GDP growth, with GDP growth correlation leading inflation correlation (Table 3.6). Similarly, we notice positive correlations in inflation and GDP growth in country pairs: Russia – South Africa, India – China, India – South Africa, and South Africa – China. It is interesting to note that though China – Brazil experienced negative correlation in inflation (-0.31), they have a strong positive correlation in GDP growth (0.68). In the case of India – Russia, the inflation correlation is negative (-0.66), however, the GDP growth correlation is positive (0.07). Similarly, China – Russia have a negative correlation in inflation (-0.47) but experienced a strong positive correlation (0.68) in GDP growth.

Table 3.7 presents the correlations of Inflation and GDP growth in the BRICS countries. Among the BRICS countries, the growth correlations are stronger than the inflation correlations. India has a positive inflation correlation of 0.30 and a positive growth correlation of 0.50 with China. Similarly, India has a positive inflation correlation of 0.17 and positive growth correlation of 0.22 with South Africa among the BRICS group.

Table 3.8 presents the comparison of the mean correlations of Inflation and GDP growth in the BRICS countries. Among the BRICS countries, the growth correlations are stronger than the inflation correlations. Russia has the least mean inflation positive correlation (0.03) and China has the highest mean growth positive correlation (0.68).

Table 3.7: Correlations of Inflation and GDP growth in the BRICS countries

	Brazil		Russia		India		China		South Africa	
	Inflation correlation	GDP growth correlation	Inflation correlation	GDP growth correlation	Inflation correlation	GDP growth correlation	Inflation correlation	GDP growth correlation	Inflation correlation	GDP growth correlation
Brazil	1	1								
Russia	0.37	0.76	1	1						
India	-0.47	0.15	-0.66	0.07	1	1				
China	-0.31	0.68	-0.47	0.68	0.30	0.50	1	1		
South Africa	-0.04	0.62	0.17	0.95	0.17	0.22	0.03	0.73	1	1

Table 3.8: Comparison of Mean inflation and mean growth correlations in BRICS

	Mean inflations correlation	Mean growths correlations
Brazil	-0.1	0.55
Russia	0.03	0.66
India	-0.17	0.24
China	-0.06	0.68
SA	0.08	0.63

Table 3.9 presents the comparison of the mean correlations of Inflation and GDP growth in the sample countries. Interestingly, the growth correlations are stronger than the inflation correlations. Russia has the least mean inflation correlation (-0.1) and Euro area has the highest mean growth positive correlation (0.82). On the other hand, Euro area has the highest mean inflation correlation (0.45) and India has the least mean growth positive correlation (0.25).

Table 3.9: Comparison of Growth and Inflation correlations

	Mean Growth correlations	Mean Inflation correlations
Brazil	0.44	-0.2
China	0.44	0.28
France	0.81	0.44
Germany	0.72	0.43
India	0.25	-0.1
Russia	0.68	-0.1
SA	0.73	0.15
UK	0.69	0.2
USA	0.68	0.34
Euro area	0.82	0.45
World	0.76	0.42

In the context of inflation dynamics, it is necessary to look at the cross country real interest rates among the countries. Table 3.10 presents the cross-country real interest rate comparison of the countries under review. Brazil has the highest mean real interest rate of 32.3 percent and Russia has the lowest mean real interest rate of -0.64 with a standard deviation of 6.78. India has a mean real interest rate of 4.78 percent with a standard deviation of 2.34 during the sample period followed by South Africa with 3.88 percent (standard deviation of 1.14). Brazil has a mean real interest rate of 32.3 percent with a standard deviation of 7.14. USA has a more stable real interest rate with a mean value of 2.58 (lowest standard deviation of 1.28).

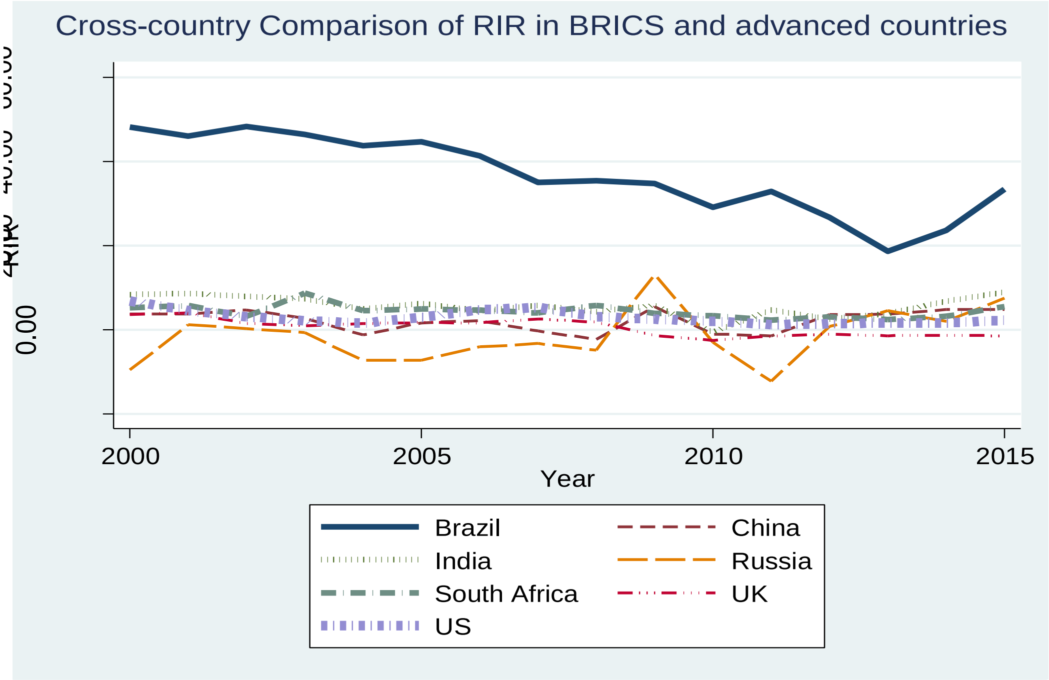
Table 3.10: Cross-country Real Interest Rate Comparison

	Mean	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Brazil	32.3	44.6	41.2	35.0	35.3	34.7	29.1	32.8	26.7	18.6	23.5	33.3
China	1.89	1.64	2.13	-0.34	-2.32	5.42	-1.05	-1.46	3.52	3.68	4.74	4.82
India	4.78	6.25	4.48	5.71	4.28	5.77	-0.60	4.68	2.55	3.83	6.73	8.92
Russia	-0.64	-7.23	-4.12	-3.31	-4.86	13.0	-2.95	-12.2	0.74	4.48	1.98	7.46
SA	3.88	4.91	4.60	3.97	5.78	3.91	3.27	2.20	3.07	2.37	3.15	5.44
UK	-0.17	1.68	1.60	2.57	1.76	-1.38	-2.53	-1.56	-1.11	-1.46	-1.31	NA
USA	2.58	2.88	4.74	5.25	3.07	2.47	2.00	1.16	1.38	1.59	1.58	2.24

Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent

Figure 3.5 presents a graphical description of the real interest rates in the sample countries during the period 2015 – 2015. Most of the countries excluding Russia, exhibit a similar trend. Figure 3.10 (at the end of this section) provides a country wise comparison of inflation, GDP growth, and real interest rate. Figure 3.11 provides the country-wise comparison of India inflation, real interest rate & GDP growth with advanced economies.

Figure 3.5: Cross-country comparison of real interest rates



Source: World Development Indicators, August 2015 of World Bank Database
Note: Figures in percent year-on-year

The descriptive statistics of M1 growth in the countries is reported in Table 3.11. China has the highest M1 growth during the period at 0.20 and France has the least M1 growth and also the least standard deviation of 0.02. Russia has the highest standard deviation of M1growth of 0.34. India has a mean M1 growth of 0.08 with a standard deviation of 0.12.

Table 3.11: Descriptive Statistics of M1 growth in cross-country comparison

	Brazil	Russia	India	China	SA	World	France	Germany	UK	USA
Mean	0.06	0.19	0.08	0.20	0.05	0.07	0.01	0.02	0.06	0.10
Median	0.07	0.13	0.11	0.20	0.05	0.07	0.01	0.02	0.07	0.15
Min	-0.09	-0.15	-0.10	0.07	-0.10	0.04	-0.01	-0.01	0.01	-0.08
Max	0.17	0.66	0.19	0.32	0.20	0.10	0.03	0.04	0.10	0.16
Std. Dev.	0.11	0.34	0.12	0.11	0.13	0.03	0.02	0.02	0.04	0.12

The cross-countries M1 growth correlations are reported in Table 3.12. India has a strong positive correlation with Brazil (0.95), South Africa (0.88). The negative correlations are observed France (-0.37), Germany (-0.12). Figure 3.12 (at the end of this section) provides a country-wise comparison of Inflation and M1 growth in BRICS group. Figure 3.13 provides a country-wise comparison of inflation and M1 growth in advanced economies

Table 3.12: Cross-countries Correlations of M1 growth

	Brazil	Russia	India	China	SA	World	France	Germany	UK	USA
Brazil	1									
Russia	0.44	1								
India	0.95	0.44	1							
China	0.59	-0.05	0.32	1						
SA	0.98	0.51	0.88	0.67	1					
World	0.79	0.35	0.55	0.91	0.88	1				
France	-0.63	0.01	-0.37	-1	-0.71	-0.93	1			
Germany	-0.41	0.2	-0.12	-0.98	-0.5	-0.81	0.96	1		
UK	-0.11	-0.87	0.01	-0.03	-0.24	-0.32	0.04	-0.04	1	
USA	-0.72	-0.92	-0.63	-0.34	-0.8	-0.68	0.37	0.16	0.76	1

3.2 Lead-Lag Relationship between Output and Inflation

The contemporaneous correlation between output and inflation is positive for Russia, India, China in the BRICS group and is negative is the case of Brazil and South Africa (Table 3.13). However, in the case of Brazil, the correlation turns from negative in contemporaneous GDP growth to positive in GDP growth (lag_01). Among the advanced countries, in the case of France, Germany, and USA the correlation of inflation changes from positive in contemporaneous GDP growth to positive in GDP growth (lag_01). Interestingly, in the case of UK, the correlation of inflation continues to be negative both in the case of GDP growth and GDP growth (lag_01). Figure 3.14 (at the end of this section) provides a graphical presentation of the lead-lag relationship between Output and Inflation in BRICS group. Figure 3.15 provides a lead-lag relationship between Output and Inflation in Advanced countries.

Table 3.13: Correlation of Inflation with GDP growth and GDP growth (lag_01)

Inflation	GDP growth	GDP growth(Lag_01)
BRAZIL	-0.3494	0.0156
RUSSIA	0.2854	0.2018
INDIA	0.2531	0.1154
CHINA	0.2803	-0.2018
SOUTH AFRICA	-0.2738	-0.738
FRANCE	0.4928	-0.3607
GERMANY	0.4323	-0.6937
UK	-0.363	-0.5466
USA	0.5149	-0.4431

Table 3.14 presents the cross-countries correlations of inflation and growth. Brazil has a strong positive correlation with inflation and its M1 growth (0.50). Similarly, India has a positive correlation of 0.51 with its inflation and M1 growth. Germany has a correlation of

0.85 with its inflation and M1 growth. However, China (-0.52), France (-0.65), and USA (-0.52) exhibit a negative correlation.

3.3 Inflation dynamics in India:

Inflation dynamics in India is broadly analyzed under two approaches: the Monetarist approach and the Structuralist approach. The Monetarist approach views inflation as the result of the excess growth of money supply over real output growth (Chand, 1996; Coe and McDermott, 1997; Pradhan and Subramanian, 1998; Callen and Chang, 1999). On the other hand, the Structuralist approach considers inflation as a result of structural disequilibrium in the economy (Balakrishnan, 1994).

The rise in commodity prices, in the post-global financial crisis period, has affected different countries differently depending on whether they are net importers or exporters of commodities. India being a net importer of commodities, the adverse impact on domestic inflation has been intense. Inflation has intensified in developing and emerging economies with a combination of the closing of output gaps and a sharp increase in commodity prices. However, the level of inflation in India has been high compared to those in many EMEs. In India, in addition to the global factors, the domestic factors have a significant influence in the analysis of the inflation dynamics. In terms of the measure of inflation, India comes out as a moderate inflation country, though sporadically inflation crossed the double digit mark. The historical average long-term inflation rate was around 7.5 percent. However, during the study period under consideration in this analysis, the mean inflation in India was 6.88 (as against a mean GDP growth of 7.59) in view of the substantial moderation in inflation in the recent years. India’s CPI inflation shows a structural break in 2011. It is interesting to observe that the standard deviation of inflation is 2.86 as against the standard deviation of GDP growth of

1.76 during the review period. Figure 3.16 captures the movement of consumer price inflation and wholesale price inflation in India.

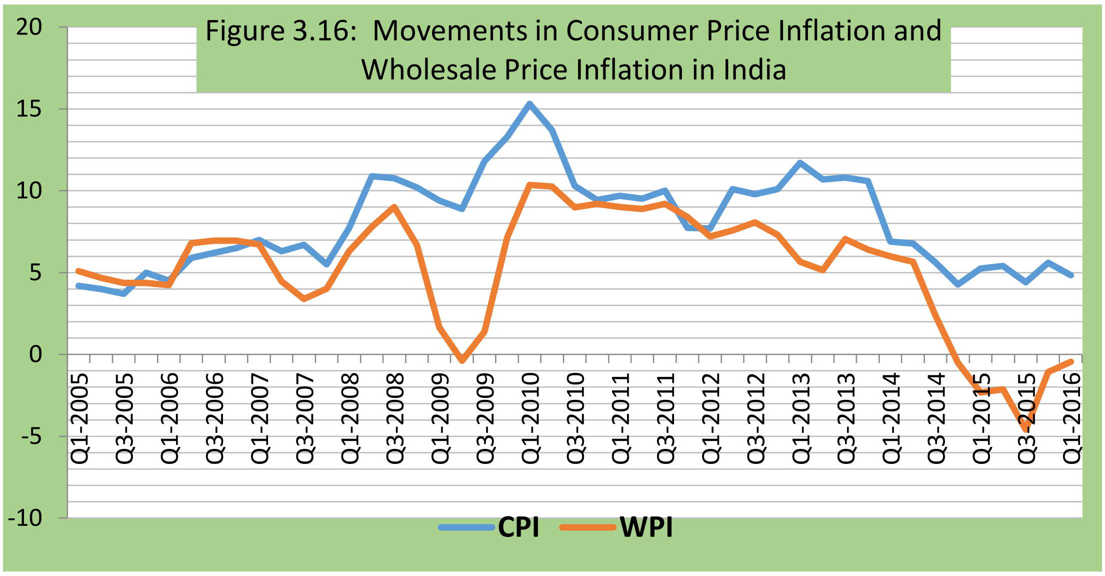
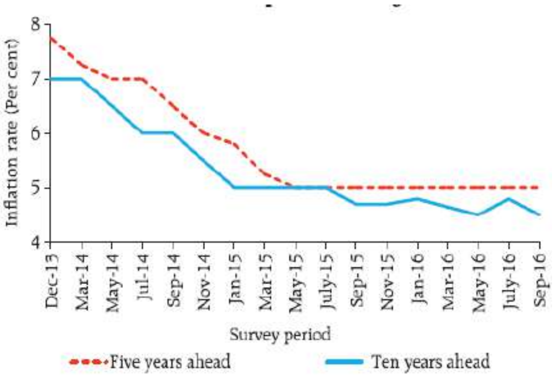
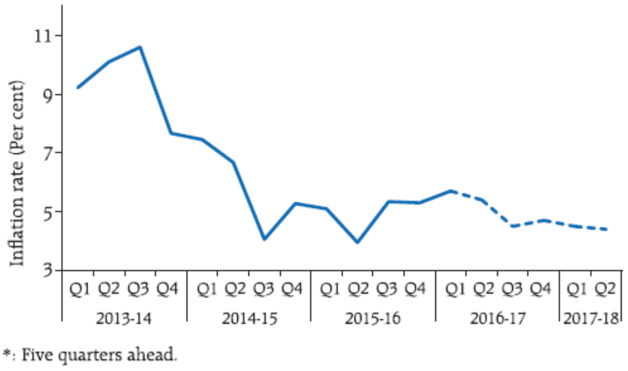


Figure 3.16: Movements in Consumer Price Inflation and Wholesale Price Inflation in India

Reserve Bank of India’s baseline model forecasts (Figure 3.17 a & b), taking into account the forward looking surveys of various classes of economic agents as well as from lead indicators, set a trajectory that takes consumer price index (CPI) inflation down from 5.7 percent in June 2016 to 5.0 percent in December 2016 before it firms up moderately to 5.3 per cent in March 2017. The baseline projection of Inflation for March 2018 is 4.5 percent. On the other hand, the GDP growth projection for March 2017 and March 2018 are 7.6 and 7.9 percent respectively.

Figure 3.17a: Inflation expectations – Long Run. Figure 3.17b: Inflation Expectations – Short Run.





Source: Reserve Bank of India – Monetary Policy Report October 2016.

With regard to the measures of inflation; Headline inflation is more volatile than core: it fluctuates due to large changes in the relative prices of certain industries that are largely but not exclusively industries that produce food and energy. Headline inflation is found to be feeding into expected inflation and future core inflation (Ball, Chari, and Mishra, 2015). India's inflation behavior is observed to be similar to inflation in advanced economies in the 1970s and 80s.

The growing integration of the Indian economy with the world since the mid-1990s has led to greater transmission from the global financial and oil markets into the domestic economy. This has indeed posed growing challenges and is causing unpredictable inflation. In recent years India has surfaced as an outlier compared to its own past inflation as measured by the consumers' cost of living has averaged 9 percent over the last six years (Darbha and Patel, 2012). Other emerging economies have fared better in keeping inflation under check compared to India. The distress with chronically high inflation should not be viewed solely as a concern of academics and policy hawks the Indian voters too have shown traditional aversion to high inflation and priority on price stability (Pew, 2014).

Inflation in India is affected by a host of causal factors such as high fiscal deficit, rising farm wages, domestic supply-side constraints, unexpected weather patterns, rise in international oil prices, rupee depreciation, increased demand, pass-through of global prices for input commodities such as coal, iron ore and aluminium, volatile capital flows and expansionary monetary policy (Gulati and Saini 2013; Patra et al., 2013; Economic Survey, 2013; Rajan, 2014). Transmission impediments and second-order effects of policies targeting consumption patterns, monetary policies impact exchange rates more instantaneously than inflation. Exchange rate volatility renders inflation management much more complex and hence a stable exchange rate augurs well for better monetary transmission. Therefore, monetary policy seems to be more operative in influencing exchange rates rather than targeting inflation.

Conclusion

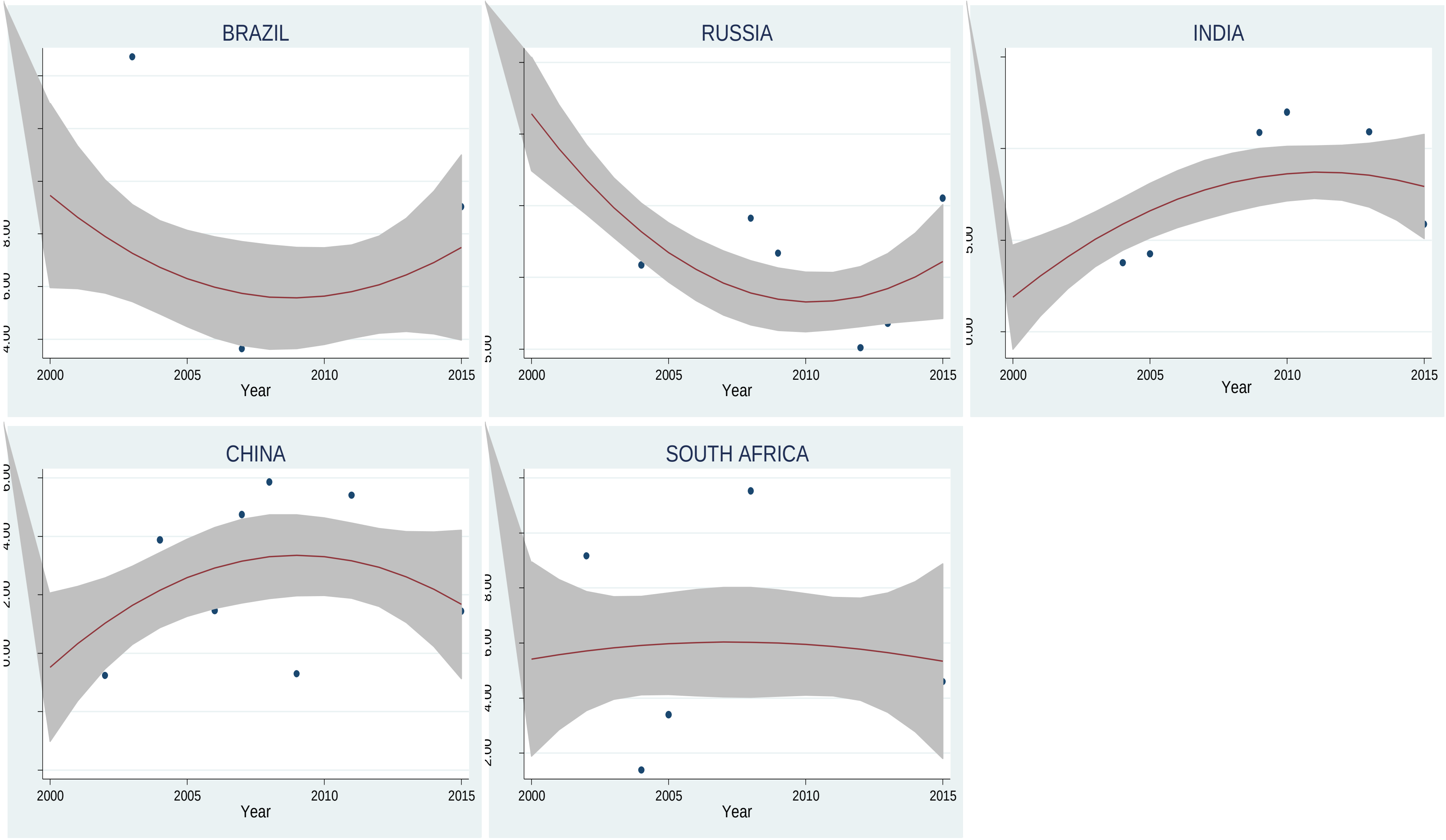
Understanding the dynamics of inflation is critical to an efficient monetary policy formulation. In the last decade, till the unfolding of the global financial crisis, inflation was low, both in advanced countries as well as in emerging and developing economies. Subsequently, the global economy slid into a recession and global output declined by 0.5 per cent in 2009. As the global economy recovered from the severe effect of the global financial crisis, inflation picked up in emerging and developing economies as the global commodity prices rebounded given the higher level of commodity intensity of growth in these emerging economies. The cross-country inflation dynamics discussed above suggests that India has a distinct pattern of inflation behavior due to its unique features. In addressing the inflation dynamics in the Indian context, there is a need for an India specific approach instead of the simple textbook approach.

Table 3.14: Cross country Correlations of Inflation and M1 growth

	Brazil M1 growth (0.05)	Russia M1 growth (0.19)	India M1 growth (0.08)	China M1 growth (0.19)	S A M1 growth (0.05)	World M1 growth (0.07)	France M1 growth (0.01)	Germany M1 growth (0.01)	UK M1 growth (0.06)	USA M1 growth (0.09)
World Inflation (3.86)	0.6033	-0.8651	0.0638	-0.826	-0.6517	-0.8023	-0.6573	0.6751	0.5304	-0.3823
Brazil Inflation (5.49)	**0.5087**	-0.9288	-0.1022	-0.9173	-0.5711	-0.863	-0.6528	0.6022	0.4183	-0.269
China Inflation (2.66)	0.6142	-0.5658	0.4877	**-0.5201**	-0.6256	-0.4899	-0.4534	0.6295	0.5906	-0.6915
France Inflation (1.42)	0.8661	-0.5127	0.4494	-0.3444	-0.861	-0.5085	**-0.6554**	0.8554	0.8611	-0.4803
Germany Inflation (1.37)	0.9359	-0.6893	0.1704	-0.4887	-0.9496	-0.7143	-0.8465	**0.9535**	0.905	-0.2239
India Inflation (10.26)	-0.7018	0.9306	**0.5161**	0.7738	0.7636	0.9811	0.9484	-0.7937	-0.6096	-0.3389
Russia Inflation (8.00)	-0.8381	0.0142	-0.5784	-0.2375	0.786	0.0839	0.4755	-0.7556	-0.8966	0.3047
South Africa Inflation (5.51)	-0.3915	0.0025	-0.895	-0.0169	0.3535	-0.0783	0.0084	-0.3322	-0.437	0.9124
UK Inflation (3.19)	0.4158	-0.6692	0.3284	-0.7043	-0.4498	-0.5588	-0.3728	0.4663	0.3646	-0.6665
USA Inflation (1.62)	0.773	-0.6508	0.366	-0.5397	-0.787	-0.6133	-0.641	0.7917	0.7439	**-0.5206**

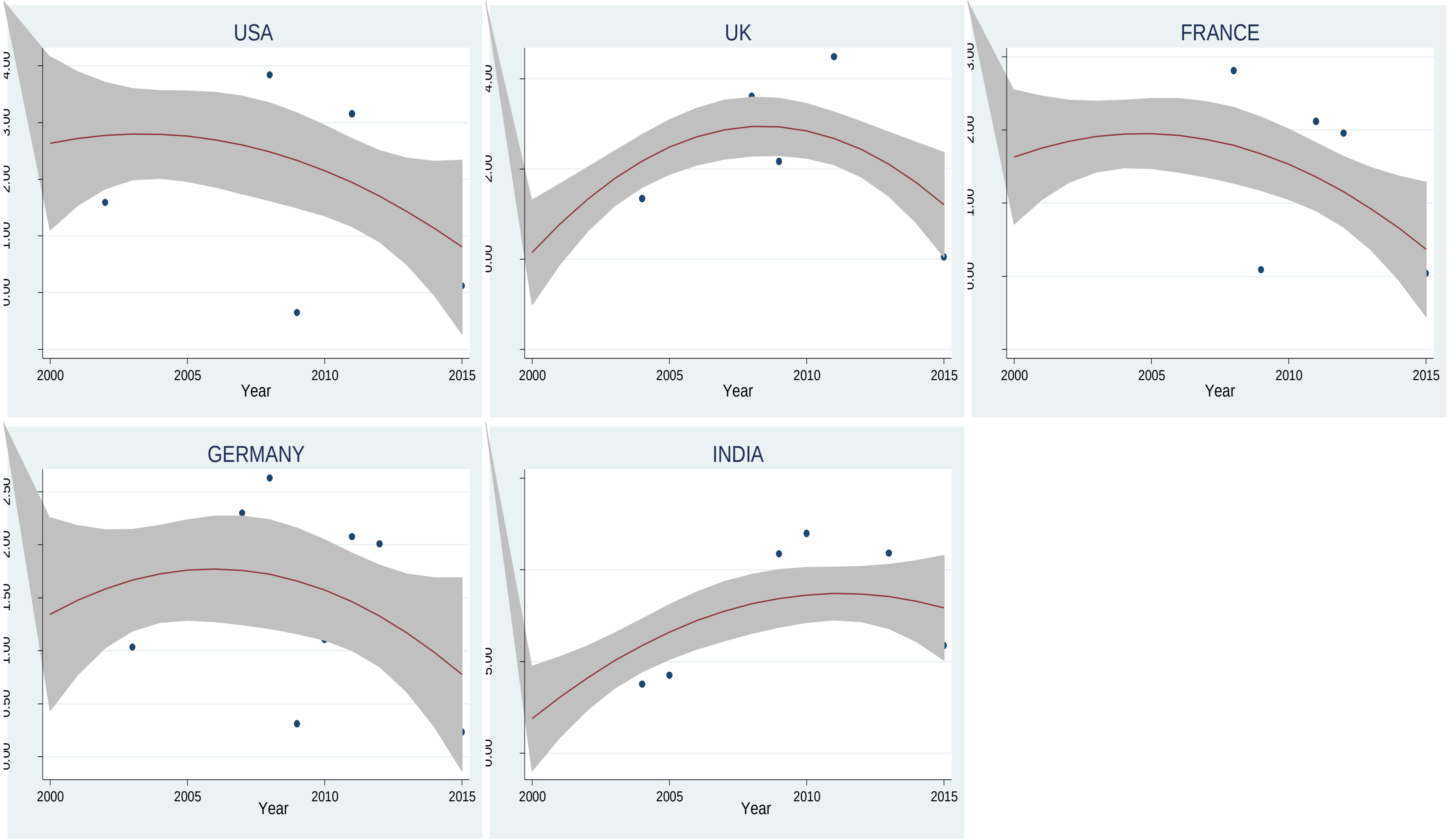
Note: Mean values are presented in parenthesis.

Figure 3.6: Inflation in BRICS countries



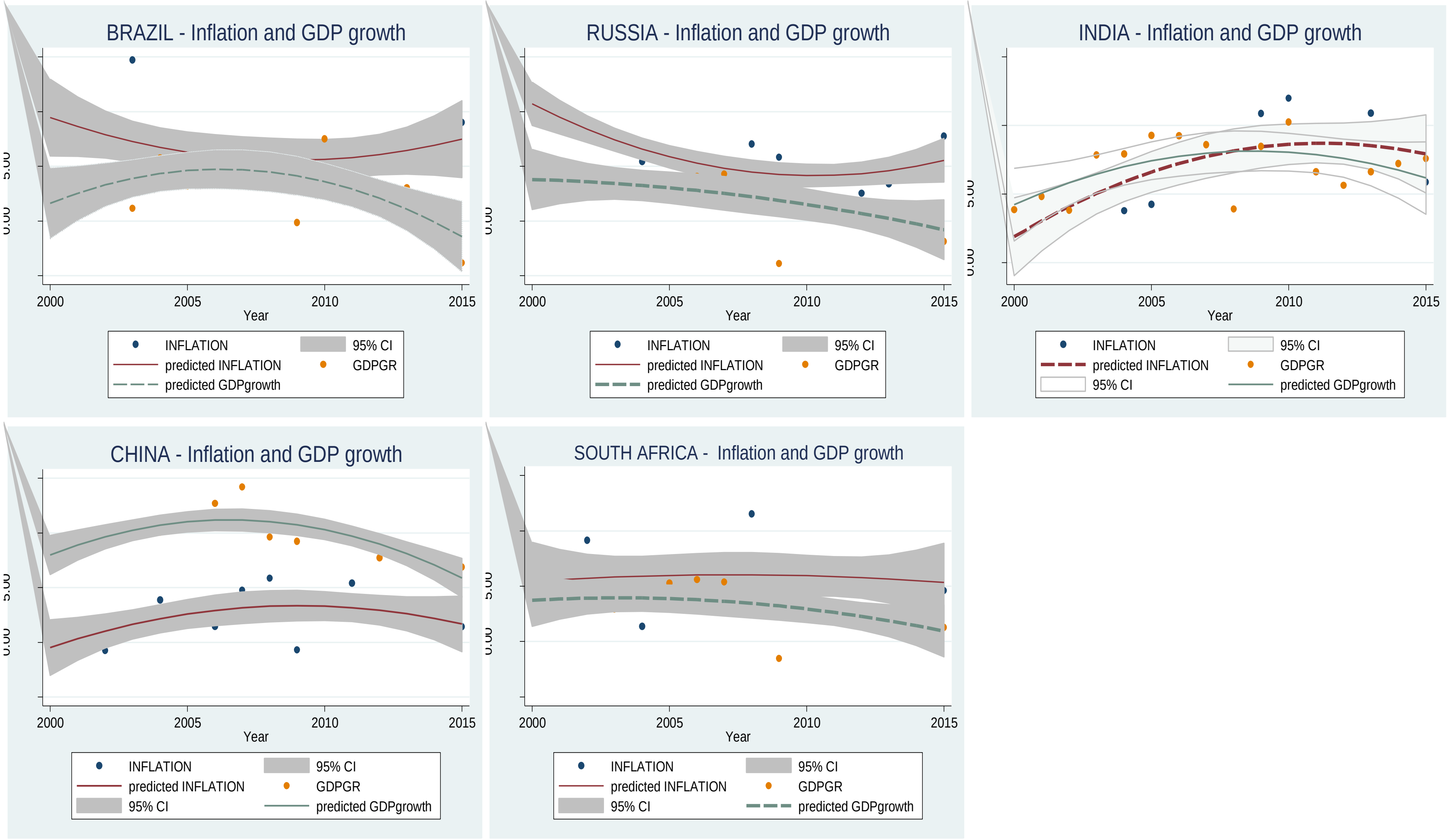
Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.7: Comparison of India Inflation with Advanced Economies



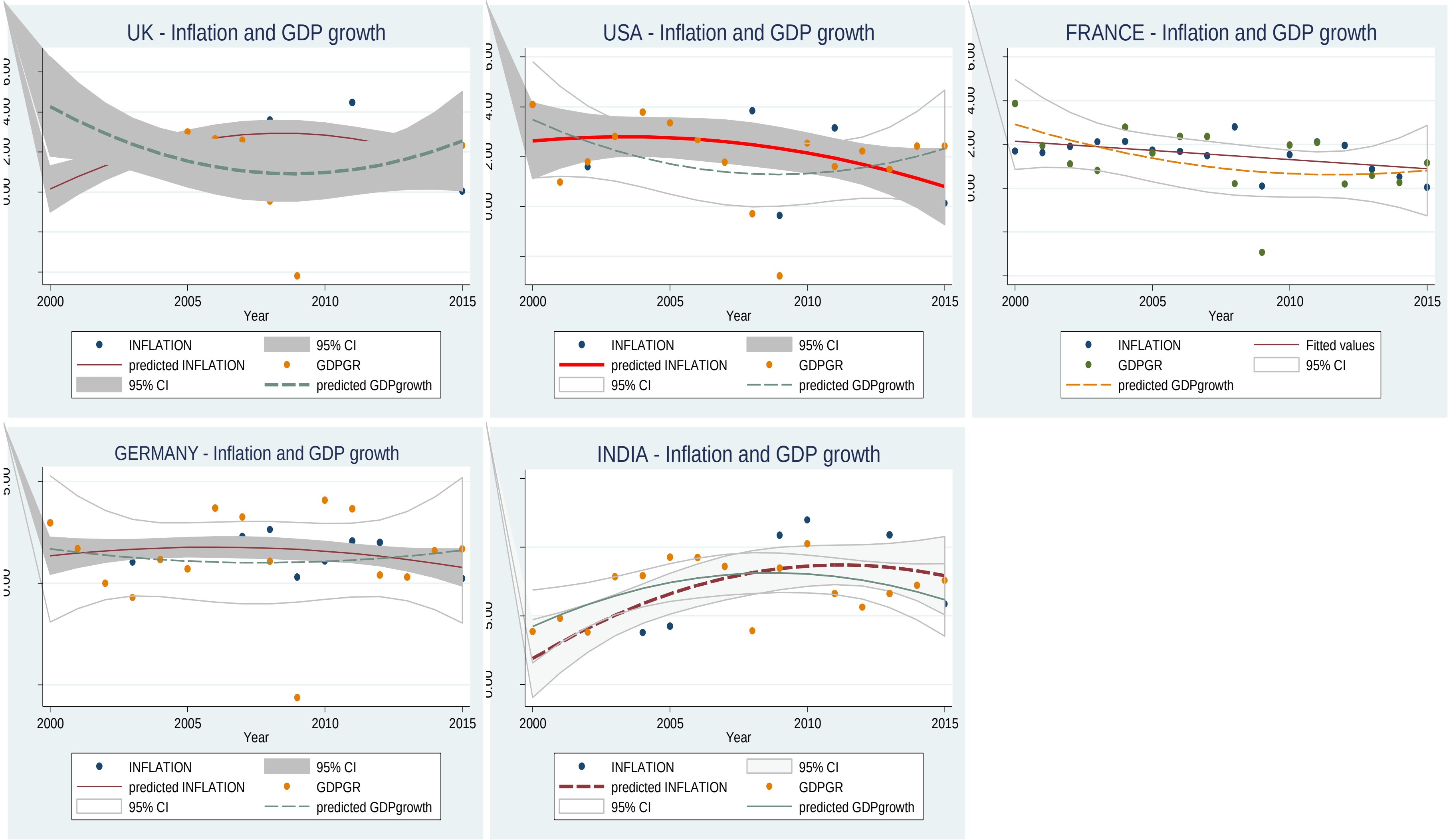
Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.8: Inflation and GDP growth in BRICS countries



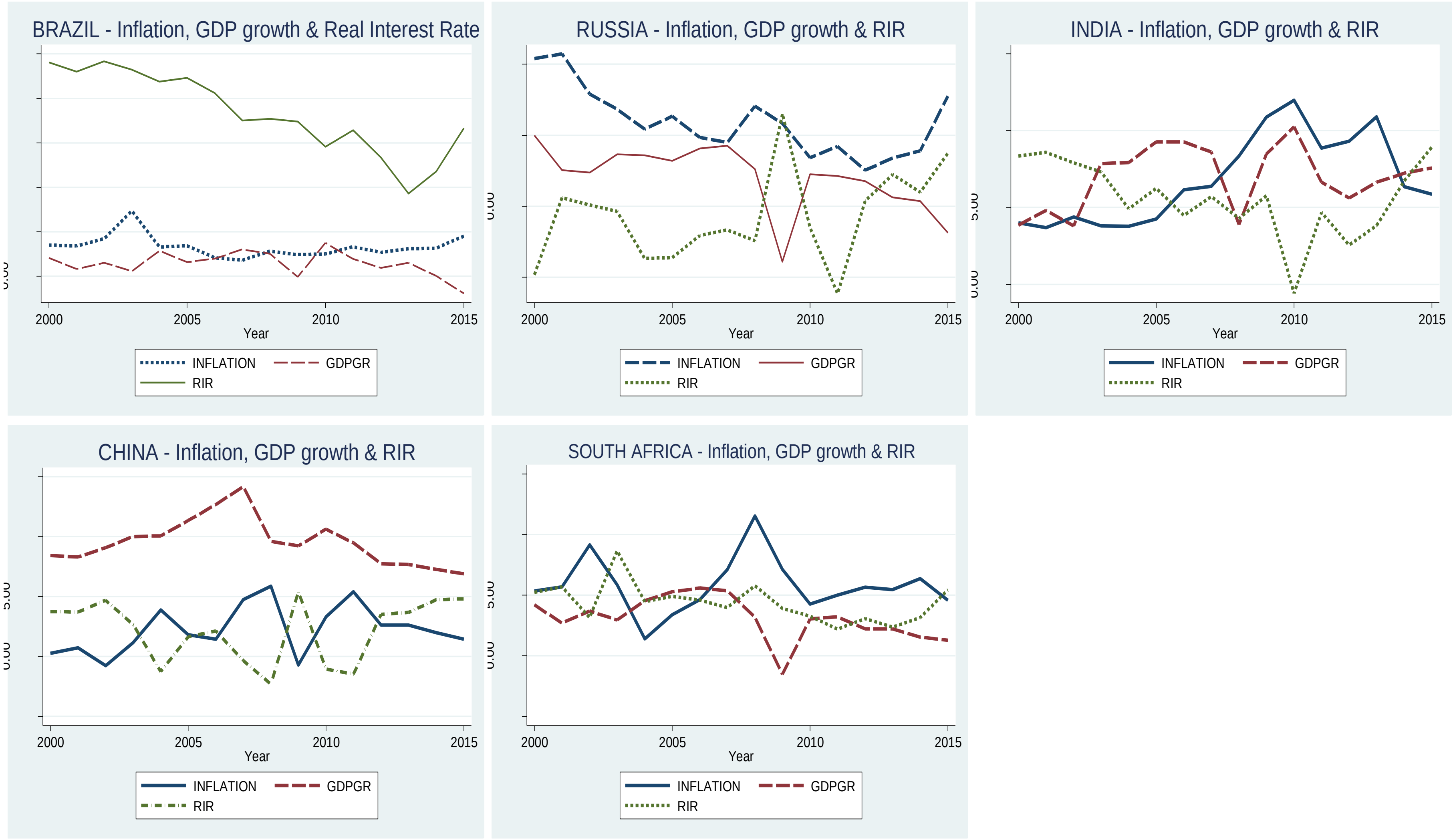
Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.9: Comparison of India Inflation and GDP growth with Advanced Economies



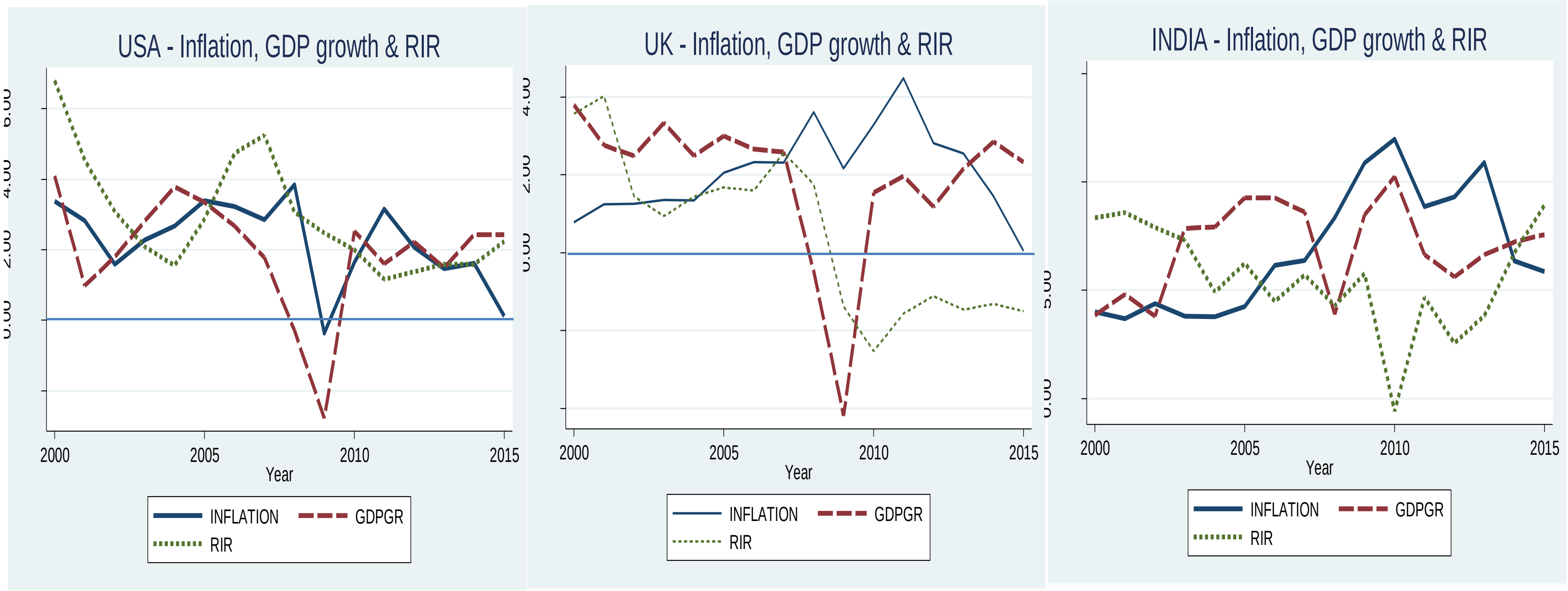
Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.10: Comparison of Inflation, Real Interest Rate & GDP growth in BRICS



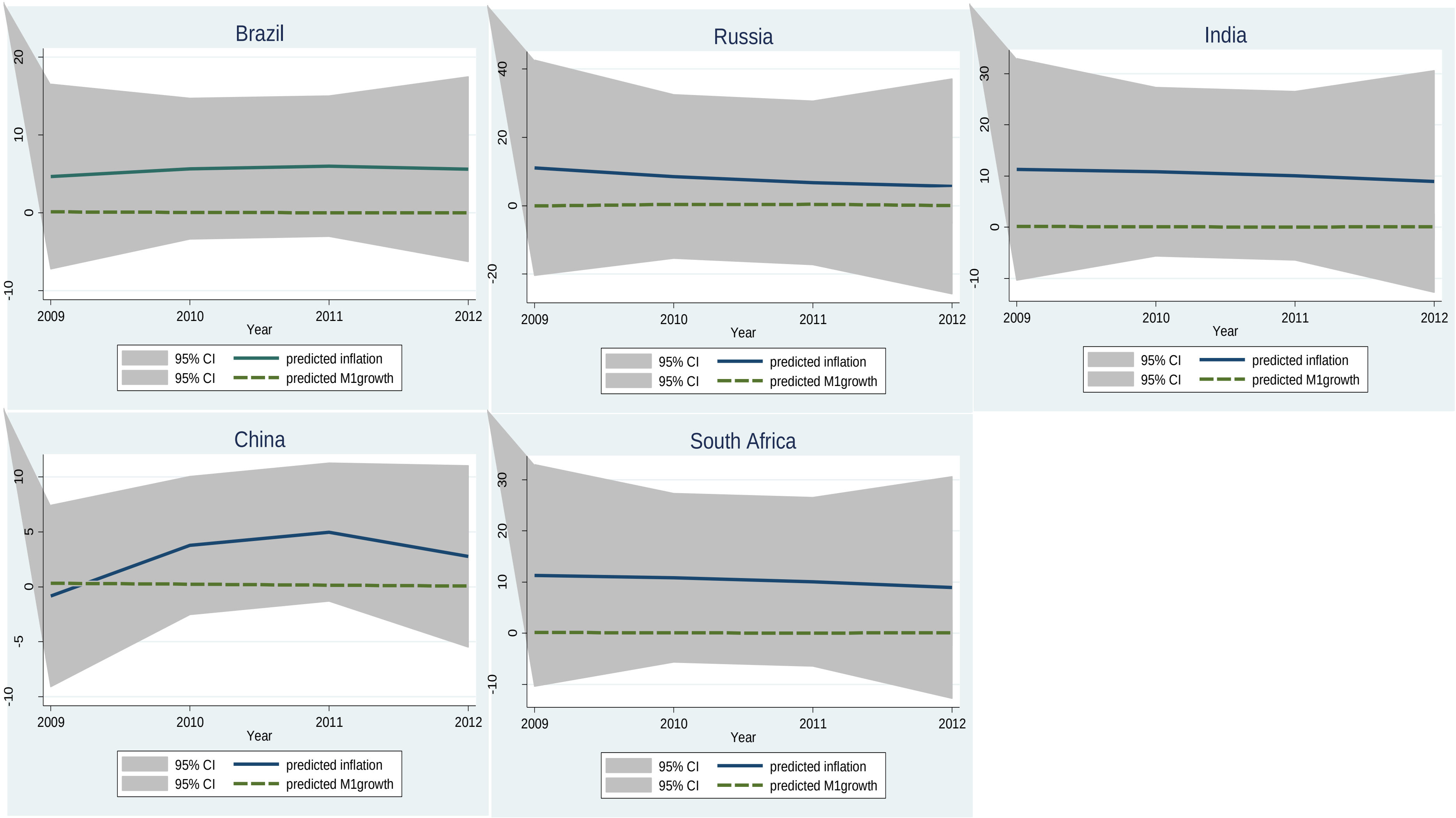
Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.11: Comparison of India Inflation, Real Interest Rate & GDP growth with Advanced Economies



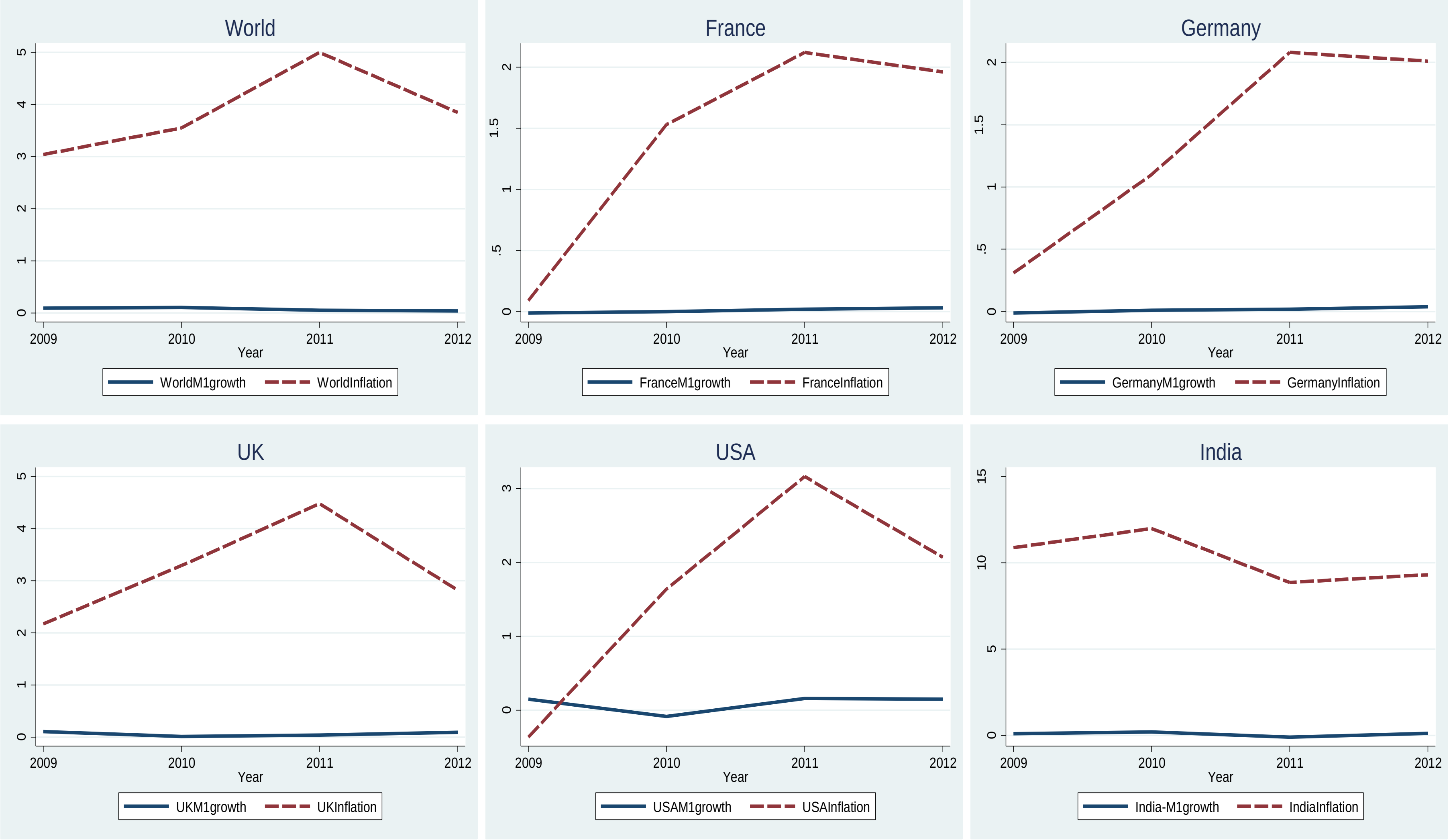
Source: World Development Indicators, August 2015 of World Bank Database   Note: Figures in percent year-on-year

Figure 3.12: Comparison of Inflation and M1 growth in BRICS



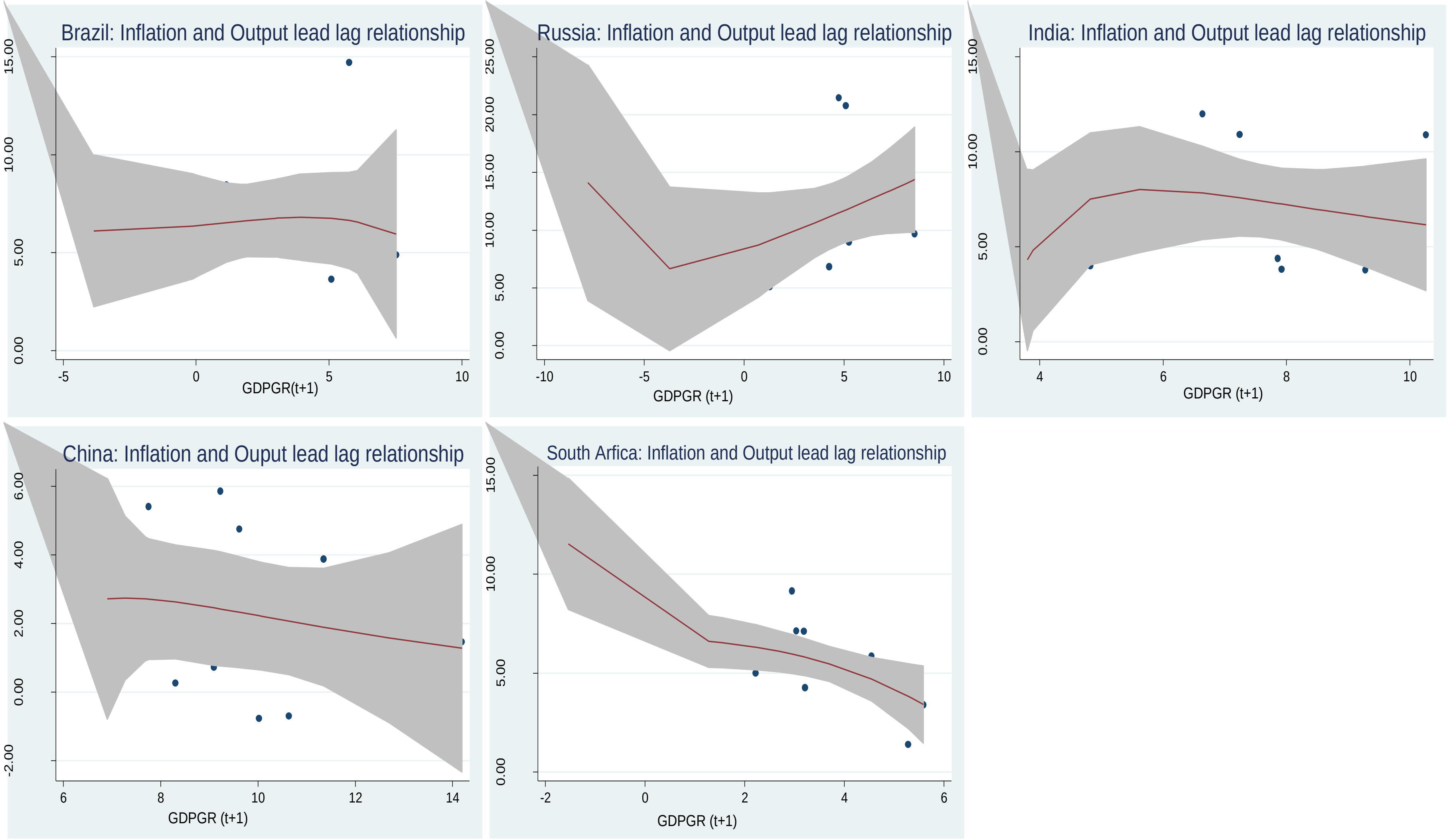
Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.13: Comparison of Inflation and M1 growth in Advanced Economies



Source: World Development Indicators, August 2015 of World Bank Database   Note: Figures in percent year-on-year

Figure 3.14: Lead-Lag Relationship between Output and Inflation in BRICS countries


Brazil: Inflation and Output lead lag relationship

Russia: Inflation and Output lead lag relationship

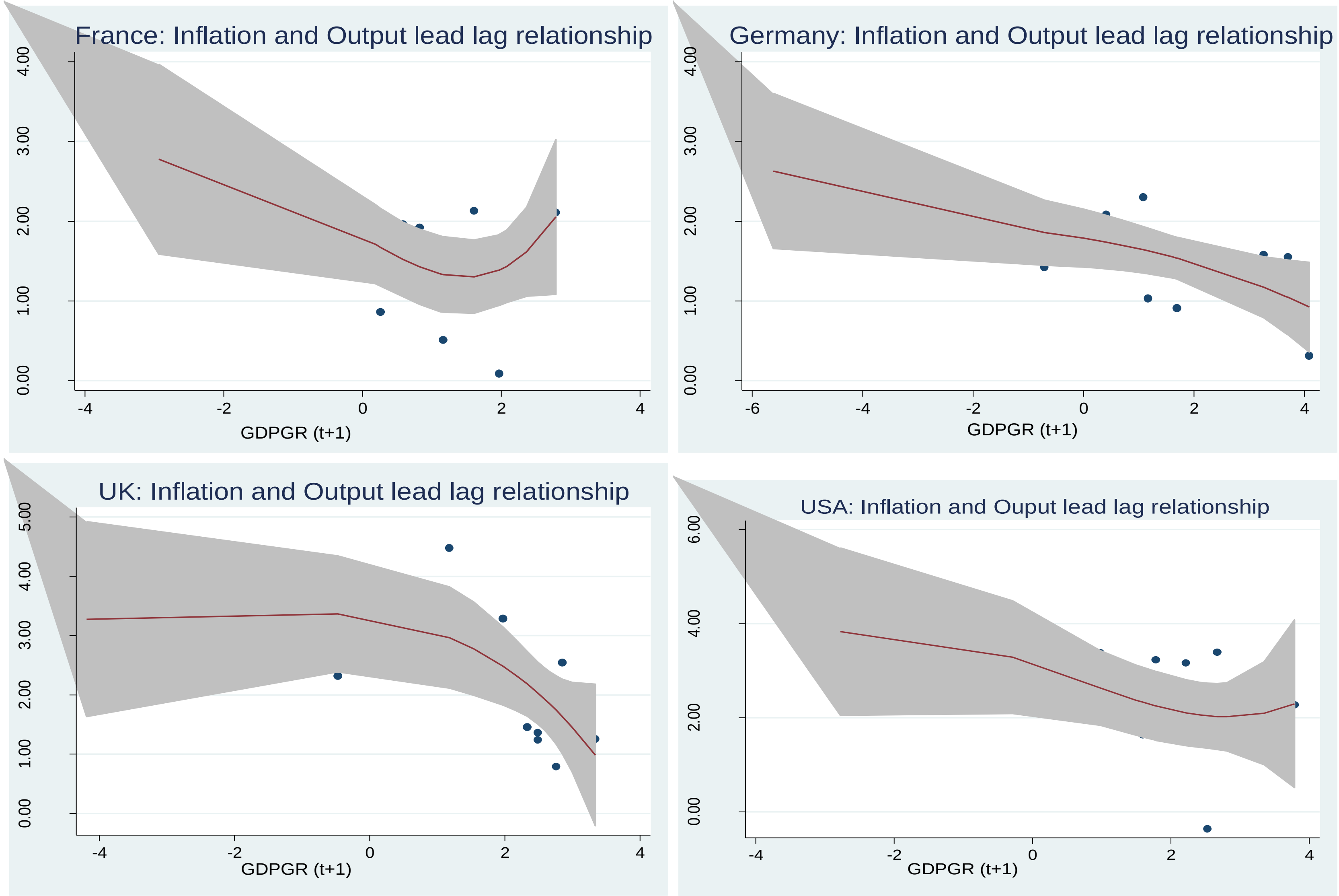
India: Inflation and Output lead lag relationship

China: Inflation and Ouput lead lag relationship

South Arfica: Inflation and Output lead lag relationship

Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Figure 3.15: Lead-Lag Relationship between Output and Inflation in Advanced countries



Source: World Development Indicators, August 2015 of World Bank Database Note: Figures in percent year-on-year

Chapter 4

Monetary Policy in India

Monetary policy aims at the management of money supply and interest rates by the central banks to affect prices and employment. Monetary policy works through expansion or contraction of investment and consumption expenditure in the economy. Monetary policy cannot change long-term trend growth. There is no long-term trade-off between growth and inflation as high inflation can only hurt growth. At its best, monetary policy can achieve low and stable inflation, thus reducing the volatility of the business cycle. Essentially, monetary policy is expected to be about pinning down the short term rate so as to achieve an inflation target, and thus stabilize the macroeconomy. Monetary policy in an open economy faces the impossible trinity: (i) Open capital account, (ii) Pegged currency regime, and (iii) Independent monetary policy.

In India, monetary policy is the macroeconomic policy is in the functional domain of the central bank i.e., the Reserve Bank of India (RBI). It encompasses management of money supply and interest rate and is the demand side economic policy used by the government of a country to achieve macroeconomic objectives like inflation, consumption, growth and liquidity. Mostly, the monetary policy in India is directed at managing the quantity of money in order to meet the requirements of different sectors of the economy and to increase the pace of economic growth. In India, the principal objective of the monetary policy has been ‘price stability’ while keeping in mind the objective of growth − though not necessarily the sole objective. As the RBI statute suggests, the primary role of central bank is monetary stability with the basic underlying motive of sustaining confidence in the value of the domestic currency. Essentially, it is aimed at low and stable levels of inflation as price stability is a necessary precondition to sustainable growth.

The RBI operates the monetary policy through its open market operations, bank rate policy, the reserve system, credit control policy, moral persuasion and through many other instruments. The use of any of these instruments results in the changes in the interest rate, or the money supply in the economy. Increasing money supply and reducing interest rates implies an expansionary policy and the reverse of this is a contractionary monetary policy. Liquidity is vital for an economy to spur growth. To maintain liquidity, the RBI is depends on its monetary policy.

The RBI act provides the legislative mandate for RBI to operate the monetary policy framework of the country. The framework provides for setting the policy (repo) rate based on an assessment of the current and evolving macroeconomic situation; and modulation of liquidity conditions to anchor money market rates at or around the repo rate. The Repo rate changes transmit through the money market to the entire financial system consequently influences aggregate demand – a key determinant of inflation and growth. Once the repo rate is announced, the operating framework designed by the RBI envisages liquidity management on a day-to-day basis through appropriate actions, which aim at anchoring the operating target – the weighted average call money rate (WACMR) – around the repo rate. The operating framework is often fine-tuned and reviewed depending on the evolving financial market and monetary conditions, while ensuring consistency with the monetary policy stance. The Financial Markets Operations Department (FMOD) of RBI operationalises the monetary policy, mostly through day-to-day liquidity management operations. Besides, the Financial Markets Committee (FMC) meets daily to review the liquidity conditions so as to ensure that the operating target of monetary policy (weighted average lending rate) is kept close to the policy repo rate.

In the light of persistent high levels of inflation and sluggish growth mostly in the backdrop of global financial crisis, there has been a growing debate centered on the monetary policy framework. India's monetary policy framework has undergone several transformations reflecting underlying macroeconomic and financial conditions. Reserve Bank of India, in the post-reform period, has espoused market-oriented monetary policy instruments and operating procedures. Issues related to the transmission mechanisms are gaining importance.

4.1. Instruments of Monetary Policy

RBI employs several direct and indirect instruments in implementing its monetary policy.

- *Repo Rate* (a price based instrument) is a fixed interest rate at which RBI provides overnight liquidity to banks against the collateral of government and other approved securities under the liquidity adjustment facility (LAF).
- *Reverse Repo Rate* (a price based instrument) is a fixed interest rate – currently 50 bps below the repo rate – at which the RBI absorbs liquidity, on an overnight basis, from banks against the collateral of eligible government securities under the LAF.
- *The LAF* consists of overnight as well as term repo auctions. Progressively, the RBI has increased the proportion of liquidity injected under fine-tuning variable rate repo auctions of tenors ranging between overnight and 56 days. The objective of term repo is to help develop the inter-bank term money market, which in turn can set market based benchmarks for pricing of loans and deposits, and hence improve transmission of monetary policy. The RBI also conducts variable interest rate reverse repo auctions, as necessitated under the market conditions.
- *Marginal Standing Facility (MSF)* is a facility under which scheduled commercial banks can borrow an additional amount of overnight money from the RBI by dipping into their Statutory Liquidity Ratio (SLR) portfolio up to a limit of two per cent of

their net demand and time liabilities deposits (NDTL) at a penal rate of interest of 50 basis points above the repo rate. This provides a safety valve against unanticipated liquidity shocks to the banking system. The MSF rate and reverse repo rate determine the corridor for the daily movement in the weighted average call money rate.

- *Bank Rate* is the rate at which the RBI offers to buy or rediscount bills of exchange or other commercial papers. The Bank Rate has been aligned to the MSF rate and, therefore, changes automatically as and when the MSF rate changes alongside policy repo rate changes.
- *Cash Reserve Ratio* (CRR) (a quantity based instrument) is the average daily balance that a bank shall maintain with the RBI as a share of such per cent of its NDTL that the RBI may notify from time to time in the Gazette of India.
- *Statutory Liquidity Ratio* (SLR) (a quantity based instrument) is the share of NDTL that banks shall maintain in safe and liquid assets, such as, unencumbered government securities, cash and gold. The changes in SLR often affect the availability of resources in the banking system for lending to the private sector.
- *Open Market Operations* (OMOs) include both outright purchase and sale of government securities for injection and absorption of durable liquidity, respectively.
- *Market Stabilization Scheme* (MSS) is an instrument for monetary management introduced in 2004. Surplus liquidity of a more enduring nature arising from large capital inflows is absorbed through the sale of short-dated government securities and treasury bills. The cash so mobilized is held in a separate government account with the RBI.

Monetary Policy making in India has been open and transparent. Under the amended RBI Act, the monetary policy committee (MPC) is required to meet at least four times in a year. The RBI is required to publish the Monetary Policy Report once in every six months to explain the sources of inflation; and the forecast of inflation for 6-18 months ahead.

Table 4.1: Frequency of Changes in Monetary Policy Instruments in India: 2001-02 to 2015-16

Year	Bank Rate	Repo	Reverse	Cash Reserve Ratio	Marginal Standing Facility	Statutory Liquidity Ratio
2001-02	2	4	3	4		
2002-03	1	3	3	2		
2003-04	1	1	1	1		
2004-05	0	0	0	2		
2005-06	0	2	3	0		
2006-07	0	5	2	4		
2007-08	0	0	0	4		1
2008-09	0	8	3	10		1
2009-10	0	2	2	2		1
2010-11	0	7	7	1		1
2011-12	0	5	5	1	5	
2012-13	3	3	3	3	3	1
2013-14	6	4	4		6	
2014-15	2	2	2		2	3
2015-16	2	1	1		2	1

Source: Compiled from the data sourced from RBI Database

Monetary policy instruments in India have undergone frequent changes in tune with set objectives of the policy changes. Table 4.1 presents the frequency of changes in the monetary policy instruments such as Bank rate, repo rate, reverse repo rate, cash reserve ratio, marginal standing facility and statutory liquidity ratio in India for the period from 2001-02 to 2015-16. Table 4.2 presents the monthly open market operations (including the dated securities and treasury bills) of the Reserve Bank of India during the period 1996 to 2016. Figure 4.1 presents the movement of major monetary policy rates and reserve requirements during the period from 1991 to 2015. Figure 4.2 presents the movement of policy instruments (bank rate, repo rate, reverse rate, in India from for the period from 2006 Q1 to 2016 Q1.

Empirical evidence shows that monetary transmission in India has been taking place through several channels.

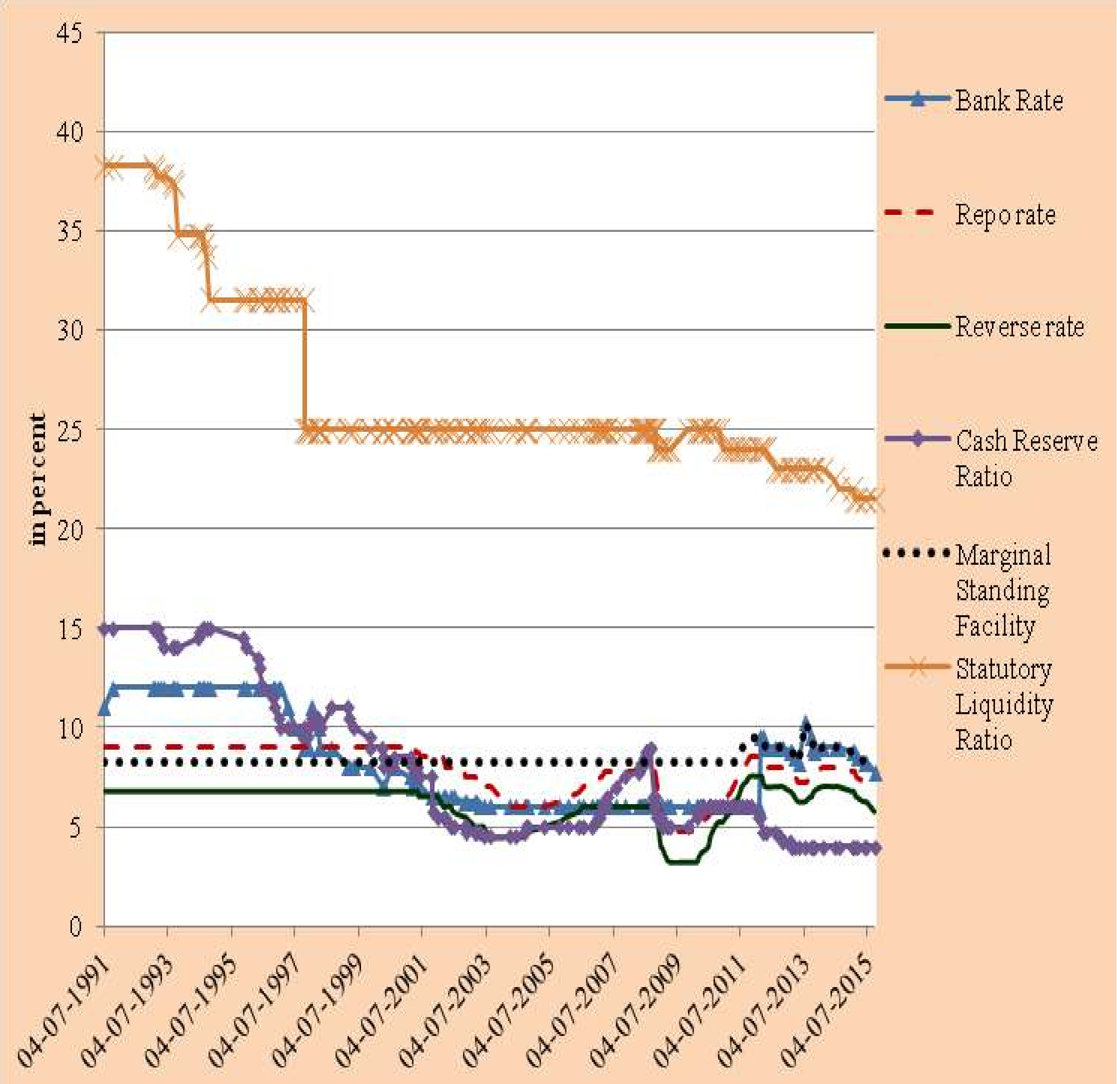
Table 4.3 reports the major monetary policy rates and reserve requirements. Table .4 reports the structure of interest rates, including the call money rates; savings deposit rates, term deposit rates, and lending rates. Table 4.5 reports the lending rate structure for loans and main sectors including the rates for agriculture, industry, services, housing, personal loans, and weighted average lending rate in India. Table 4.6 reports the weighted average lending rate structure according to the credit limit range. Table 4.7 reports the weighted average lending rate structure according to the type of accounts. At the end of this section, Table 4.8 reports the major monetary policy rates and reserve requirements in India from 04.07.1991 to 29.09.2015

Table 4.2: Monthly Open Market Operations of the Reserve Bank of India
(Amount in Rupees Billion)

March-Year	Dated Securities Net Purchase(+)/ Net Sale(-)	Treasury Bills Net Purchase(+)/ Net Sale(-)
1996	-0.25	0.00
1997	-23.93	0.00
1998	-44.60	0.00
1999	-33.32	-0.90
2000	-0.09	26.94
2001	-0.40	0.00
2002	-0.37	0.00
2003	-0.66	0.00
2004	-1.26	0.00
2005	-3.58	0.00
2006	-1.86	0.00
2007	-13.31	0.00
2008	18.09	0.00
2009	552.37	0.00
2010	-0.06	0.00
2011	-0.16	0.00
2012	233.77	0.00
2013	156.52	0.00
2014	0.00	0.00
2015	-6.40	0.00
2016	414.08	0.00

Source: Reserve Bank of India database

Figure 4.1: Major Monetary Policy Rates and Reserve Requirements



Source: Reserve Bank of India database

Table 4.3: Major Monetary Policy Rates and Reserve Requirements

This table presents the policy rates Bank rate, Liquidity adjustment facility rates (repo and reverse repo) and reserve requirements (cash reserve ratio and statutory liquidity ratio) in percent per annum

Effective Date	Bank Rate	Repo	Reverse	Cash Reserve Ratio	Marginal Standing Facility	Statutory Liquidity Ratio
29-09-2015	7.75	6.75	5.75	-	7.75	-
27-06-2015	-	-	-	4.00	-	-
02-06-2015	8.25	7.25	6.25	-	8.25	-
04-03-2015	8.50	7.50	6.50	-	8.50	-
07-02-2015	-	-	-	-	-	21.50
15-01-2015	8.75	7.75	6.75	-	8.75	-
09-08-2014	-	-	-	-	-	22.00
14-06-2014	-	-	-	-	-	22.50
28-01-2014	9.00	8.00	7.00	-	9.00	-
29-10-2013	8.75	7.75	6.75	-	8.75	-
07-10-2013	9.00	-	-	-	9.00	-
20-09-2013	9.50	7.50	6.50	-	9.50	-
15-07-2013	10.25	-	-	-	10.25	-
03-05-2013	8.25	7.25	6.25	-	8.25	-
19-03-2013	8.50	7.50	6.50	-	8.50	-
09-02-2013	-	-	-	4.00	-	-
29-01-2013	8.75	7.75	6.75	-	8.75	-
03-11-2012	-	-	-	4.25	-	-
22-09-2012	-	-	-	4.50	-	-
11-08-2012	-	-	-	-	-	23.00
17-04-2012	9.00	8.00	7.00	-	9.00	-
10-03-2012	-	-	-	4.75	-	-
13-02-2012	9.50	-	-	-	-	-
28-01-2012	-	-	-	5.50	-	-

Source: Reserve Bank of India Database

Table 4.4: Structure of Interest Rates

This table presents the interest rates in Per cent per annum for call money, deposits and loans of scheduled commercial banks in India.

Year	Call/Notice Money Rates	Deposit Rates				Lending Rates
		Savings	Term Deposits			
			1-3 yrs	3-5 yrs	Above 5 yrs	
2000-01	9.15	4.00	8.50-9.50	9.50-10.00	8.50-10.00	11.00-12.00
2001-02	7.16	4.00	7.50-8.50	8.00-8.50	8.00-8.50	11.00-12.00
2002-03	5.89	3.50	4.25-6.00	5.50-6.25	5.50-6.25	10.75-11.50
2003-04	4.62	3.50	4.00-5.25	5.25-5.50	5.25-5.50	10.25-11.00
2004-05	4.65	3.50	5.25-5.75	5.75-6.25	6.25	10.25-11.00
2005-06	5.60	3.50	6.00-6.75	6.25-7.00	6.50-7.00	10.25-12.75
2006-07	7.22	3.50	6.75-8.50	7.75-9.50	7.75-8.50	12.25-14.75
2007-08	6.07	3.50	8.00-8.75	8.00-8.75	8.50-9.00	12.25-15.75
2008-09	7.26	3.50	8.00-8.75	8.00-8.50	7.75-8.50	11.50-16.75
2009-10	3.29	3.50	6.00-7.00	6.50-7.50	7.00-7.75	11.00-15.75
2010-11	5.89	3.50	8.25-9.00	8.25-8.75	8.50-8.75	8.25-9.50
2011-12	8.22	4.00	9.25	9.00-9.25	8.50-9.25	10.00-10.75
2012-13	8.09	4.00	8.75-9.00	8.75-9.00	8.50-9.00	9.70-10.25
2013-14	8.28	4.00	8.75-9.25	8.75-9.10	8.50-9.10	10.00-10.25
2014-15	7.97	4.00	8.50-8.75	8.50-8.75	8.25-8.50	10.00-10.25
2015-16	7.04	4.00	8.00-8.50	8.00-8.50	8.00	9.70-10.00

Source: Reserve Bank of India Database

Table 4.5: Lending Rate Structure in India – Weighted average lending rate for all loans and main sectors

The table presents the weighted average lending rates (WALR) in percent for all loans and for main sectors as on 31st March of the corresponding year for the borrowal accounts in the scheduled commercial banking in India.

	AGRCULTURE		INDUSTRY		SERVICES		LOAN FOR HOUSING		OTHER PERSONAL LOANS		ALL OTHERS		TOTAL	
Year	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR
1992	8.5	14.8	58.7	17.9	22.6	17.1	3.4	7.9	3.2	15.2	3.6	16.4	100	16.8
1993	8.0	15.7	58.5	17.9	22.9	17.2	3.6	8.3	3.2	15.7	3.9	16.9	100	17.0
1994	7.5	15.5	57.1	17.4	23.5	16.5	3.5	8.7	3.8	15.2	4.7	16.3	100	16.5
1995	6.8	15.3	52.8	16.5	25.9	16.2	3.1	9.6	4.6	15.5	6.9	16.1	100	16.0
1996	6.7	15.7	54.8	17.8	23.3	17.2	3.1	10.9	4.4	16.3	7.8	17.0	100	17.1
1997	6.8	15.7	55.8	17.5	22.5	17.0	3.0	11.3	5.0	16.5	6.9	16.8	100	16.9
1998	6.6	15.3	54.8	16.7	23.5	16.2	3.1	11.2	5.7	16.2	6.3	16.2	100	16.2
1999	4.5	15.2	61.0	15.5	24.4	15.4	1.8	12.4	2.6	16.2	5.8	15.5	100	15.4
2000	4.1	14.8	57.4	14.9	27.7	14.5	2.6	12.5	2.3	15.5	5.9	15.2	100	14.8
2001	4.1	14.4	52.7	14.5	30.2	13.6	3.5	12.8	2.7	15.2	6.9	14.4	100	14.1
2002	5.0	13.9	49.6	14.0	29.7	13.2	4.1	12.1	2.8	14.7	8.9	13.9	100	13.7
2003	5.2	13.3	49.4	13.7	29.2	12.9	5.8	11.6	3.6	14.4	6.8	13.6	100	13.3
2004	6.8	13.0	45.7	13.5	27.4	12.6	9.6	12.6	5.5	15.1	4.9	13.2	100	13.2
2005	6.3	12.5	46.0	13.2	26.2	12.6	11.5	8.9	6.3	14.8	3.7	13.2	100	12.6
2006	7.5	11.7	44.0	12.6	25.8	12.1	12.9	8.6	6.7	14.6	3.2	11.8	100	12.0
2007	7.9	11.7	43.8	12.4	26.6	12.1	12.6	9.0	6.5	14.5	2.6	11.9	100	11.9
2008	7.2	11.8	44.0	12.4	27.4	12.6	11.0	10.5	6.5	14.3	3.9	12.6	100	12.3
2009	6.9	11.0	44.9	11.3	29.4	11.7	10.6	10.7	5.9	13.2	2.2	11.9	100	11.5
2010	7.6	10.0	45.0	10.5	30.2	10.6	9.7	9.7	5.0	12.4	2.7	10.9	100	10.5
2011	7.3	11.1	43.5	11.7	30.4	11.4	9.0	10.3	5.8	12.4	4.0	11.1	100	11.4
2012	7.5	12.0	44.3	12.8	30.3	12.5	8.3	11.1	5.7	13.1	3.9	13.3	100	12.6

Source: Reserve Bank of India Database - Basic Statistical Returns of Scheduled Commercial Banks in India

Table 4.6: Lending Rate Structure in India – Weighted average lending rate according to credit limit range

The table presents the weighted average lending rates (WALR) in percent for credit limit range for all loans as on 31st March of the corresponding year for the borrowal accounts in the scheduled commercial banking in India.

	INR25,000 < Credit Limit <= INR200,000		INR200,000 < Credit Limit <= INR10 million		INR10 million < Credit Limit <= INR100 million		INR100 million < Credit Limit <= INR1 billion		Credit Limit > INR1 billion		TOTAL	
Year	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR
1992	17.2	13.8	35.6	17.4	32.8	18.0	11.3	17.0	3.1	17.9	100	16.8
1993	15.5	14.3	32.0	17.6	32.1	17.9	13.6	17.2	6.8	17.4	100	17.0
1994	15.0	14.0	30.8	17.0	29.4	16.8	12.4	16.2	12.4	18.4	100	16.5
1995	13.5	13.8	29.5	16.8	32.1	16.4	15.8	16.0	9.2	15.8	100	16.0
1996	12.9	14.3	28.7	17.7	35.1	17.9	16.6	17.5	6.8	16.5	100	17.1
1997	13.1	14.3	27.6	17.6	34.1	17.6	19.2	17.0	6.0	16.0	100	16.9
1998	13.7	14.2	26.1	17.1	31.8	16.9	20.2	16.1	8.3	15.0	100	16.2
1999	NA	NA	29.5	16.2	32.6	15.9	25.3	14.9	12.6	13.9	100	15.4
2000	NA	NA	28.7	15.5	29.7	15.3	26.6	14.2	15.1	13.4	100	14.8
2001	NA	NA	27.9	15.0	26.9	14.8	27.4	13.8	17.7	12.5	100	14.1
2002	NA	NA	25.5	14.4	23.6	14.4	29.5	13.5	21.4	12.3	100	13.7
2003	NA	NA	28.0	13.7	22.0	13.9	30.3	13.3	19.8	12.3	100	13.3
2004	NA	NA	33.0	13.4	20.7	13.5	29.8	13.5	16.6	12.1	100	13.2
2005	NA	NA	33.3	11.9	19.2	13.0	29.3	13.3	18.2	12.4	100	12.6
2006	NA	NA	34.9	11.3	17.5	12.2	27.5	12.6	20.2	12.2	100	12.0
2007	NA	NA	34.6	11.4	16.0	12.3	29.1	12.2	20.2	12.1	100	11.9
2008	NA	NA	32.4	12.3	16.3	12.5	29.0	12.3	22.2	12.5	100	12.3
2009	NA	NA	29.4	12.1	14.4	12.4	29.6	11.4	26.6	10.4	100	11.5
2010	NA	NA	27.4	11.2	14.3	11.6	29.8	10.6	28.5	9.3	100	10.5
2011	NA	NA	25.8	11.8	13.4	12.6	27.8	11.8	33.0	10.4	100	11.4
2012	NA	NA	25.8	12.6	12.5	13.7	27.1	13.0	34.6	11.8	100	12.6

Source: Reserve Bank of India Database - Basic Statistical Returns of Scheduled Commercial Banks in India

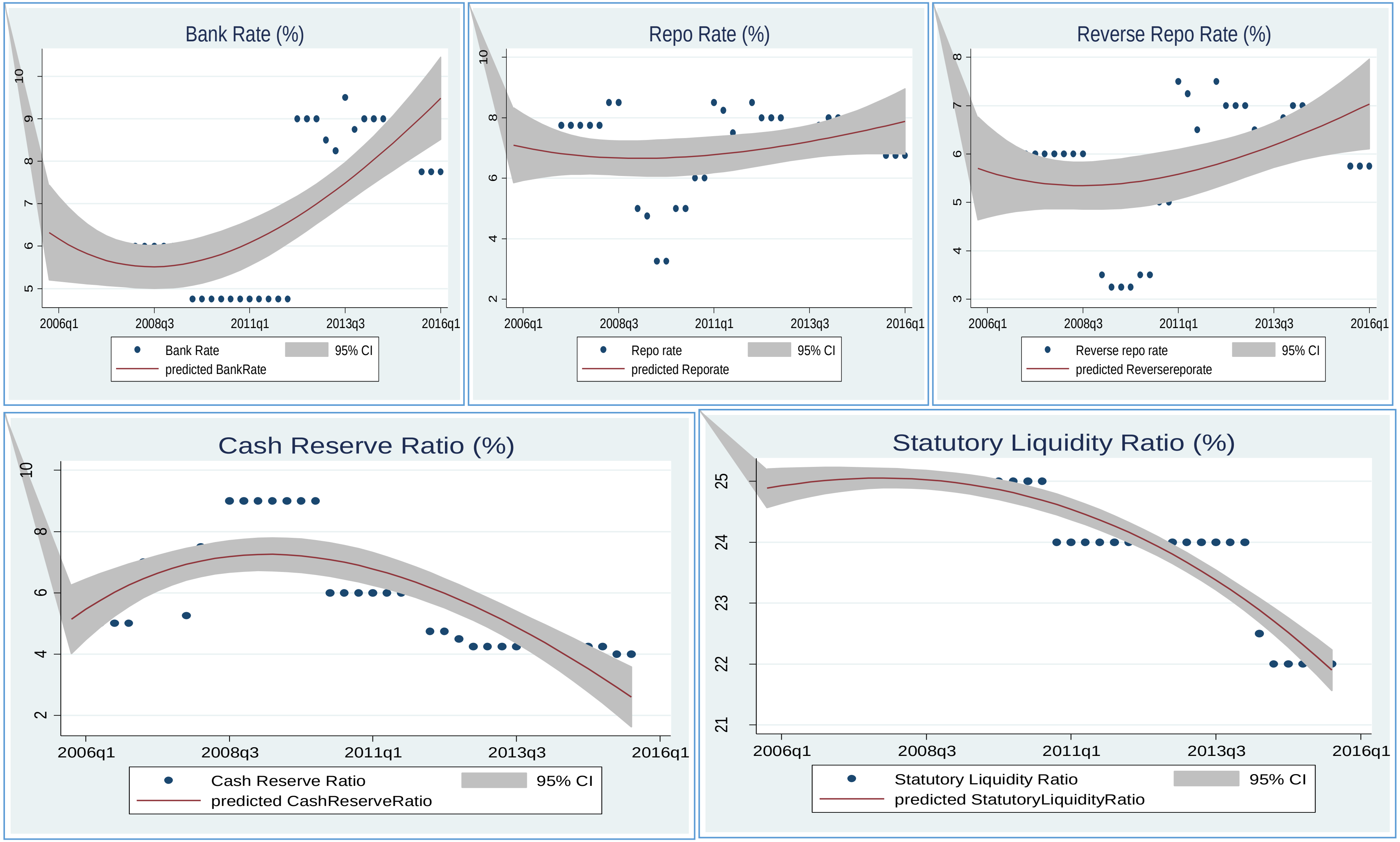
Table 4.7: Lending Rate Structure in India – Weighted average lending rate according to type of accounts

The table presents the weighted average lending rates (WALR) in percent for different type of borrowal accounts as on 31st March of the corresponding year in the scheduled commercial banking in India.

	Cash Credit		Overdraft		Demand Loans		Medium Term Loans		Long Term Loans		Packing Credit		All accounts	
Year	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR	Share	WALR
1992	42.5	18.6	10.0	18.5	5.4	17.0	7.3	15.3	29.1	14.6	5.8	14.1	100	16.8
1993	46.1	18.4	8.5	18.7	5.9	17.5	6.5	15.7	26.9	15.0	6.0	14.2	100	17.0
1994	45.4	18.0	8.8	16.7	7.3	16.6	7.1	15.5	25.3	14.8	6.0	13.5	100	16.5
1995	43.2	17.0	8.0	16.7	7.0	16.0	9.6	15.7	25.3	15.1	6.9	13.0	100	16.0
1996	40.5	18.2	8.4	18.0	9.1	18.1	11.7	17.0	22.5	15.9	7.9	13.7	100	17.1
1997	35.1	17.8	8.6	17.7	13.9	17.6	11.4	16.9	23.6	15.9	7.5	13.8	100	16.9
1998	32.9	17.0	8.2	17.2	16.1	16.6	12.5	16.3	23.8	15.5	6.6	13.0	100	16.2
1999	35.6	16.2	8.3	16.4	15.6	15.5	10.2	15.8	23.4	15.1	7.0	11.0	100	15.4
2000	38.3	15.2	7.4	16.1	14.2	14.9	9.4	15.2	24.4	14.4	6.3	11.2	100	14.8
2001	39.5	14.2	7.0	15.2	13.5	14.3	9.7	14.6	24.9	14.1	5.4	11.2	100	14.1
2002	33.4	13.8	6.2	14.6	12.6	13.9	10.9	13.9	31.7	13.6	5.3	10.8	100	13.7
2003	28.7	13.2	6.2	14.2	12.6	13.9	10.1	13.7	37.4	13.3	5.0	10.8	100	13.3
2004	23.0	12.4	5.8	14.0	14.0	14.1	11.9	13.9	40.7	13.3	4.7	11.2	100	13.2
2005	19.7	12.0	5.7	13.9	11.5	14.0	13.9	13.6	45.3	12.1	3.9	11.6	100	12.6
2006	17.9	11.7	5.1	13.1	10.9	13.2	13.3	12.9	49.1	11.6	3.6	10.4	100	12.0
2007	18.3	11.9	5.4	13.2	9.2	12.9	13.2	12.7	50.5	11.5	3.5	10.2	100	11.9
2008	17.7	12.5	5.1	12.8	10.6	12.8	16.7	12.8	46.7	12.1	3.2	10.3	100	12.3
2009	17.2	12.2	4.9	12.5	14.0	11.1	17.3	11.5	44.0	11.3	2.7	9.7	100	11.5
2010	17.3	11.3	4.5	11.5	11.8	9.5	17.9	10.2	45.9	10.6	2.7	9.2	100	10.5
2011	18.2	12.6	6.2	11.7	13.0	11.0	17.6	11.1	42.4	11.4	2.6	9.3	100	11.4
2012	20.5	13.7	6.8	12.5	10.9	11.8	15.1	12.2	44.2	12.5	2.5	9.8	100	12.6

Source: Reserve Bank of India Database - Basic Statistical Returns of Scheduled Commercial Banks in India

Figure 4.2: Movement of Policy Instruments in India – 2006 Q1 to 2016 Q1



Source: Reserve Bank of India database

4.2 Evolution of Monetary Policy Operating Framework in India

In India, as in most other countries, monetary policy framework has evolved in response to and in consequence of financial developments, openness and shifts in the underlying transmission mechanism. The evolution of monetary policy framework in India can be envisaged in phases.

I. Formative Phase:

The unfolding of monetary policy during the colonial era from the establishment of RBI in 1935 till 1950, the focus of monetary policy was to regulate the supply of and demand for credit in the economy through the Bank Rate, reserve requirements and open market operations (OMO).

II. Foundation Phase:

During the foundation phase during 1951–1970, monetary policy was geared towards the centralized planning and resource allocation, which led to introduction of several quantitative control measures to contain the consequent inflationary pressures. While ensuring credit to preferred sectors, the Bank Rate was often used as a monetary policy instrument. During 1971–90, the focus of monetary policy was on credit planning. Both the statutory liquidity ratio (SLR) and the cash reserve ratio (CRR) prescribed for banks were used to balance government financing and inflationary pressure.

III. Monetary Targeting Phase:

The 1980s saw the formal adoption of monetary targeting framework based on the recommendations of Chakravarty Committee (1985). Under this framework, reserve money was used as operating target and broad money (M3) as an intermediate target. Thereafter, the structural reforms and financial liberalisation in the early 1990s led to a shift in the financing paradigm for the government and commercial sectors with increasingly market-determined interest rates and exchange rate. During 1971-1985, the monetisation of the fiscal deficit exerted a dominant influence on the conduct of monetary policy.

IV. Multiple Indicator Approach (MIA) Phase:

During this phase from 1998 to 2011, the MIA approach monitors through multiple indicators besides money supply, such as interest rates, fiscal deficits, balance of payments, GDP, etc. Moreover, it also captures the expectations of various macroeconomic fundaments. It highlights the transition from direct to indirect and market oriented instruments of monetary policy.

V. Disinflation and a New Framework Phase:

Subsequent to the recommendations of the Expert committee on Monetary Policy Framework, RBI is moving towards a flexible inflation targeting framework. The move towards a flexible inflation targeting framework has been formalized through an agreement between the RBI and the government in February 2015. The Finance Act 2016 amended the RBI, 1934 to state price stability as the primary objective of the monetary policy, adoption of flexible inflation targeting with CPI as the nominal anchor for monetary policy along with the setting up of a Monetary Policy Committee (MPC) to set the policy rate to achieve the inflation objective. Accordingly, the Government notified in September 2016, the formation of Monetary Policy Committee with six members and an inflation target of 4.0 per cent with plus or minus 2 percent tolerance levels.

4.3 Monetary Policy Approaches:

Since 1998, in a forward looking approach, the RBI has adopted a '*multiple indicator approach*' with a greater focus on rate channels for monetary policy formulation compared to quantity instruments. Multiple Indicator Approach (MIA) involves variables such as money, credit, output, trade, capital flows, fiscal position, and rate variables such as rate of return in markets, inflation rate and exchange rate to draw monetary policy perspectives.

The indicators suggest that the MIA has appeared to work reasonably well since 2000-09 as reflected in the average real gross domestic product (GDP) growth rate of 7.1 percent colligated with average inflation of 5.5 percent in terms of wholesale price index (WPI). In the recent years, there has been a growing public condemnation on the efficacy and the credibility of MIA in the recent years due to the coexistence of weakening growth and inconsistent levels of inflation. The criticism is largely founded on the argument that a large set of indicators has failed to provide a clear and well defined nominal anchor for monetary policy, leaving the policy analysts wondering what actually is looking at while taking policy decisions.

The multiple indicator approach is considered to have worked fairly well from 1998-99 to 2008-09, as evidenced by the average real gross domestic product (GDP) growth rate of 7.1 per cent associated with average inflation of about 5.5 per cent in terms of both the wholesale price index (WPI) and the CPI.

Several expert committees in the recent past have made recommendations on the monetary policy stance in India. The Mistry Committee in 2007 has underscored importance of the gold standard for a monetary policy framework as a transparent, independent, inflation-targeting central bank. It is argued that such an arrangement would be underlining the commitment of the state to deliver low and predictable inflation, and induces greater confidence in the Indian currency in the eyes of domestic and global investors. Rajan committee on financial sector reforms in 2009 has suggested that RBI should have a single objective to stay close to the low inflation number of within a range in the medium term, and move steadily towards a single instrument – repo rate. On the other hand, The Srikrishna Commission in 2013 on financial sector legislative reforms has recommended that price stability is a desirable goal in India as inflation continues to hurt the common man and therefore the central government should give a quantitative monitorable predominant target two RBI in addition to additional or subsidiary targets could also be for its monetary policy function.

4.4 Flexible-Inflation Targeting (FIT) in India:

Flexible–inflation targeting in India follows upon the recommendations of the Expert Committee to Revise and Strengthen the Monetary Policy Framework Report (January 2014), the subsequent Agreement on Monetary Policy Framework by Government of India and RBI (February 20, 2015) and the amendment of the Reserve Bank of India Act (May 2016) paving the way for the adoption of flexible inflation targeting framework for monetary policy and the constitution of a Monetary Policy Committee. The change in monetary policy framework in India towards FIT has to be seen in the context of macroeconomic developments that preceded this major development. A closer scrutiny of the Indian economy indicates that it underwent three distinct phases with different inflation trajectory and policy response: (i) Phase I: Moderate Inflation and Strong Growth, 2000-2008, (ii) Phase II: Persistently High Inflation: 2008-2013, and (iii) Phase III: Disinflation and a New Framework: since 2014. Actual inflation at any point of time may not be equal to the target within FIT as there are multiple shocks that affect inflation. The actual speed at which inflation adjusts to the long-run target depends on the nature and magnitude of shocks hitting the economy and the response of monetary policy.

4.5. Monetary Policy Operations:

The monetary policy framework in India has swiftly evolved during the recent years. An Interim Liquidity Adjustment Facility (ILAF) was introduced in April 1999 and then transitioned towards a full-fledged LAF through periodic adjustments. The LAF is operated since November 2004, using overnight fixed rate repos and reverse repos with banks. The LAF has evolved as a key component in the monetary policy operating framework and is intended to operate in a deficit liquidity mode to ensure more effective monetary transmission, with liquidity contained around +/- one percent of all banks' net demand and time liabilities (NDTL). The LAF was again enhanced along several dimensions in 2011, an important component of which was the explicit recognition of the weighted average overnight call money rate as the operating target of monetary policy. The liquidity management framework has been fine-tuned of late, with liquidity provision to banks shifting from overnight repos to term repos of varying maturities.

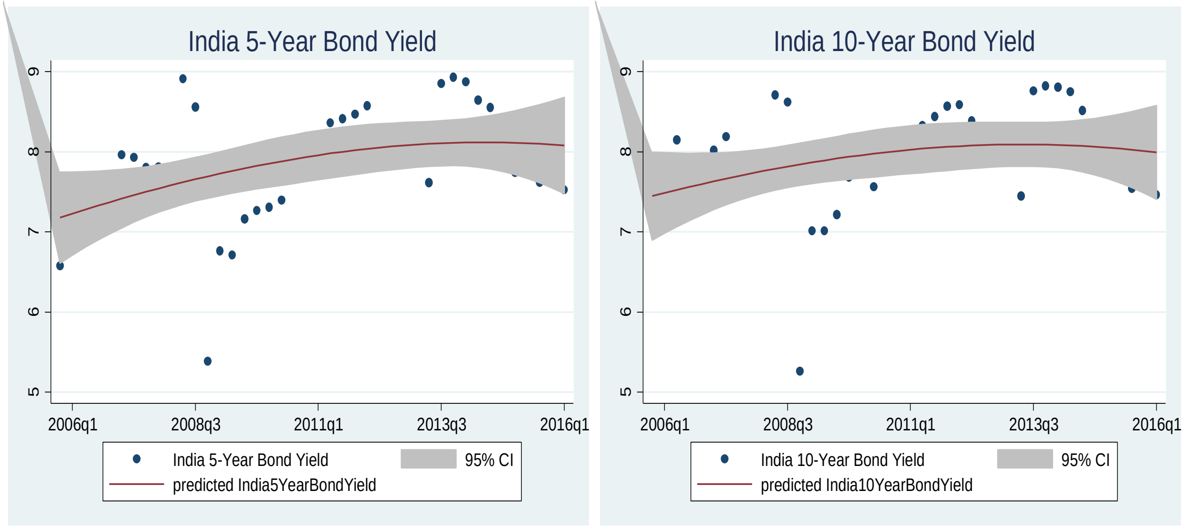
Further, Patel Committee Report (RBI 2014) discusses important aspects of monetary policy transmission and the likely impediments to transmission in India and provides exploratory evidence of an asymmetric effect of the policy rate on deposit and lending rates in India.

The following section presents the performance of the monetary policy in India through the different channels of transmission.

Interest Rate Channel

Monetary policy rates movements are observed to share a co-integrating relationship with rates across different segments of financial markets. The block exogeneity tests evidence the existence of bi-directional causality between call money rates and interest rates in other segments such as the government debt market, credit market or returns on equity market and the foreign exchange market. Bank deposit rates and lending rates are found to exhibit asymmetrical responses to policy rate changes under varied market conditions, with a faster and lager response during the liquidity deficit conditions than in surplus conditions. Moreover, lending rates for housing and automobiles are found to respond relatively faster to policy rate changes compared with other sectors. Figure 4.3 presents the movement of yields of 5-year and 10-year Government of India bonds.

Figure 4.3: Government of India Bond Yields



Source: Reserve Bank of India database

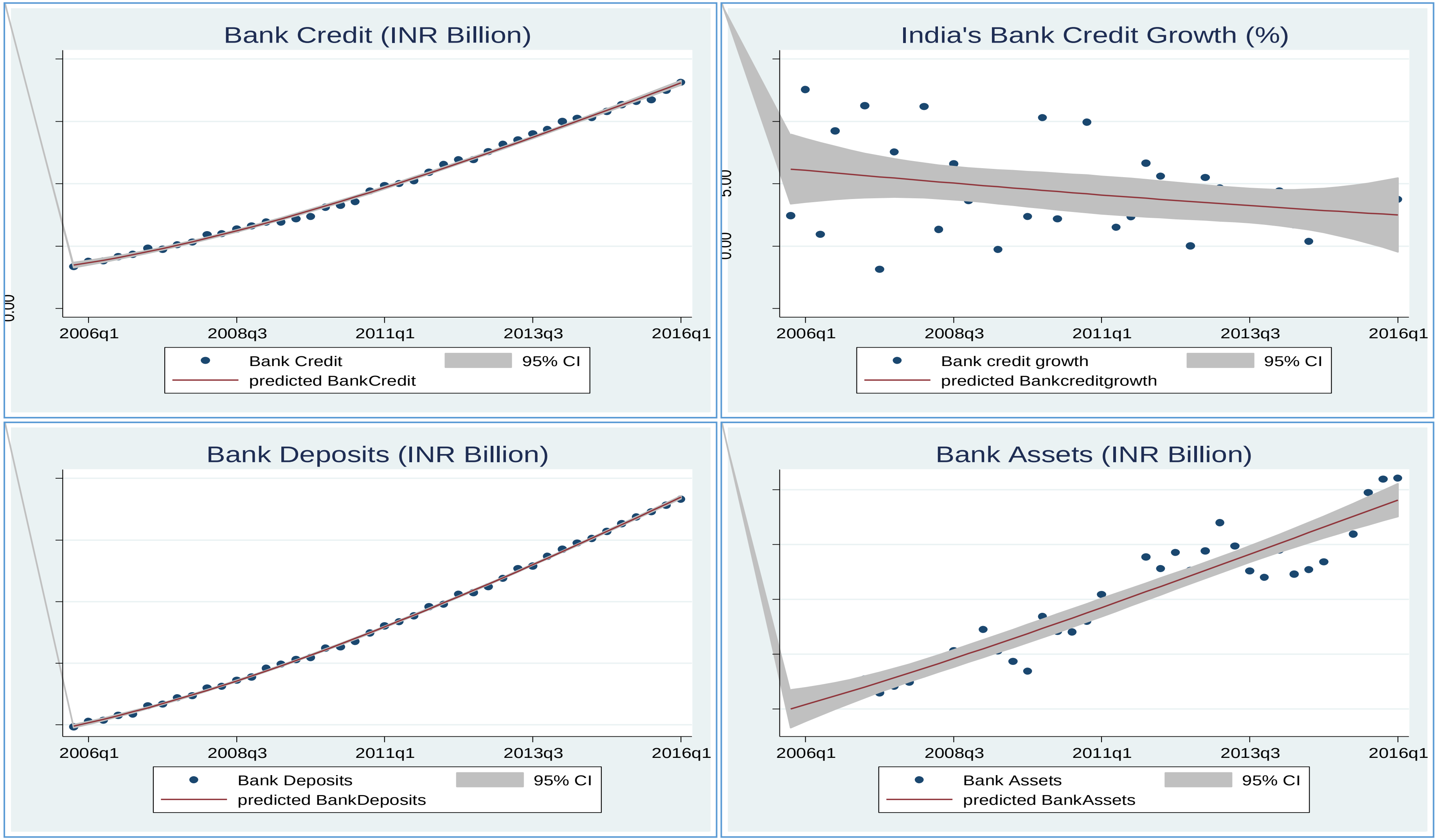
Bank Credit Channel

The Bank credit channel has been prominent channel of monetary policy transmission in India. The monetary policy instruments have affected the real sector through the bank credit channel by impacting the bank credit, bank deposits and the bank assets. Figure 4.4 presents the response of bank credit, bank credit growth, bank deposits, and banks assets during the period 2006 Q1 and 2016Q1.

Exchange Rate Channel

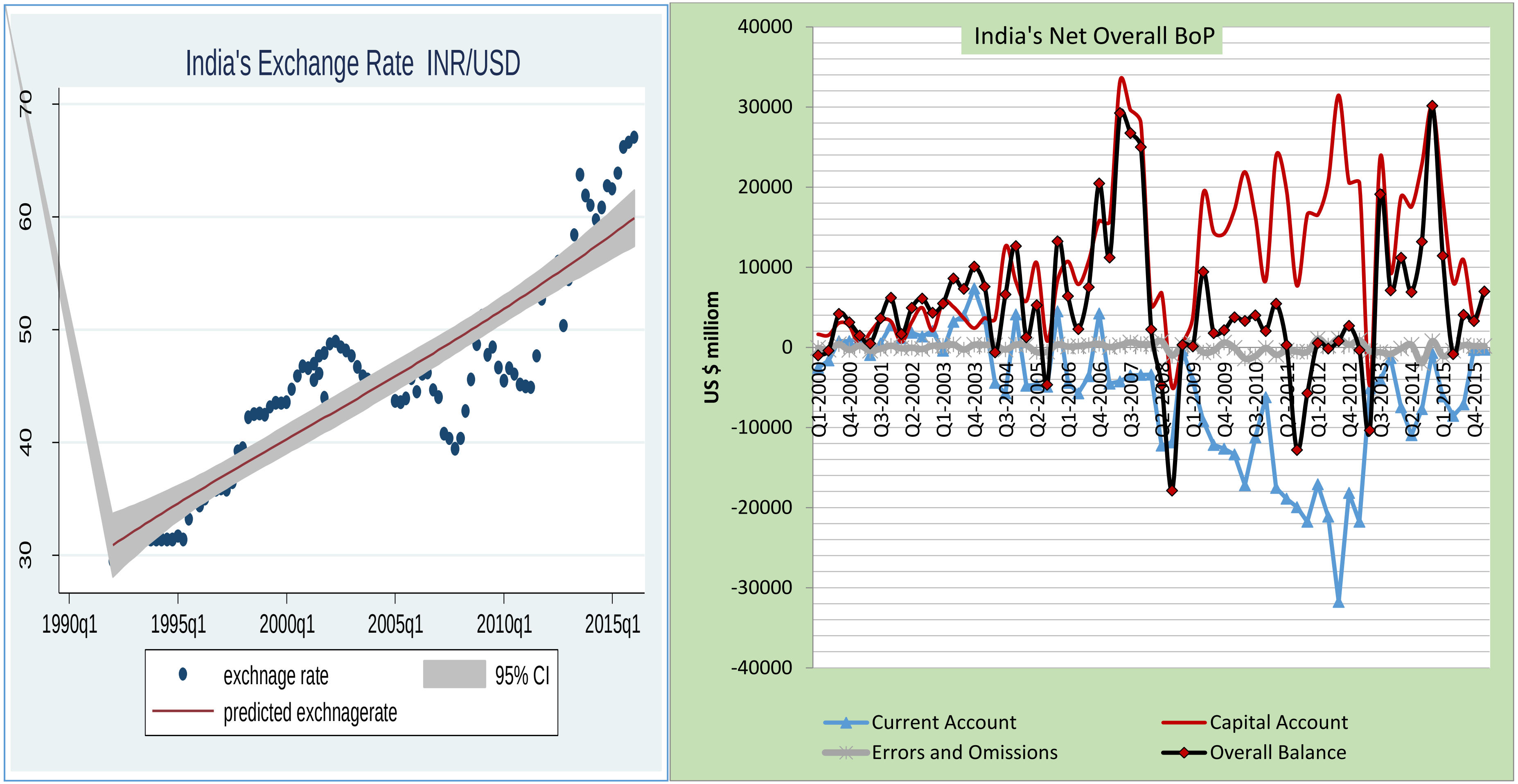
In the case of the exchange rate channel, the block exogeneity tests show a weak evidence bi-directional causality. Though changes in policy rates influence the exchange rate movement, the exchange rate is not the target of monetary policy interventions of RBI. Exchange rate depreciation is a found to be a major source of risk to inflation as indicated by the estimated pass-through coefficients. Figure 4.5 presents the exchange rate (INR/USD) and India’s net overall balance of payments during the period from 1992 to 2016. Figure 4.6 presents India’s Current account balance, Capital account balance, and the overall Balance of payments during the period from 1992 to 2016.

Figure 4.4: Bank credit, credit growth, deposits and assets in India



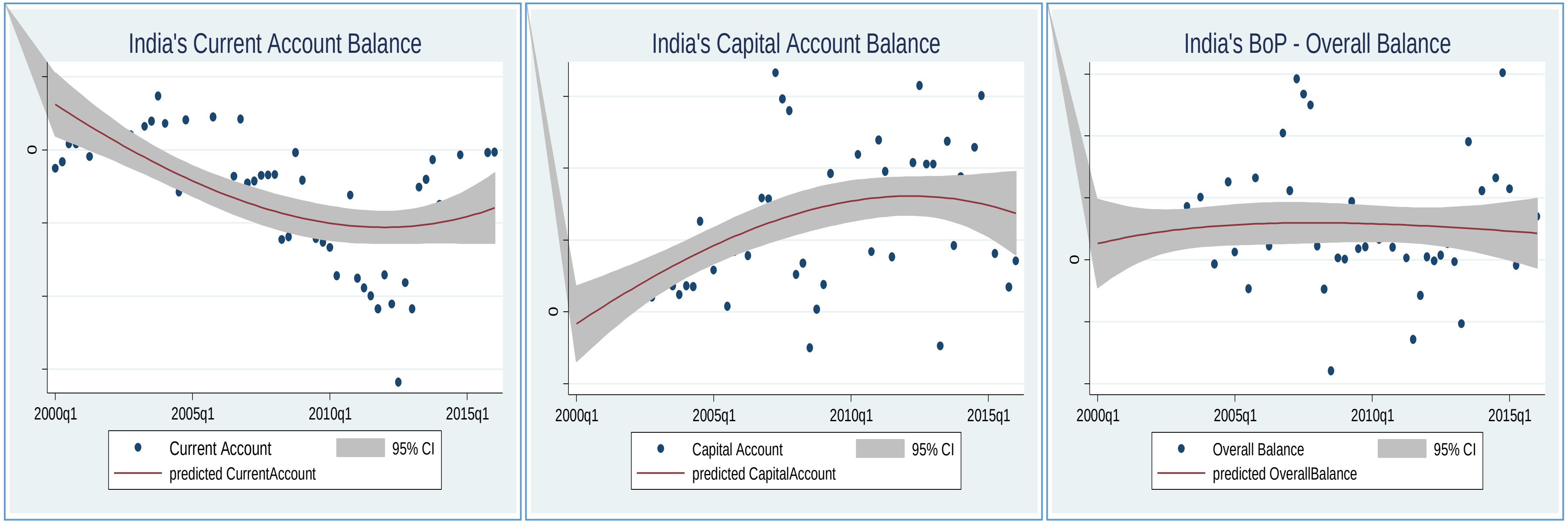
Source: Reserve Bank of India database

Figure 4.5: Exchange Rate (INR/USD) and India's net overall Balance of Payments



Source: Reserve Bank of India database

Figure 4.6: India’s current account balance, Capital account balance, and overall balance of payments

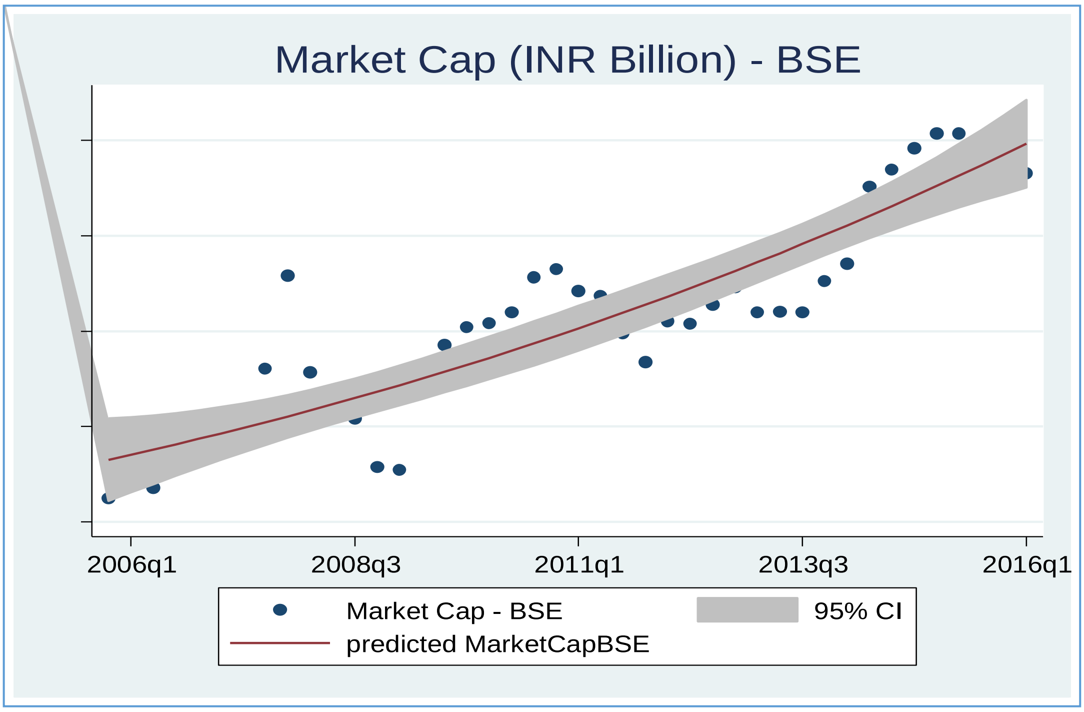


Source: Reserve Bank of India database

Asset Price Channel

Empirical evidence from India suggests that asset prices, particularly stock prices, react to interest rate changes, but the magnitude of the impact is little. With the growing use of formal finance for acquisition of real estate, the asset price channel of transmission has intensified. During periods of high inflation, there is a tendency for households to shift away from financial savings to other forms of savings such as gold and real estate that are likely to provide a better hedge against inflation. Figure 4.7 presents the market capitalization of BSE listed companies.

Figure 4.7: Market Capitalization of Companies in BSE



Source: Reserve Bank of India database

4.6. Impediments to Monetary Policy Transmission

Financial sector reforms in India and progressive deregulation of the financial sector created pre-conditions for conducting monetary policy primarily through changes in the interest rate as the main policy instrument. The effectiveness of monetary policy, yet, remains constrained by several country-specific factors that affect transmission of the policy impulses through the interest rate channel. Some of the major factors are briefly explained below.

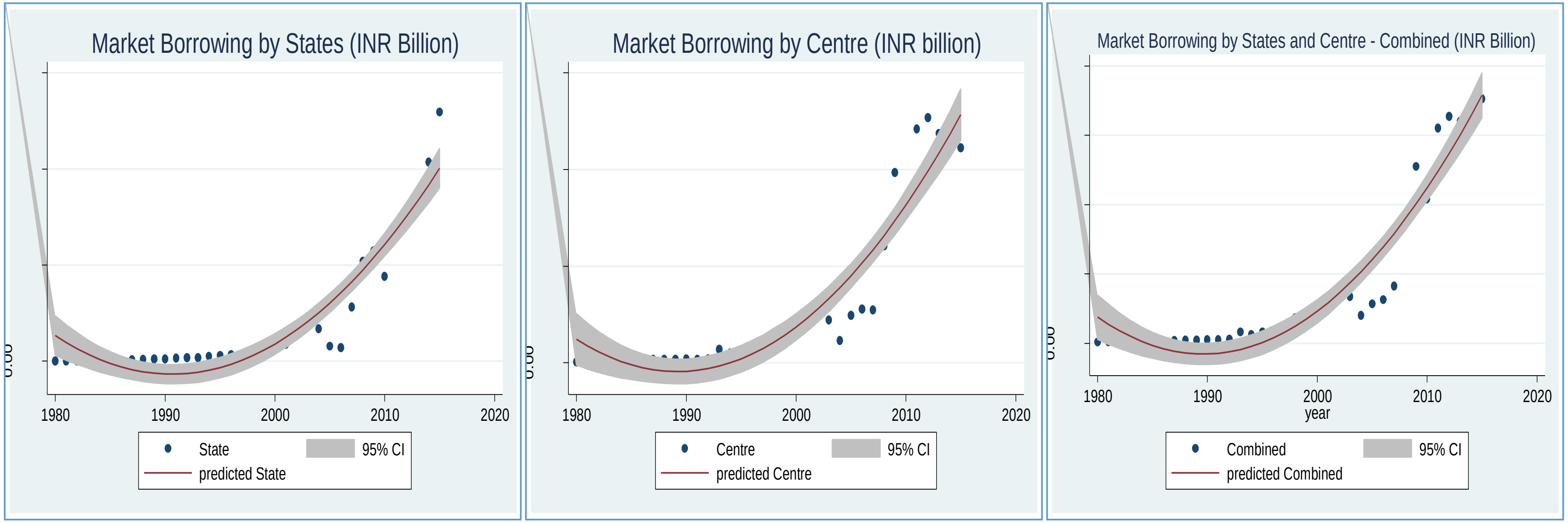
1. Persistent Fiscal Dominance:

The biggest impediment to monetary targeting was lack of control over RBI's credit to the central government, which accounted for the bulk of reserve money creation. Notwithstanding the phasing out of the Reserve Bank's participation in primary issuances of government securities (G-Secs), fiscal dominance continues to interrupt monetary policy efficacy as open market operations are intermittently employed to 'manage yields' in the context of large government borrowings.

2. Financial Sector Dominance

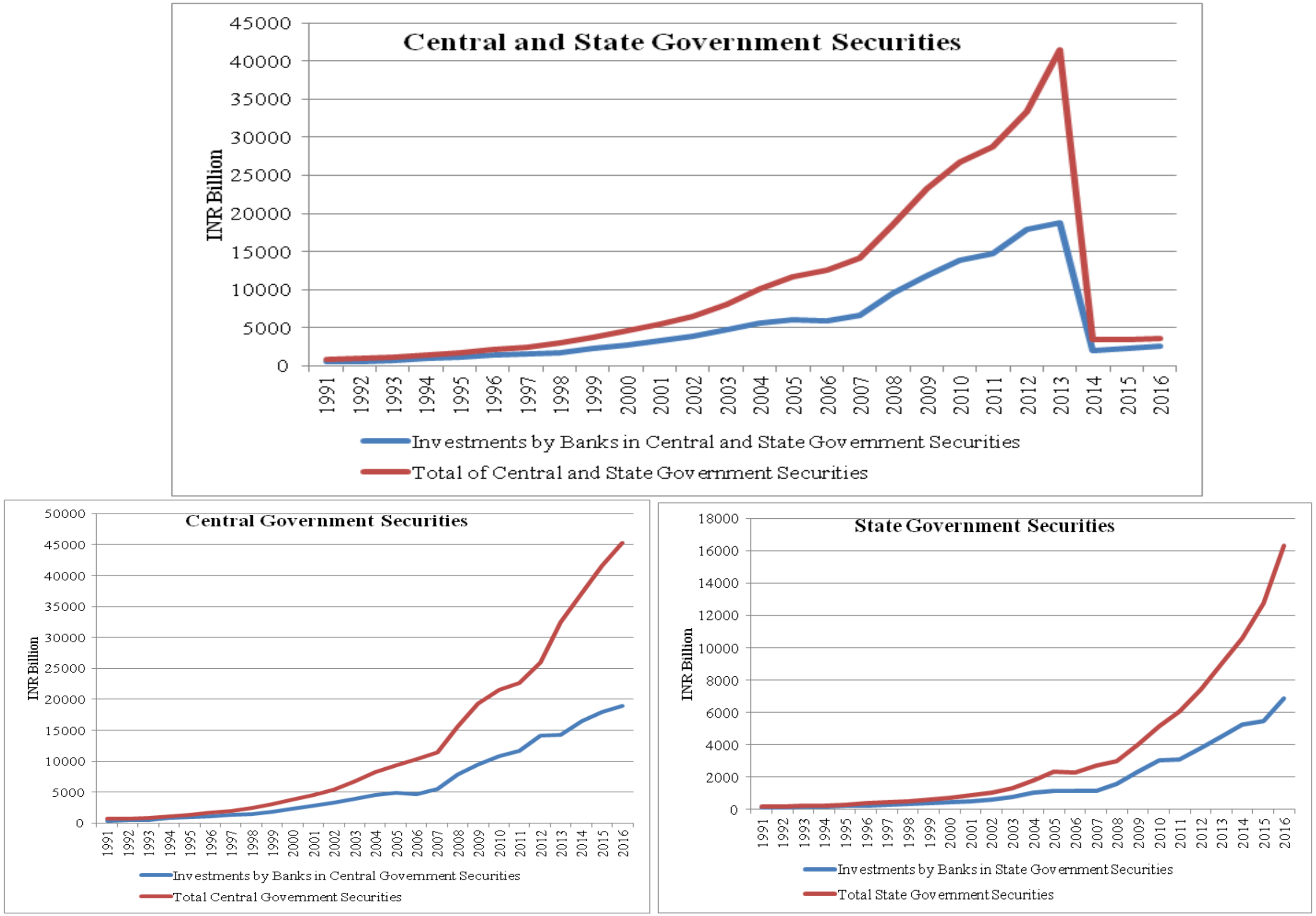
Undoubtedly a sound and stable financial system is indispensable for an objective and efficient implementation of monetary policy. Small and incompletely integrated market segments inhibit the transmission of monetary policy through the interest rate channel. A fragmented and fragile financial sector poses challenges in the smooth conduct of monetary policy, as the interest rate channel may not have the desired effects. Thus, these problems that arise due to the segmented financial system are typified as financial sector dominance. Data for the past decade show that whenever the net market borrowing of the government has increased, the ratio of incremental investment by banks in government securities has gone up, leading to lower share of non-food credit in bank finance, i.e., pointing to crowding out of the private sector. Figure 4.8 presents the Market borrowing by states, Market borrowing by centre, and the total borrowing by states and centre and Figure 4.9 illustrates the Central and State government securities in total and separately. Figure 4.10 presents the Gross Fiscal Deficit, Gross Primary Deficit, and Gross Revenue Deficit as percent of GDP. Figure 4.11 presents India Inflation and GDP Growth during the period 1997 Q3 to 2015 Q3.

Figure 4.8: Market borrowing by states, Market borrowing by centre, and the total borrowing by states and centre



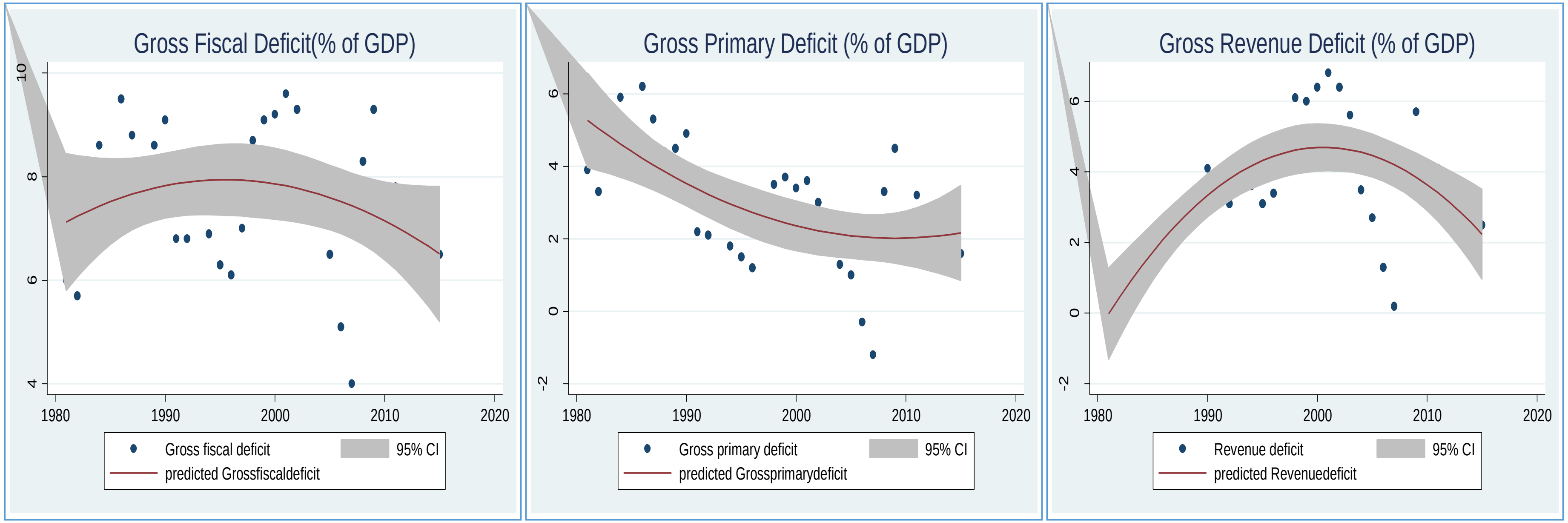
Source: Reserve Bank of India database

Figure 4.9: Central and State government securities



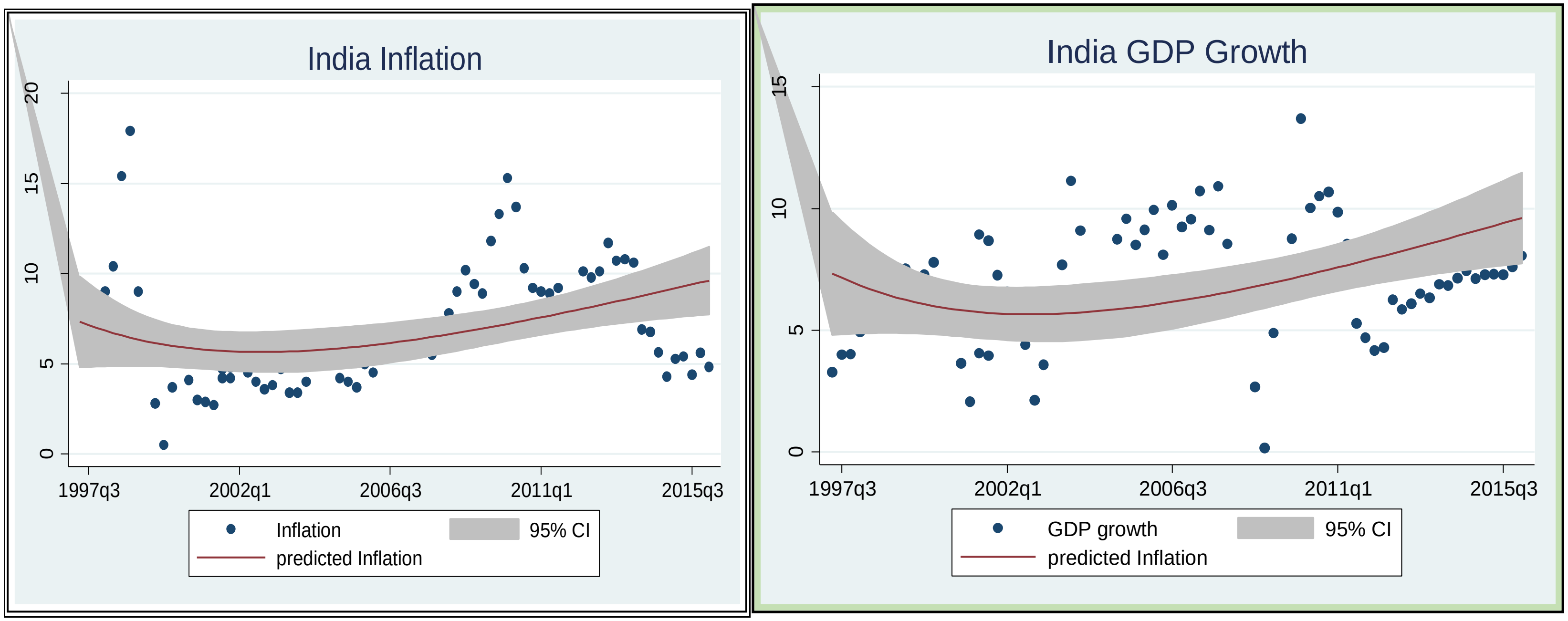
Source: Reserve Bank of India database

Figure 4.10: Gross Fiscal Deficit, Gross Primary Deficit, and Gross Revenue Deficit as percent of GDP



Source: Reserve Bank of India database

Figure 4.11: India Inflation and GDP Growth



Source: Reserve Bank of India database

Table 4.8: Major Monetary Policy Rates and Reserve Requirements (percent per annum)

Effective Date	Bank Rate	Repo rate	Reverse rate	Cash Reserve Ratio	Marginal Standing Facility	Statutory Liquidity Ratio
29-09-2015	7.75	6.75	5.75	4	7.75	21.5
27-06-2015	8.25	7.25	6.25	4	8.25	21.5
02-06-2015	8.25	7.25	6.25	4	8.25	21.5
04-03-2015	8.5	7.5	6.5	4	8.5	21.5
07-02-2015	8.75	7.75	6.75	4	8.75	21.5
15-01-2015	8.75	7.75	6.75	4	8.75	22
09-08-2014	9	8	7	4	9	22
14-06-2014	9	8	7	4	9	22.5
28-01-2014	9	8	7	4	9	23
29-10-2013	8.75	7.75	6.75	4	8.75	23
07-10-2013	9	7.5	6.5	4	9	23
20-09-2013	9.5	7.5	6.5	4	9.5	23
15-07-2013	10.25	7.25	6.25	4	10.25	23
03-05-2013	8.25	7.25	6.25	4	8.25	23
19-03-2013	8.5	7.5	6.5	4	8.5	23
09-02-2013	8.75	7.75	6.75	4	8.75	23
29-01-2013	8.75	7.75	6.75	4.25	8.75	23
03-11-2012	9	8	7	4.25	9	23
22-09-2012	9	8	7	4.5	9	23
11-08-2012	9	8	7	4.75	9	23
17-04-2012	9	8	7	4.75	9	24
10-03-2012	9.5	8.5	7.5	4.75	9.5	24
13-02-2012	9.5	8.5	7.5	5.5	9.5	24
28-01-2012	6	8.5	7.5	5.5	9.5	24
25-10-2011	6	8.5	7.5	6	9.5	24
16-09-2011	6	8.25	7.25	6	9.25	24
26-07-2011	6	8	7	6	9	24
16-06-2011	6	7.5	6.5	6	8.5	24
03-05-2011	6	7.25	6.25	6	8.25	24
17-03-2011	6	6.75	5.75	6	8.25	24
25-01-2011	6	6.5	5.5	6	8.25	24
18-12-2010	6	6.25	5.25	6	8.25	24
02-11-2010	6	6.25	5.25	6	8.25	25
16-09-2010	6	6	5	6	8.25	25
27-07-2010	6	5.75	4.5	6	8.25	25
02-07-2010	6	5.5	4	6	8.25	25
24-04-2010	6	5.25	3.75	6	8.25	25
20-04-2010	6	5.25	3.75	5.75	8.25	25
19-03-2010	6	5	3.5	5.75	8.25	25
27-02-2010	6	4.75	3.25	5.75	8.25	25
13-02-2010	6	4.75	3.25	5.5	8.25	25
07-11-2009	6	4.75	3.25	5	8.25	25
21-04-2009	6	4.75	3.25	5	8.25	24
05-03-2009	6	5	3.5	5	8.25	24
17-01-2009	6	5	4	5	8.25	24
05-01-2009	6	5.5	4	5.5	8.25	24
08-12-2008	6	6.5	5	5.5	8.25	24
08-11-2008	6	7.5	6	5.5	8.25	24
03-11-2008	6	7.5	6	6	8.25	25
25-10-2008	6	8	6	6	8.25	25
20-10-2008	6	8	6	6.5	8.25	25

11-10-2008	6	9	6	6.5	8.25	25
30-08-2008	6	9	6	9	8.25	25
30-07-2008	6	9	6	8.75	8.25	25
19-07-2008	6	8.5	6	8.75	8.25	25
05-07-2008	6	8.5	6	8.5	8.25	25
25-06-2008	6	8.5	6	8.25	8.25	25
12-06-2008	6	8	6	8.25	8.25	25
24-05-2008	6	7.75	6	8.25	8.25	25
10-05-2008	6	7.75	6	8	8.25	25
26-04-2008	6	7.75	6	7.75	8.25	25
10-11-2007	6	7.75	6	7.5	8.25	25
04-08-2007	6	7.75	6	7	8.25	25
28-04-2007	6	7.75	6	6.5	8.25	25
14-04-2007	6	7.75	6	6.25	8.25	25
31-03-2007	6	7.75	6	6	8.25	25
03-03-2007	6	7.5	6	6	8.25	25
17-02-2007	6	7.5	6	5.75	8.25	25
31-01-2007	6	7.5	6	5.5	8.25	25
06-01-2007	6	7.25	6	5.5	8.25	25
23-12-2006	6	7.25	6	5.25	8.25	25
31-10-2006	6	7.25	6	5	8.25	25
25-07-2006	6	7	6	5	8.25	25
08-06-2006	6	6.75	5.75	5	8.25	25
24-01-2006	6	6.5	5.5	5	8.25	25
26-10-2005	6	6.25	5.25	5	8.25	25
29-04-2005	6	6	5	5	8.25	25
27-10-2004	6	6	4.75	5	8.25	25
02-10-2004	6	6	4.5	5	8.25	25
18-09-2004	6	6	4.5	4.75	8.25	25
14-06-2004	6	6	4.5	4.5	8.25	25
31-03-2004	6	6	4.5	4.5	8.25	25
25-08-2003	6	7	4.5	4.5	8.25	25
14-06-2003	6	7	5	4.5	8.25	25
29-04-2003	6	7	5	4.75	8.25	25
19-03-2003	6.25	7	5	4.75	8.25	25
07-03-2003	6.25	7.1	5	4.75	8.25	25
03-03-2003	6.25	7.5	5	4.75	8.25	25
16-11-2002	6.25	7.5	5.5	4.75	8.25	25
12-11-2002	6.25	7.5	5.5	5	8.25	25
29-10-2002	6.25	8	5.5	5	8.25	25
27-06-2002	6.5	8	5.75	5	8.25	25
01-06-2002	6.5	8	6	5	8.25	25
28-03-2002	6.5	8	6	5.5	8.25	25
05-03-2002	6.5	8.5	6	5.5	8.25	25
29-12-2001	6.5	8.5	6.5	5.5	8.25	25
03-11-2001	6.5	8.5	6.5	5.75	8.25	25
23-10-2001	6.5	8.5	6.5	7.5	8.25	25
07-06-2001	7	8.5	6.5	7.5	8.25	25
28-05-2001	7	8.75	6.5	7.5	8.25	25
19-05-2001	7	8.75	6.75	7.5	8.25	25
30-04-2001	7	8.75	6.75	8	8.25	25
27-04-2001	7	9	6.75	8	8.25	25
10-03-2001	7	9	6.75	8	8.25	25
02-03-2001	7	9	6.75	8.25	8.25	25
24-02-2001	7.5	9	6.75	8.25	8.25	25
17-02-2001	7.5	9	6.75	8.5	8.25	25
12-08-2000	8	9	6.75	8.5	8.25	25

29-07-2000	8	9	6.75	8.25	8.25	25
22-07-2000	8	9	6.75	8	8.25	25
22-04-2000	7	9	6.75	8	8.25	25
08-04-2000	7	9	6.75	8.5	8.25	25
02-04-2000	7	9	6.75	9	8.25	25
20-11-1999	8	9	6.75	9	8.25	25
06-11-1999	8	9	6.75	9.5	8.25	25
08-05-1999	8	9	6.75	10	8.25	25
13-03-1999	8	9	6.75	10.5	8.25	25
02-03-1999	8	9	6.75	11	8.25	25
29-08-1998	9	9	6.75	11	8.25	25
29-04-1998	9	9	6.75	10	8.25	25
11-04-1998	9	9	6.75	10	8.25	25
03-04-1998	10	9	6.75	10.25	8.25	25
28-03-1998	10.5	9	6.75	10.25	8.25	25
19-03-1998	10.5	9	6.75	10.5	8.25	25
17-01-1998	11	9	6.75	10.5	8.25	25
06-12-1997	9	9	6.75	10	8.25	25
22-11-1997	9	9	6.75	9.5	8.25	25
25-10-1997	9	9	6.75	9.75	8.25	25
22-10-1997	9	9	6.75	10	8.25	31.5
26-06-1997	10	9	6.75	10	8.25	31.5
16-04-1997	11	9	6.75	10	8.25	31.5
18-01-1997	12	9	6.75	10	8.25	31.5
04-01-1997	12	9	6.75	10.5	8.25	31.5
09-11-1996	12	9	6.75	11	8.25	31.5
26-10-1996	12	9	6.75	11.5	8.25	31.5
06-07-1996	12	9	6.75	12	8.25	31.5
11-05-1996	12	9	6.75	13	8.25	31.5
27-04-1996	12	9	6.75	13.5	8.25	31.5
09-12-1995	12	9	6.75	14	8.25	31.5
11-11-1995	12	9	6.75	14.5	8.25	31.5
29-10-1994	12	9	6.75	15	8.25	31.5
17-09-1994	12	9	6.75	15	8.25	33.75
20-08-1994	12	9	6.75	15	8.25	34.25
06-08-1994	12	9	6.75	15	8.25	34.75
09-07-1994	12	9	6.75	14.75	8.25	34.75
11-06-1994	12	9	6.75	14.5	8.25	34.75
16-10-1993	12	9	6.75	14	8.25	34.75
18-09-1993	12	9	6.75	14	8.25	37.25
21-08-1993	12	9	6.75	14	8.25	37.5
15-05-1993	12	9	6.75	14	8.25	37.75
17-04-1993	12	9	6.75	14.5	8.25	37.75
06-03-1993	12	9	6.75	15	8.25	37.75
06-02-1993	12	9	6.75	15	8.25	38
09-01-1993	12	9	6.75	15	8.25	38.25
09-10-1991	12	9	6.75	15	8.25	38.25
04-07-1991	11	9	6.75	15	8.25	38.25

Source: Reserve Bank of India

Chapter 5

Assessing the Efficiency of Monetary Policy Transmission in India

This section examines monetary transmission mechanism for India in the context of a small macro model using quarterly data. According to the standard monetary transmission mechanism, variations in interest rates first shock the aggregate demand and GDP growth, and in turn, then impact inflation. Therefore, inflation management causes certain temporary loss of output. To the extent that growth is impacted, and it should be inferred as a short-term trade-off, with positive consequences for long-term performance (Gokarn, 2011).

5.1. Cross-Country Empirical Evidence:

The literature on cross-country empirical evidence on monetary transmission show lagged impact of monetary impulses on growth and inflation. For instance, in a vector autoregression (VAR) framework for the US economy Christiano et al., (1999) find that output, consumption, investment and inflation display a hump-shaped response and the peak effect on output is observed to pass on after 1.5 years of the monetary policy shock and on inflation after 2 years.

Boivin et al., (2011) study the transmission of monetary policy shocks in the US by comparing the impact of monetary policy shocks for the period 1962–1979 with the period 1984–2008 in a factor-augmented VAR (FAVAR) model as well as a dynamic stochastic general equilibrium (DSGE) model. The magnitude of responses of real GDP according to the FAVAR model was greater in the pre-1979 period than in the post-1984 period, but the response in the later period was more delayed and persistent. The authors observe that the response of the prices was noticeably reduced in the post-1984 period, compared to the earlier period, due to the better anchoring of inflationary expectations. However, according to the DSGE model results, during the 1984–2008 period, an increase of 100 bps in the policy rate reduces real GDP by around 40 bps with a lag of 2 quarters and inflation by around 30 bps with a lag of 3 quarters. Though the results are qualitatively similar in both the models, there are some differences in terms of the responses of inflation and output growth following policy innovation. Els et al., (2003) study the monetary transmission in the euro area using a range of models – a VAR model and three macro models. For an increase of 100 bps in the interest rate, they find that the peak effect on output is observed in the first 1-2 years and hence GDP squeezes by 20–40 bps after 1 year and by 30–70 bps after 2 years across models. The effect on the prices is found to be slower and is more persistent and hence the prices decline by 20–40 bps after 3 years.

The monetary transmission has been studied by Bank of England (2000) using a macro model. The study observes that in response to an increase of 100 bps in interest rates for about 4 quarters, the peak decline in the output after a year is about 0.3 percent and output returns to the baseline after 3 years. Inflation is mostly unaltered during the first year and the peak decline of 0.3 percent occurs by the beginning of the third year. However, another study by Bank of England (2004) using DSGE model throws up slightly different results: the demand effects come through a little more quickly reflecting the stronger short-run response of consumption to interest rate changes, the effects of the temporary change in interest rates on inflation are somewhat less persistent reflecting forward-looking households and firms who expect monetary policy will be set so as to return inflation to the base.

In a Swedish study, Bardsen et al., (2011) using an aggregated econometric model observe that a one-quarter 100 bps increase in the policy rate lowers the output by 50 bps (peak effect) and inflation by 20 bps (peak effect) after 6 quarters. For Norway, Olsen (2011) examines the monetary transmission and find that the peak decline in output is 40-70 bps (lag of 5-6 quarters) across a range of VAR models while that in inflation is 20-30 bps (lag of 9-11 quarters) following a one-period tightening of 100 bps. However, according to the Norges Bank's macro-model, the peak decline in output and inflation for a similar monetary policy shock is 40 bps (after 4 quarters) and 25 bps (after 2 years).

For Poland, a hike in short-term interest rates of 100 bps sustained for 4 quarters results in a decline in GDP growth by 30 bps after 4 quarters and a decline in inflation by 20 bps after 8 quarters (Pruski and Szpunar, 2008). For Hungary, Vonnak (2008) observes that the prices are affected in the first year after an increase in the policy rate and the response is persistent. However, the output reacts but marginally as the drop in investment after monetary tightening is offset by step up in consumption. The output response is extenuated by short-run nominal wage rigidity and the quick exchange rate pass-through. As a result, the income effect offsets the interest rate effect on consumption.

According to Catao et al., (2008), in Brazil, a one-period 100 bps increase in interest rate leads to a peak decline of 12 bps in output after 2 quarters (cumulative decline of 23 bps in output in the first year), while inflation declined peaks at just under 40 bps in the third quarter. The greater part of the effects of both output and inflation occur within 4 quarters. The transmission lags are thus shorter than in advanced economies, attributable to factors such as shorter maturity of domestic credit, and the considerable weight of the exchange rate in domestic currency pricing. For Chile, Garcia et al., (2005) using a structural model, observe that a one-quarter 100 bps increase in the interest rate shrinks the output by 60 bps (the peak effect) after 1 quarter and the accompanying the peak decline in inflation is about

25 bps after 7 quarters. In Mexico, Sidaoui and Ramos-Francia (2008) observe that exchange rate fluctuations have become less important in the determination of prices, while interest rate movements have had a faster and stronger effect on inflation on the back of the ‘expectations channel’ of monetary policy.

In the case of Indonesia, in the post-Asian crisis period, exchange rate movements have become more marked in impacting output and prices, while the effectiveness of monetary policy to influence the exchange rate has been weakened with exchange rate movements being driven more by non-economic factors. Goeltom (2008) observes that although the interest rate channel still works quite well in transmitting monetary policy in Indonesia, its magnitude has been impacted by the state of the banking system and overall higher levels of uncertainty and risk factors.

Fukunaga et al., (2011) study the monetary transmission efficiency for Japan using the Bank of Japan’s large-scale hybrid-type macro model and observe that in response to a monetary policy shock of one-period tightening of 100 bps, the peak decline in output and inflation is 14 bps (after 7 quarters) and 4 bps (after 10 quarters) respectively. One interesting observation here can be of the relatively smaller impact of monetary policy on output and prices in Japan, which mostly could perhaps be a reflection of the reduced efficacy of monetary policy in view of near-zero policy interest rates since the mid-1990s.

Studying the monetary transmission in emerging market economies (EMEs), Mohanty and Turner (2008) observe that the transmission lags mostly follow a comparable pattern as in key advanced economies, albeit the lags are shorter in some cases. They notice that during the 2000s, monetary policy frameworks in the EMEs became more credible, and central banks were more flexible in their operations, gaining from trimmed fiscal dominance and increased exchange rate flexibility. Therefore, inflation in most EMEs became lower and less volatile due to these shifts and the associated balance sheet changes that strengthened the interest rate channel. In an assessment of monetary transmission mechanism of select inflation targeting EMEs in a panel regression framework, Mukherjee and Bhattacharya (2011) find that private consumption and private investment declined by 26 bps and 46 bps in response to an increase of 100 bps in real deposit rate and real lending rate, respectively.

To summarize, the cross-country empirical evidence indicates that the peak effect of monetary policy on output and inflation in advanced economies occurs after a lag of around 4 and 6 quarters respectively. However, the lags appear to be relatively shorter in EMEs and the peak effect of an increase of 100 bps in interest rate is around 30-70 bps on output and around 20-40 bps on inflation.

5.2. Empirical Evidence: India

The literature on monetary policy transmission in India is yet in an incipient stage, though of late we find studies using traditional vector auto-regression (VAR) and structural vector autoregression (SVAR) approaches. However, the impact of the policy interest rate changes of the Reserve Bank of India (RBI) on the real economy and inflation still remains an open question.

The dynamics of monetary policy transmission have been studied using alternative approaches. Al-Mashat (2003), RBI (2004), Aleem (2010), Bhattacharya et al., (2011), and Khundrakpam and Das (2011) have employed VAR approaches to assess the various aspects of transmission. RBI (2002), Patra and Kapur (2012), Goyal (2008), and Anand et al., (2010) use the New Keynesian model (NKM) to estimate the extent of monetary transmission. Some of the studies viz., Dua and Gaur (2009), Paul (2009), Patra and Ray (2010), Mazumdar (2011), Singh et al., (2011) used the individual equations of the NKM focusing on Philips curve. On the other hand, Taylor-type rules have been examined in the studies by Mohanty and Klau (2004), Virmani (2004), Srinivasan et al. (2008), Takeshi and Hamori (2009), Anand et al., (2010), Hutchison et al., (2010), and Singh (2010).

RBI (2004) analyze monetary transmission using a VAR approach and find that the peak effect of an interest rate shock on output and inflation occurred after 6 months which is consistent with evidence of shorter lags in EMEs. The lags are substantiated by Aleem (2010) who observes that the peak decline in both GDP and prices occurs in the third quarter subsequent to the interest rate shock. Mohanty (2012) used a quarterly structural VAR (SVAR) model and observed that policy rate increases have a negative effect on output and inflation. The peak effect of the rate shock on output growth was with a lag of two-quarters and that on inflation with a lag of three-quarters. The study observed that the overall impact persists through 8–10 quarters. Anand et al., (2010) employ a DSGE model framework and observe that the peak effect of a 100 bps increase in the nominal policy rate (call rate) is 35–45 bps on output and about 15 bps on inflation. The peak effect on both output and inflation is found in the first quarter after the policy rate shock.

On the contrary, modeling a long-run cointegrating relationship, Bhattacharya et al., (2011) observe a weak interest rate channel and suggests that the exchange rate channel is the most effective mechanism. They observe that an increase of 100 bps in the call money rate has a negligible impact on industrial production and a reduction of only 1 bps in inflation; in comparison, one percent currency depreciation increases inflation by 20 bps. They argue that the impact of interest rate on inflation is not direct, but via the exchange rate channel. The higher interest rates lead to an appreciation of the domestic currency, which then impacts inflation. Similarly, Goyal (2008) observes that a monetary stimulus preceding a temporary supply shock can abort inflation at minimum output cost, on account of exchange rate appreciation, associated with a fall in interest rates and rise in output.

Bank Credit Channel

Given the bank-dominated financial system, some of the studies have focussed on the credit channel. According to Khundrakpam (2011), the credit channel seems to be significant and robust in India. An increase of 100 bps in the policy rate was observed to shrink bank credit by 2.2–2.8 percent. Pandit and Vashisht (2011) study the effectiveness of credit channel for India and six other EMEs in a panel regression framework and notice that the monetary policy rate is a significant determinant of firms' demand for bank credit, confirming the role of countercyclical monetary policy as a tool for setting the speed of economic activity. Khundrakpam and Das (2011) study the relative response of food and manufactured products prices to changes in interest rate and money supply. They observe that in the long-run, variations in money supply impact prices of both food and manufactured products prices but the impact of the money supply is relatively higher on food prices than on manufactured products prices. On the contrary, variations in call rate have a negative effect only on manufactured products prices. Their results suggest that the credit channel is more effective vis-a-vis the interest rate channel to deal with supply shocks.

Exchange Rate Channel

We present here some of the empirical evidence available in the literature. Khundrakpam (2007) in their study for the period from August 1991 to March 2005, observed that a 10 percent change in exchange rate increases final WPI prices by 60 bps in short run and 90 bps in long run. Kapur (2012), and Kapur and Behera (2012) in their study for the period from 1996 Q2 to 2011 Q1, found that 10 percent appreciation (depreciation) of rupee vis-à-vis the US dollar reduces (increases) WPI inflation by 60 bps in the same quarter, while the long-run pass-through is about 120 basis points. Patra and Kapur (2010), in their study for the period for 1996 Q2 to 2009 Q3, observe that a 10 per cent appreciation (depreciation) of the Indian rupee (vis-a-vis the US dollar) would reduce (increase) WPI inflation by 50 bps in the same quarter, by 150 percentage points after seven quarters.

In another study for the period from 1996 Q2 to 2013 Q1, Patra et al., (2013) observe that a 10 percent change in the exchange rate resulted in 1.5 percent change in WPI prices prior to the global crisis and 1.0 percent change including post-crisis period. Ghosh and Rajan (2007), in their study covering the period from 1980 Q1 to 2006 Q4, observed an exchange rate pass-through elasticity of the rupee-USD to CPI to be between 45 and 50 percent and quite stable over the period under consideration. Bhattacharya, et al., (2008) in their study for the period from 1997 M9 to 2007 M10, found that one per cent increase in exchange rate causes rise in CPI level by 0.10-0.11per cent in the short run and 0.04-0.17per cent in the long-run

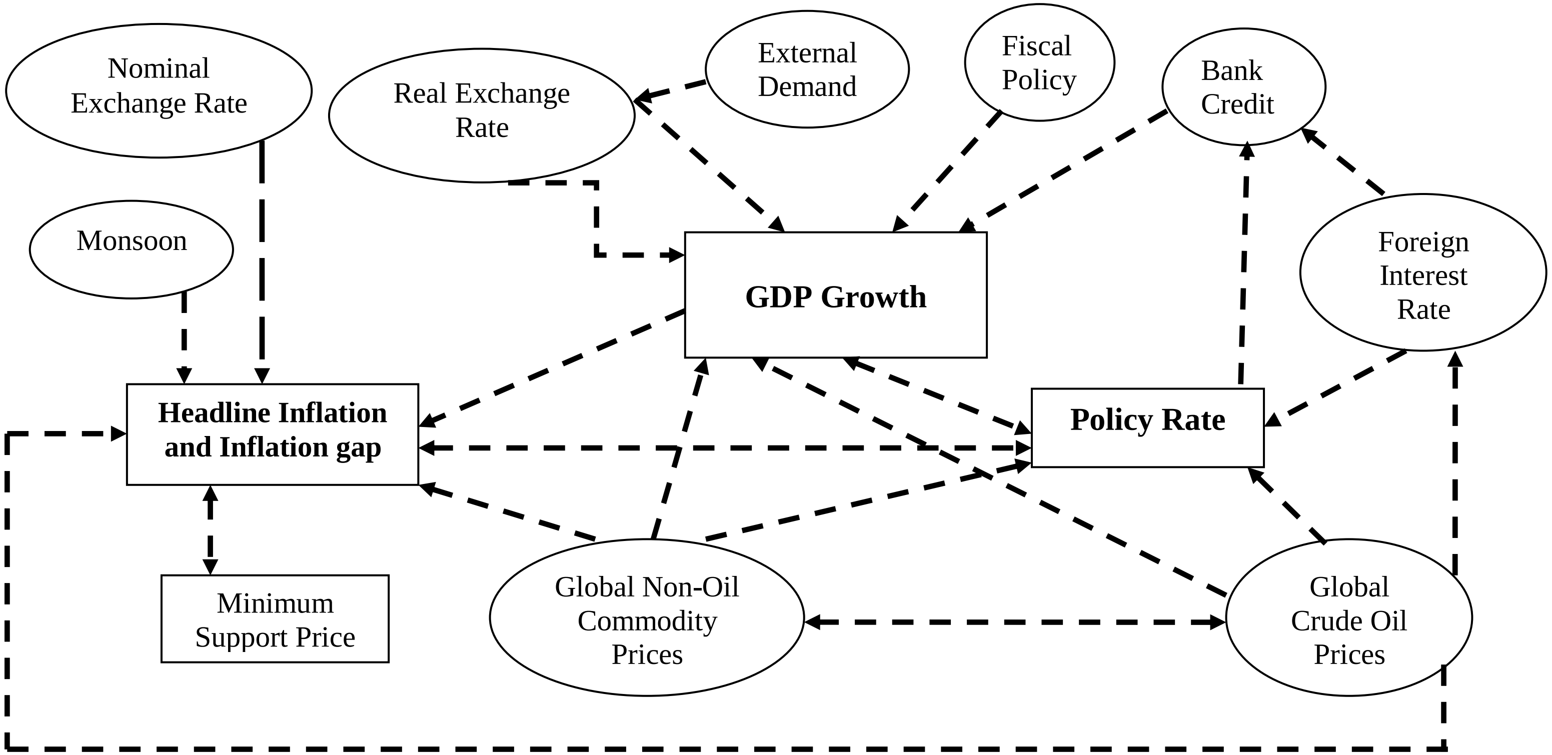
Asset Price Channel

Empirical evidence for India suggests that asset prices, particularly stock prices, react to interest rate changes, but the magnitude of the impact is little (Singh and Pattanaik 2012). Furthermore, the wealth effect of rising equity prices in India is noticed to be limited (Singh, 2012). With the growing use of formal finance for acquisition of real estate, the asset price channel of transmission has intensified. Nevertheless, during periods of high inflation, there is a tendency for households to shift away from financial savings to other forms of savings such as gold and real estate that are likely to provide a better hedge against inflation. However, the asset price channel weakens when the acquisitions of such real assets are funded by informal sources bypassing the formal finance.

5.3. Transmission Mechanisms of Monetary Policy:

An effective implementation of monetary policy needs an assessment of how the monetary policy changes propagate through the financial markets and the broader economy. A schematic presentation of the model of determinants of inflation and economic growth is provided in Figure 5A. Following the Phillips curve approach, inflation is determined as a function of domestic demand conditions, supply shocks, rainfall conditions, trends in minimum support prices and inflation expectations. Even though the share of the agricultural sector in GDP has weakened over the years, it remains significant. Simultaneously, the agricultural output shows considerable volatility given its continued dependence upon monsoon rainfall. Correspondingly, food prices have a large weight in the various price indices and agricultural supply shocks impact both food inflation and headline inflation. Volatility in the agricultural sector induces volatility in both overall GDP and headline inflation, which poses challenges to modeling. Minimum support prices are endogenised, given their role in the inflation process. Following the IS curve framework, output growth is assumed to depend upon interest rate, bank credit, asset prices, external demand, oil prices and real exchange rate. In view of the dominance of the banks in the credit system, determinants of demand for bank credit are modeled. Finally, the monetary policy reaction function is estimated on the lines of a Taylor rule, with the policy rate reacting to deviations of inflation from the inflation target/objective and the output gap.

Figure 5A: Determinants of Inflation and Economic Growth



5.4 Estimation Strategy

The estimation of the efficiency of monetary policy transmission in India is carried out in five separate sub-studies that are detailed here below. Study 1 reports the estimation of the impulse responses of macroeconomic indicators to the policy repo rate shocks in India. Study 2 reports the estimation of the cointegrating relationship of the monetary policy repo rate movements with the rates across the financial markets in India. Study 3 reports the examination of the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel. Study 4 reports the estimation of the pass-through to call money rate from monetary policy. Study 5 reports the estimation of the pass-through to bank interest rates from call money rate. Finally, Study 6 reports the estimation of the cointegrating relationship of monetary policy rates movements with call money rate.

Study 1: Estimating Impulse Responses of macroeconomic Indicators

This section details the estimation of the impulse responses of macroeconomic indicators to the policy repo rate shocks in India.

The Model

A vector autoregressive model (VAR) can be the best solution in testing the long-run dynamic relationship between the variables concerned in such situation where the priori assumption of endogeneity and exogeneity of variables concerned may not always be made. VAR model treats all variables systematically without making reference to the issue of dependence or independence. A VAR model additionally offers a scope for intervention analysis through the study of impulse response functions for the endogenous s variables in the model. Moreover, a VAR model allows the analysis of ‘variance decompositions’ for these variables and further helps to understand the interrelationships among the variables concerned.

Vector auto regressions (VARs) are powerful tools for describing data and for generating reliable multivariate benchmark forecasts. Sims (1980) advocated VAR models as providing a theory-free method to estimate economic relationships, thus being an alternative to the “incredible identification restrictions” in structural models. Used wisely and based on economic reasoning and institutional detail, VARs both can fit the data and, at their best, can provide sensible estimates of some causal connections. Although VARs have limitations when it comes to structural inference and policy analysis, so do the alternatives. A recursive VAR constructs the error terms in the each regression equation to be uncorrelated with the error in the preceding equations. This is done by judiciously including some contemporaneous values as regressors.

Puzzles related to Monetary Policy Transmission

It is desirable to briefly take note of the four puzzles that have been widely prevalent in the exchange rate literature. Theory anticipates that an increase in the domestic interest rates should lead to an appreciation of the exchange rate (exchange rate overshooting) and thereafter depreciation of the currency in line with the uncovered interest parity. Higher return on investments due to increase in interest rates in the domestic economy leads to a higher demand for domestic currency, appreciating the domestic currency vis-à-vis the foreign currency. The *exchange rate puzzle* takes place when a restrictive domestic monetary policy leads to on impact depreciation of domestic currency. Otherwise, if it appreciates, it does so for a prolonged period of time violating the uncovered interest parity condition which is known as the *forward discount bias puzzle* or delayed overshooting. The *liquidity puzzle* is an empirical finding when a money market shock is associated with increases in the interest rate instead of a decrease. This situation is due to the absence of the liquidity effect (negative correlation between monetary aggregates and interest rates) in the system. *Price puzzle* is a phenomenon where a contractionary monetary policy shock identified with an increase in interest rates, leads to a persistent rise in price level instead of a reduction of it.

Identification

The baseline model includes five variables given in the order: REPO, INFL, CPI, STLR, ER, and GDPGR. The estimation sample has been chosen so as to exclude any structural changes. We employ a VAR model of the form:

$$\boldsymbol{Z_t = A(L)Z_{t-1} + \mu + \varepsilon_t}$$

Z_t is a vector of endogenous variables, $A(L)$ describes parameter matrices, μ is a vector of constant terms and ε_t is a vector of error terms that are assumed to be white noise. The vector Z_t comprises the following variables:

$$Z_t = (REPO_t + +INFL_t + CPI_t + STLR_t + ER_t + GDPGR_t)$$

Where, $REPO_t$ – the policy repo rate of the central bank,

$INFL_t$ – the inflation rate

CPI_t – commodity price inflation rate

$STLR_t$ – the short-term loan rate

ER_t – the currency exchange rate (nominal exchange rate of Indian rupee per USD)

$GDPGR_t$ –real output growth

Real Output Growth

How does monetary policy affect economic output? The monetary policy framework of a central bank aims to attain the desired objectives of policy in terms of inflation and growth. Changes in interest rates by the monetary authorities can induce movements in asset prices to generate wealth effects in terms of market valuations of financial assets and liabilities. Higher interest rates can induce an appreciation of the domestic currency, which in turn, can influence net exports and, hence, aggregate demand and output. Hence, real output growth is one of the important variables in the VAR model.

Inflation Rate

An increase in the nominal interest rate will bring about an increase in the real interest rate if the rationally expected inflation rate does not increase by the same amount. Because of slow adjustment of goods prices, the expectation of changes in goods prices over short time horizons will also adjust slowly if expectations are rational. Hence, an increase in the nominal interest rate results in a change in the real interest rate, over the time period where prices and expectations are adjusting. According to the standard monetary transmission mechanism, variations in interest rates first impact aggregate demand and GDP growth, which, in turn, then impact inflation. Therefore, inflation management needs some temporary loss of output.

Commodity Price Inflation

A monetary contraction temporarily raises the real interest rate, whether via a rise in the nominal interest rate, a fall in expected inflation, or both. Real commodity prices fall. Rising commodity prices result in an increase in inflation, but at the same time have negative consequences on economic activity. Their implications for monetary policy are less straightforward than those of demand shocks. For example, a positive demand shock, that increases inflation and output, calls for monetary tightening in order to stabilize both. A commodity price shock is an inflation shock and has negative effects on income at the same time. The inflationary consequences of rising commodity prices represent an important challenge for monetary policy. Hence, commodity price inflation is included as a variable in the VAR model.

Short-term loan rate

A complete story of the monetary transmission mechanism should thus include a description of the central bank's reaction function showing how the central bank adjusts the short-term interest rate in response to various factors in the economy, including real GDP and inflation (Taylor, 1995; Bernanke and Mihov, 1998). Bryant, Hooper, and Mann (1993) provide a review of many examples of such central bank reaction functions, or policy rules, that appear in the literature. Matthias (2013) argue that work on monetary policy transmission should incorporate short-term interest rate.

Exchange Rate

The monetary policy framework has been internationalized; changes in exchange rates are now a key part of the monetary transmission mechanism. Interest rate parity explains why changes in nominal short-term interest rates would affect nominal exchange rates. Given the temporary rigidities in the prices of goods and services, as described earlier, lower short-term rates would reduce the real exchange rate in the short run. In the long run, however, the change in monetary policy would have no effect on real GDP; the price level would be higher by the same percentage amount by which the central bank increased the money supply as implied by the initial reduction in short-term interest rates, and the exchange rate would return to its previous baseline path (Taylor, 1995). As Robert Mundell (1962) showed long ago, capital mobility implies a very simple relationship between short-term interest rates and the exchange rate: the interest rate parity relationship states that the interest rate differential between any two countries is equal to the expected rate of change in the exchange rate between those two countries. Hence, in theory, monetary policy can affect the exchange rate.

The VAR model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1. The output growth rate, the inflation rate, commodity price inflation rate, policy repo rate, and the short-term lending rate are expressed in percent and the exchange rate is the ratio of number of INR per each USD. The vector of constant terms comprises a linear trend and a constant. Choosing a lag length of four ensures that the error terms dismiss signs of autocorrelation and conditional heteroscedasticity.

The baseline model is estimated with four lags, which are chosen to eliminate residual serial autocorrelation. Moreover, two lags have been indicated by all information selection criteria (Akaike, Schwarz, Hannan-Quinn, Final Prediction Error and LR). The VAR is estimated with a constant and a time trend. The variables in the models are either stationary or integrated of order one, as indicated by Augmented Dickey-Fuller and KPSS tests. Following Sims *et al.*, (1990), the VAR is estimated consistently in levels as Trace and Maximum Eigenvalue tests indicate two cointegration relationships between the variables. Structural Chow breakpoint and sample split tests do not indicate a change in the coefficients in the model. The VAR satisfies the stability condition because all roots of characteristic polynomial lie within the unit circle.

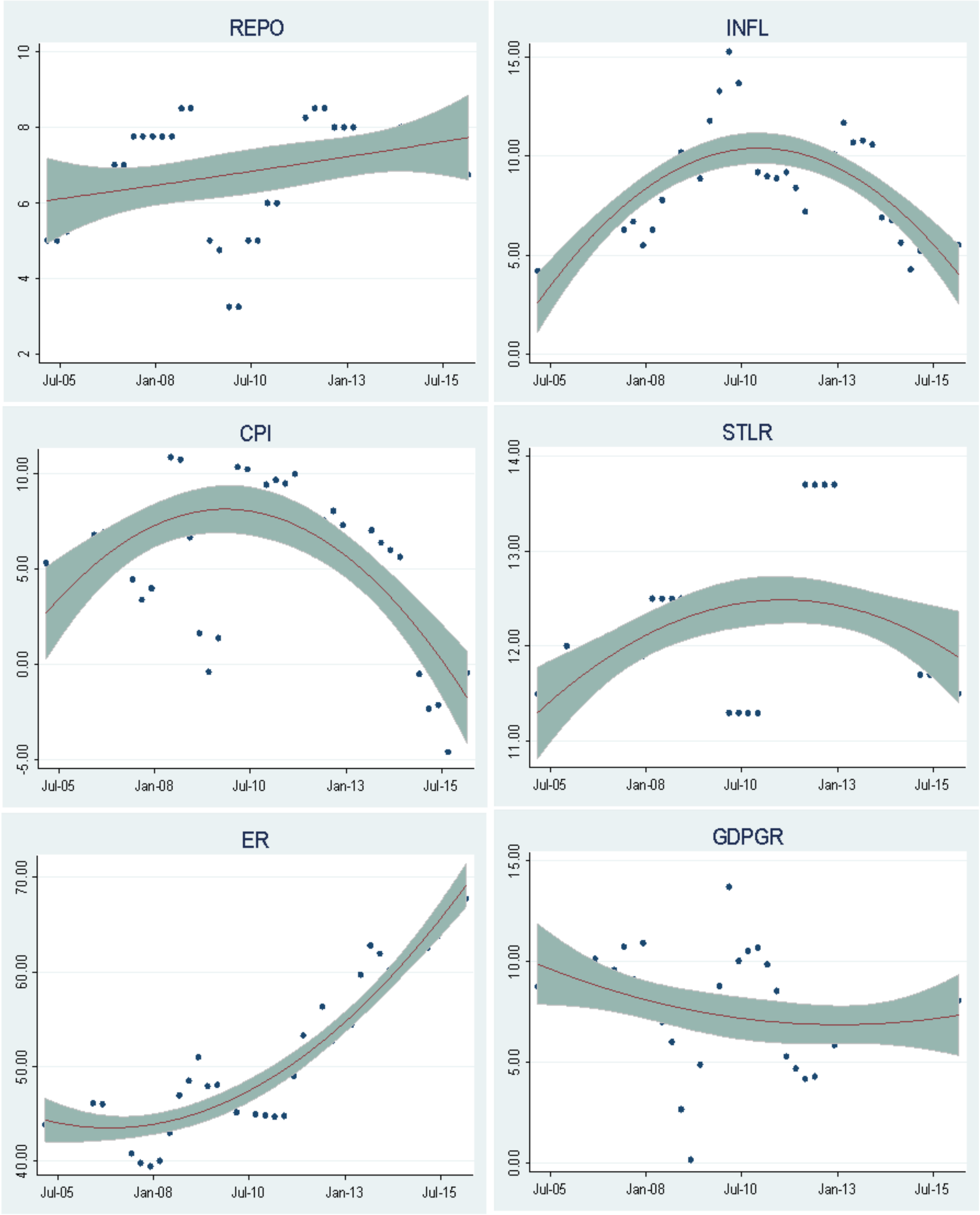
Table 5.1.1 provides the descriptive statistics of the variables. Repo rate ranges from a minimum of 3.25 to a maximum of 8.50 with a mean value of 6.87. Inflation ranges from a minimum of 3.70 to a maximum of 15.30 with a mean value of 7.93. CPI ranges from a minimum of -4.59 to a maximum of 10.88 with a mean value of 5.37. STLR ranges from a minimum of 11.30 to a maximum of 13.70 with a mean value of 12.16. Nominal exchange rate ranges from a minimum of 39.41 to a maximum of 67.74 with a mean value of 50.89. The real GDP growth ranges from a minimum of 0.16 to a maximum of 13.69 with a mean value of 7.64.

Table 5.1.1: Descriptive Statistics

	REPO	INFL	CPI	STLR	ER	GDPGR
Mean	6.872	7.932	5.378	12.160	50.898	7.642
Median	7.500	7.200	6.398	12.200	47.870	7.431
Maximum	8.500	15.300	10.889	13.700	67.748	13.697
Minimum	3.250	3.700	-4.595	11.300	39.410	0.164
Std. Dev.	1.358	2.826	3.852	0.635	8.349	2.424
Skewness	-1.000	0.528	-0.749	0.955	0.572	-0.460
Kurtosis	3.281	2.619	2.856	3.729	1.968	4.096
Jarque-Bera	7.652	2.363	4.241	7.835	4.449	3.841
Probability	0.022	0.307	0.120	0.020	0.108	0.147
Observations	45	45	45	45	45	45

The covariates of the model are presented in Figure 5.1.1.

Figure 5.1.1: Covariates



Source: Reserve Bank of India database

The correlations among the variables are presented in Table 5.1.2. The correlation between repo rate and CPI is obviously observed to be statistically significant at the 1 percent level. Similarly, nominal exchange rate and real GDP growth exhibit significant correlation. As expected inflation and repo rate have a negative correlation. Similarly, STLR has a negative correlation with the nominal exchange rate and GDP growth. Inflation has a negative correlation with STLR and GDP Growth.

Table 5.1.2: Correlations

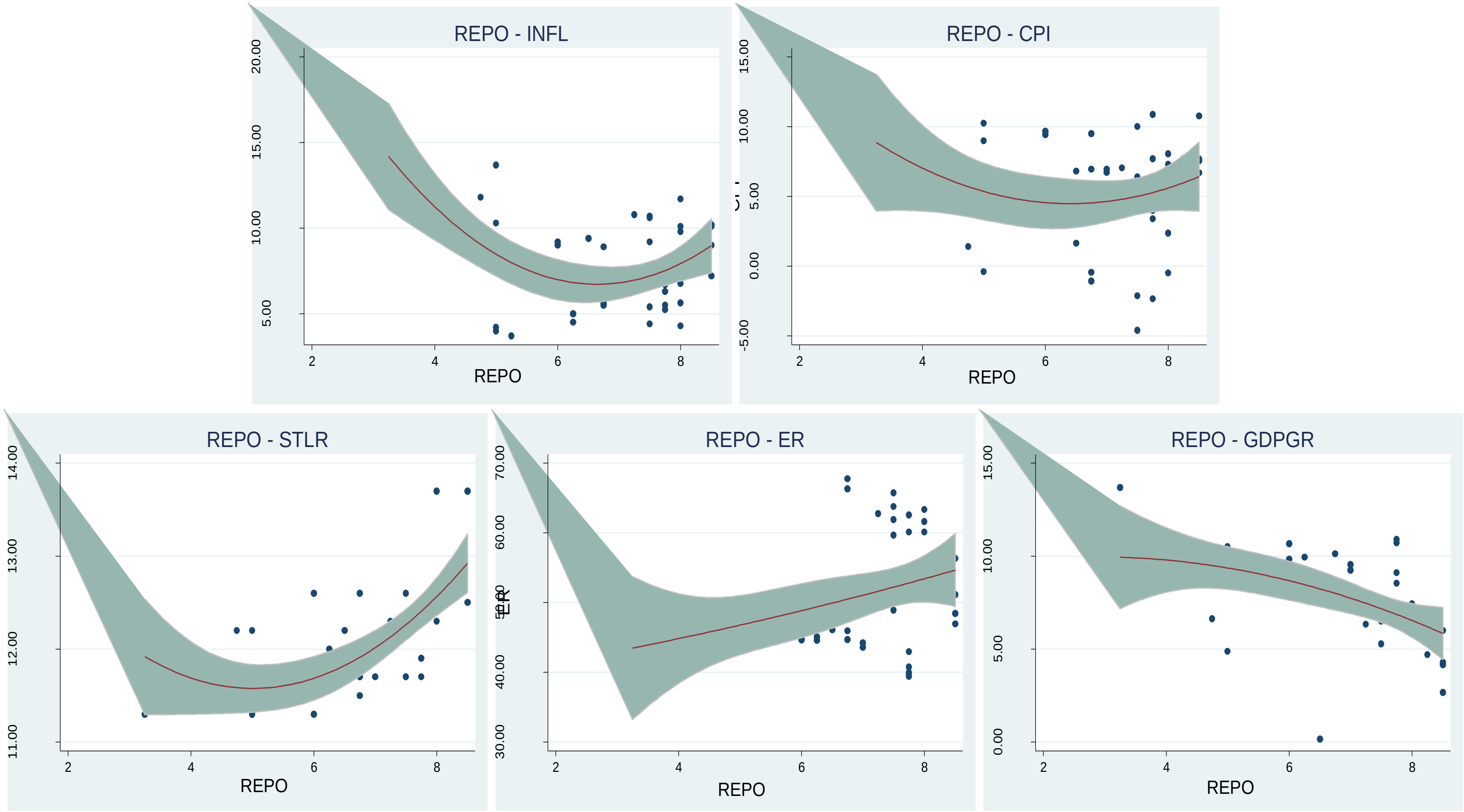
	REPO	INFL	CPI	STLR	ER	GDPGR
REPO	1					
INFL	-0.128	1				
CPI	**0.429****	0.048	1			
STLR	0.139	-0.215	0.185	1		
ER	0.139	0.212	0.068	-0.010	1	
GDPGR	**0.380***	-0.081	0.170	-0.022	**-0.414****	1

The interactions of REPO rate with other covariates are presented in Figure 5.1.2.

Testing for Stationarity

We estimate an ADF test that includes a constant in the test regression and employs an automatic lag length selection using a Schwarz Information Criterion (BIC) and a maximum lag length of 14. The results of the unit root tests are provided in Table 5.1.3. We notice that the statistic t_α value is greater than the critical values so that we do not reject the null at conventional test sizes. With the ADF test, we fail to reject the null hypothesis of a unit root in the INFL, CPI, STLR, ER series at conventional significance levels. Based on the results of unit root tests we find that INFL, CPI, STLR, ER are stationary at the first difference level. Accordingly, these variables are transformed into first difference level for further analysis.

Figure 5.1.2: Interaction of REPO with Covariates



REPO - INFL

REPO - CPI

REPO - STLR

REPO - ER

REPO - GDPGR

Source: Reserve Bank of India database

Table 5.1.3: Unit Root Tests

		REPO		INFL		CPI		STLR		ER		GDPGR	
		t-stat	Prob.	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.
Augmented Dickey-Fuller test statistic		-2.57	0.11	-1.76	0.39	-3.02	0.04	-2.18	0.22	0.18	0.97	-4.41	0.00
Test critical values:	1% level	-3.59		-3.59		-3.59		-3.59		-3.59		-3.60	
	5% level	-2.93		-2.93		-2.93		-2.93		-2.93		-2.94	
	10% level	-2.60		-2.60		-2.60		-2.60		-2.60		-2.61	

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

Source: Reserve Bank of India database

The VAR Lag Exclusion Wald Test indicates that for each lag, the χ 2 (Wald) statistic for the joint significance of all endogenous variables at that lag is reported for each equation separately and jointly (last column) (Table 5.1.4). The test suggests that jointly all four lags of all endogenous variables are statistically significant. Accordingly, all the four lags should be retained and we do not have to exclude any lag.

Table 5.1.4: VAR Lag Exclusion Wald Tests

	DREPO	DINFL	CPI	DSTLR	DER	GDPGR	Joint
Lag 2	9.318	3.100	29.945	7.153	2.762	22.055	178.650
	[0.156]	[0.796]	[4.03e-05]	[0.306]	[0.838]	[0.001]	[0.000]
Lag 3	13.273	4.631	11.492	18.512	4.931	6.165	74.635
	[0.038]	[0.591]	[0.074]	[0.005]	[0.552]	[0.404]	[0.000]
Lag 4	6.706	8.982	11.107	37.497	3.296	17.233	221.076
	[0.034]	[0.017]	[0.085]	[1.41e-06]	[0.077]	[0.008]	[0.000]
df	6	6	6	6	6	6	36

Note: Chi-squared test statistics for lag exclusion
Numbers in [ ] are p-values

Lag Length Selection

An important step in the estimation of the large VAR model is the lag selection. This matters not only for OLS estimates of the autoregressive coefficients but also in impulse-response functions analysis. We perform the sequentially modified likelihood ratio (LR) test is carried out using the criteria are discussed in Lutkepohl (1991, Section 4.3). The test computes various criteria to select the lag order of unrestricted VAR. Table 5.1.5 displays various information criteria for all lags up to the specified maximum. The table indicates the selected lag from each column criterion by an asterisk "*". Four of the five available tests (Sequential modified LR test, Final prediction error, Akaike information criterion, Schwarz information criterion, and Hannan-Quinn criterion) select lag 4 order and hence there should be 4 lags included in the model. Therefore 4 (four) lags are chosen for each endogenous variable in their autoregressive and distributed lag structures in the estimable VAR model.

Table 5.1.5: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-405.3542	NA	34.484	20.5677	20.8210	20.6593
1	-322.8754	136.090	3.4499	18.2438	20.017*	18.8850
2	-285.7812	50.0772	3.7007	18.1891	21.4824	19.3798
3	-238.5677	49.5742	3.0018	17.6284	22.4417	19.3687
4	-144.6347	70.4497*	0.368*	14.731*	21.0650	17.021*

Endogenous variables: DREPO DINFL CPI DSTLR DER GDPGR
Exogenous variables: C
* indicates lag order selected by the criterion
LR: Sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Estimates

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. The number of lags in the VAR is chosen considering several tests as detailed in the lag selection section of this report. Table 5.1.6 presents the vector autoregression estimates.

Table 5.1.6: Vector Autoregression Estimates
Note: Standard errors in ( ) & t-statistics in [ ]

	REPO	INFL	CPI	STLR	ER	GDPGR
REPO(-2)	-0.226	0.405	1.044	-0.082	0.128	0.253
	(0.254)	(0.603)	(1.407)	(0.117)	(1.133)	(0.737)
	[-0.8913]	[0.6719]	[0.7420]	[-0.7011]	[0.1128]	[0.3433]
REPO(-3)	0.153	-0.127	-0.452	0.163	-0.316	0.783
	(0.228)	(0.543)	(1.266)	(0.106)	(1.020)	(0.663)
	[0.6690]	[-0.2345]	[-0.3569]	[1.5487]	[-0.3097]	[1.1806]
REPO(-4)	0.020	0.181	-1.315	-0.356	-0.004	-0.358
	(0.230)	(0.547)	(1.276)	(0.106)	(1.027)	(0.668)
	[0.0880]	[0.3312]	[-1.0304]	[-3.3484]	[-0.0038]	[-0.5356]
INFL(-2)	-0.123	0.201	0.182	-0.025	-0.374	0.191
	(0.094)	(0.224)	(0.523)	(0.044)	(0.421)	(0.274)
	[-1.3003]	[0.8952]	[0.3476]	[-0.5814]	[-0.8884]	[0.6985]
INFL(-3)	0.043	0.385	0.893	-0.092	-0.166	0.359
	(0.104)	(0.247)	(0.576)	(0.048)	(0.464)	(0.302)
	[0.4150]	[1.5579]	[1.5510]	[-1.9224]	[-0.3575]	[1.1904]
INFL(-4)	-0.116	-0.292	0.232	0.119	-0.202	0.227
	(0.082)	(0.196)	(0.456)	(0.038)	(0.368)	(0.239)
	[-1.4035]	[-1.4904]	[0.5082]	[3.1255]	[-0.5490]	[0.9478]
CPI(-2)	0.163	-0.065	1.578	0.053	-0.022	-0.041
	(0.071)	(0.170)	(0.396)	(0.033)	(0.319)	(0.208)
	[2.2861]	[-0.3844]	[3.9820]	[1.6027]	[-0.0680]	[-0.1988]

CPI(-3)	-0.204	-0.161	-2.305	-0.121	0.255	-0.445
	(0.129)	(0.306)	(0.713)	(0.059)	(0.574)	(0.373)
	[-1.5850]	[-0.5258]	[-3.2317]	[-2.0317]	[0.4448]	[-1.1909]
CPI(-4)	0.071	0.167	1.644	0.085	-0.326	0.468
	(0.099)	(0.235)	(0.547)	(0.046)	(0.440)	(0.287)
	[0.7162]	[0.7131]	[3.0048]	[1.8611]	[-0.7390]	[1.6332]
STLR(-2)	-0.207	0.684	1.185	-0.168	0.068	-0.483
	(0.269)	(0.639)	(1.491)	(0.124)	(1.200)	(0.781)
	[-0.7706]	[1.0704]	[0.7952]	[-1.3554]	[0.0567]	[-0.6193]
STLR(-3)	0.262	-0.458	0.899	0.047	1.436	-0.481
	(0.306)	(0.728)	(1.697)	(0.141)	(1.366)	(0.889)
	[0.8568]	[-0.62929]	[0.52944]	[0.3299]	[1.0512]	[-0.5411]
STLR(-4)	-0.250	-0.199	-1.808	0.118	-0.049	-1.667
	(0.327)	(0.779)	(1.815)	(0.151)	(1.461)	(0.951)
	[-0.7629]	[-0.2560]	[-0.9958]	[0.7803]	[-0.0338]	[-1.7535]
ER(-2)	0.031	-0.125	0.150	0.044	0.183	-0.301
	(0.072)	(0.171)	(0.400)	(0.033)	(0.322)	(0.209)
	[0.4322]	[-0.7275]	[0.3762]	[1.3313]	[0.5677]	[-1.4366]
ER(-3)	-0.007	-0.248	-0.247	-0.005	-0.352	-0.246
	(0.069)	(0.165)	(0.384)	(0.032)	(0.309)	(0.201)
	[-0.1072]	[-1.5062]	[-0.6446]	[-0.16241]	[-1.1375]	[-1.2250]
ER(-4)	-0.013	-0.057	-0.078	0.056	-0.320	0.130
	(0.061)	(0.144)	(0.336)	(0.028)	(0.271)	(0.176)
	[-0.2075]	[-0.3957]	[-0.23140]	[1.9896]	[-1.1824]	[0.7361]
GDPGR(-2)	0.004	-0.227	0.779	0.055	-0.268	0.605
	-0.107	-0.254	-0.593	-0.049	-0.477	-0.310
	[0.0343]	[-0.8925]	[1.3138]	[1.1144]	[-0.5614]	[1.9496]
GDPGR(-3)	0.225	-0.329	-0.693	-0.087	-0.189	0.092
	(0.101)	(0.240)	(0.560)	(0.047)	(0.451)	(0.293)
	[2.2299]	[-1.3696]	[-1.2372]	[-1.8584]	[-0.4198]	[0.3139]
GDPGR(-4)	-0.137	0.373	0.332	0.176	0.178	-0.419
	(0.088)	(0.208)	(0.486)	(0.040)	(0.391)	(0.255)
	[-1.5652]	[1.7875]	[0.6831]	[4.3447]	[0.4540]	[-1.6464]
Intercept	-0.830	1.877	-2.969	-1.237	3.526	5.586
	(0.982)	(2.337)	(5.449)	(0.454)	(4.387)	(2.854)
	[-0.8453]	[0.8030]	[-0.5448]	[-2.7237]	[0.8036]	[1.9575]
R-squared	0.612	0.503	0.685	0.788	0.316	0.770
Adj. R-squared	0.279	0.077	0.414	0.606	-0.269	0.573
Sum sq. resids	6.648	37.635	204.556	1.420	132.589	56.098
S.E. equation	0.563	1.339	3.121	0.260	2.513	1.634
F-statistic	1.837	1.181	2.532	4.338	0.540	3.905
Log likelihood	-20.867	-55.539	-89.397	10.009	-80.725	-63.522
Akaike AIC	1.993	3.727	5.420	0.450	4.986	4.126
Schwarz SC	2.796	4.529	6.222	1.252	5.788	4.928
Mean dependent	0.013	0.025	5.475	-0.005	0.578	7.450
S.D. dependent	0.663	1.394	4.078	0.414	2.230	2.501
Determinant resid covariance (dof adj.)		0.299				
Determinant resid covariance		0.006				
Log likelihood		-239.049				
Akaike information criterion		17.652				
Schwarz criterion		22.466				

Robustness tests

We perform multivariate LM test to test the presence of the autocorrelations and the VAR residual portmanteau tests and for autocorrelations to establish the residual autocorrelations. Further, we also perform the VAR Granger causality/block exogeneity Wald tests, residual normality tests, and VAR residual heteroskedasticity tests with without cross terms.

Residual Autocorrelations

The VAR Residual Portmanteau test for autocorrelations is done for further confirmation of serial independence for residuals. Test results are presented in Table 51.7. The adjusted Q-Statistics for the corresponding Chi-Square values, given the degrees of freedom, in Table 5.1.7 show that (a) the hypothesis of serial correlations have been rejected for up to the 8th lag at 1% level, (b) the hypothesis of serial correlations have been rejected for the 9th lag at 5% level. Consequently, Portmanteau test testifies for the serial independence of the VAR residuals ($\hat{u}_{1t}$ and $\hat{u}_{2t}$)).

Table 5.1.7: VAR Residual Portmanteau Tests for Autocorrelations

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	58.29075	NA*	59.78539	NA*	NA*
2	80.02153	NA*	82.65989	NA*	NA*
3	96.51538	NA*	100.4911	NA*	NA*
4	120.9536	NA*	127.6447	NA*	NA*
5	155.5393	0	167.1712	0	72
6	189.068	0	206.6167	0	108
7	209.5575	0.0003	231.4525	0	144
8	228.078	0.0088	254.6031	0.0002	180
9	262.5942	0.0166	299.1401	0.0002	216
10	279.7233	0.1109	321.9789	0.0019	252
11	301.5416	0.2798	352.0731	0.0058	288
12	318.9796	0.5683	376.9846	0.0226	324

Note: Null Hypothesis: no residual autocorrelations up to lag h.
*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for the (approximate) chi-square distribution

Residual Serial Correlation

The VAR residual serial correlation LM test is conducted for further confirmation of serial independence of residuals. Under the null hypothesis of no serial correlation of order, the LM statistic is asymptotically distributed χ^2 with κ^2 degrees of freedom. The results of the VAR residual serial correlation LM tests have been presented in Table 5.1.8. It is observed from Table 7 that the marginal significance of LM statistics for autocorrelation at lag h (h = 1, 2, 3, 4) is not large enough to reject the null hypothesis of 'no serial correlation.'

Table 5.1.8: VAR Residual Serial Correlation LM Tests

Lags	LM-Stat	Prob
1	46.97992	0.1041
2	25.05559	0.9145
3	23.71252	0.9424
4	34.53784	0.5381
5	47.82186	0.0899
6	50.05562	0.0598
7	29.13118	0.7845
8	39.41254	0.3198
9	66.83434	0.0013
10	49.06089	0.072
11	38.68187	0.3495
12	33.93286	0.5673

Note: Null Hypothesis: no serial correlation at lag order h
Probs from chi-square with 36 df.

VAR Residual Normality Test

We perform the residual normality test and Table 5.1.9 reports the multivariate extensions of the Jarque-Bera residual normality test, which compares the third and fourth moments of the residuals to those from the normal distribution. The null hypothesis is of normality, and the acceptance of the hypothesis (because of an insignificant p-value) leads to the conclusion that the residuals are normally distributed.

Table 5.1.9: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	-0.52569	1.842326	1	0.1747
2	0.270993	0.489583	1	0.4841
3	-0.18206	0.220973	1	0.6383
4	0.156633	0.163559	1	0.6859
5	0.555214	2.055087	1	0.1517
6	0.307642	0.630957	1	0.427
Joint		5.402486	6	0.4933
Component	Kurtosis	Chi-sq	df	Prob.
1	3.823203	1.129437	1	0.2879
2	2.810169	0.060059	1	0.8064
3	2.55288	0.333194	1	0.5638
4	2.264667	0.901192	1	0.3425
5	3.035446	0.002094	1	0.9635
6	4.104923	2.034758	1	0.1537
Joint		4.460735	6	0.6146
Component	Jarque-Bera	df	Prob.	
1	2.971763	2	0.2263	
2	0.549643	2	0.7597	
3	0.554168	2	0.7580	
4	1.064751	2	0.5872	
5	2.057181	2	0.3575	
6	2.665715	2	0.2637	
Joint	9.863221	12	0.6280	

Note: Null Hypothesis: residuals are multivariate normal
Orthogonalization: Cholesky (Lutkepohl)

VAR Residual Heteroscedasticity Tests

We perform White Heteroscedasticity Test with No Cross Terms option which uses only the levels and squares of the original regressor. Table 5.1.10 reports the joint significance of the regressors excluding the constant term for each test regression. Under the null of no heteroscedasticity or (no misspecification), the non-constant regressors should not be jointly significant.

Table 5.1.10: VAR Residual Heteroskedasticity Tests:
No Cross Terms (only levels and squares)

Joint test:

Chi-sq	df	Prob.
760.0421	756	0.4519

Individual components:

Dependent	R-squared	F(36,3)	Prob.	Chi-sq(36)	Prob.
res1*res1	0.8414	0.4420	0.9022	33.6543	0.5807

res2*res2	0.9476	1.5069	0.4201	37.9039	0.3825
res3*res3	0.8461	0.4581	0.8931	33.8430	0.5716
res4*res4	0.9869	6.2887	0.0768	39.4769	0.3173
res5*res5	0.9670	2.4433	0.2527	38.6807	0.3495
res6*res6	0.8045	0.3428	0.9527	32.1780	0.6510
res2*res1	0.9633	2.1890	0.2859	38.5331	0.3557
res3*res1	0.9824	4.6505	0.1147	39.2959	0.3245
res3*res2	0.9353	1.2047	0.5139	37.4121	0.4041
res4*res1	0.8736	0.5758	0.8232	34.9428	0.5187
res4*res2	0.9570	1.8558	0.3413	38.2811	0.3663
res4*res3	0.9009	0.7575	0.7171	36.0356	0.4670
res5*res1	0.8976	0.7302	0.7323	35.9029	0.4732
res5*res2	0.9562	1.8203	0.3482	38.2490	0.3677
res5*res3	0.8915	0.6850	0.7582	35.6617	0.4845
res5*res4	0.9157	0.9057	0.6399	36.6297	0.4395
res6*res1	0.8470	0.4614	0.8912	33.8812	0.5697
res6*res2	0.9732	3.0315	0.1962	38.9299	0.3393
res6*res3	0.9775	3.6136	0.1582	39.0984	0.3324
res6*res4	0.8754	0.5857	0.8172	35.0180	0.5151
res6*res5	0.9094	0.8365	0.6747	36.3760	0.4511

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation.

With a view to examining how changes in policy rate affect other set of variables, block exogeneity test was performed with the first block as policy REPO rate and the second block consisting of other variables (Table 5.1.11). In this case, empirical results suggest a unidirectional causality running from changes in policy rate to other set of variables. In the case of STLR, we notice a joint significance in the unidirectional causality running from changes in STLR to other set of variables. Similarly, in the case of GDPGR as well, we notice a joint significance in the unidirectional causality running from changes in GDPGR to other set of variables.

Table 5.1.11: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: REPO

Excluded	Chi-sq	df	Prob.
INFL	3.8776	3	0.2750
CPI	5.5359	3	0.1365
STLR	2.6506	3	0.4487
ER	0.3655	3	0.9473
GDPGR	5.3022	3	0.1510
All	**29.3837**	**15**	**0.0143**

Dependent variable: INFL

Excluded	Chi-sq	df	Prob.
REPO	0.6064	3	0.8950
CPI	2.4002	3	0.4936
STLR	1.7612	3	0.6234
ER	2.2923	3	0.5140
GDPGR	4.0678	3	0.2542
All	15.4049	15	0.4227

Dependent variable: CPI

Excluded	Chi-sq	df	Prob.
REPO	1.9807	3	0.5764
INFL	2.9665	3	0.3968
STLR	2.6237	3	0.4533
ER	1.0931	3	0.7787
GDPGR	2.9247	3	0.4034
All	10.7990	15	0.7667

Dependent variable: STLR

Excluded	Chi-sq	df	Prob.
REPO	15.2032	3	0.0017
INFL	12.2116	3	0.0067
CPI	4.4347	3	0.2182
ER	7.5585	3	0.0561
GDPGR	24.7658	3	0.0000
All	**75.0416**	**15**	**0.0000**

Dependent variable: ER

Excluded	Chi-sq	df	Prob.
REPO	0.1156	3	0.9899
INFL	1.2356	3	0.7445
CPI	0.6033	3	0.8957
STLR	1.2971	3	0.7298
GDPGR	0.6127	3	0.8935
All	5.4414	15	0.9877

Dependent variable: GDPGR

Excluded	Chi-sq	df	Prob.
REPO	1.9850	3	0.5755
INFL	3.0166	3	0.3891
CPI	5.0184	3	0.1705
STLR	3.2417	3	0.3558
ER	3.9328	3	0.2688
All	**26.0181**	**15**	**0.0378**

Pairwise Granger–causality tests

Correlation does not necessarily imply causation in any meaningful sense of that word. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term. The null hypothesis is that x does not Granger-cause y in the first regression and that y does not Granger-cause x in the second regression (Granger, 1969). Based on the results of the lag order selection criterion test, we use a lag length of 6 in estimating the F-statistic and the probability values. Granger-causality statistics examine whether lagged values of one variable helps to predict another variable. We perform the Pairwise Granger–causality tests for variables of VAR model. The F-statistics and the corresponding value of probability in Table 5.1.12 suggest that the Granger causality runs from REPO to INFL, REPO to STLR, REPO to GDPGR, INFL to STLR, CPI to GDPGR, CPI to REPO, CPI to INFL, GDPGR to INFL, and GDPGR to STLR.

Table 5.1.12: Pairwise Granger Causality Tests

Lags: 4

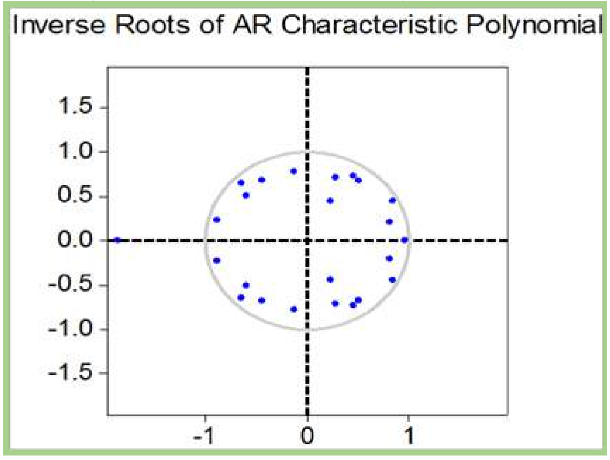
Null Hypothesis:	Obs	F-Statistic	Prob.
INFL does not Granger Cause REPO	40	0.4702	0.7572
REPO does not Granger Cause INFL		2.1877	0.0935
CPI does not Granger Cause REPO	40	3.9225	0.0109
REPO does not Granger Cause CPI		0.7732	0.5510
STLR does not Granger Cause REPO	40	0.4898	0.7431
REPO does not Granger Cause STLR		4.4675	0.0058
ER does not Granger Cause REPO	40	1.7383	0.1667
REPO does not Granger Cause ER		0.1608	0.9565
GDPGR does not Granger Cause REPO	40	7.3325	0.0003
REPO does not Granger Cause GDPGR		2.1909	0.0931
CPI does not Granger Cause INFL	40	3.5014	0.0180
INFL does not Granger Cause CPI		1.8961	0.1361
STLR does not Granger Cause INFL	40	0.9211	0.4642
INFL does not Granger Cause STLR		3.0762	0.0304
ER does not Granger Cause INFL	40	0.7292	0.5789
INFL does not Granger Cause ER		0.6091	0.6592
GDPGR does not Granger Cause INFL	40	2.3209	0.0788
INFL does not Granger Cause GDPGR		1.4652	0.2366
STLR does not Granger Cause CPI	40	0.6943	0.6016
CPI does not Granger Cause STLR		1.0462	0.3994
ER does not Granger Cause CPI	40	0.7150	0.5880

CPI does not Granger Cause ER		0.3760	0.8240
GDPGR does not Granger Cause CPI	41	0.8556	0.5010
CPI does not Granger Cause GDPGR		3.9142	0.0107
ER does not Granger Cause STLR	40	0.3847	0.8179
STLR does not Granger Cause ER		1.0353	0.4048
GDPGR does not Granger Cause STLR	40	7.0014	0.0004
STLR does not Granger Cause GDPGR		1.2322	0.3175
GDPGR does not Granger Cause ER	40	1.2161	0.3240
ER does not Granger Cause GDPGR		1.8014	0.1537

Stability Condition Check

We perform the VAR stability condition check and we observe from Figure 5.1.3 that (a) values of the roots are less than unity (b) modulus values are also less than unity, and (c) the inverse roots of the AR Characteristic Polynomials lie within the Unit Circle. All these observations testify for the stability of the VAR model and thus, all these findings confirm that the estimated VAR model is stable.

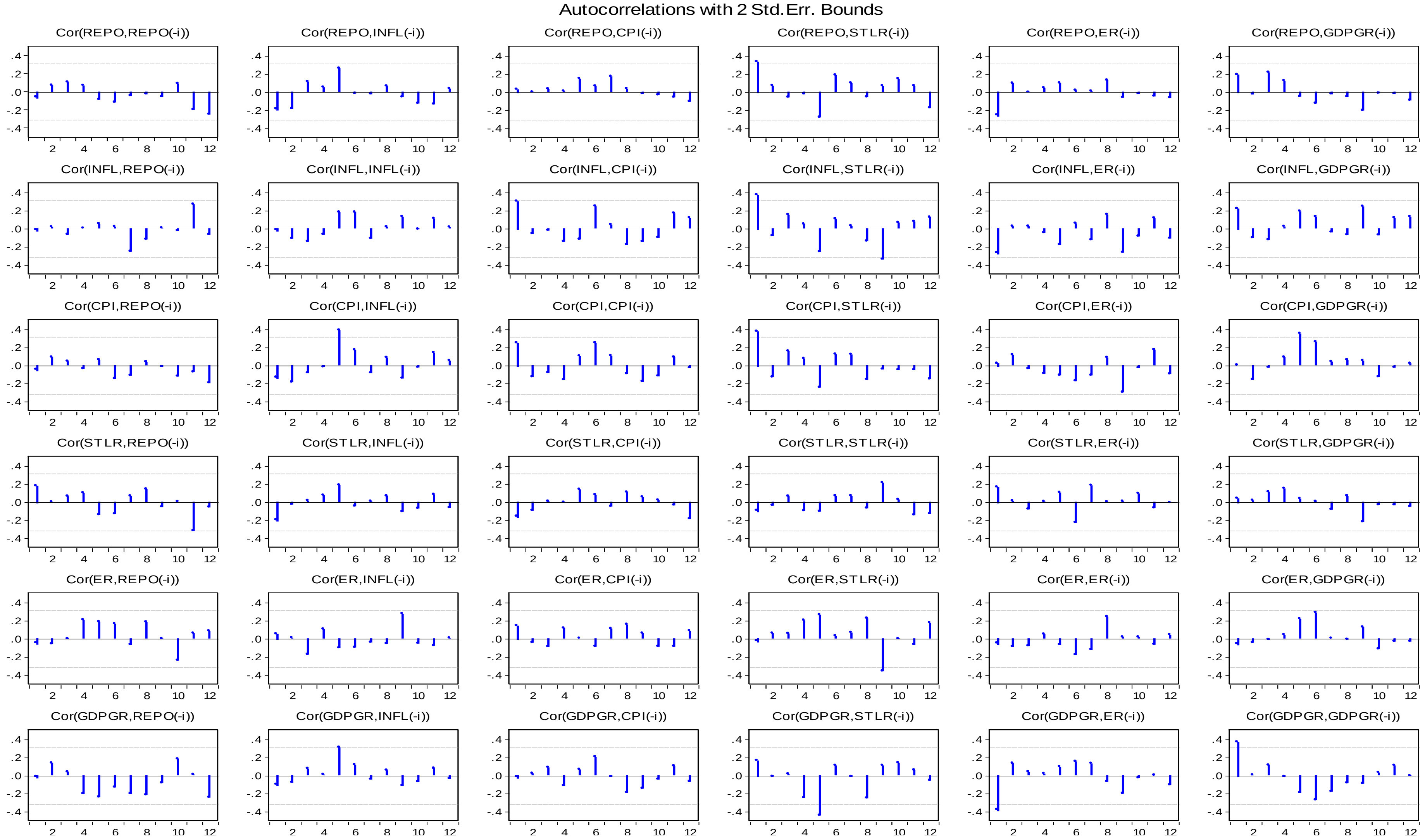
Figure 5.1.3: VAR Stability Condition



Correlograms

These display the Pairwise cross-correlograms (sample autocorrelations) for the estimated residuals in the VAR for the specified number of lags. The cross-correlograms in the Graph form displays a matrix of Pairwise cross-correlograms (Figure 5.1.4). The dotted line in the graphs represent plus or minus two times the asymptotic standard errors of the lagged correlations.

Figure 5.1.4: Correlograms



Structural VAR

Sim’s vector auto-regression (VAR) methodology has been extensively used in examining the efficacy of monetary policy transmission across several countries. According to Sims *et al.*, (1990), VAR approach is constructed to identify the relation of the variables instead of parametric estimation. This approach provides a major advantage of taking into account the simultaneity between monetary policy instruments and relevant macroeconomic variables. However, there are several versions of VAR models to examine monetary policy transmissions such as the traditional VAR, Structural VAR (SVAR) and Factor Augmented VAR (FAVAR). SVAR models, unlike in the traditional VAR models, provide explicit behavioural interpretations for all the parameters. The main purpose of structural VAR (SVAR) estimation is to obtain non-recursive orthogonalization of the error terms for impulse response analysis. This alternative to the recursive Cholesky orthogonalization requires the user to impose enough restrictions to identify the orthogonal (structural) components of the error terms. Following Bernanke and Blinder (1992), we use a standard SVAR approach to examine how monetary policy shocks affect the real economy. SVAR model has been preferred as it enables providing explicit behavioral interpretations of the parameters.

SVAR is a multivariate, linear representation of a vector of observables on its own lags and (possibly) other variables as a trend or a constant. The interpretations of SVAR models require additional identifying assumptions that must be motivated based on institutional knowledge, economic theory, or other extraneous constraints on the model responses. Only after decomposing forecast errors into structural shocks that are mutually uncorrelated and have an economic interpretation, one assesses the causal effects of these shocks on the model variables.

We consider a K-dimensional time series, $\boldsymbol{By_{t,}}\ \boldsymbol{t = 1, 2, \ldots., T}$. Let, $\boldsymbol{y_t}$ be approximated by a vector autoregression of finite order ‘p’. The parameters of the SVAR model:

$$\boldsymbol{B_0 y_t = B_1 y_{t-1} + \cdots + B_p y_{y-p} + \varepsilon_t}$$

where, $\boldsymbol{\varepsilon_t}$ denotes a mean zero serially uncorrelated error term, also referred as structural innovation or structural shock. The error term is assumed to be unconditionally homoskedastic, unless noted otherwise. The model can be written more compactly as

$$\boldsymbol{B(L) y_t = \varepsilon_t}$$

Let $\boldsymbol{y_t}$ be k-element verctor of the endogenous variables and let $\boldsymbol{\Sigma} = \mathbf{E}[\boldsymbol{e_t\ e_t'}]$ be the residual covariance matrix. We follow Amisano and Giannini (1997) models of SVAR that may be written as

$$\boldsymbol{Ae_t} = \mathbf{Bu_t}$$

where $\boldsymbol{e_t}$ and $\boldsymbol{u_t}$ are vectors of length k. $\boldsymbol{e_t}$ is the observed (or reduced form) residuals, while $\boldsymbol{u_t}$ is the unobserved structural innovations. $\boldsymbol{A}$ and **B** are $\mathrm{k} \times k$ matrices to be estimated. The structural innovations $\boldsymbol{u_t}$ are assumed to be orthogonal i.e. its covariance matrix is an identity matrix written as $\mathbf{E}[\boldsymbol{e_t\ e_t'}] = \boldsymbol{I}$. The assumption of orthonormal innovations imposes the following identifying restrictions on $\boldsymbol{A}$ and **B**:

$$\boldsymbol{A}\mathbf{\Sigma A' = BB'}$$

Noting that the expressions on either side of are symmetric, this imposes $\mathrm{k(k+1)/2}$ restrictions on the $2\mathrm{k}^2$ unknown elements in $\boldsymbol{A}$ and **B** . Therefore, in order to identify $\boldsymbol{A}$ and **B** you, need to supply at least $2\mathrm{k}^2 - \frac{\mathrm{k(k+1)}}{2} = \frac{\mathrm{k(3k-1)}}{2}$ aditional restrictions. In order to estimate the orthogonal factorization matrices and, we provide additional identifying restrictions. We distinguish two types of identifying restrictions: short-run and long-run. The identifying restrictions are specified either in text form or by pattern matrices.

Short-run Restrictions by Pattern Matrices

For many problems, the identifying restrictions on the $\boldsymbol{A}$ and $\mathbf{B}$ matrices are simple zero exclusion restrictions. In this case, you can specify the restrictions by creating a named "pattern" matrix for $\boldsymbol{A}$ and $\mathbf{B}$. Any elements of the matrix that you want to be estimated should be assigned a missing value "NA". All non-missing values in the pattern matrix will be held fixed at the specified values.

For example, suppose you want to restrict $\boldsymbol{A}$ to be a lower triangular matrix with ones on the main diagonal and $\mathbf{B}$ to be a diagonal matrix. Then the pattern matrices (for a $\mathrm{k} = 3k$ variable VAR):

$$A = \begin{bmatrix} 1 & 0 & 0 \\ NA & 1 & 0 \\ NA & NA & 1 \end{bmatrix} \qquad B = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Short-run Restrictions in Text Form

For more general restrictions, you can specify the identifying restrictions in text form. In text form, you will write out the relation $\boldsymbol{Ae_t} = \mathbf{Bu_t}$ as a set of equations, identifying each element of the $\boldsymbol{e_t}$ and $\boldsymbol{u_t}$ vectors with special symbols. Elements of the $\boldsymbol{A}$ and $\mathbf{B}$ matrices to be estimated must be specified as elements of a coefficient vector. Under these restrictions, the relation $\boldsymbol{Ae_t} = \mathbf{Bu_t}$ can be written as:

$$\boldsymbol{e_1 = b_{11}\, u_1}$$

$$\boldsymbol{e_2 = -a_{21}\, e_1 + b_{22} u_2}$$

$$\boldsymbol{e_3 = -a_{31}\, e_1 - a_{32}\, e_2 + b_{33} u_3}$$

The restrictions in the text form are as follows:

@e1 = c(1)*@u1

@e2 = -c(2)*@e1 + c(3)*@u2

@e3 = -c(4)*@e1 - c(5)*@e2 + c(6)*@u3

@e4 = -c(7)*@e1 - c(8)*@e2 + c(9)*@u3 + c(10)*@u4

@e5 = -c(11)*@e1 - c(12)*@e2 + c(13)*@u3 + c(14)*@u4 + c(15)*@u5

@e6 = -c(16)*@e1 - c(17)*@e2 + c(18)*@u3 + c(19)*@u4 + c(20)*@u5 + c(21)*@u6

where, @e1 represents REPO residuals, @e2 represents INFL residuals, @e3 represents CPI residuals, @e4 represents STLR residuals, @e5 represents ER residuals, @e6 represents GDPGR residuals.

Long-run Restrictions

The identifying restrictions embodied in the relation $\boldsymbol{Ae} = \mathbf{Bu}$ are commonly referred to as short-run restrictions. Blanchard and Quah (1989) proposed an alternative identification method based on restrictions on the long-run properties of the impulse responses. The (accumulated) long-run response C to structural innovations takes the form:

$$\mathrm{C} = \widehat{\Psi}_{\infty}\mathrm{A}^{-1}\mathrm{B}$$

where $\widehat{\Psi}_{\infty} = (I - \hat{A}_1 - \ldots . - \hat{A}_p)^{-1}$ is the estimated accumulated responses to the reduced form (observed) shocks. Long-run identifying restrictions are specified in terms of the elements of this C matrix, typically in the form of zero restrictions. The restriction $C_{i,j} = 0$ means that the (accumulated) response of the ith variable to the jth structural shock is zero in the long-run.

The expression for the long-run response $\mathrm{C} = \widehat{\Psi}_{\infty}\mathrm{A}^{-1}\mathrm{B}$ involves the inverse of $\boldsymbol{A}$. We place all the restrictions linear form in the elements of $\boldsymbol{A}$ and $\mathbf{B}$, and the in the long-run restriction, the matrix $\boldsymbol{A}$ is a identity matrix.

To specify long-run restrictions by a pattern matrix, we create a named matrix that contains the pattern for the long-run response matrix C . Unrestricted elements in the

C matrix should be assigned a missing value “NA”. For example, suppose you have a $\mathrm{k} = 3k$ variable VAR where you want to restrict the long-run response of the second endogenous variable to the first structural shock to be zero $C_{2,1} = 0$. Then the long-run response matrix will have the following pattern:

$$C = \begin{bmatrix} NA & NA \\ 0 & NA \end{bmatrix}$$

$\boldsymbol{A}$ and **B** and are estimated by maximum likelihood, assuming the innovations are multivariate normal. We evaluate the likelihood in terms of unconstrained parameters by substituting out the constraints.

Identification Condition

The assumption of orthonormal structural innovations imposes $\mathrm{k}(\mathrm{k}+1)/2$ restrictions on the $2\mathrm{k}^2$ unknown elements in $\boldsymbol{A}$ and **B**, where k is the number of endogenous variables in the VAR. In order to identify $\boldsymbol{A}$ and **B**, we provide at least $2\mathrm{k}^2 - \frac{\mathrm{k}(\mathrm{k}+1)}{2} = \frac{\mathrm{k}(3\mathrm{k}-1)}{2}$ additional identifying restrictions. This is a necessary order condition for identification and is checked by counting the number of restrictions provided.

We have a 6-variable VAR that includes the GDPGR_t – growth in real output, INFL_t – the inflation rate, CPINFL_t – commodity price inflation rate, REPO_t – the policy repo rate of the central bank, STLR_t – the short-term loan rate, and ER_t – the currency exchange rate.

$$\begin{bmatrix} u_t^{repo} \\ u_t^{infl} \\ u_t^{cpi} \\ u_t^{stlr} \\ u_t^{er} \\ u_t^{gdpgr} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b21 & 1 & 0 & 0 & 0 & 0 \\ b31 & b32 & 1 & 0 & 0 & 0 \\ b41 & b42 & b43 & 1 & 0 & 0 \\ b51 & b52 & b53 & b54 & 1 & 0 \\ b61 & b62 & b63 & b64 & b65 & 1 \end{bmatrix} \begin{bmatrix} \epsilon_t^{repo} \\ \epsilon_t^{infl} \\ \epsilon_t^{cpi} \\ \epsilon_t^{stlr} \\ \epsilon_t^{er} \\ \epsilon_t^{gdpgr} \end{bmatrix}$$

u is the vector of structural innovations and ϵ is the vector of errors from the reduced form equations where the vector is given by (REPO, INFL, CPI, STLR, ER, GDPGR)

In a VAR, differencing the variable throws the information away because a VAR in differences will not capture the cointegrating relationship and there are no gains in terms of asymptotic efficiency. Hence, the model is solved using structural decomposition techniques. The policy instrument is chosen on the basis of impulse response functions and variance decompositions. In the innovation analysis, orderings assume importance in the case of a standard VAR where Cholesky decomposition is the identification scheme. Since ours is a structural VAR, where we impose restrictions according to economic theory, orderings are not important.

The SVAR model is sensitive to the lag length p, and the latter is commonly determined by AIC (Akaike information criterion) and SC (Schwarz criterion) with reference to LR (Likelihood Ration), LPE (Final Prediction Error) and HQ (Hannan-Quinn information criterion). In this study, the lag length p is 4 for the model. We present the results of the SVAR estimates in Table 5.1.13.

Table 5.1.13: Structural VAR Estimates

Model: Ae = Bu where E[uu']=I
Restriction Type: short-run text form
@e1 = c(1)*@u1
@e2 = -c(2)*@e1 + c(3)*@u2
@e3 = -c(4)*@e1 - c(5)*@e2 + c(6)*@u3
@e4 = -c(7)*@e1 - c(8)*@e2 + c(9)*@u3 + c(10)*@u4
@e5 = -c(11)*@e1 - c(12)*@e2 + c(13)*@u3 + c(14)*@u4 + c(15)*@u5
@e6 = -c(16)*@e1 - c(17)*@e2 + c(18)*@u3 + c(19)*@u4 + c(20)*@u5 + c(21)*@u6

where, @e1 represents REPO residuals, @e2 represents INFL residuals, @e3 represents CPI residuals, @e4 represents STLR residuals, @e5 represents ER residuals, @e6 represents GDPGR residuals

	Coefficient	Std. Error	z-Statistic	Prob.
C(2)	-0.1908	0.3750	-0.5088	0.6109
C(4)	-1.5394	0.6686	-2.3024	0.0213
C(5)	-1.3196	0.2810	-4.6961	0.0000
C(7)	-0.1088	0.0618	-1.7598	0.0784
C(8)	0.0976	0.0260	3.7558	0.0002
C(11)	-0.2447	0.6876	-0.3559	0.7219
C(12)	-0.4315	0.2890	-1.4930	0.1354
C(16)	-1.4000	0.3806	-3.6784	0.0002
C(17)	-0.3129	0.1600	-1.9558	0.0505
C(1)	0.5627	0.0629	8.9443	0.0000
C(3)	-1.3344	0.1492	-8.9443	0.0000
C(6)	-2.3715	0.2651	-8.9443	0.0000
C(9)	-0.1403	0.0309	-4.5380	0.0000
C(10)	-0.1685	0.0188	-8.9443	0.0000
C(13)	-0.1029	0.3855	-0.2670	0.7894
C(14)	0.4767	0.3816	1.2491	0.2116
C(15)	-2.3897	0.2672	-8.9443	0.0000
C(18)	0.1355	0.2129	0.6364	0.5245
C(19)	-0.3569	0.2086	-1.7111	0.0871
C(20)	1.0469	0.1680	6.2319	0.0000
C(21)	0.7621	0.0852	8.9443	0.0000
Log likelihood	-316.3721			

Estimated A matrix:

1	0	0	0	0	0
-0.1908	1.0000	0.0000	0.0000	0.0000	0.0000
-1.5394	-1.3196	1.0000	0.0000	0.0000	0.0000
-0.1088	0.0976	0.0000	1.0000	0.0000	0.0000
-0.2447	-0.4315	0.0000	0.0000	1.0000	0.0000
-1.4000	-0.3129	0.0000	0.0000	0.0000	1.0000

Estimated B matrix:

0.5627	0.0000	0.0000	0.0000	0.0000	0.0000
0	1.3344	0.0000	0.0000	0.0000	0.0000
0	0.0000	2.3715	0.0000	0.0000	0.0000
0	0.0000	0.1403	0.1685	0.0000	0.0000
0	0.0000	0.1029	-0.4767	2.3897	0.0000
0	0.0000	-0.1355	0.3569	-1.0469	0.7621

Note: Structural VAR is just-identified

SVAR Impulse Responses

The estimations based on SVAR of the specification are presented in Table 5.1.14.

Table 5.1.14: SVAR Impulse Responses to REPO rate shocks

Impulse response of INFL

Period	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	0.1074	1.3344	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0092	-0.1029	-0.0411	0.0938	-0.0605	-0.1729
4	-0.5317	0.0098	-0.4266	-0.0765	-0.2479	-0.2509
5	0.2776	-0.0279	0.3304	0.0371	-0.2298	0.1611
6	-0.5733	-0.6452	-0.5877	-0.0957	0.4140	-0.2722
7	1.0263	1.4071	1.5204	0.0817	-0.2044	0.3980
8	-1.2040	-2.4683	-2.5427	-0.0095	0.4634	-0.2161
9	3.0118	4.0068	4.8699	0.1860	-0.4592	0.5694
10	-5.7034	-7.4604	-9.2893	-0.2783	0.5499	-0.9994

SVAR impulse response of CPI

Period	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	1.0078	1.7609	2.3715	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	2.9250	3.2793	3.8196	0.4060	-0.4560	0.5935
4	-3.0505	-3.4151	-5.2711	0.0219	0.1346	-0.5284
5	6.2024	9.1930	9.8929	0.6137	-2.0784	1.5395
6	-11.9691	-14.1000	-18.7221	-0.7720	1.1342	-2.5009
7	21.8512	29.5083	35.0486	1.4487	-4.8814	4.5005
8	-40.2527	-51.0085	-64.1944	-2.6735	6.4811	-8.4945
9	75.8975	98.7491	120.6878	4.9027	-13.5021	15.5552
10	-139.7421	-179.8061	-223.1723	-9.1449	24.2035	-29.0957

SVAR impulse response of STLR

Period	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	0.0507	-0.1302	0.1403	0.1685	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0492	0.1298	0.0990	-0.0298	0.0483	0.0419
4	-0.1095	-0.3809	-0.2685	-0.0206	0.0784	-0.0661
5	0.2251	0.5319	0.3418	0.0919	-0.1301	0.1789
6	-0.5319	-0.5040	-0.5818	-0.0752	0.1429	-0.1194
7	0.9902	1.0244	1.2393	0.1201	-0.3509	0.2556
8	-1.5398	-2.0298	-2.4851	-0.1009	0.2376	-0.4174
9	2.7335	3.8083	4.4659	0.1668	-0.5927	0.6320
10	-5.2688	-6.7828	-8.4385	-0.3554	0.9175	-1.0923

SVAR impulse response of ER

Period	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	0.1840	0.5758	0.1029	-0.4767	2.3897	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	-0.1731	-0.5526	0.0131	-0.1712	0.7170	-0.2042
4	-0.0854	-0.2399	0.7968	0.3420	-0.6417	-0.1443
5	-0.5041	-1.1364	-0.7736	0.0499	-0.4132	0.0295
6	1.0106	1.1817	1.7098	0.1552	0.0737	0.3016
7	-1.9556	-2.7053	-3.4104	-0.1723	0.4392	-0.2794
8	3.8215	5.1702	5.5930	0.3417	-0.4533	1.1296
9	-7.0856	-8.7215	-10.7148	-0.6282	1.5027	-1.6585
10	12.8234	16.4168	19.9318	0.9878	-2.8627	2.8473

SVAR Impulse response of GDPGR

Period	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6

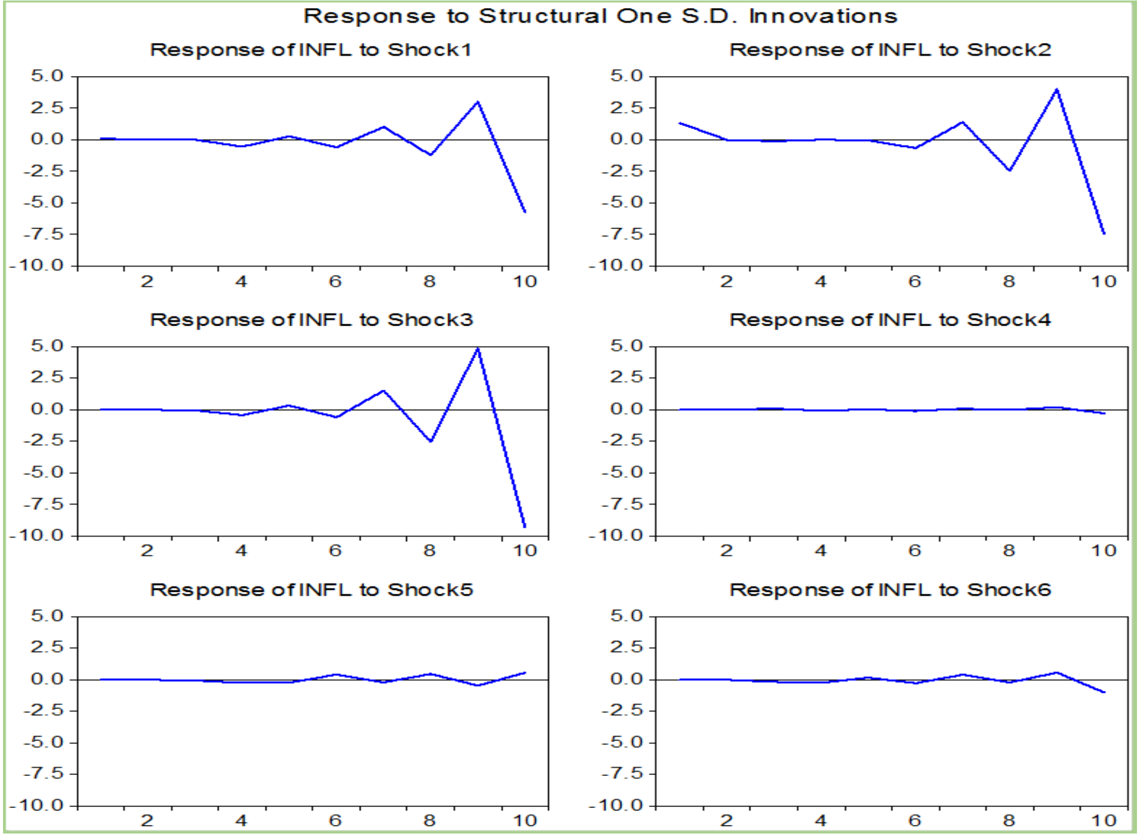
1	0.8213	0.4175	-0.1355	0.3569	-1.0469	0.7621
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.5384	0.3249	-0.2787	0.2779	-1.3520	0.4612
4	0.0368	-0.3447	-1.1601	0.0692	-0.6848	0.0702
5	0.1305	1.4313	0.6514	-0.2693	-0.2835	-0.0560
6	-1.0655	-1.1299	-2.3041	-0.1368	-0.4645	-0.1162
7	2.3600	3.2350	3.5329	-0.1101	0.1034	0.1390
8	-4.2707	-4.9672	-6.3387	-0.4451	0.8086	-1.1056
9	7.8789	9.4613	12.1789	0.4435	-1.1713	1.4106
10	-14.1298	-18.3481	-22.1719	-1.0170	2.9888	-3.2154
Factorization: Structural						

Impulse Response of Inflation to Policy REPO rate shock

The impulse response functions imply that increase in the policy interest rate has a negative impact on the inflation rate. There is a negative response of 0.5317 (Table 5.1.14) in the 4th quarter for the first shock of policy rate and the maximum decline in inflation was observed with a lag of ten quarters with the overall impact continuing through 4 – 10 quarters (Figure 5.1.5a).

Figure 5.1.5a: Impulse Response of INFL in SVAR

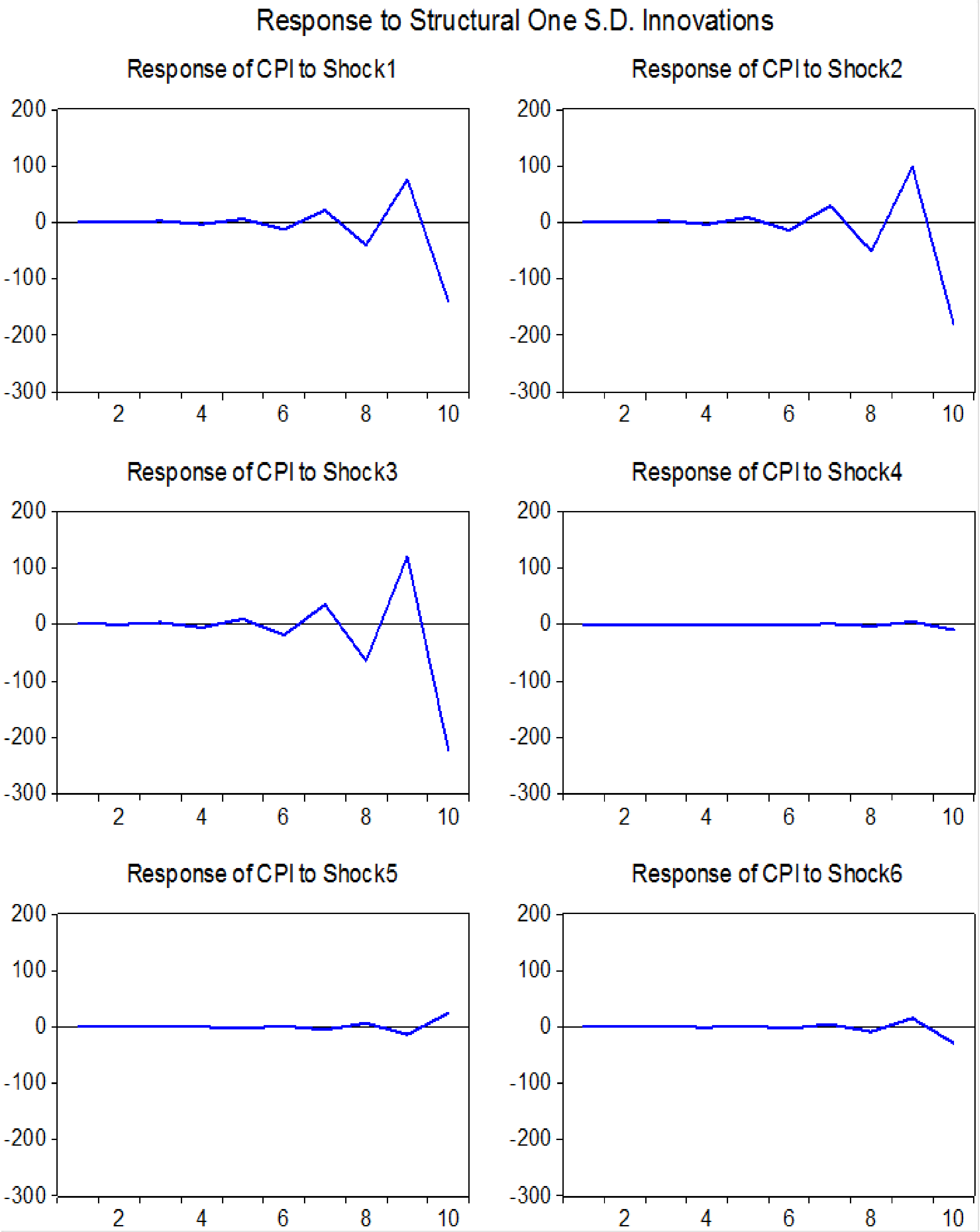
Impulse responses to a monetary policy shock of one standard deviation in size, identified as the innovation in the policy repo rate, ordered forth in a Cholesky decomposition



Impulse Response of Commodity Price Inflation to Policy REPO Rate Shock

The impulse response functions imply that increase in policy REPO rate is associated with a fall in CPI by 3.0505 for the first shock in the 4th quarter (Table 5.1.14). In response to the first shock, the maximum decline in CPI (-139.7421) occurs with a lag of eight quarters with the overall impact continuing through 4 – 10 quarters (Figure 5.1.5b).

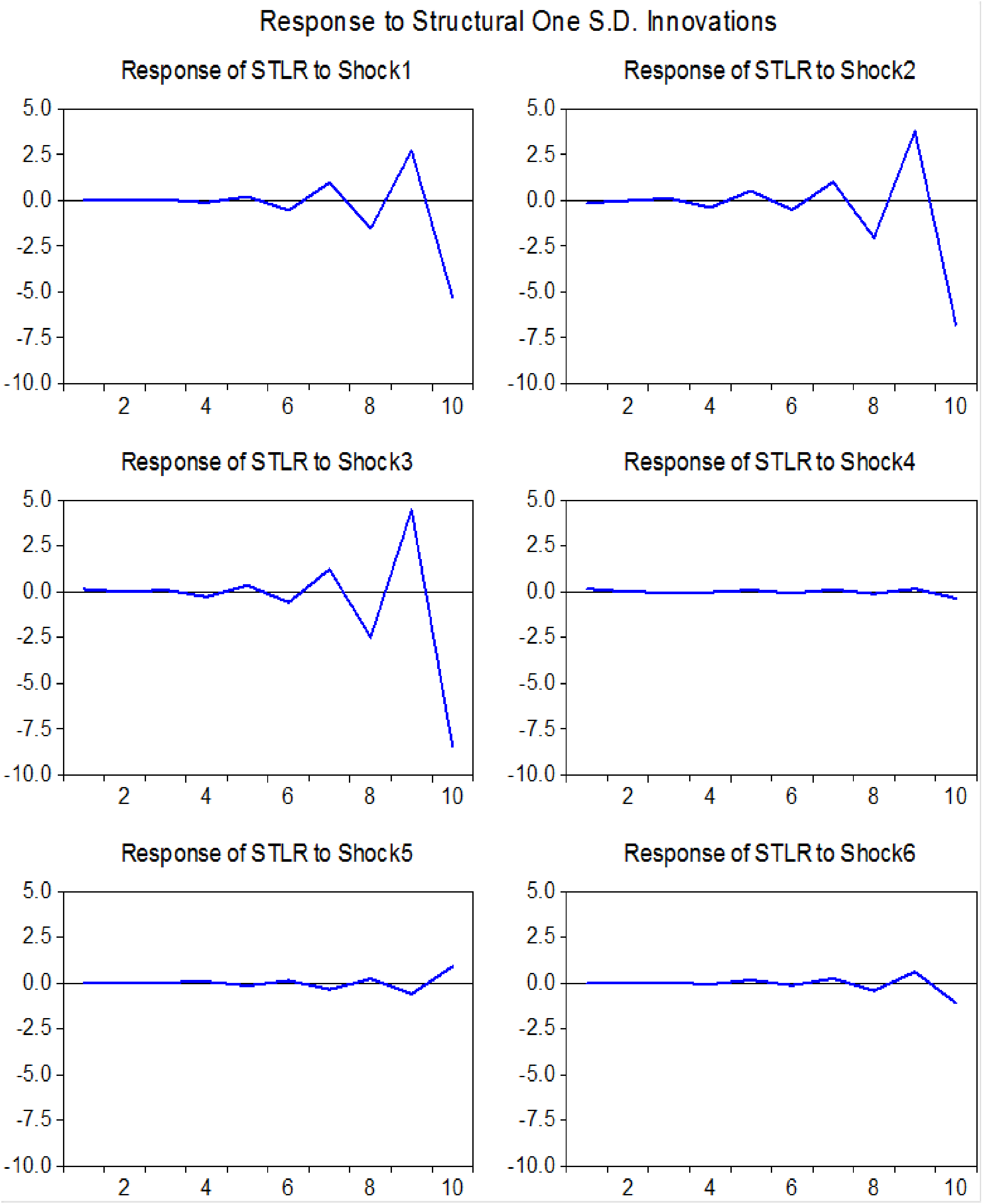
Figure 5.1.5b: Impulse Response of CPI in SVAR



Impulse Response of Short Term Lending Rate to Policy REPO Rate Shock

The impulse response functions imply that increase in policy REPO rate is associated with a fall in STLR by 0.1095 for the first shock in the 4th quarter (Table 5.1.14). In response to the first shock, the maximum decline in STLR (-5.2688) occurs with a lag of ten quarters with the overall impact continuing through 4 – 10 quarters (Figure 5.1.5c).

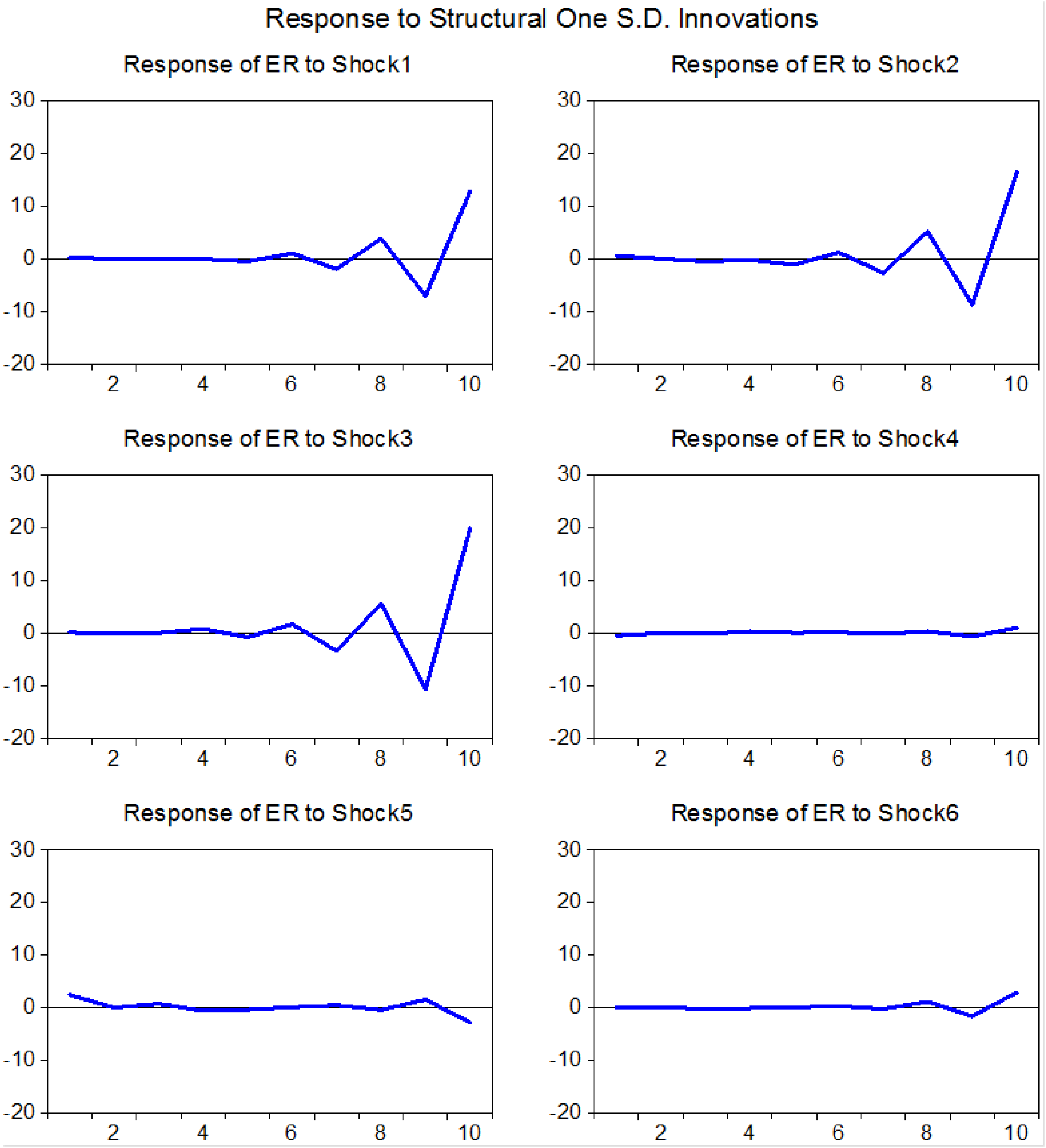
Figure 5.1.5c: Impulse Response of STLR in SVAR



Impulse Response of Exchange Rate to Policy REPO Rate Shock

The impulse response functions imply that increase in policy REPO rate is associated with a fall in ER by 0.1731 for the first shock in the 3rd quarter (Table 5.1.14). In response to the first shock, the maximum decline in ER (-7.0856) occurs with a lag of nine quarters with the overall impact continuing through 3 – 9 quarters (Figure 5.1.5d). In the graphs below the effect of monetary policy shock is normalized so that the policy rate increases by one S.D. innovation point in the first month and a decrease in exchange rate implies appreciation

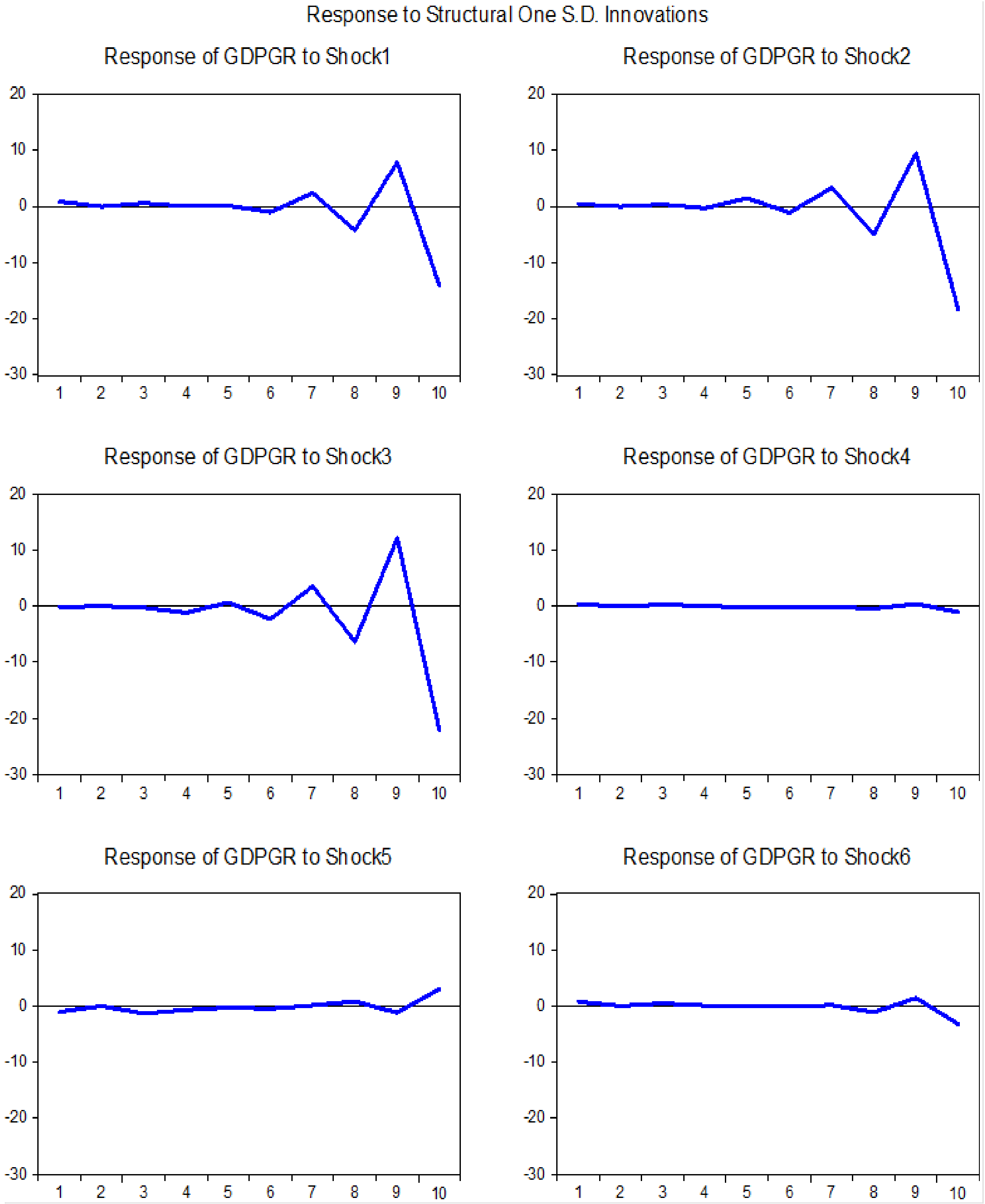
Figure 5.1.5d: Impulse Response of ER in SVAR



Impulse Response of Economic Output to Policy REPO rate shock

The impulse response functions imply that increase in policy REPO rate is associated with a fall in real GDP growth by 1.0655 in the 6th quarter (Table 5.1.14). The maximum decline in GDP growth (-4.2707) occurs with a lag of eight quarters with the overall impact continuing through 6 – 8 quarters (Figure 5.1.5e).

Figure 4e: Impulse Response of GDPGR



SVAR Variance Decompositions

We provide the variance decomposition of the VAR estimates in Table 5.1.15.

Table 5.1.15: Variance Decomposition in SVAR

Variance Decomposition of REPO:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	0.5627	100.000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.5627	100.000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.6956	65.5245	6.0159	26.9440	0.4847	1.0293	0.0016
4	0.9431	36.4074	10.0592	40.3210	2.1092	7.7886	3.3145
5	1.2934	28.9502	15.1603	48.7612	1.1395	4.2265	1.7623
6	2.3128	23.8080	22.2848	51.1929	0.3742	1.6149	0.7252
7	4.1059	21.6297	29.2453	46.8289	0.1657	1.3341	0.7963
8	7.3886	20.7778	29.1335	48.0308	0.1622	1.0151	0.8806
9	13.817	19.4386	30.9705	47.9224	0.1016	0.7576	0.8093
10	25.556	18.8612	31.2249	48.3164	0.0902	0.6776	0.8297

Variance Decomposition of INFL:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	1.3387	0.6431	99.3569	0.0000	0.0000	0.0000	0.0000
2	1.3387	0.6431	99.3569	0.0000	0.0000	0.0000	0.0000
3	1.3590	0.6286	96.9864	0.0914	0.4761	0.1980	1.6194
4	1.5627	12.0527	73.3549	7.5232	0.5998	2.6669	3.8025
5	1.6459	13.7087	66.1510	10.8099	0.5916	4.3530	4.3857
6	2.0135	17.2685	54.4718	15.7438	0.6212	7.1364	4.7583
7	3.0993	18.2541	43.5999	30.7102	0.3317	3.4469	3.6571
8	4.8862	13.4164	43.0607	39.4359	0.1338	2.2862	1.6671
9	8.5607	16.7482	35.9347	45.2083	0.0908	1.0325	0.9855
10	15.7842	17.9830	32.9098	47.9337	0.0578	0.4251	0.6908

Variance Decomposition of CPI:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	3.1210	10.4272	31.8335	57.7393	0.0000	0.0000	0.0000
2	3.1210	10.4272	31.8335	57.7393	0.0000	0.0000	0.0000
3	6.6607	21.5741	31.2287	45.5629	0.3716	0.4686	0.7940
4	9.6651	20.2072	27.3165	51.3814	0.1770	0.2420	0.6759
5	17.9258	17.8463	34.2415	45.3947	0.1687	1.4147	0.9341
6	31.9696	19.6276	30.2174	48.5674	0.1113	0.5706	0.9056
7	60.3726	18.6037	32.3629	47.3212	0.0888	0.8138	0.8097
8	110.0420	18.9802	31.2278	48.2748	0.0858	0.5918	0.8396
9	206.4822	18.9019	31.7412	47.8745	0.0807	0.5957	0.8060
10	381.8571	18.9190	31.4530	48.1550	0.0810	0.5759	0.8162

Variance Decomposition of STLR:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	0.2600	3.8068	25.0790	29.1166	41.9976	0.0000	0.0000
2	0.2600	3.8068	25.0790	29.1166	41.9976	0.0000	0.0000
3	0.3189	4.9129	33.2557	29.0030	28.8021	2.2961	1.7301
4	0.5847	4.9665	52.3469	29.7187	8.6920	2.4821	1.7937
5	0.9217	7.9647	54.3588	25.7059	4.4918	2.9901	4.4888
6	1.3287	19.8565	40.5523	31.5466	2.4819	2.5956	2.9673
7	2.3524	24.0523	31.8972	37.8182	1.0525	3.0527	2.1271
8	4.2944	20.0741	31.9128	44.8367	0.3710	1.2222	1.5832
9	7.8192	18.2763	33.3471	46.1451	0.1574	0.9433	1.1308
10	14.4318	18.6938	31.8782	47.7353	0.1069	0.6811	0.9048

Variance Decomposition of ER:

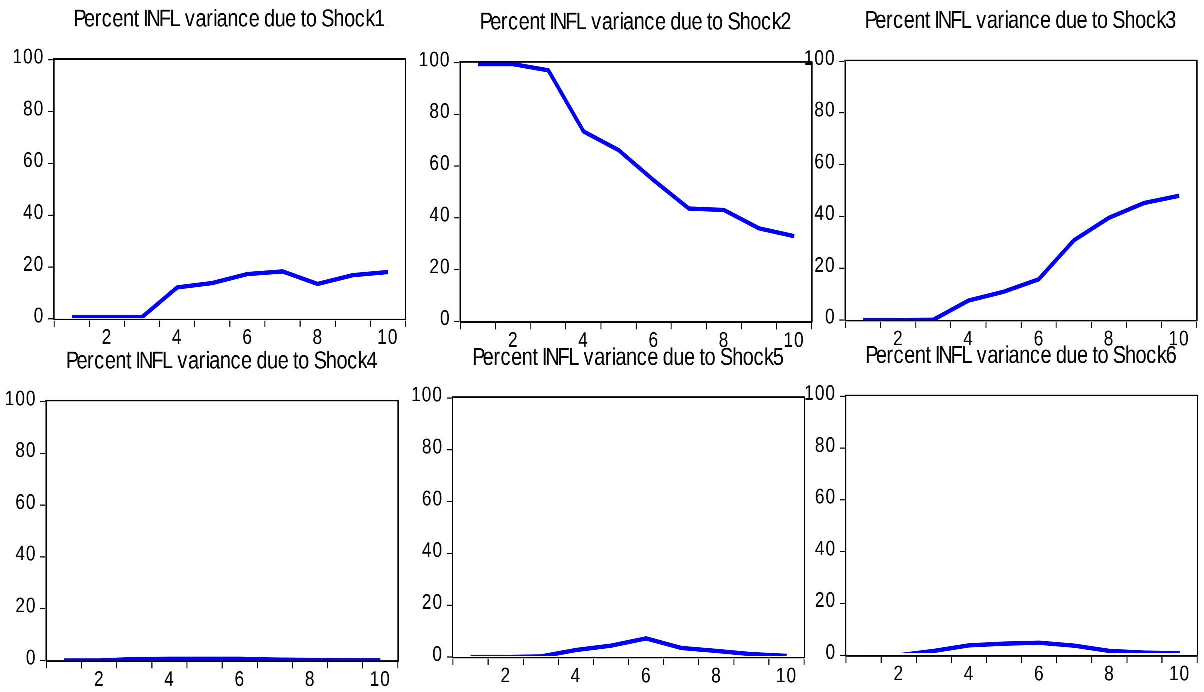
Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6

1	2.5127	0.5363	5.2503	0.1678	3.5985	90.4472	0.0000
2	2.5127	0.5363	5.2503	0.1678	3.5985	90.4472	0.0000
3	2.6897	0.8820	8.8038	0.1488	3.5458	86.0434	0.5762
4	2.9127	0.8381	8.1859	7.6106	4.4024	78.2261	0.7370
5	3.2866	3.0105	18.3838	11.5179	3.4807	63.0202	0.5869
6	4.0328	8.2798	20.7966	25.6246	2.4599	41.8901	0.9491
7	6.2720	13.1450	27.2025	40.1607	1.0925	17.8085	0.5908
8	10.6561	17.4144	32.9642	41.4615	0.4813	6.3503	1.3283
9	18.9745	19.4373	31.5240	44.9644	0.2614	2.6300	1.1829
10	34.7641	19.3971	31.6918	46.2677	0.1586	1.4616	1.0232
Variance Decomposition of GDPGR:							
Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6
1	1.6344	25.2503	6.5243	0.6873	4.7693	41.0263	21.7426
2	1.6344	25.2503	6.5243	0.6873	4.7693	41.0263	21.7426
3	2.2940	18.3267	5.3183	1.8245	3.8880	55.5632	15.0793
4	2.6846	13.4005	5.5322	20.0054	2.9054	47.0778	11.0788
5	3.1390	9.9748	24.8383	18.9394	2.8610	35.2509	8.1355
6	4.2216	11.8851	20.8963	40.2585	1.6868	20.6998	4.5736
7	6.8103	16.5758	30.5932	42.3806	0.6743	7.9771	1.7991
8	11.4693	19.7092	29.5428	45.4866	0.3883	3.3096	1.5635
9	20.8572	20.2295	29.5109	47.8506	0.1626	1.3161	0.9302
10	38.5127	19.3937	31.3528	47.1780	0.1174	0.9883	0.9699
Factorization: Structural							

Variance Decomposition of Inflation

The variance decomposition of INFL is presented in Table 51.15 and the percent variance due to the shocks is captured in Figure 5.1.6a. We notice that at period 1 and 2, shock 1 explains 0.64 percent and shock 2 explains 99.35 percent of the error in the forecast of INFL. In period 3, shock 1 explains 0.62 percent, shock 2 explains 96.98 percent, shock 3 explains 0.09 percent, shock 4 explains 0.47 percent, shock 5 explains 0.19 percent, and shock 6 explains 1.61 percent of the error in the forecast of INFL. In period 6, shock 1 explains 17.26 percent, shock 2 explains 54.47 percent, shock 3 explains 15.74 percent, shock 4 explains 0.62 percent, shock 5 explains 7.13 percent, and shock 6 explains 4.75 percent of the error in the forecast of INFL. Similarly, in the period 10, shock 1 explains 17.98 percent, shock 2 explains 32.90 percent, shock 3 explains 47.93 percent, shock 4 explains 0.05 percent, shock 5 explains 0.42 percent, and shock 6 explains 0.69 percent of the error in the forecast of INFL.

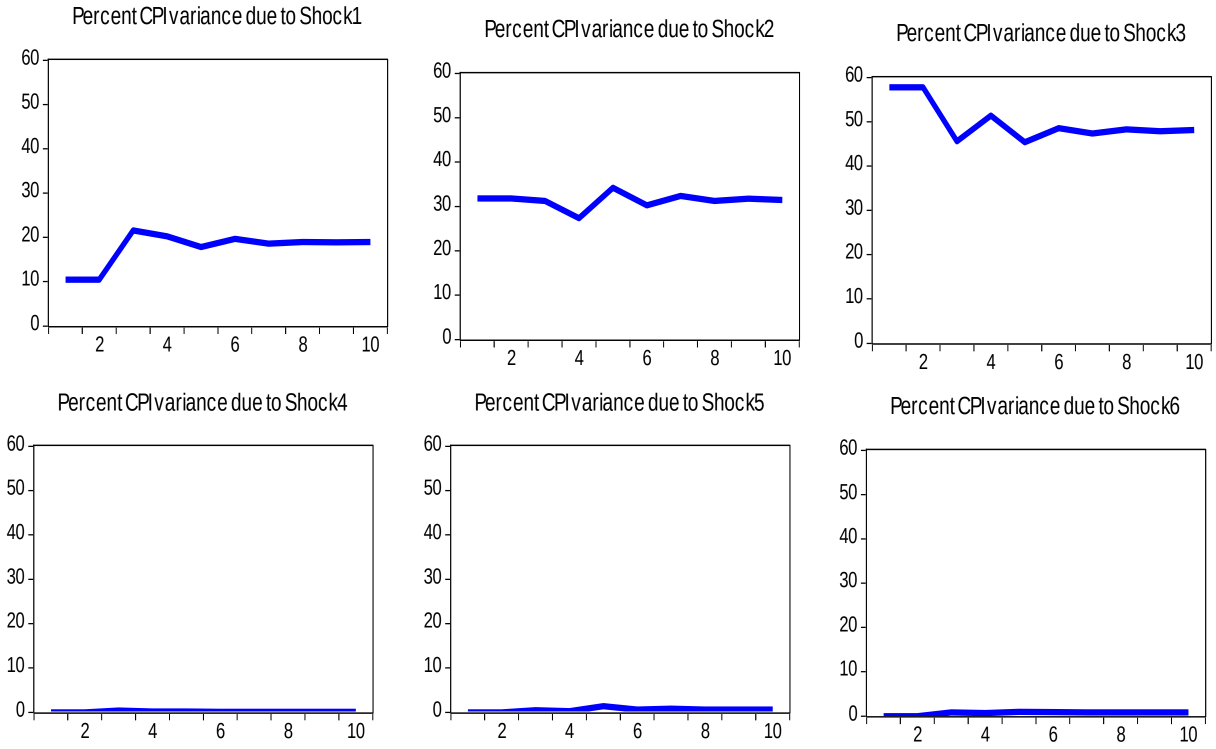
Figure 5.1.6a: Variance Decomposition of INFL (SVAR)



Variance Decomposition of Commodity Price Inflation

The variance decomposition of CPI is presented in Table 5.1.15 and the percent variance due to the shocks is captured in Figure 5.1.6b. We notice that at period 1 and 2, shock 1 explains 10.42 percent, shock 2 explains 31.83 percent, and shock 3 explains 57.73 percent of the error in the forecast of CPI. In period 3, shock 1 explains 21.57 percent, shock 2 explains 31.22 percent, shock 3 explains 45.56 percent, shock 4 explains 0.37 percent, shock 5 explains 0.46 percent, and shock 6 explains 0.79 percent of the error in the forecast of CPI. In period 6, shock 1 explains 19.62 percent, shock 2 explains 30.21 percent, shock 3 explains 48.56 percent, shock 4 explains 0.11 percent, shock 5 explains 0.57 percent, and shock 6 explains0.905 percent of the error in the forecast of CPI. Similarly, in the period 10, shock 1 explains 18.91 percent, shock 2 explains 31.45 percent, shock 3 explains 48.15 percent, shock 4 explains 0.08 percent, shock 5 explains 0.57 percent, and shock 6 explains 0.81 percent of the error in the forecast of CPI.

Figure 5.1.6b: Variance Decomposition of CPI (SVAR)

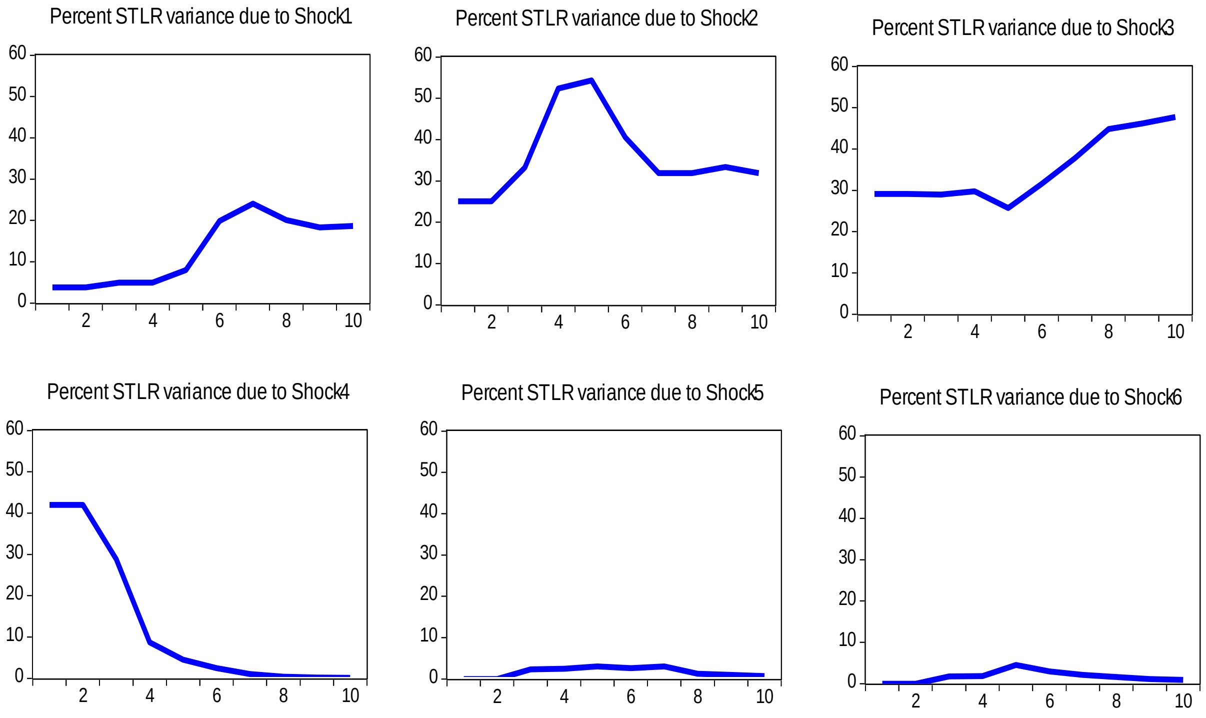


Variance Decomposition of Short Term Lending Rate

The variance decomposition of STLR is presented in Table 5.1.15 and the percent variance due to the shocks is captured in Figure 5.1.6c. We notice that at period 1 and 2, shock 1 explains 3.80 percent, shock 2 explains 25.07 percent, shock 3 explains 29.11 percent, and shock 4 explains 41.99 percent of the error in the forecast of STLR. In period 3, shock 1 explains 4.91 percent, shock 2 explains 33.25 percent, shock 3 explains 29.00 percent, shock 4 explains 28.80 percent, shock 5 explains 2.29 percent, and shock 6 explains 1.73 percent of the error in the forecast of STLR. In period 6, shock 1 explains 19.85 percent, shock 2 explains 40.55 percent, shock 3 explains 31.54 percent, shock 4 explains 2.78 percent, shock 5 explains 2.59 percent, and shock 6 explains 2.96 percent of the error in the forecast of STLR. Similarly, in the period 10, shock 1 explains 18.69 percent, shock 2 explains 31.87 percent, shock 3 explains 47.73 percent, shock 4 explains 0.10 percent, shock

5 explains 0.68 percent, and shock 6 explains 0.90 percent of the error in the forecast of STLR.

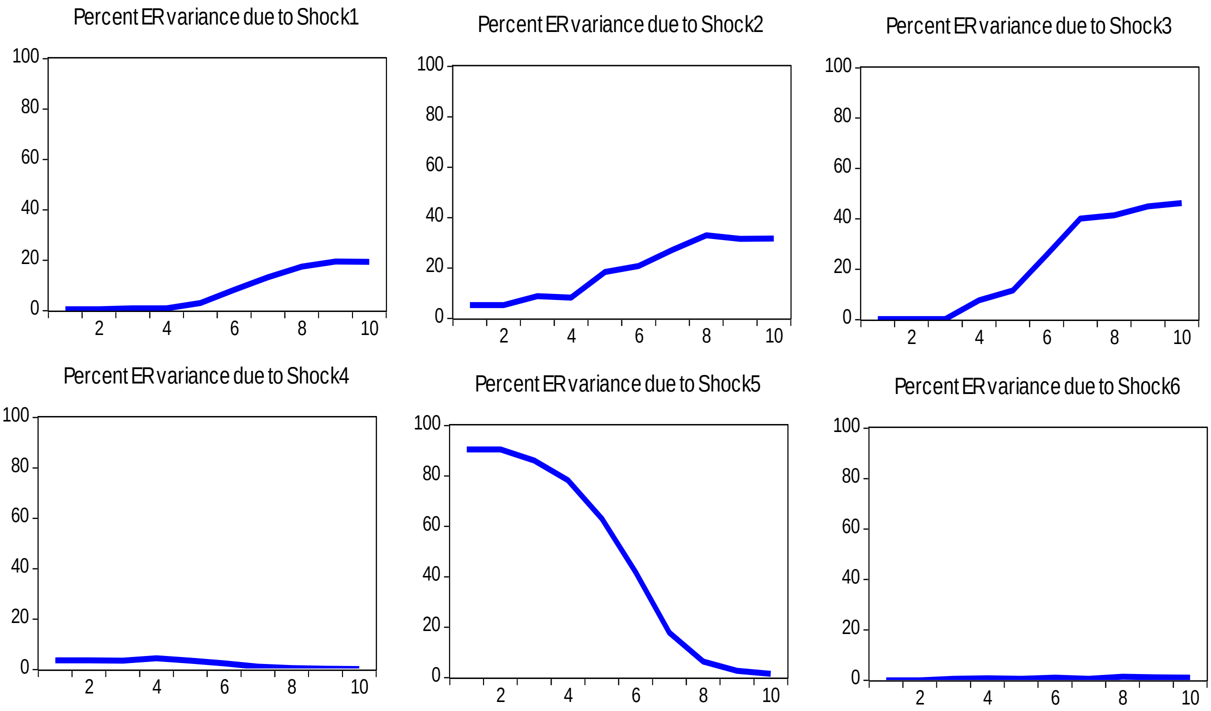
Figure 5.16c: Variance Decomposition of STLR (SVAR)



Variance Decomposition of Exchange Rate

The variance decomposition of ER is presented in Table 5.1.15 and the percent variance due to the shocks is captured in Figure 5.1.6d. We notice that at period 1 and 2, shock 1 explains 0.53 percent, shock 2 explains 5.25 percent, shock 3 explains 0.16 percent, shock 4 explains 3.59 percent, and shock 5 explains 90.44 percent of the error in the forecast of ER. In period 3, shock 1 explains 0.88 percent, shock 2 explains 8.80 percent, shock 3 explains 0.14 percent, shock 4 explains 3.54 percent, shock 5 explains 86.04 percent, and shock 6 explains 0.57 percent of the error in the forecast of ER. In period 6, shock 1 explains 8.27 percent, shock 2 explains 20.79 percent, shock 3 explains 25.62 percent, shock 4 explains 2.45 percent, shock 5 explains 41.89 percent, and shock 6 explains 0.94 percent of the error in the forecast of ER. Similarly, in the period 10, shock 1 explains 19.39 percent, shock 2 explains 31.69 percent, shock 3 explains 46.26 percent, shock 4 explains 0.15 percent, shock 5 explains 1.46 percent, and shock 6 explains 1.02 percent of the error in the forecast of ER.

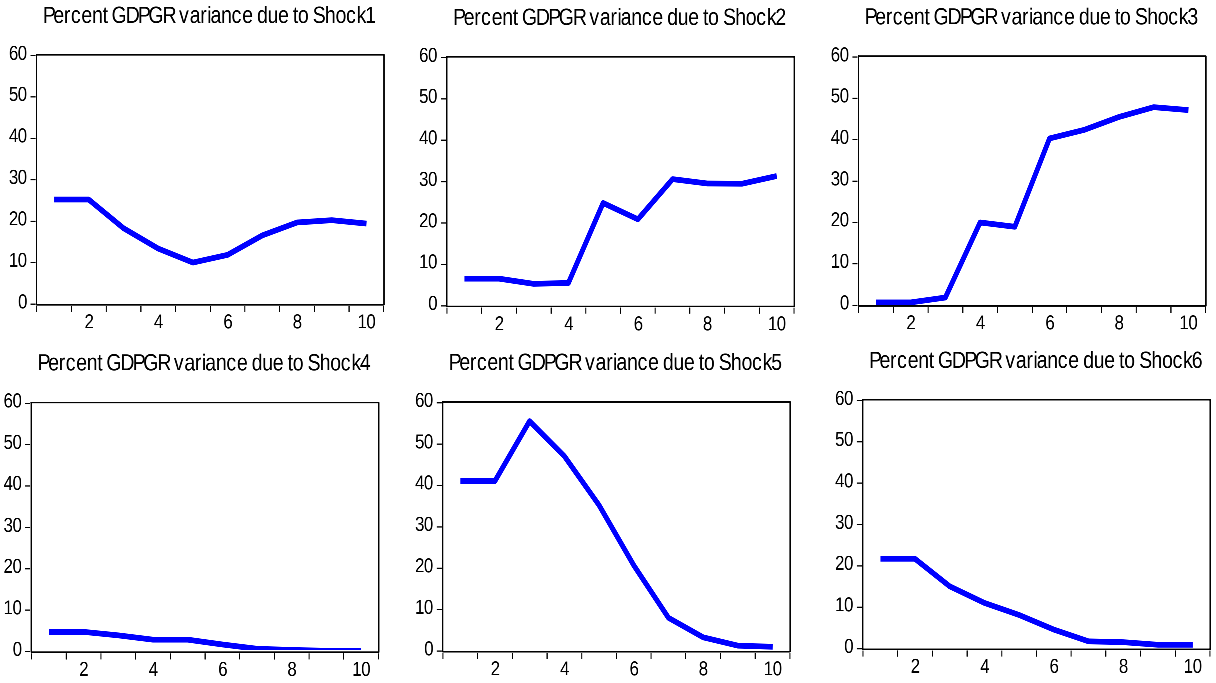
Figure 5.1.6d: Variance Decomposition of ER (SVAR)



Variance Decomposition of Real GDP Growth

The variance decomposition of GDPGR is presented in Table 5.1.15 and the percent variance due to the shocks is captured in Figure 5.1.6e. We notice that at period 1 and 2, shock 1 explains 25.25 percent, shock 2 explains 6.52 percent, shock 3 explains 0.68 percent, shock 4 explains 4.76 percent, shock 5 explains 41.02 percent, and shock 6 explains 21.74 percent of the error in the forecast of GDPGR. In period 3, shock 1 explains 18.32 percent, shock 2 explains 5.31 percent, shock 3 explains 1.82 percent, shock 4 explains 3.88 percent, shock 5 explains 55.56 percent, and shock 6 explains 15.07 percent of the error in the forecast of GDPGR. In period 6, shock 1 explains 11.88 percent, shock 2 explains 20.89 percent, shock 3 explains 40.25 percent, shock 4 explains 1.68 percent, shock 5 explains 20.69 percent, and shock 6 explains 4.57 percent of the error in the forecast of GDPGR. Similarly, in the period 10, shock 1 explains 19.39 percent, shock 2 explains 31.35 percent, shock 3 explains 47.17 percent, shock 4 explains 0.11 percent, shock 5 explains 0.98 percent, and shock 6 explains 0.96 percent of the error in the forecast of GDPGR.

Figure 5.1.6e: Variance Decomposition of GDPGR (SVAR)

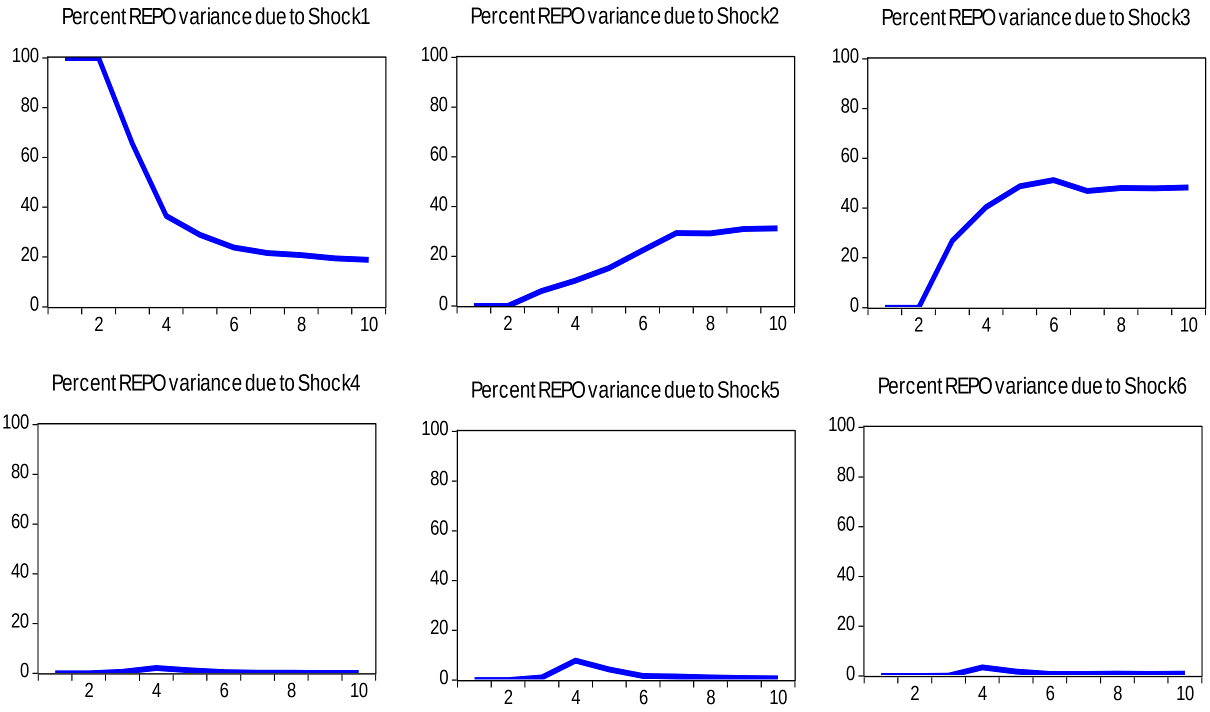


Variance Decomposition of Repo rate

The variance decomposition of REPO is presented in Table 5.1.15 and the percent variance due to the shocks is captured in Figure 5.1.6f. We notice that at period 1 and 2, shock 1 explains 100 percent of the error in the forecast of REPO. In period 3, shock 1 explains 65.52 percent, shock 2 explains 6.01 percent, shock 3 explains 26.94 percent, shock 4 explains 0.48 percent, shock 5 explains 1.02 percent, and shock 6 explains 0.72 percent of the error in the forecast of REPO. In period 6, shock 1 explains 23.80 percent, shock 2 explains 22.28 percent, shock 3 explains 51.19 percent, shock 4 explains 0.37 percent, shock 5 explains 1.61 percent, and shock 6 explains 0.72 percent of the error in the forecast of REPO. Similarly, in the period 10, shock 1 explains 18.86 percent, shock 2 explains 31.22

percent, shock 3 explains 48.31 percent, shock 4 explains 0.09 percent, shock 5 explains 0.67 percent, and shock 6 explains 0.82 percent of the error in the forecast of REPO.

Figure 5.1.6f: Variance Decomposition of REPO (SVAR)



Recursive VAR

The mathematical representation of a VAR is:

$$Z_t = (REPO_t + +INFL_t + CPI_t + STLR_t + ER_t + \ GDPGR_t)$$

$$y_t = A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} \ + Bx_t + \epsilon_t$$

Where y_t is k vector of endogenous variables, x_t is a d vector of exogenous variables, A_1, ... , A_p and B are matrices of coefficients to be estimated, and ϵ_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables. Since only lagged values of the endogenous variables appear on the right-hand side of the equations, simultaneity is not an issue and OLS yields consistent estimates. Moreover, even though the innovations $\boldsymbol{\epsilon_t}$ may be contemporaneously correlated, OLS is efficient and equivalent to GLS since all equations have identical regressors. We provide the estimations of the recursive VAR model in Table 5.1.16.

Table 5.1.16: Vector Autoregression Estimates

Standard errors in ( ) & t-statistics in [ ]

	REPO	INFL	CPI	STLR	ER	GDPGR
REPO(-2)	-0.2260	0.4054	1.0438	-0.0821	0.1278	0.2529
	(0.2536)	(0.6033)	(1.4067)	(0.1172)	(1.1325)	(0.7368)
	[-0.8913]	[0.6719]	[0.7420]	[-0.7011]	[0.1128]	[0.3438]
REPO(-3)	0.1527	-0.1274	-0.4520	0.1634	-0.3158	0.7830
	(0.2283)	(0.5432)	(1.2664)	(0.1055)	(1.0196)	(0.6632)
	[0.6690]	[-0.2345]	[-0.3569]	[1.5487]	[-0.3097]	[1.1806]
REPO(-4)	0.0202	0.1812	-1.3146	-0.3559	-0.0039	-0.3578
	(0.2299)	(0.5472)	(1.2757)	(0.1062)	(1.0271)	(0.6680)
	[0.0880]	[0.3312]	[-1.0304]	[-3.3484]	[-0.0038]	[-0.5356]
INFL(-2)	-0.1225	0.2007	0.1816	-0.0253	-0.3738	0.1911
	(0.0942)	(0.2241)	(0.5226)	(0.0435)	(0.4207)	(0.2737)
	[-1.3003]	[0.8952]	[0.3476]	[-0.5814]	[-0.8884]	[0.6985]
INFL(-3)	0.0430	0.3848	0.8933	-0.0922	-0.1657	0.3590
	(0.1038)	(0.2470)	(0.5759)	(0.0479)	(0.4637)	(0.3016)
	[0.4150]	[1.5579]	[1.5510]	[-1.9224]	[-0.3575]	[1.1904]
INFL(-4)	-0.1155	-0.2918	0.2320	0.1188	-0.2017	0.2265
	(0.0822)	(0.1958)	(0.4564)	(0.0380)	(0.3675)	(0.2390)
	[-1.4035]	[-1.4904]	[0.5082]	[3.1255]	[-0.5490]	[0.9478]
CPI(-2)	0.1633	-0.0653	1.5784	0.0529	-0.0217	-0.0412
	(0.0714)	(0.1700)	(0.3963)	(0.0330)	(0.3191)	(0.2078)
	[2.2861]	[-0.3844]	[3.9820]	[1.6027]	[-0.0680]	[-0.1982]
CPI(-3)	-0.2037	-0.16084	-2.3046	-0.1207	0.2554	-0.4447
	(0.1285)	(0.3058)	(0.7131)	(0.0594)	(0.5741)	(0.3734)
	[-1.5850]	[-0.5258]	[-3.2317]	[-2.0317]	[0.4448]	[-1.1909]
CPI(-4)	0.0706	0.1673	1.6439	0.0848	-0.3255	0.4679
	(0.0986)	(0.2346)	(0.5471)	(0.0455)	(0.4404)	(0.2865)
	[0.7162]	[0.7131]	[3.0048]	[1.8611]	[-0.7390]	[1.6332]
STLR(-2)	-0.2070	0.6843	1.1853	-0.1683	0.0680	-0.4834
	(0.2687)	(0.6393)	(1.4905)	(0.1241)	(1.2000)	(0.7805)
	[-0.7706]	[1.0704]	[0.7952]	[-1.3554]	[0.0567]	[-0.6193]
STLR(-3)	0.2621	-0.4581	0.8986	0.0466	1.4364	-0.4809
	(0.3059)	(0.7280)	(1.6972)	(0.1414)	(1.3664)	(0.8888)
	[0.8568]	[-0.6292]	[0.5294]	[0.3299]	[1.0512]	[-0.5411]
STLR(-4)	-0.2496	-0.1993	-1.8075	0.1180	-0.0494	-1.6668
	(0.3272)	(0.7785)	(1.8150)	(0.1512)	(1.4613)	(0.9505)
	[-0.7629]	[-0.2560]	[-0.9958]	[0.7803]	[-0.0338]	[-1.7535]
ER(-2)	0.0311	-0.1247	0.1503	0.0443	0.1826	-0.3006
	(0.0720)	(0.1714)	(0.3996)	(0.0333)	(0.3217)	(0.2092)
	[0.4322]	[-0.7275]	[0.3762]	[1.3313]	[0.5677]	[-1.4366]
ER(-3)	-0.0074	-0.2479	-0.2473	-0.0051	-0.3515	-0.2462
	(0.0691)	(0.1646)	(0.3838)	(0.0319)	(0.3090)	(0.2009)
	[-0.1072]	[-1.5062]	[-0.6446]	[-0.1624]	[-1.1375]	[-1.2250]
ER(-4)	-0.0125	-0.0570	-0.0778	0.0557	-0.3202	0.1296

	(0.0606)	(0.1442)	(0.3363)	(0.0280)	(0.2708)	(0.1761)
	[-0.2075]	[-0.3957]	[-0.2314]	[1.9896]	[-1.1824]	[0.7361]
GDPGR(-2)	0.0036	-0.2269	0.7787	0.0550	-0.2679	0.6051
	(0.1068)	(0.2542)	(0.5927)	(0.0493)	(0.4772)	(0.3104)
	[0.0343]	[-0.8925]	[1.3138]	[1.1144]	[-0.5614]	[1.9496]
GDPGR(-3)	0.2252	-0.3292	-0.6933	-0.0867	-0.1893	0.0921
	(0.1010)	(0.2403)	(0.5603)	(0.0466)	(0.4511)	(0.2934)
	[2.2299]	[-1.3696]	[-1.2372]	[-1.8584]	[-0.4198]	[0.3139]
GDPGR(-4)	-0.1371	0.3726	0.3319	0.175909	0.177647	-0.419022
	(0.0876)	(0.2084)	(0.4859)	(0.04049)	(0.39126)	(0.25450)
	[-1.5652]	[1.7875]	[0.6831]	[4.34472]	[0.45404]	[-1.64647]
Intercept	-0.8304	1.8770	-2.9691	-1.2366	3.5260	5.5863
	(0.9824)	(2.3374)	(5.4494)	(0.4540)	(4.3873)	(2.8537)
	[-0.8453]	[0.8030]	[-0.5448]	[-2.7237]	[0.8036]	[1.9575]
R-squared	0.6116	0.5031	0.6846	0.7880	0.3164	0.7699
Adj. R-squared	0.2787	0.0772	0.4142	0.6063	-0.2694	0.5728
Sum sq. resids	6.6480	37.635	204.55	1.4198	132.58	56.098
S.E. equation	0.5626	1.3387	3.1210	0.2600	2.5127	1.6344
F-statistic	1.8374	1.1814	2.5323	4.3378	0.5400	3.9054
Log likelihood	-20.866	-55.538	-89.396	10.009	-80.725	-63.522
Akaike AIC	1.9933	3.7269	5.4198	0.4495	4.9862	4.1261
Schwarz SC	2.7955	4.5291	6.2220	1.2517	5.7884	4.9283
Mean dependent	0.0125	0.0252	5.4751	-0.0050	0.5784	7.4502
S.D. dependent	0.6625	1.3936	4.0779	0.4144	2.2301	2.5007
Determinant resid covariance (dof adj.)		0.2985				
Determinant resid covariance		0.0062				
Log likelihood		-239.04				
Akaike information criterion		17.656				
Schwarz criterion		22.465				

Impulse Responses in Recursive VAR

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.1.7.

Figure 5.1.7: Impulse Response to Cholesky One S.D. Innovations ± 2 S.E. (Recursive VAR)

The impulse responses show the effect of an unexpected 1 percentage point increase in REPO on all other variables, as it works through the recursive VAR system with the coefficients estimated from actual data (Figure 5.1.7). Also plotted are ±1 standard error bands for each of the impulse responses. An unexpected rise in REPO is associated with a decline in INFL by around 0.5 in the 4th period, 6th period, and 10th period (Table 5.1.17). However, there is a substantial decline of 1.2 in the 8th period. In the case of CPI, an unexpected rise in REPO is associated a decline of 3.05 in the 4th period, 11.96 in the 6th period, 40.25 in the 8th period and 139.74 in the 10th period. In the case of STLR, an unexpected rise in REPO is associated a decline of 0.10 in the 4th period, and subsequent declines of 0.53 in the 6th period, 1.53 in the 8th period, and 5.26 in the 10th period. In the case of ER, an unexpected rise in REPO is associated an appreciation by 0.17 in the 3rd period, 0.08 in the 4th period, 0.50 in the 5th period, 1.95 in the 7th period, and 7.08 in the 9th period. We notice that an unexpected rise in REPO is associated with a decline in GDPGR by 1.06 in the 6th period, 4.27 in the 8th period, and 14.12 in the 10th period.

Table 5.1.17: Response to Cholesky One +- S.D. Innovations in REPO

Period	INFL	CPI	STLR	ER	GDPGR
1	0.1074	1.0078	0.0507	0.1840	0.8213
	(0.2113)	(0.4804)	(0.0407)	(0.3968)	(0.2416)
2	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
3	0.0092	2.9250	0.0492	-0.1731	0.5384
	(0.4167)	(1.3019)	(0.0856)	(0.7935)	(0.5639)
4	-0.5317	-3.0505	-0.1095	-0.0854	0.0368
	(0.4672)	(1.4949)	(0.1169)	(0.8719)	(0.5975)
5	0.2776	6.2024	0.2251	-0.5041	0.1305
	(0.6487)	(3.8184)	(0.1753)	(1.4082)	(1.2157)
6	-0.5733	-11.9691	-0.5319	1.0106	-1.0655
	(1.3323)	(7.5337)	(0.3432)	(2.8227)	(1.9845)
7	1.0263	21.8512	0.9902	-1.9556	2.3600
	(2.3881)	(15.8514)	(0.6756)	(4.8546)	(3.7421)
8	-1.2040	-40.2527	-1.5398	3.8215	-4.2707
	(4.4378)	(32.4813)	(1.3048)	(8.8760)	(6.9883)
9	3.0118	75.8975	2.7335	-7.0856	7.8789
	(8.6563)	(67.7351)	(2.6623)	(16.9213)	(13.4881)
10	-5.7034	-139.7421	-5.2688	12.8234	-14.1298
	(16.4472)	(137.3860)	(5.3505)	(31.3566)	(25.8604)

Note: Cholesky Ordering: REPO INFL CPI STLR ER GDPGR
Standard Errors: Analytic

Recursive VAR Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

The variance decomposition is an alternative method to the impulse response functions for examining the effects of shocks to the dependent variables. This technique determines how much of the forecast error variance of any variable in a system, is explained by innovations to each explanatory variable, over a series of time horizons. Usually, own series shocks explain most of the error variance, although the shock will also affect other variables in the system. It is also important to consider the ordering of the variables when conducting these tests, as in practice the error terms of the equations in the VAR will be correlated, so the result will be dependent on the order in which the equations are estimated in the model. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. The variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

Table 5.1.18: Variance Decompositions of Variables

Variance decomposition of INFL

Period	S.E.	REPO	INFL	CPI	STLR	ER	GDPGR
1	0.5627	0.6431	99.3569	0.0000	0.0000	0.0000	0.0000
2	0.5627	0.6431	99.3569	0.0000	0.0000	0.0000	0.0000
3	0.6956	0.6286	96.9864	0.0914	0.4761	0.1980	1.6194
4	0.9431	12.0527	73.3549	7.5232	0.5998	2.6669	3.8025
5	1.2934	13.7087	66.1510	10.8099	0.5916	4.3530	4.3857
6	2.3128	17.2685	54.4718	15.7438	0.6212	7.1364	4.7583
7	4.1059	18.2541	43.5999	30.7102	0.3317	3.4469	3.6571
8	7.3886	13.4164	43.0607	39.4359	0.1338	2.2862	1.6671
9	13.8179	16.7482	35.9347	45.2083	0.0908	1.0325	0.9855
10	25.5567	17.9830	32.9098	47.9337	0.0578	0.4251	0.6908

Variance decomposition of CPI

Period	S.E.	REPO	INFL	CPI	STLR	ER	GDPGR
1	0.5627	10.4272	31.8335	57.7393	0.0000	0.0000	0.0000

2	0.5627	10.4272	31.8335	57.7393	0.0000	0.0000	0.0000
3	0.6956	21.5741	31.2287	45.5629	0.3716	0.4686	0.7940
4	0.9431	20.2072	27.3165	51.3814	0.1770	0.2420	0.6759
5	1.2934	17.8463	34.2415	45.3947	0.1687	1.4147	0.9341
6	2.3128	19.6276	30.2174	48.5674	0.1113	0.5706	0.9056
7	4.1059	18.6037	32.3629	47.3212	0.0888	0.8138	0.8097
8	7.3886	18.9802	31.2278	48.2748	0.0858	0.5918	0.8396
9	13.8179	18.9019	31.7412	47.8745	0.0807	0.5957	0.8060
10	25.5567	18.9190	31.4530	48.1550	0.0810	0.5759	0.8162
Variance decomposition of STLR							
Period	S.E.	REPO	INFL	CPI	STLR	ER	GDPGR
1	0.5627	3.8068	25.0790	29.1166	41.9976	0.0000	0.0000
2	0.5627	3.8068	25.0790	29.1166	41.9976	0.0000	0.0000
3	0.6956	4.9129	33.2557	29.0030	28.8021	2.2961	1.7301
4	0.9431	4.9665	52.3469	29.7187	8.6920	2.4821	1.7937
5	1.2934	7.9647	54.3588	25.7059	4.4918	2.9901	4.4888
6	2.3128	19.8565	40.5523	31.5466	2.4819	2.5956	2.9673
7	4.1059	24.0523	31.8972	37.8182	1.0525	3.0527	2.1271
8	7.3886	20.0741	31.9128	44.8367	0.3710	1.2222	1.5832
9	13.8179	18.2763	33.3471	46.1451	0.1574	0.9433	1.1308
10	25.5567	18.6938	31.8782	47.7353	0.1069	0.6811	0.9048
Variance decomposition of ER							
Period	S.E.	REPO	INFL	CPI	STLR	ER	GDPGR
1	0.5627	0.5363	5.2503	0.1678	3.5985	90.4472	0.0000
2	0.5627	0.5363	5.2503	0.1678	3.5985	90.4472	0.0000
3	0.6956	0.8820	8.8038	0.1488	3.5458	86.0434	0.5762
4	0.9431	0.8381	8.1859	7.6106	4.4024	78.2261	0.7370
5	1.2934	3.0105	18.3838	11.5179	3.4807	63.0202	0.5869
6	2.3128	8.2798	20.7966	25.6246	2.4599	41.8901	0.9491
7	4.1059	13.1450	27.2025	40.1607	1.0925	17.8085	0.5908
8	7.3886	17.4144	32.9642	41.4615	0.4813	6.3503	1.3283
9	13.8179	19.4373	31.5240	44.9644	0.2614	2.6300	1.1829
10	25.5567	19.3971	31.6918	46.2677	0.1586	1.4616	1.0232
Variance decomposition of GDPGR							
Period	S.E.	REPO	INFL	CPI	STLR	ER	GDPGR
1	0.5627	25.2503	6.5243	0.6873	4.7693	41.0263	21.7426
2	0.5627	25.2503	6.5243	0.6873	4.7693	41.0263	21.7426
3	0.6956	18.3267	5.3183	1.8245	3.8880	55.5632	15.0793
4	0.9431	13.4005	5.5322	20.0054	2.9054	47.0778	11.0788
5	1.2934	9.9748	24.8383	18.9394	2.8610	35.2509	8.1355
6	2.3128	11.8851	20.8963	40.2585	1.6868	20.6998	4.5736
7	4.1059	16.5758	30.5932	42.3806	0.6743	7.9771	1.7991
8	7.3886	19.7092	29.5428	45.4866	0.3883	3.3096	1.5635
9	13.8179	20.2295	29.5109	47.8506	0.1626	1.3161	0.9302
10	25.5567	19.3937	31.3528	47.1780	0.1174	0.9883	0.9699
Cholesky Ordering: REPO INFL CPI STLR ER GDPGR							

Table 5.1.18 displays separate variance decomposition for each endogenous variable. The second column, labeled "SE", contains the forecast error of the variable at the given forecast horizon. The source of this forecast error is the variation in the current and future values of the innovations to each endogenous variable in the VAR. The remaining columns

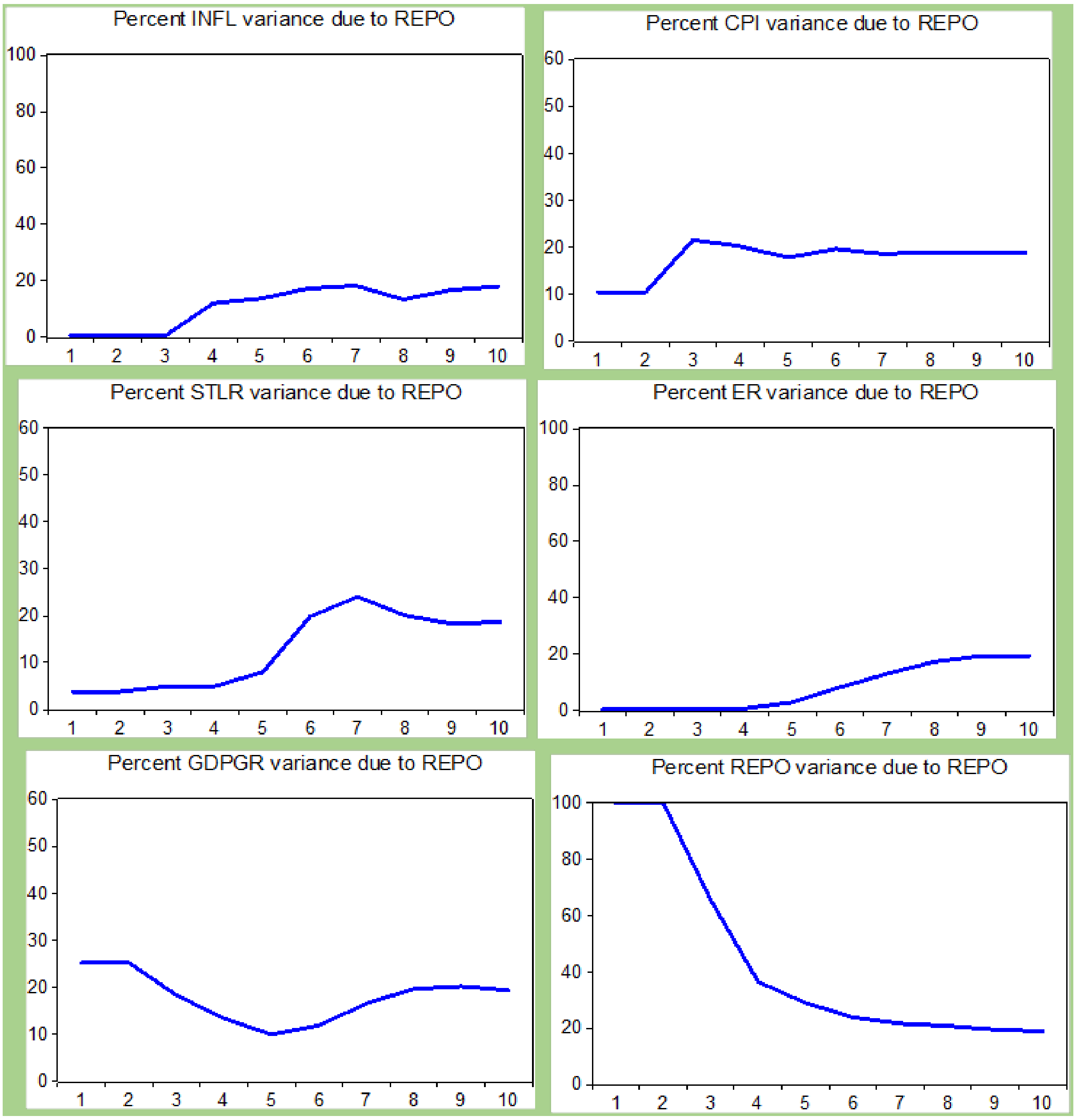
give the percentage of the forecast variance due to each innovation, with each row adding up to 100. With the impulse responses, the variance decomposition based on the Cholesky factor can change dramatically if the ordering of the variables in the VAR is altered. For example, the first-period decomposition for the first variable in the VAR ordering is completely due to its own innovation. The above results suggest considerable interaction among the variables.

The variance of decompositions (Recursive VAR) is presented in Figure 5.1.8. We notice that at period 10, 67.09 percent of the error in the forecast of INFL is attributed to REPO (17.98 percent), CPI (47.93 percent), STLR (0.05 percent), ER (0.42 percent), and GDPGR (0.69 percent) shocks in the recursive VAR. Similarly, at period 10, 51.85 percent of the error in the forecast of CPI is attributed to REPO (18.91 percent), INFL (31.45 percent), STLR (0.08 percent), ER (0.57 percent), and GDPGR (0.81 percent) shocks in the recursive VAR. For STLR at the same period, 99.9 percent of the error in the forecast is attributed to REPO (18.69 percent), INFL (31.87 percent), CPI (47.73 percent), ER (0.68 percent), and GDPGR (0.90 percent) shocks in the recursive VAR. For ER at the same 10th period, 98.54 percent of the error in the forecast is attributed to REPO (19.39 percent), INFL (31.69 percent), CPI (46.26 percent), STLR (0.15 percent), and GDPGR (1.02 percent) shocks in the recursive VAR. Finally, for GDPGR at the same 10th period, 98.98 percent of the error in the forecast is attributed to REPO (19.39 percent), INFL (31.35 percent), CPI (47.17 percent), STLR (0.11 percent), and ER (0.98 percent) shocks in the recursive VAR.

Robustness of Results:

We check for the robustness of the results by examining the statistical significance of the impulse responses. Accordingly, +/-2S.E. confidence interval was estimated for each of the impulse response function of the variables under study. It was observed that they are statistically significant at the conventional level in around the periods where the maximum impacts are felt.

Figure 5.1.8: Variance of Decompositions (Recursive VAR)



Forecasting

The state-of-the-art VAR forecasting systems contain more than three variables and allow for time-varying parameters to capture important drifts in coefficients (Sims, 1993).

Multistep ahead forecasts, computed by iterating forward the recursive VAR, are assessed in Table 5.1.18.

The first two forecast error statistics largely depend on the scale of the dependent variable and are used as relative measures to compare forecasts for the same series of different models; the smaller the error, the better the forecasting ability of that model according to that criterion. Very low scores of root mean squared error (RMSE) and mean absolute error (MAE) for the forecasts indicate the strength and accuracy of the forecast based on the VAR model. The RMSE is computed using the formula:

$$RMSE = \sqrt{\frac{\Sigma(\mathrm{y}-\hat{\mathrm{y}})^2}{\mathrm{n}-\mathrm{k}-1}} = \sqrt{\frac{\mathrm{RSS}}{\mathrm{n}-\mathrm{k}-1}}$$

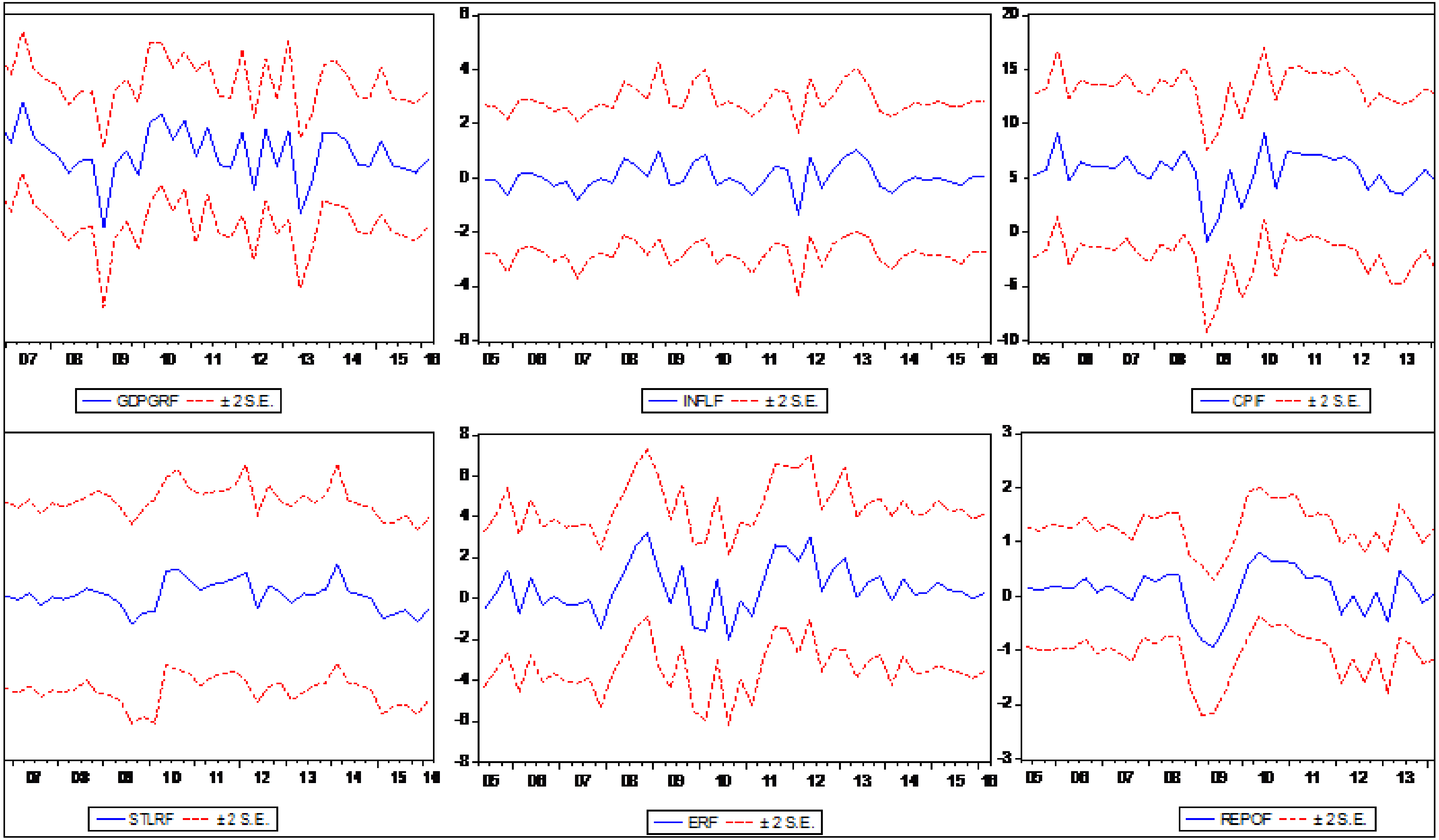
The remaining two statistics are scale invariant. The Theil inequality coefficient always lies between 0 and 1, where 0 indicates a perfect fit. Further, as the ultimate test of a forecasting model is its out-of-sample performance, Table 19 focuses on pseudo out-of-sample forecasts over the period 2005Q1 – 2016q1 (Figure 5.1.9).

Table 5.1.19 : Forecast statistics

	REPOf	INFLf	CPIf	STLRf	ERf	GDPGRf
Root mean squared error[a]	0.5019	1.2390	3.4054	0.3806	1.7407	1.9069
Mean absolute error[b]	0.3966	0.9174	2.7038	0.2239	1.3301	1.5265
Mean absolute percentage error	51.152	104.12	124.26	27.157	485.92	61.748
Theil inequality coefficient	0.4804	0.6830	0.2771	0.7281	0.4982	0.1210
Bias proportion	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Variance proportion	0.2323	0.4672	0.3631	0.5302	0.2772	0.2385
Covariance proportion	0.7676	0.5327	0.6368	0.4697	0.7227	0.7614

Notes: [a]The mean squared forecast error is computed as the average squared value of the forecast error over the 1996-2009 out-of-sample period, and the resulting square root is the root mean squared forecast error reported in the table; root mean squared errors (RMSEs) are the errors squared before they are averaged and give a relatively high weight to large errors, which infers that RMSE is most useful when large errors are particularly undesirable; [b]mean absolute error (MAE), which is a linear score (that all the individual differences are weighted equally in the average), measures the magnitude of the errors in a set of forecasts without considering their direction and measures accuracy for continuous variable; entries are the root mean square error of forecasts computed recursively for VARs.

Figure 5.1.9: Forecasting for the covariates

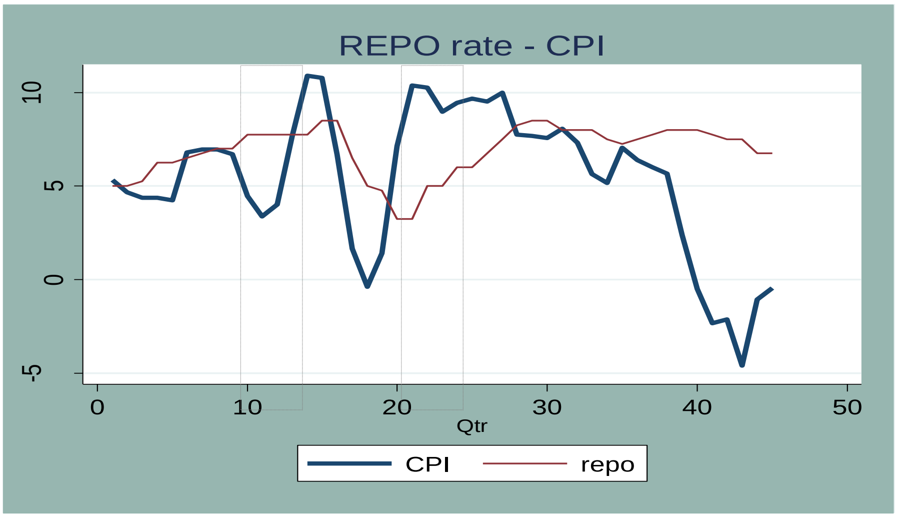


Findings

Transmission to Commodity Price Inflation:

The correlation statistics reveal a negative relationship between policy repo rate and commodity price inflation (Figure 10). The commodity price inflation (CPI), experiences a lull impact for the first shock in monetary policy repo rate and turns negative in the 4th period by 3.05 percent. In response to the first shock, the maximum decline in CPI (-139.7421) occurs with a lag of eight quarters with the overall impact continuing through 4–10 quarters. However, during the 4th quarter, there is a spurt in the CPI leading us to observe the presence of a “price puzzle” (Eichenbaum, 1992). In their study, Barnett et al., (2016) evaluate the monetary policy in India in a SVAR approach using the data for period from January 2000 – January 2008, and report that price growth measured using the CPI stays negative on the initial impact of the shock. However, between the 6th and the 12th month they observe a positive price growth. Hanson (2004) showed that it is not easy to explain away the price puzzle. Interpretations of the price puzzle can differ. A conventional view is that nobody should believe that policy rate shocks (hikes) are ever inflationary in reality. A relatively new explanation for the price puzzle lets in the possibility that surprise policy rate hikes really could be inflationary in some circumstances.

Figure 5.1.10: The Price Puzzle



Source: Reserve Bank of India database

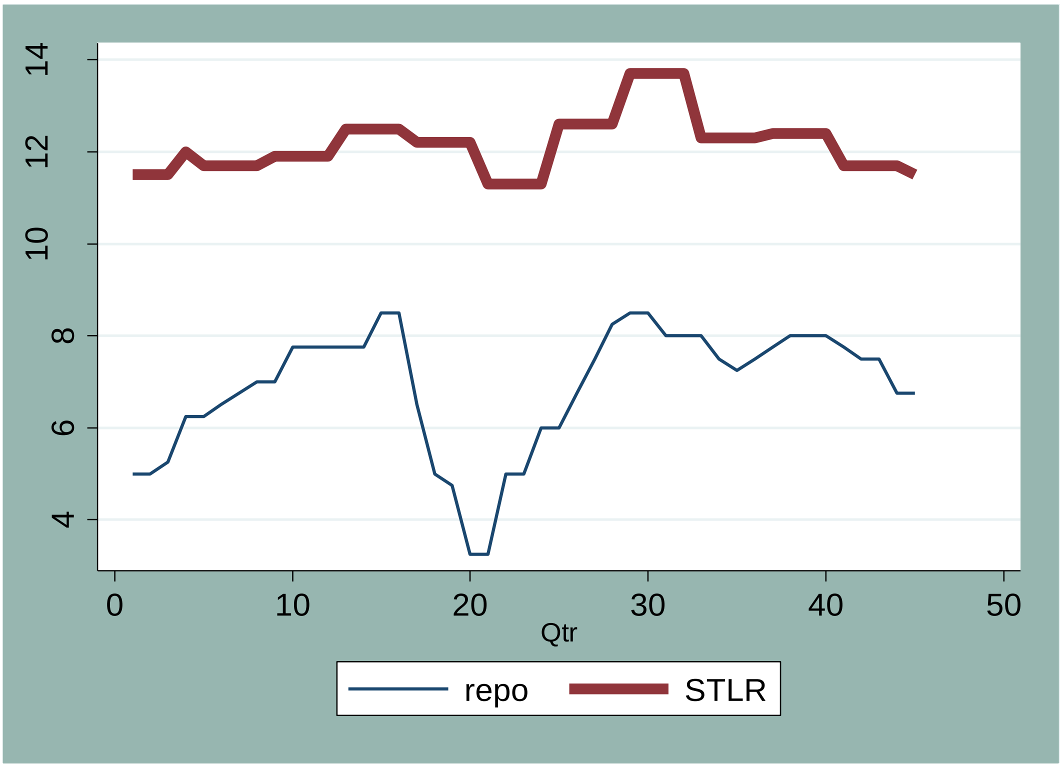
Price puzzle is a short-run increase in prices after monetary tightening. The possible explanation could be (a) it is caused by the cost channel (real increase in prices); (b) it is caused by omitted variables (econometric misspecifications). The empirical evidence on price puzzle suggests that; (i) with higher average inflation the effect of monetary policy on prices gets weaker (lower credibility hypothesis), (ii) with a higher openness of the economy the effect on prices gets stringer (exchange rate channel), and (iii) with a higher degree of central bank independence the effect on prices gets stronger (higher credibility hypothesis).

Another explanation to the 'price puzzle' effect is that it is possible to show in a macroeconomic model that some combinations of characteristics (such as how risk-averse people are, how sticky prices are updated, and how monetary policy is set) pertain to "determinacy" and others pertain to "indeterminacy" (Lubik and Schorfheide, 2003). Though the observed price puzzle in the short run can be due to specification issues, the long-run response is driven by structural country-specific characteristics. On an average, the transmission of monetary policy shocks is relatively fast.

Transmission to Short Term Lending Rate:

The correlation statistics reveal a positive significant relationship (0.56*) between policy repo rate and short term lending rate (Figure 5.11). The impulse response functions imply that increase in policy REPO rate is associated with a decline in STLR by 0.1095 for the first shock in the 4th quarter. In response to the first shock, the maximum decline in STLR (-5.2688) occurs with a lag of ten quarters with the overall impact continuing through 4 – 10 quarters (Figure 5.12).

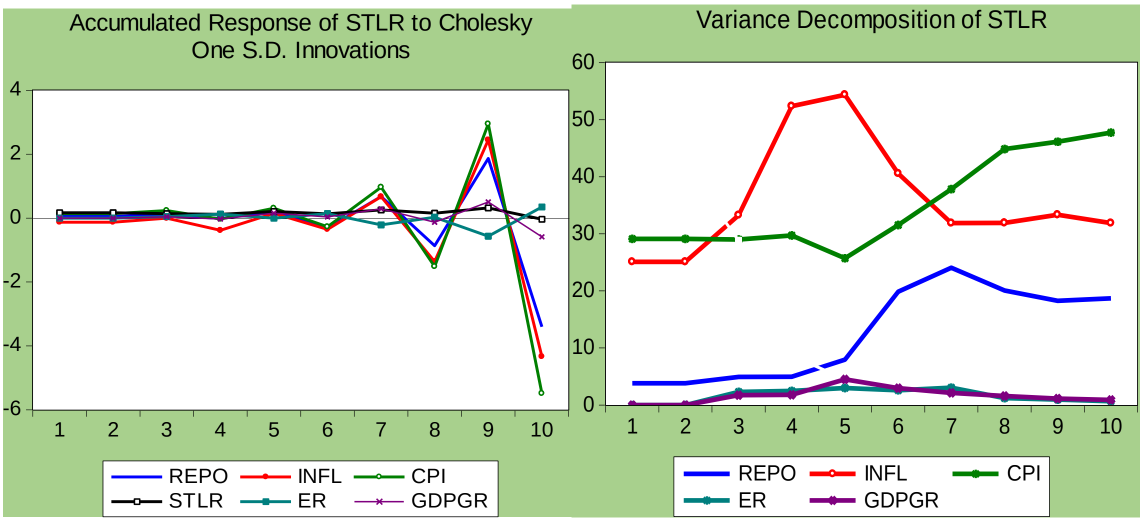
Figure 5.1.11: The Liquidity Puzzle



Source: Reserve Bank of India database

The variance decomposition of STLR reveals that at period 1 and 2, shock 1 explains 3.80 percent, shock 2 explains 25.07 percent, shock 3 explains 29.11 percent, and shock 4 explains 41.99 percent of the error in the forecast of STLR. Similarly, in the 10th period, shock 1 explains 18.69 percent, shock 2 explains 31.87 percent, shock 3 explains 47.73 percent, shock 4 explains 0.10 percent, shock 5 explains 0.68 percent, and shock 6 explains 0.90 percent of the error in the forecast of STLR. The monetary policy shock itself explains variation in short-term interest which could be explained in terms of interest rate smoothing behavior of the monetary policy. In the recursive VAR estimations, for STLR at the same period, 99.9 percent of the error in the forecast is attributed to REPO (18.69 percent), INFL (31.87 percent), CPI (47.73 percent), ER (0.68 percent), and GDPGR (0.90 percent) shocks in the recursive VAR.

Figure 5.1.12: Impulse Response and Variance Decomposition of STLR

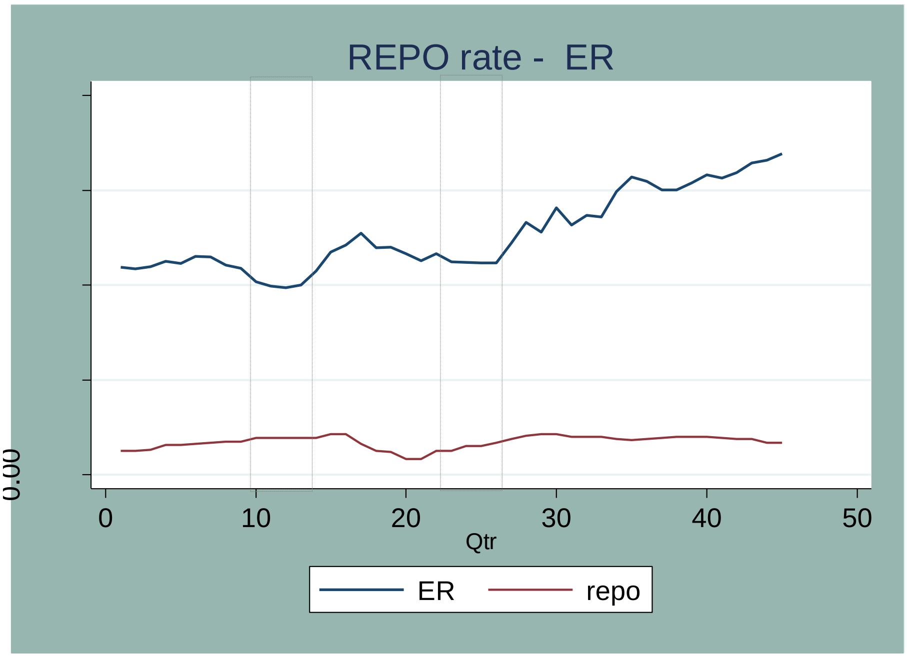


Immediately following an expansionary monetary policy shock, the interest rate increases rather than decreases (the "liquidity puzzle"). The liquidity puzzle is often found in VAR models that measure monetary policy shocks by the orthogonalized innovation in conventional monetary aggregates. It is believed that a positive interest rate innovation leads to an initial fall in money, consistent with the liquidity effect. Moreover, significant unidirectional causality was observed from policy repo rate to short term lending rate.

Transmission to Exchange Rates:

The correlation statistics reveal a positive relationship between policy repo rate and nominal exchange rate. We examine the impact of monetary policy shocks on the nominal exchange rate. The study shows that a hike in monetary policy (REPO) rate is associated with an appreciation of the exchange rate (ER) by 0.1731 for the first shock in the 3rd quarter. In response to the first shock, the maximum decline (appreciation) in ER (-7.0856) occurs with a lag of nine quarters with the overall impact continuing through 3 – 9 quarters. However, the depreciation of ER persists in the 6th, 8th and 10th period. We notice that the domestic currency appreciates initially (during the 1st and 2nd periods) in response to a positive shock to policy REPO rate and subsequently depreciates (Figure 5.1.13). An ‘exchange rate puzzle’ suggests that one percentage point increase in the policy interest rate leads to an impact depreciation of the currency and persistent depreciation thereafter.

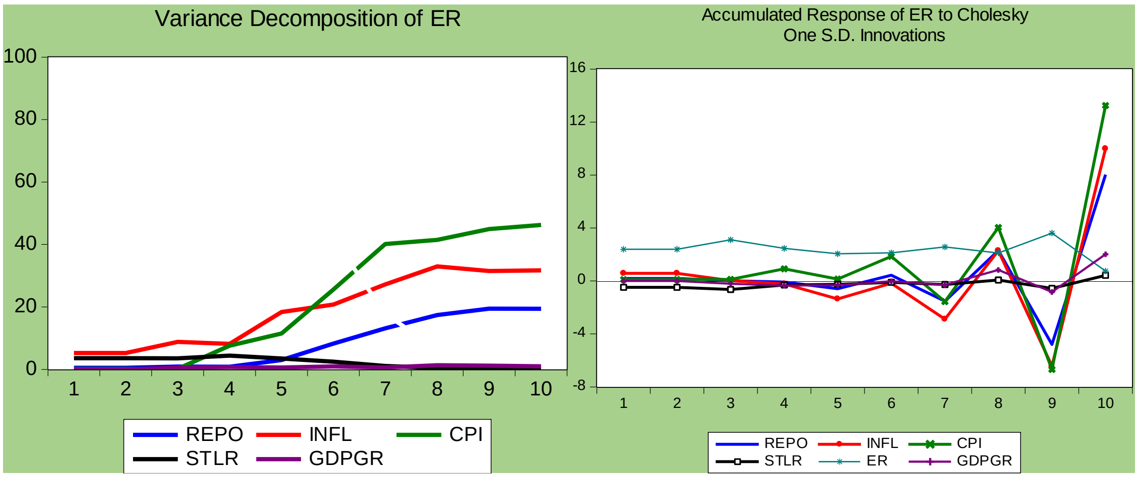
Figure 5.1.13: The Exchange Rate Puzzle



Source: Reserve Bank of India database

The available empirical evidence shows that the correlation between exchange rates and interest rates is low, on average. However, the correlation is consistently negative in developed countries and consistently positive in developing economies (Vegh et al., 2011). A contractionary monetary policy in the United States leads to an appreciation of the dollar relative to all major currencies (Eichenbaum and Evans, 1995). Using a structural VAR approach study the non-US G-7 countries, Kim and Roubini (2000) provide support for the conventional wisdom that exchange rates appreciate in response to a monetary tightening. Hnatkovska et al., (2013) show that the relationship between interest rates and the exchange rate is non-monotonic. They argue that the exchange rate response depends on the size of the interest rate increase and on the initial level of the interest rate. Moreover, they suggest that the model can replicate the heterogeneous responses of the exchange rate to interest rate innovations in several developing economies.

Figure 5.1.14: Impulse Response and Variance Decomposition of ER

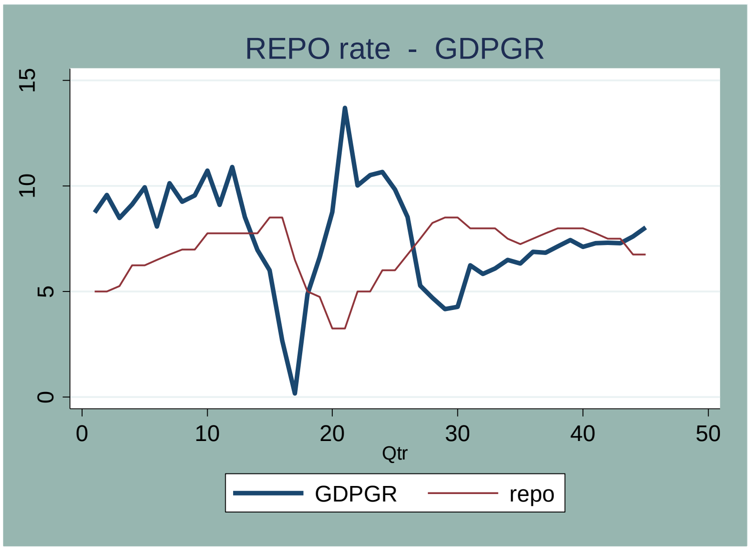


Our results, though show the persistence of 'exchange rate puzzle', it can be due to differences in the ability to precommit to monetary policy rules; it can be due to differences in the nature of the shocks; developing countries respond differently to interest rate increases relative to developed countries; or it can be due to differences in the monetary transmission mechanism itself. Further, the results can be explained to the differences in the inflation shocks, output shocks, risk premium shocks etc.

Transmission to Economic Output:

The correlation statistics reveal a statistically significant inverse relationship between policy repo rate and GDP growth rate. According to conventional wisdom, monetary contractions should raise the policy repo rate, lower prices and reduce real output. If a particular identification scheme does not accomplish this, then the observed responses are called a 'puzzle', while successful identification needs to deliver results matching the conventional wisdom. We notice that in the last 20 quarters, the 'growth puzzle' exists in the Indian context wherein, the response of real GDP growth is unconventional to the policy repo rate impulse (Figure 5.1.15).

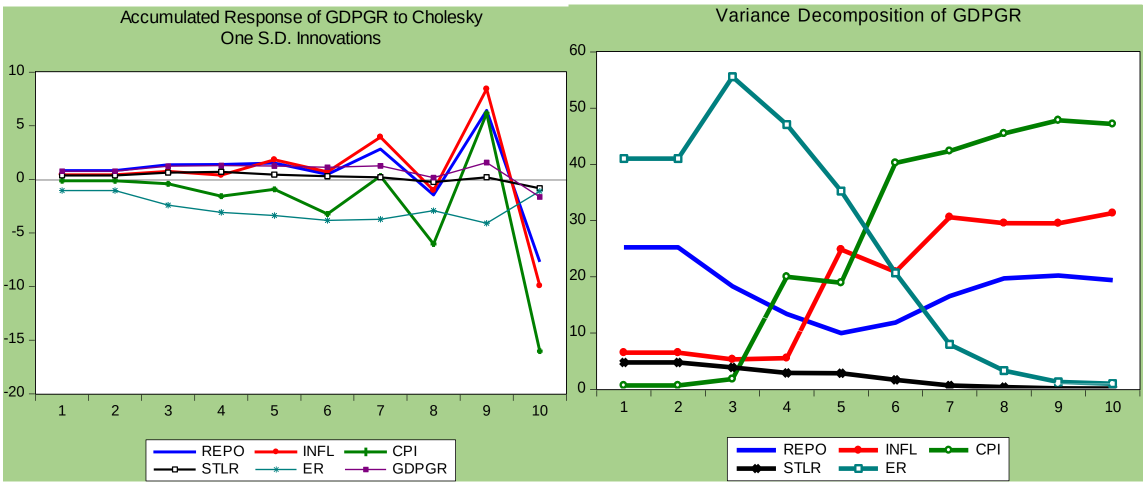
Figure 5.1.15: The Growth Puzzle



Source: Reserve Bank of India database

The impulse response functions imply that increase in policy interest rate is associated with a fall in real GDP growth rate. The estimation of the impact of monetary policy shocks on the economic growth shows that a hike in monetary policy (REPO) rate is associated with a decline in real GDP growth rate by -1.0655 for the first shock in the 6th quarter. In response to the first shock, the maximum decline in GDP growth (-4.2707) occurs with a lag of eight quarters with the overall impact continuing through 6 – 8 quarters (Figure 5.1.16). The real GDP growth responds to the policy repo rate shock with a lag of three-quarters[5].

Figure 5.1.16: Impulse Response and Variance Decomposition of GDPGR



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[5] Patra and Kapur (2010) also found that aggregate demand responds to interest rate changes with a lag of at least three quarters.

The overall impact persists through 8-10 quarters. Mohanty (2012) provides evidence that policy rate increases have a negative effect on output growth with a lag of two quarters and a moderating impact on inflation with a lag of three quarters, with both effects persisting for eight to ten quarters. Aleem (2010) report that an increase in call money rate leads to a decline in GDP which bottoms out in the 3rd quarter and shows a V–shaped response.

The observed association between high–interest rates and subsequent low output is due mainly to the underlying source of inflationary pressure as monetary policy disturbances have very weak effects on output, stronger effects on prices. We notice that monetary policy shock *via* the interest rate channel affected real output significantly. The impulse responses tend to suggest that monetary policy repo rate shocks affect commodity price inflation more than the output growth. Mallick (2009) in his study covering the period from 1996Q2 to 2009Q1 for India reports that a contractionary monetary policy shock is associated with a statistically significant reduction in real output, but monetary policy shocks accounted for a small part of the forecast error variance in real output.

The interest rate channel was still the most relevant channel in influencing economic output and prices, while exchange rate channel is relatively weaker (Disyatat and Vongsinsirikul, 2003; Boivin et al., 2010; Loyaza and Schmidt-Hebbel, 2002; Angeloni et al., 2003; Smets and Wouters, 2002; Acosta-Ormaechea and Coble, 2011; Singh and Kalirajan, 2007; Patra and Kapur, 2010).

The presence of institutional impediments in the credit market such as administered interest rates could lead to persistence of the impact of the monetary policy up to two years. As suggested by Bhaumik *et al.*, (2010) bank ownership plays a role in monetary policy transmission through the credit channel. Pandit and Vashisht (2011) found that policy rate channel of the transmission mechanism, a hybrid of the traditional interest rate channel and credit channel, works in India, as in other six EMEs considered by them. The changes in policy repo rate affect the spending, saving and investment behaviour of individuals and firms in the economy. In simple terms, other things being equal, the higher interest rates tend to encourage saving rather than spending. Thus, the contractionary monetary policy shock was indeed associated with a statistically significant reduction in real economic output. Moreover, significant bidirectional causality was observed from policy repo rate to economic output.

Conclusion

This section of the study has explored the effectiveness of monetary transmission to commodity price inflation, short-term interest rate, exchange rate and economic output growth in the Indian context, using a structural VAR methodology that has commonly been applied to investigate the monetary policy effectiveness not only in advanced and emerging economies, but also in many low-income ones. Following a quarterly structural vector auto-regression (SVAR) model, we find evidence that policy rate increases have a negative effect on output growth with a lag of two-quarters and a moderating impact on inflation with a lag of three-quarters.

The commodity price inflation experiences a negative impact for the first shock in monetary policy repo rate in 10 – 12 months by 3.05 percent. However, during the 13th to 15th months, there is a spurt in the CPI, leading us to observe the presence of a “price puzzle”. The impulse response functions imply that increase in the policy Repo rate is associated with a decline the maximum decline in short-term lending rate (-5.2688) occurs with a lag of ten quarters with the overall impact continuing through 4 – 10 quarters.

The study shows that a hike in the monetary policy repo rate is associated with an appreciation of te exchange rate by 0.1731 for the first shock in the 3rd quarter. In response to the first shock, the maximum decline (appreciation) in the exchange rate (-7.0856) occurs with a lag of nine quarters with the overall impact continuing through 3–9 quarters. However, the depreciation of ER persists in the 6th, 8th and 10th period. We notice that the domestic currency appreciates initially (during the 1st and 2nd periods) in response to a positive shock to policy repo rate and subsequently depreciates. Estimation of the impact of monetary policy shocks on the economic output growth shows that a hike in monetary policy repo rate is associated with a decline in real GDP growth rate by -1.0655 for the first shock in the 6th quarter. The real GDP growth responds to the policy repo rate shock with a lag of three-quarters. In response to the first shock, the maximum decline in GDP growth (-4.2707) occurs with a lag of eight quarters with the overall impact continuing through 6–8 quarters. The results are consistent with a broad class of theories and suggest that monetary policy has a limited sharp influence on real variables, such as real output. However, the results underscore the importance of interest rate as a potent monetary policy tool.

Monetary policy transmission mechanism in India, an emerging economy, is found to be weaker compared to the advanced economies. The possible reasons could be: One is that the small size of the formal financial sector in India would tend to undermine the effects on bank lending rates on aggregate demand. With the expansion of domestic financial markets and gradual deregulation of interest rates, monetary policy operating procedure in India in the recent years has evolved towards greater reliance on interest rates to signal the stance of monetary policy. This process is bolstered by significant evidence that policy rate changes transmit through the term structure of interest rates, though the intensity of transmission differs across financial markets. The relationship between monetary policy and the term structure of interest rates would also be an interesting avenue for further research which indeed is pursued in the ensuing section of this study. The second possible reason could be: the exchange rate channel is rather weak due to the fact that India remained characterised by a low degree of de facto capital mobility during the sample period, at least when compared to other emerging markets. Further, a possibility is that the RBI’s intervention in the foreign exchange market has tended to mute the exchange rate response to monetary policy. This explains the possibly weak exchange rate channel.

Study 2: Examining the Co-integrating Relationship of Monetary Policy Interest Rate Movements with Rates across Financial Markets

This section details the estimation of the cointegrating relationship of the monetary policy repo rate movements with the rates across the financial markets in India. The baseline VAR model includes the weighted average call money rate (WACMR), weighted average lending rate (WALR) indicating credit market, BSE Sensex showing equity market (SENSEX)[6], Exchange rate (Rupee per US dollar) representing foreign exchange market (ER), and the yield on government securities with residual maturity of 10-years (BOND 10Y) and the yield on the 5-year government securities (BOND 5Y). We also conduct Granger's causality across markets based on a VAR framework using monthly data from January 2010 to December 2015.

I. The Model with 10-year Bond Yield

The baseline model includes five variables given in the order: WACMR, WALR, CPI, SENSEX, ER, and BOND 10Y. The estimation sample has been chosen so as to exclude any structural changes. We employ a VAR model of the form:

$$\boldsymbol{Z_t = A(L)Z_{t-1} + \mu + \varepsilon_t}$$

Z_t is a vector of endogenous variables, A(L) describes parameter matrices, μ is a vector of constant terms and ε_t is a vector of error terms that are assumed to be white noise. The vector Z_t comprises the following variables:

$$\boldsymbol{Z_t = (WACMR_t + WALR_t + SENSEX_t + DER_t + BOND10Y_t)}$$

Where, $WACMR_t$ – Weighted Average Call Money Rate

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[6] SENSEX is an index of the Bombay Stock Exchange (BSE) and is a widely reported index in both domestic and international markets. It is a basket of thirty constituent stocks representing a sample of large liquid and representative companies.

$WALR_t$ – Weighted average lending rate (WALR) indicating credit market

$SENSEX_t$ – BSE Sensex showing equity market

ER_t – the currency exchange rate (nominal exchange rate of Indian rupee per USD)

$BOND10Y_t$ – The yield on government securities with residual maturity of 10-years

The VECM model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1. The WACMR, WALR, and BOND10Y expressed in percent and the ER is the ratio of number of INR per each USD. SENSEX is expressed in the index numbers. The vector of constant terms comprises a linear trend and a constant. Choosing a lag length of one ensures that the error terms dismiss signs of autocorrelation and conditional heteroscedasticity.

The baseline model is estimated with four lags, which are chosen to eliminate residual serial autocorrelation. Moreover, two lags have been indicated by all information selection criteria (Akaike, Schwarz, Hannan-Quinn, Final Prediction Error and LR). The VAR is estimated with a constant and a time trend. The variables in the models are either stationary or integrated of order one, as indicated by Augmented Dickey-Fuller and KPSS tests. Following Sims *et al.*, (1990), the VAR is estimated consistently in levels as Trace and Maximum Eigenvalue tests indicate two cointegration relationships between the variables. Structural Chow breakpoint and sample split tests do not indicate a change in the coefficients in the model. The VAR satisfies the stability condition because all roots of the characteristic polynomial lie within the unit circle.

Table 5.2.1 provides the descriptive statistics of the variables. WACMR rate had a minimum value of 2.42 and a maximum of 14.07 with a mean value of 6.92 in the sample data. WALR ranges from a minimum of 10.00 to a maximum of 13.20 with a mean value of 11.39. SENSEX ranges from a minimum of 6679 to a maximum of 27656 with a mean value of 17295. ER (Rupee to USD) ranges from a minimum of 39.44 to a maximum of 67.02 with a mean value of 50.93. BOND10Y yield ranges from a minimum of 5.26 to a maximum of 8.82 with a mean value of 7.84.

Table 5.2.1: Descriptive Statistics

	WACMR	WALR	SENSEX	ER	BOND10Y
Mean	6.9253	11.3967	17295.57	50.9365	7.8482
Median	7.2300	11.4000	17299.75	47.6320	7.8600
Maximum	14.0700	13.2000	27656.11	67.0219	8.8250
Minimum	2.4200	10.0000	6679.18	39.4400	5.2600
Std. Dev.	2.1380	0.9085	5693.15	8.2653	0.6767
Skewness	0.3591	0.1660	0.0872	0.5918	-1.1922
Kurtosis	4.6042	1.8515	2.4022	1.9829	6.0270
Jarque-Bera	5.7924	2.6800	0.7270	4.5670	27.840
Probability	0.0552	0.2619	0.6952	0.1019	0.0000
Observations	45	45	45	45	45

The correlations among the variables are presented in Table 5.2.2. The correlation between WACMR and BOND 10Y is obviously observed to be statistically significant (0.511*) at the 1 percent level. Similarly, WALR and BOND 10Y exhibit significant negative correlation (-0.3*). As expected WALR and ER have a negative correlation (0.647**). WALR has a negative negative correlation with the SENSEX (-0.803**). ER has a statically significant correlation with SENSEX (0.735**)

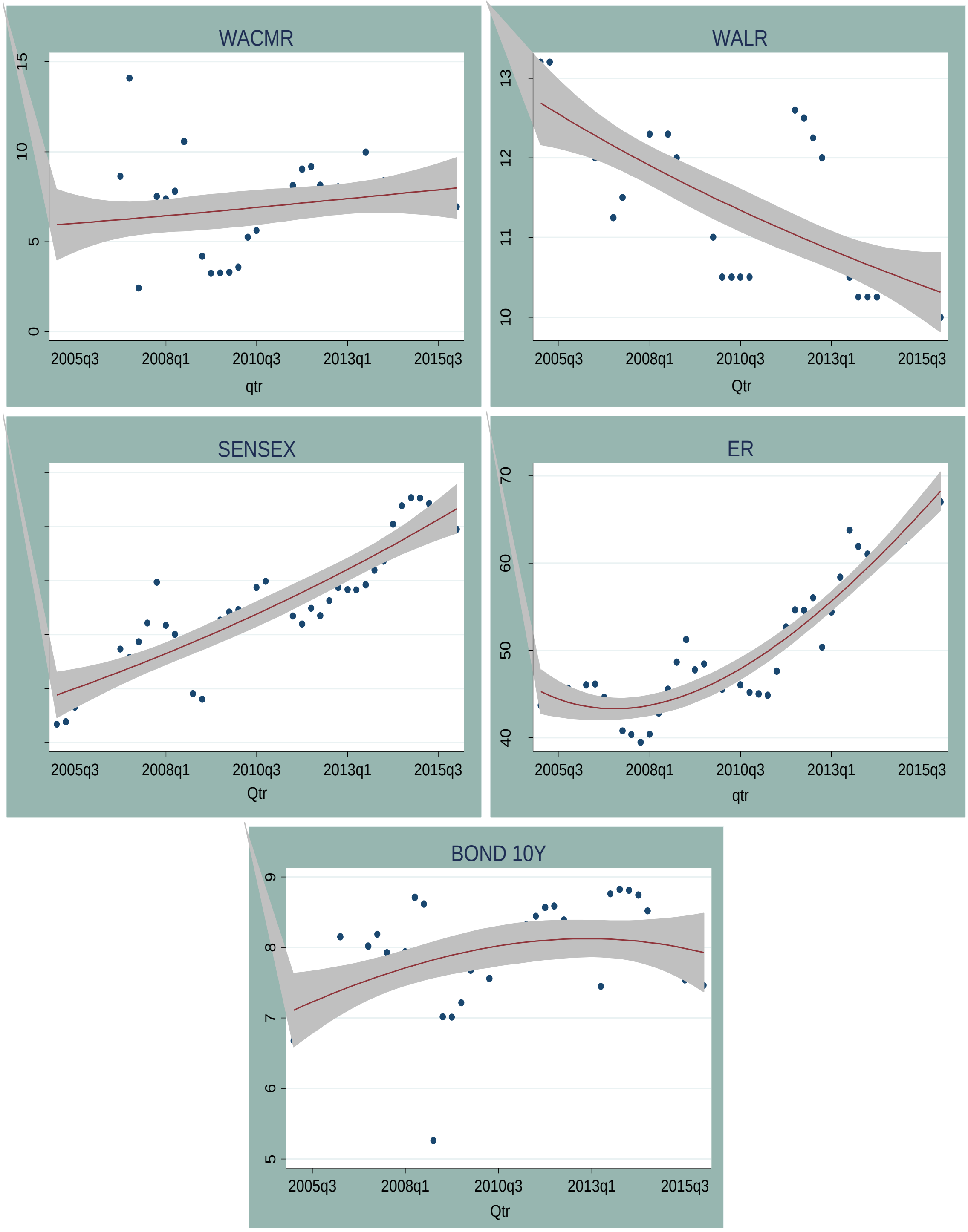
Table 5.2.2: Correlations

	WACMR	WALR	BOND 10Y	ER	SENSEX
WACMR	1				
WALR	-0.113	1			
BOND 10Y	0.511**	-0.300*	1		
ER	0.270	-0.647**	0.219	1	
SENSEX	0.268	-0.803**	0.439**	0.735**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The covariates of the model are presented in Figure 5.2.1.

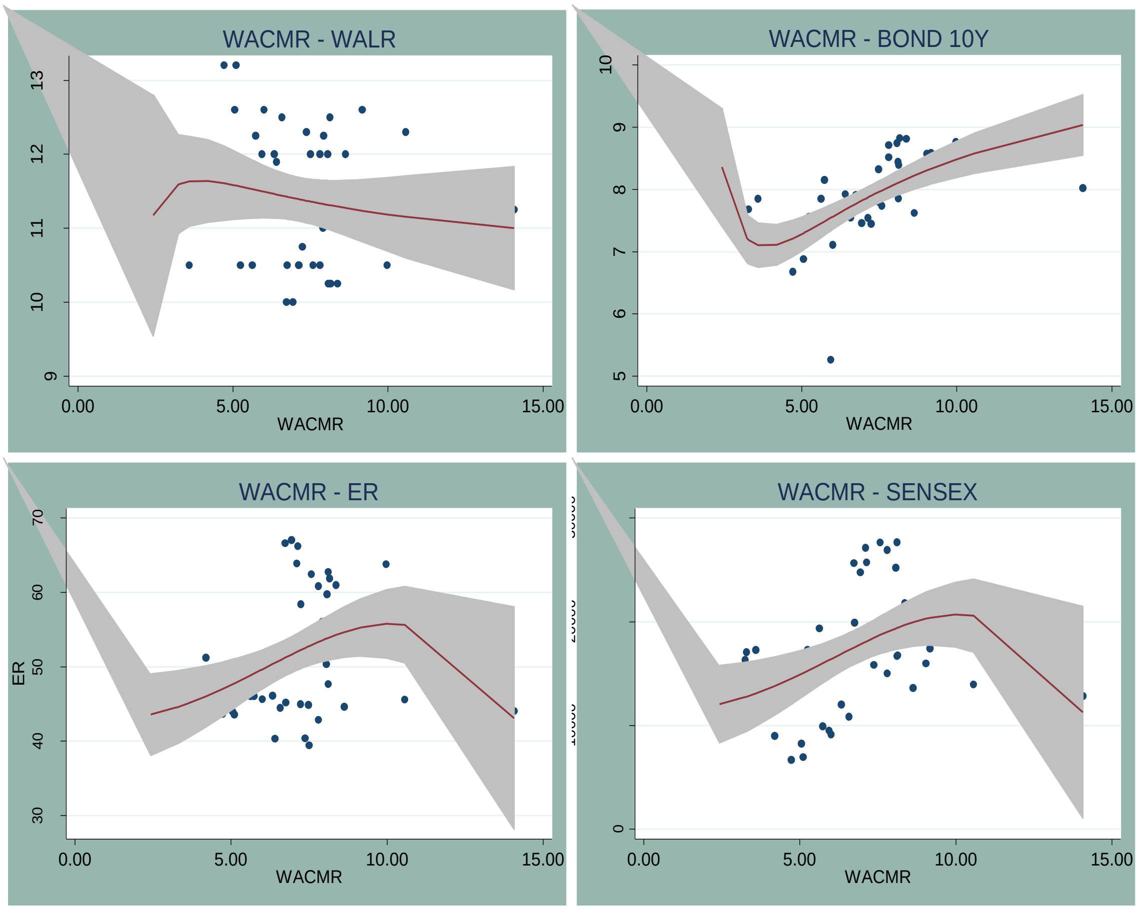
Figure 5.2.1: Covariates – WACMR, WALR, SENSEX, ER, BOND 10Y



Source: Reserve Bank of India database

The interactions of WACMR with other covariates are presented in Figure 5.2.2.

Figure 5.2.2: Interaction of covariates with WCMR



Source: Reserve Bank of India database

The VAR Lag Exclusion Wald Test indicates that for each lag, the χ 2 (Wald) statistic for the joint significance of all endogenous variables at that lag is reported for each equation separately and jointly (last column) (Table 5.2.3). The test suggests that in the first lag of all endogenous variables are statistically significant. Accordingly, first lag should be retained.

Table 5.2.3: VAR Lag Exclusion Wald Tests

	WACMR	WALR	BOND10Y	ER	SENSEX	Joint
Lag 1	16.36	177.05	14.33	534.00	549.59	2120.60
	[0.0058]	[0.0000]	[0.0136]	[0.0000]	[0.0000]	[0.0000]
df	5	5	5	5	5	25

Note: Chi-squared test statistics for lag exclusion
Numbers in [ ] are p-values

Lag Length Selection

An important step in the estimation of the large VAR model is the lag selection. This matters not only for OLS estimates of the autoregressive coefficients but also in impulse-response functions analysis. We perform the sequentially modified likelihood ratio (LR) test is carried out using the criteria are discussed in Lutkepohl (1991, Section 4.3). The test computes various criteria to select the lag order of an unrestricted VAR. Table 5.2.4 displays various information criteria for all lags up to the specified maximum. The table indicates the selected lag from each column criterion by an asterisk "*". Four of the five available tests (Sequential modified LR test, Final prediction error, Akaike information criterion, Schwarz information criterion, and Hannan-Quinn criterion) select lag 1 order and hence there should be 1 lag included in the model. Therefore first lag is chosen for each endogenous variable in their autoregressive and distributed lag structures in the estimable VAR model.

Table 5.2.4: VAR Lag Order Selection Criteria

Endogenous variables: WACMR WALR BOND10Y ER SENSEX

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-722.3	NA	33900000	33.83	34.03	33.90
1	-592.6	223.25*	2620451*	28.95*	30.18*	29.41*
2	-578.0	21.6121	4480336	29.44	31.6992	30.27

Included observations: 43
* indicates lag order selected by the criterion
LR: sequentially modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Estimates

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. The number of lags in the VAR is chosen considering several tests as detailed in the lag selection section of this report. Table 5.2.5 presents the vector autoregression estimates.

Table 5.2.5: Vector Autoregression Estimates

	WACMR	WALR	BOND10Y	ER	SENSEX
WACMR(-1)	0.1534	0.0206	0.0207	0.1068	-281.42
	(0.16)	(0.03)	(0.05)	(0.19)	(127.86)
	[0.943]	[0.613]	[0.403]	[0.549]	[-2.201]
WALR(-1)	0.7345	0.7294	-0.1795	0.4895	-916.59
	(0.55)	(0.11)	(0.17)	(0.65)	(429.70)
	[1.344]	[6.473]	[-1.042]	[0.749]	[-2.133]
BOND10Y(-1)	1.083	0.1008	0.3782	-0.3969	759.737
	(0.55)	(0.11)	(0.17)	(0.66)	(434.16)
	[1.961]	[0.885]	[2.173]	[-0.601]	[1.749]
ER(-1)	-0.0016	-0.0159	-0.0056	0.9388	132.40
	(0.05)	(0.01)	(0.02)	(0.07)	(43.01)
	[-0.028]	[-1.409]	[-0.326]	[14.34]	[3.078]
SENSEX(-1)	0.0001	0	0	0.0002	0.6649
	(0.00)	0.00	0.00	(0.00)	(0.08)
	[1.260]	[-0.826]	[-0.019]	[1.521]	[8.176]
Intercept	-13.143	3.1912	7.1071	-2.8107	5907.38
	(8.79)	(1.81)	(2.77)	(10.51)	(6910.7)
	[-1.495]	[1.760]	[2.565]	[-0.267]	[0.854]
R-squared	0.301	0.8233	0.2739	0.9336	0.9353
Adj. R-squared	0.209	0.8001	0.1783	0.9248	0.9268
Sum sq. resids	137.11	5.829	13.619	196.11	84773418
S.E. equation	1.8996	0.3917	0.5987	2.2718	1493.6
F-statistic	3.2726	35.411	2.8662	106.80	109.91
Log likelihood	-87.43	-17.96	-36.63	-95.31	-380.8
Akaike AIC	4.2472	1.0893	1.9379	4.6051	17.5819
Schwarz SC	4.4905	1.3326	2.1812	4.8484	17.8252
Mean dependent	6.9755	11.3557	7.8748	51.1012	17536.8
S.D. dependent	2.1358	0.8759	0.6604	8.2858	5521.32
Determinant resid covariance (dof adj.)		1264369			
Determinant resid covariance		607475.2			
Log likelihood		-605.14			
Akaike information criterion		28.87			
Schwarz criterion		30.08			

Note: Standard errors in ( ) & t-statistics in [ ]

Robustness tests

We perform multivariate LM test to test the presence of the autocorrelations and the VAR residual portmanteau tests and for autocorrelations to establish the residual autocorrelations. Further, we also perform the VAR Granger causality/block exogeneity Wald tests, residual normality tests, and VAR residual heteroscedasticity tests with without cross terms.

Residual Autocorrelations

The VAR Residual Portmanteau test for autocorrelations is done for further confirmation of serial independence for residuals. Test results are presented in Table 5.2.6. The adjusted Q-Statistics for the corresponding Chi-Square values, given the degrees of freedom, in Table 5.2.6 show that (a) the hypothesis of serial correlations have been rejected for the 5th lag at 5% level. Consequently, Portmanteau test testifies for the serial independence of the VAR residuals ($\hat{u}_{1t}$ and $\hat{u}_{2t}$)).

Table 5.2.6: VAR Residual Portmanteau Tests for Autocorrelations

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	13.4833	NA*	13.7969	NA*	NA*
2	35.9115	0.0730	37.2931	0.0541	25
3	70.2221	0.0311	74.1142	0.0150	50
4	102.8631	0.0181	110.0193	0.0052	75
5	125.1551	0.0451	135.1693	0.0110	100
6	142.8691	0.1309	155.6802	0.0327	125
7	184.0143	0.0307	204.6096	0.0020	150
8	201.9477	0.0796	226.5283	0.0053	175
9	220.0104	0.1582	249.2356	0.0102	200
10	232.9701	0.3436	266.0071	0.0316	225
11	242.4528	0.6221	278.6506	0.1029	250
12	266.5480	0.6314	311.7815	0.0628	275

Note: Null Hypothesis: no residual autocorrelations up to lag h.
*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for the (approximate) chi-square distribution

Residual Serial Correlation

The VAR residual serial correlation LM test is conducted for further confirmation of serial independence of residuals. Under the null hypothesis of no serial correlation of order, the LM statistic is asymptotically distributed χ^2 with κ^2 degrees of freedom. The results of the VAR residual serial correlation LM tests have been presented in Table 5.2.7. It is observed from Table 5.2.7 that the marginal significance of LM statistics for autocorrelation is not large enough to reject the null hypothesis of 'no serial correlation.'

Table 5.2.7: VAR Residual Serial Correlation LM Tests

Lags	LM-Stat	Prob
1	19.7453	0.7601
2	23.2837	0.5610
3	35.7974	0.0747
4	32.1465	0.1538
5	21.2412	0.6791
6	16.3644	0.9035
7	54.6024	0.0006
8	18.4752	0.8216
9	18.4960	0.8206
10	12.6840	0.9801
11	9.1959	0.9983
12	26.1512	0.3996

Note: Null Hypothesis: no serial correlation at lag order h
Probs from chi-square with 36 df.

VAR Residual Normality Test

We perform the residual normality test and Table 5.2.8 reports the multivariate extensions of the Jarque-Bera residual normality test, which compares the third and fourth moments of the residuals to those from the normal distribution. The null hypothesis is of normality, and the acceptance of the hypothesis (because of an insignificant p-value) leads to the conclusion that the residuals are normally distributed.

Table 5.2.8: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	1.0127	7.5211	1	0.0061
2	1.1783	10.1807	1	0.0014
3	-2.4352	43.4897	1	0.0000
4	-0.4249	1.3238	1	0.2499
5	0.8854	5.7492	1	0.0165
Joint		68.2645	5	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	8.5404	56.2759	1	0.0000
2	7.1199	31.1178	1	0.0000
3	13.4656	200.8031	1	0.0000
4	3.9764	1.7478	1	0.1862
5	4.6208	4.8162	1	0.0282
Joint		294.7609	5	0.0000

Component	Jarque-Bera	df	Prob.
1	63.7970	2	0.0000
2	41.2986	2	0.0000
3	244.2928	2	0.0000
4	3.0716	2	0.2153
5	10.5654	2	0.0051
Joint	363.0254	10	0.0000

Note: Null Hypothesis: residuals are multivariate normal
Orthogonalization: Cholesky (Lutkepohl)

VAR Residual Heteroscedasticity Tests

We perform White Heteroscedasticity Test with No Cross Terms option which uses only the levels and squares of the original regressor. Table 5.2.9 reports the joint significance of the regressors excluding the constant term for each test regression. Under the null of no heteroscedasticity or (no misspecification), the non-constant regressors should not be jointly significant.

Table 5.2.9: VAR Residual Heteroskedasticity Tests:
No Cross Terms (only levels and squares)

Joint test:

Chi-sq	df	Prob.
760.0421	756	0.4519

Individual components:

Dependent	R-squared	F(10,33)	Prob.	Chi-sq(10)	Prob.
res1*res1	0.3716	1.9511	0.0729	16.3484	0.0901
res2*res2	0.1224	0.4601	0.9035	5.3843	0.8641
res3*res3	0.1338	0.5096	0.8710	5.8854	0.8248
res4*res4	0.3353	1.6643	0.1317	14.7512	0.1414
res5*res5	0.1392	0.5336	0.8537	6.1245	0.8047
res2*res1	0.1251	0.4718	0.8962	5.5038	0.8551
res3*res1	0.1027	0.3775	0.9477	4.5169	0.9210
res3*res2	0.2231	0.9476	0.5047	9.8160	0.4568
res4*res1	0.3508	1.7828	0.1033	15.4332	0.1170
res4*res2	0.1591	0.6242	0.7823	6.9989	0.7255
res4*res3	0.1778	0.7134	0.7057	7.8211	0.6463
res5*res1	0.3248	1.5877	0.1539	14.2928	0.1601
res5*res2	0.1046	0.3855	0.9441	4.6019	0.9161
res5*res3	0.1403	0.5384	0.8502	6.1716	0.8007
res5*res4	0.2897	1.3459	0.2481	12.7467	0.2382

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row

(All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation.

With a view to examining how changes in policy rate affect other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of other variables (Table 5.2.10). Results suggest a unidirectional causality running from changes in WACMR to other set of variables in view of the joint significance. In the case of SENSEX, we notice a joint significance in the unidirectional causality running from changes in SENSEX to other set of variables.

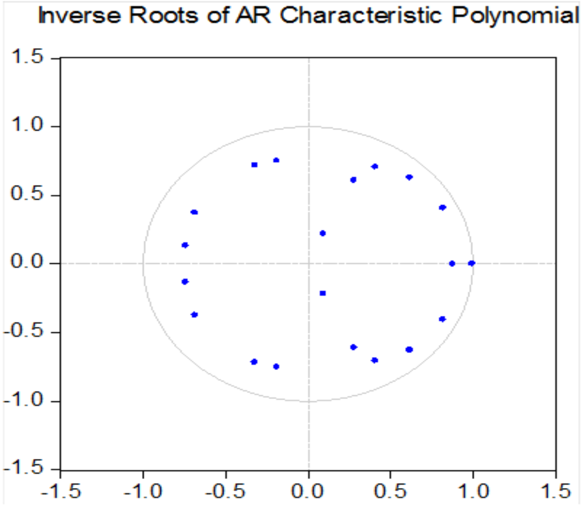
Table 5.2.10: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
WALR	1.8064	1	0.1789
BOND10Y	3.8472	1	0.0498
ER	0.0008	1	0.9774
SENSEX	1.5882	1	0.2076
All	**8.1128**	**4**	**0.0875**
Dependent variable: WALR			
Excluded	Chi-sq	df	Prob.
WACMR	0.3768	1	0.5393
BOND10Y	0.7839	1	0.3760
ER	1.9875	1	0.1586
SENSEX	0.6837	1	0.4083
All	5.8058	4	0.2141
Dependent variable: BOND10Y			
Excluded	Chi-sq	df	Prob.
WACMR	0.1629	1	0.6865
WALR	1.0861	1	0.2973
ER	0.1068	1	0.7438
SENSEX	0.0004	1	0.9847
All	1.9944	4	0.7368
Dependent variable: ER			
Excluded	Chi-sq	df	Prob.
WACMR	0.3017	1	0.5828
WALR	0.5610	1	0.4538
BOND10Y	0.3613	1	0.5478
SENSEX	2.3140	1	0.1282
All	2.7011	4	0.6090
Dependent variable: SENSEX			
Excluded	Chi-sq	df	Prob.
WACMR	4.8446	1	0.0277
WALR	4.5498	1	0.0329
BOND10Y	3.0622	1	0.0801
ER	9.4774	1	0.0021
All	**20.1722**	**4**	**0.0005**

Stability Condition Check

We perform the VAR stability condition check and we observe from Figure 5.2.3 that (a) values of the roots are less than unity (b) modulus values are also less than unity, and (c) the inverse roots of the AR Characteristic Polynomials lie within the Unit Circle. All these observations testify for the stability of the VAR model and thus, all these findings confirm that the estimated VAR model is stable.

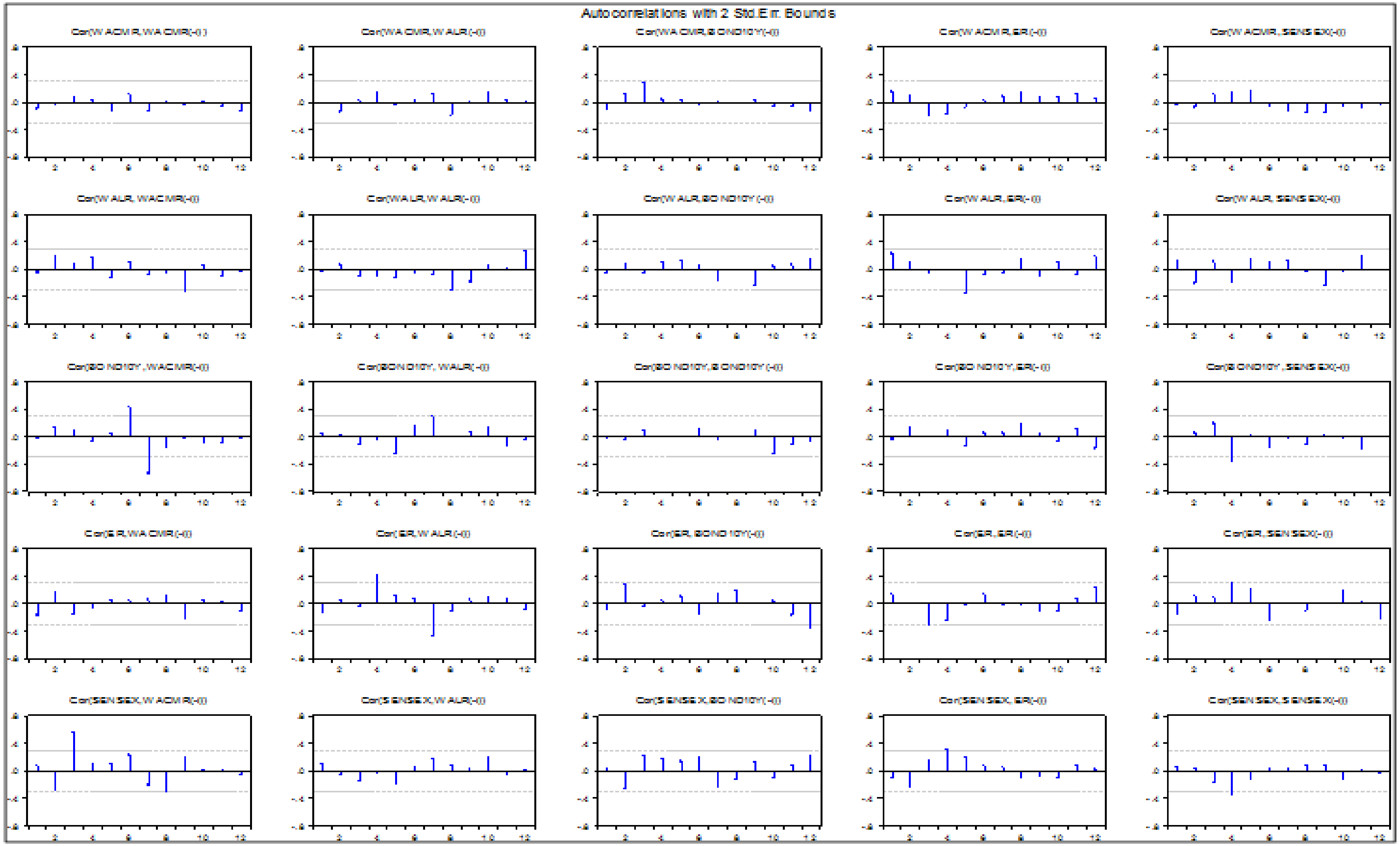
Figure 5.2.3: VAR Stability Condition



Correlograms

Correlograms display the Pairwise cross-correlograms (sample autocorrelations) for the estimated residuals in the VAR for the specified number of lags. The cross-correlograms in the Graph form displays a matrix of Pairwise cross-correlograms (Figure 5.2.4). The dotted line in the graphs represent plus or minus two times the asymptotic standard errors of the lagged correlations.

Figure 5.2.4: Correlograms



Cointegration Test

We use a Cointegration framework to identify systematic interaction effects between the markets. Accordingly, Johansen's Cointegration technique was employed to verify the existence of Cointegration between the markets. Once the order of integration of each variable is determined in three periods, the concept of Cointegration by Johansen and Juselius (1990) method (hereafter JJ method)[7] is used to examine the existence of cointegrating relationship between the variables. This method is considered to be more robust than the Engel-Granger procedure (based the residual). Therefore, we prefer the JJ method, which uses the Vector Auto Regressive (VAR) model to test the number of cointegrating vectors, and the estimation is based on Maximum Likelihood (ML) method. Following Johansen and Juselius (1990) VAR representation of column vector X_t can be written as follows:

$$X_{(t)} = Bz_t + \sum_{i=1}^{k} \Pi_i X_{(t-i)} + \varepsilon_t$$

Where X_t is a column vector of n endogenous variables, z is a (n×1) vector of deterministic variables, ε is an (n × 1) vector of white noise error terms, and Π_i is a (n×n) matrix of coefficients. Since most of the macroeconomic time series variables are non-stationary, VAR of such models is generally estimated in first-difference forms.

Johansen's procedure builds cointegrated variables directly on maximum likelihood estimation and tests for determining the number of cointegrating vectors. JJ test provides two Likelihood Ratio (LR) test statistics for cointegration analysis, the trace (λ_{trace}) statistics, and the maximum eigenvalue (λ_{max}) statistics. The trace statistics tests the null hypothesis that the number of cointegrating relations is *r* against *k* cointegration relations, where k is the number of

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[7] See Philips(1991),Cheung and Lai(1993) and Gonzala (1994)

endogenous variables. The maximum eigenvalue test tests the null hypothesis that there are *r*-cointegrating vectors against an alternative of *r+1* cointegrating vectors. To determine the rank of matrix Π, the test values obtained from the two test statistics are compared with the critical value from Mackinnon-Haug-Michelis (1999). For both tests, if the test statistic value is greater than the critical value, the null hypothesis of *r* cointegrating vectors is rejected in favour of the corresponding alternative hypothesis.

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.2.11, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.2.11: Cointegration Test Results

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.4759	75.6804	69.8189	0.0158
At most 1 *	0.4526	47.9001	47.8561	0.0495
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.4759	27.7803	33.8769	0.2238
At most 1	0.4526	25.9071	27.5843	0.0807
Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
1 Cointegrating Equation(s):	Log likelihood = -602.0496			
Normalized cointegrating coefficients (standard error in parentheses)				
WACMR	WALR	BOND10Y	ER	SENSEX
1	-0.4925	-4.0675	0.0845	-0.0001
	(0.6718)	(0.6600)	(0.0672)	(0.0001)

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.2.12, we show that WACMR, WALR, and ER have a negative error correction term (ECT) coefficient meaning that WACMR, WALR, and ER have a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. ECT coefficients for BOND 10Y and SENSEX are statistically positive, which implies that these two variables do not fit where they suffer a shock and do not adjust to restore their equilibrium. WALR depends negatively on WACMR, BOND 10Y, ER, and SENSEX delayed by one period. The BOND 10Y yield depends negatively on WACMR, WALR, ER, and positively on SENSEX. The ER depends positively on WACMR, WALR, BOND 10Y, and SENSEX. The SENSEX depends positively on WACMR, WALR, BOND 10Y and negatively on ER.

A vector error correction model (VECM) with the order (p – 1):

$$\Delta Y_t = \alpha_1 + p_1 e_1 + \sum_{i=0}^{n} \beta_i \, \Delta Y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i Z_{t-i}$$

$$\Delta X_t = \alpha_2 + p_2 e_{i-1} + \sum_{i=0}^{n} \beta_i \, Y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i Z_{t-i}$$

The above described VECM is equivalent to a Vector Autoregression (VAR p) presentation of the levels X_t. In a VAR model each variable can be endogenous and the changes in a selected target variable in period t depend on the deviations from that specific equilibrium in the previous period and the short-run dynamics. Further, VECM allows for estimation of the long-run effects and to analyze the short-run adjustment process within one model. The variable vector X_t is assumed to be vector integrated of order 1 (I(1), i.e. ΔX_t is vector stationary.

Table 5.2.12: Vector Error Correction Estimates

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
WACMR(-1)	1
WALR(-1)	-0.4925
	(0.6718)
	[-0.7331]
BOND10Y(-1)	-4.0675
	(0.6600)

	[-6.1624]				
ER(-1)	0.0845				
	(0.0672)				
	[1.2589]				
SENSEX(-1)	-0.0001				
	(0.0001)				
	[-0.6938]				
Intercept	28.0704				
Error Correction:	D(WACMR)	D(WALR)	D(BOND10Y)	D(ER)	D(SENSEX)
CointEq1	-0.5128	-0.0473	0.1164	-0.3016	130.6617
	(0.1746)	(0.0360)	(0.0560)	(0.1858)	(154.50)
	[-2.9372]	[-1.3153]	[2.0777]	[-1.6229]	[0.8456]
D(WACMR(-1))	-0.2555	-0.0012	-0.0682	0.0592	-196.2551
	(0.1505)	(0.0310)	(0.0483)	(0.1602)	(133.21)
	[-1.6971]	[-0.0389]	[-1.4127]	[0.3697]	[-1.4732]
D(WALR(-1))	-0.1210	-0.0892	-0.0210	-0.5678	-470.50
	(0.8029)	(0.1654)	(0.2576)	(0.8544)	(710.49)
	[-0.1506]	[-0.5397]	[-0.0814]	[-0.6645]	[-0.6622]
D(BOND10Y(-1))	-0.9414	-0.0991	-0.0272	-1.3308	903.68
	(0.5990)	(0.1234)	(0.1922)	(0.6375)	(530.08)
	[-1.5715]	[-0.8033]	[-0.1415]	[-2.0877]	[1.7047]
D(ER(-1))	0.1831	0.0664	-0.0369	0.0888	57.8140
	(0.1710)	(0.0352)	(0.0549)	(0.1819)	(151.28)
	[1.0707]	[1.8872]	[-0.6726]	[0.4879]	[0.3821]
D(SENSEX(-1))	0.0002	0.0000	0.0000	-0.0003	0.1776
	(0.0002)	(0.0000)	(0.0001)	(0.0002)	(0.1893)
	[1.0391]	[1.0270]	[-0.0403]	[-1.4318]	[0.9382]
Intercept	-0.1265	-0.1339	0.0293	0.6300	256.64
	(0.3536)	(0.0728)	(0.1134)	(0.3762)	(312.86)
	[-0.3578]	[-1.8388]	[0.2582]	[1.6744]	[0.8203]
R-squared	0.3787	0.1191	0.2125	0.1864	0.1373
Adj. R-squared	0.2751	-0.0277	0.0812	0.0508	-0.0065
Sum sq. resids	150.62	6.3881	15.5059	170.56	118000000
S.E. equation	2.0455	0.4212	0.6563	2.1767	1810.04
F-statistic	3.6569	0.8112	1.6189	1.3749	0.9546
Log likelihood	-87.96	-20.01	-39.08	-90.63	-379.74
Akaike AIC	4.4170	1.2567	2.1435	4.5414	17.9880
Schwarz SC	4.7037	1.5434	2.4302	4.8281	18.2747
Mean dependent	0.0426	-0.0744	0.0061	0.5450	414.35
S.D. dependent	2.4025	0.4155	0.6847	2.2342	1804.15
Determinant resid covariance (dof adj.)			2424970		
Determinant resid covariance			997416		
Log likelihood			-602.04		
Akaike information criterion			29.86		
Schwarz criterion			31.50		

The error correction coefficient for WACMR was (-0.5128) and it measures the speed of adjustment of WACMR towards long run equilibrium. The coefficient carries the expected negative sign, significant at 1% level and less than one which is appropriate. The coefficient indicates a feedback of about 51.28% of the previous quarter's disequilibrium from the long run elasticity. About 51.28 percent of disequilibrium "corrected" each quarter by changes in WACMR and about 4.73 percent of disequilibrium corrected each quarter by changes in WALR. Similarly, about 30.16 percent of disequilibrium corrected each quarter by changes in ER. The error correction coefficient for BOND 10Y was 0.1164 and carries the positive sign, indicating that there was a feedback of about 11.64 percent of the previous quarter. The error correction term of SENSEX was about 130 points, indicating that 0.75 percent of disequilibrium is corrected each quarter by changes in SENSEX.

Table 5.2.13: VECM Regression Results

D(WACMR) = C(1)*(WACMR(-1) – 0.492499320627*WALR(-1) – 4.06744977156*BOND10Y(-1) + 0.0845329112199*ER(-1) – 9.54599481395E-05*SENSEX(-1) + 28.0704369641) + C(2) *D(WACMR(-1)) + C(3)*D(WALR(-1)) + C(4)*D(BOND10Y(-1)) + C(5) *D(ER(-1)) + C(6)*D(SENSEX(-1)) + C(7)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.5128	0.1746	-2.9372	0.0057
C(2)	-0.2554	0.1505	-1.6971	0.0983
C(3)	-0.1209	0.8029	-0.1506	0.8811
C(4)	-0.9414	0.5990	-1.5715	0.1248
C(5)	0.1830	0.1709	1.0707	0.2914
C(6)	0.0002	0.0002	1.0390	0.3057
C(7)	-0.1265	0.3535	-0.3578	0.7225
R-squared	0.378681	Mean dependent var		0.042598
Adjusted R-squared	0.275127	S.D. dependent var		2.402482
S.E. of regression	2.04546	Akaike info criterion		4.417023
Sum squared resid	150.6206	Schwarz criterion		4.70373
Log likelihood	-87.96598	Hannan-Quinn criter.		4.522751
F-statistic	3.656869	Durbin-Watson stat		2.274753
Prob(F-statistic)	0.006157			

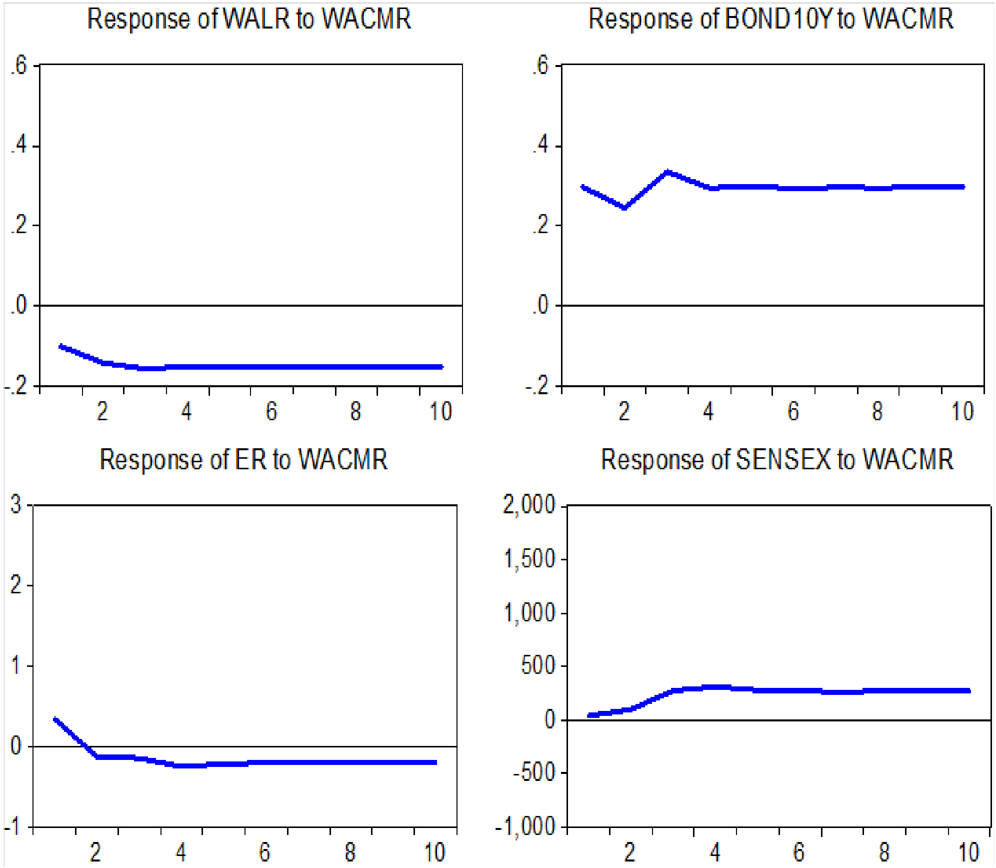
Table 5.2.13 contains the VECM and its coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2), C(3), C(4), C(5), C(6), and C(7) are short run coefficients. C(1) is

the speed of adjustment towards a long run equilibrium which is negative and significant; meaning WALR, BOND 10Y, ER, and SENSEX have long run influence on WACMR.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.2.5.

Figure 5.2.5: Impulse Responses



The impulse responses show the effect of an unexpected 1 percentage point increase in WACMR on all other variables in the VECM. An unexpected rise in WACMR is associated with a decline in WALR by around 0.1 in the first period, 0.14 in the 2nd period. The decline reaches its trough at 0.1559 in the 3rd period. From the 7th period onwards the decline stabilizes at 0.1496 (Table 5.2.14). An unexpected rise in WACMR is associated with a rise in BOND 10Y yield by around 0.29 in the first period and reaches a peak of 0.3353 in the 3rdnd period. The rise continues to hover around a rise of 0.2947 to 0.2957 during the 4th to 10th period.

Table 5.2.14: Impulse Responses

Response to Cholesky One +- S.D. Innovations

Response of WALR:	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	-0.1000	0.4092	0.0000	0.0000	0.0000
2	-0.1415	0.3863	0.0607	0.0923	0.0761
3	-0.1559	0.3822	0.1063	0.0901	0.0401
4	-0.1503	0.3916	0.1066	0.0710	0.0281
5	-0.1501	0.3940	0.1055	0.0694	0.0349
6	-0.1498	0.3923	0.1052	0.0712	0.0365
7	-0.1495	0.3916	0.1037	0.0715	0.0358
8	-0.1495	0.3916	0.1034	0.0717	0.0358
9	-0.1496	0.3917	0.1037	0.0717	0.0358
10	-0.1496	0.3917	0.1038	0.0717	0.0357
Response of BOND10Y:	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	0.2973	0.1174	0.5732	0.0000	0.0000
2	0.2450	0.0299	0.2871	-0.0462	-0.0212
3	0.3353	0.0113	0.1843	-0.0070	-0.0048
4	0.2947	0.0017	0.1791	0.0272	0.0136
5	0.2982	0.0043	0.2035	0.0279	-0.0007
6	0.2934	0.0089	0.2084	0.0205	-0.0038
7	0.2956	0.0102	0.2100	0.0185	-0.0027
8	0.2954	0.0096	0.2087	0.0187	-0.0018
9	0.2959	0.0092	0.2080	0.0191	-0.0018
10	0.2957	0.0091	0.2077	0.0192	-0.0018
Response of ER:	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	0.3436	-0.1421	-0.3059	2.1227	0.0000
2	-0.1310	-0.3472	-0.5425	2.4974	-0.4545
3	-0.1433	-0.1224	-0.0936	2.3874	-0.6445
4	-0.2532	-0.0195	0.1458	2.2701	-0.6336
5	-0.2133	-0.0080	0.1784	2.2163	-0.6344
6	-0.2027	-0.0204	0.1269	2.2130	-0.6195
7	-0.1949	-0.0298	0.1045	2.2268	-0.6124
8	-0.1982	-0.0325	0.1022	2.2334	-0.6128
9	-0.1991	-0.0315	0.1060	2.2333	-0.6151

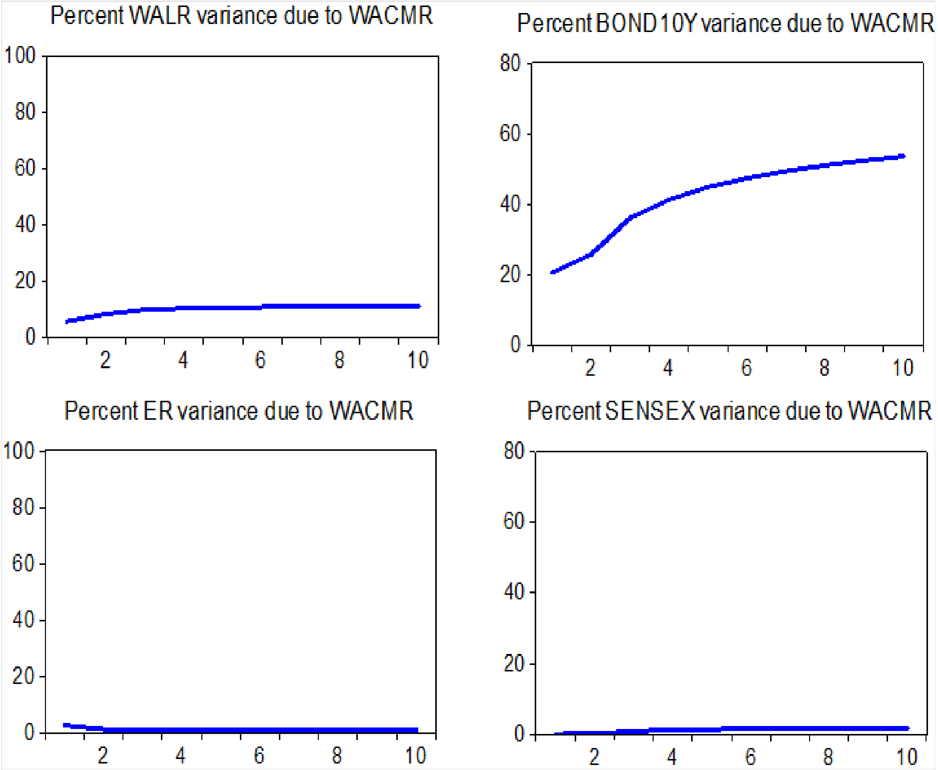
10	-0.1998	-0.0304	0.1080	2.2321	-0.6156
Response of SENSEX:	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	39.1452	41.3411	529.7808	-808.7014	1529.1620
2	99.2793	-136.7635	809.5549	-796.0870	1781.6990
3	275.9928	-303.2903	336.2684	-806.3105	1697.2250
4	312.6293	-341.9258	127.9378	-722.0274	1745.5240
5	278.9882	-350.2345	157.6891	-665.3636	1758.4450
6	266.8814	-342.1887	200.1426	-671.4604	1735.8750
7	266.6815	-333.5356	211.2615	-685.7973	1729.9620
8	268.1429	-332.0687	211.0712	-689.0320	1733.3000
9	268.9663	-333.4570	208.5770	-688.1040	1734.7680
10	269.3171	-334.2174	206.9616	-687.2867	1734.7460

A shock rise in WACMR is associated with a rise in ER by 0.3436 in the first period, and declines by 0.1310 in the 2nd period. The decline reaches the peak of 0.2532 in the 4th period and hovers around 0.2133 to 0.1998 during the 5th to 10th period. An unexpected rise in WACMR is associated with a rise in SENSEX around 39 points in the first period and reaches a peak of 312 points in the 4th period. The rise continues to hover around a rise of 266 to 269 during the 6th to 10th period.

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.2.6: Variance Decompositions



The variance of decomposition is presented in Figure 5.2.6. We notice that at period 10, 19.42 percent of the errors in the forecast of WALR are attributed to WACMR (11.06 percent), BOND 10Y (4.79 percent), ER (2.72 percent), and SENSEX (0.83 percent) shocks in the recursive VAR (Table 5.2.15). Similarly, at period 10, 54.85 percent of the errors in the forecast of BOND 10Y are attributed to WACMR (53.52 percent), WALR (0.93 percent), ER (0.34 percent), and SENSEX (0.04 percent) shocks in the recursive VAR. In the case of ER at the same 10th period, 7.9 percent of the error in the forecast is attributed to WACMR (0.83 percent), WALR (0.28 percent), BOND 10Y (0.91percent), and SENSEX (5.94 percent) shocks in the recursive VAR. For SENSEX at the same 10th period, 21.48 percent of the error in the forecast is attributed to WACMR (1.65 percent), WALR (2.42 percent), BOND 10Y (3.46 percent), and ER (13.92 percent) shocks in the recursive VAR.

Table 5.2.15: Variance Decompositions

Variance Decomposition of WALR:	S.E.	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	2.0455	5.6389	94.3611	0.0000	0.0000	0.0000
2	2.3888	8.2332	86.8316	1.0107	2.3365	1.5879
3	2.9132	9.7678	83.2145	2.6966	2.9910	1.3302
4	3.2866	10.2627	82.2320	3.5189	2.8936	1.0929
5	3.6314	10.5291	81.6963	3.9721	2.8058	0.9966
6	3.9334	10.7090	81.3062	4.2674	2.7735	0.9439
7	4.2163	10.8362	81.0467	4.4577	2.7561	0.9034
8	4.4809	10.9308	80.8568	4.5952	2.7443	0.8729
9	4.7316	11.0057	80.7046	4.7047	2.7356	0.8495
10	4.9696	11.0655	80.5823	4.7936	2.7281	0.8305
Variance Decomposition of BOND10Y:	S.E.	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	0.4212	20.5248	3.2024	76.2728	0.0000	0.0000
2	0.6039	25.7369	2.5468	71.2679	0.3703	0.0781
3	0.7457	36.0667	2.0481	61.5177	0.3021	0.0655
4	0.8656	41.2410	1.7572	56.5769	0.3467	0.0782
5	0.9717	44.8178	1.5226	53.2118	0.3801	0.0677
6	1.0668	47.3364	1.3504	50.8788	0.3733	0.0611
7	1.1536	49.3541	1.2147	49.0149	0.3611	0.0551
8	1.2344	50.9961	1.1049	47.4970	0.3520	0.0501
9	1.3102	52.3716	1.0138	46.2234	0.3454	0.0459
10	1.3819	53.5267	0.9374	45.1532	0.3403	0.0424
Variance Decomposition of ER:	S.E.	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	0.6563	2.4924	0.4263	1.9754	95.1059	0.0000
2	0.7594	1.1645	1.2120	3.3403	92.5049	1.7784
3	0.8504	0.8765	0.8763	2.2320	92.5163	3.4989
4	0.9182	0.9392	0.6668	1.7851	92.2383	4.3706
5	0.9871	0.9213	0.5422	1.5615	92.0253	4.9497
6	1.0509	0.8975	0.4587	1.3645	91.9795	5.2997
7	1.1119	0.8714	0.3984	1.2063	91.9971	5.5268
8	1.1694	0.8539	0.3528	1.0842	92.0124	5.6967
9	1.2243	0.8407	0.3168	0.9899	92.0175	5.8351
10	1.2767	0.8307	0.2877	0.9147	92.0187	5.9482
Variance Decomposition of SENSEX:	S.E.	WACMR	WALR	BOND10Y	ER	SENSEX
Period 1	2.1767	0.0468	0.0522	8.5668	19.9618	71.3725
2	3.4079	0.1466	0.2628	12.0494	16.5768	70.9644
3	4.2158	0.7561	0.9706	9.0595	16.7343	72.4795
4	4.8387	1.2048	1.4910	6.9280	15.9902	74.3860
5	5.3671	1.3748	1.8390	5.6968	15.1618	75.9276
6	5.8433	1.4644	2.0544	4.9510	14.6844	76.8458
7	6.2871	1.5288	2.1880	4.4304	14.4147	77.4381
8	6.7039	1.5792	2.2846	4.0346	14.2181	77.8834
9	7.0965	1.6198	2.3625	3.7218	14.0590	78.2370
10	7.4682	1.6529	2.4264	3.4689	13.9287	78.5231

Cholesky Ordering: WACMR WALR BOND10Y ER SENSEX

II. The Model with 5-year Bond Yield

In this section we assess the cointegrating relationship of the monetary policy repo rate movements with the rates across the financial markets in India using the 5-year government security. The baseline VAR model includes the weighted average call money rate, weighted average lending rate (WALR) indicating credit market, BSE Sensex showing equity market, Exchange rate (Rupee per US dollar) representing foreign exchange market, and the yield on government securities with residual maturity of 5-year government securities. We conduct Granger's causality across markets based on a VAR framework using monthly data from January 2010 to December 2015.

The vector Z_t comprises the following variables:

$$\boldsymbol{Z_t = (WACMR_t + WALR_t + SENSEX_t + DER_t + BOND\ 5Y_t)}$$

where, $WACMR_t$ – Weighted Average Call Money Rate

$WALR_t$ – Weighted average lending rate (WALR) indicating credit market

$SENSEX_t$ – BSE Sensex showing equity market

ER_t – the currency exchange rate (nominal exchange rate of Indian rupee per USD)

BOND $5Y_t$ – The yield on government securities with residual maturity of 10-years

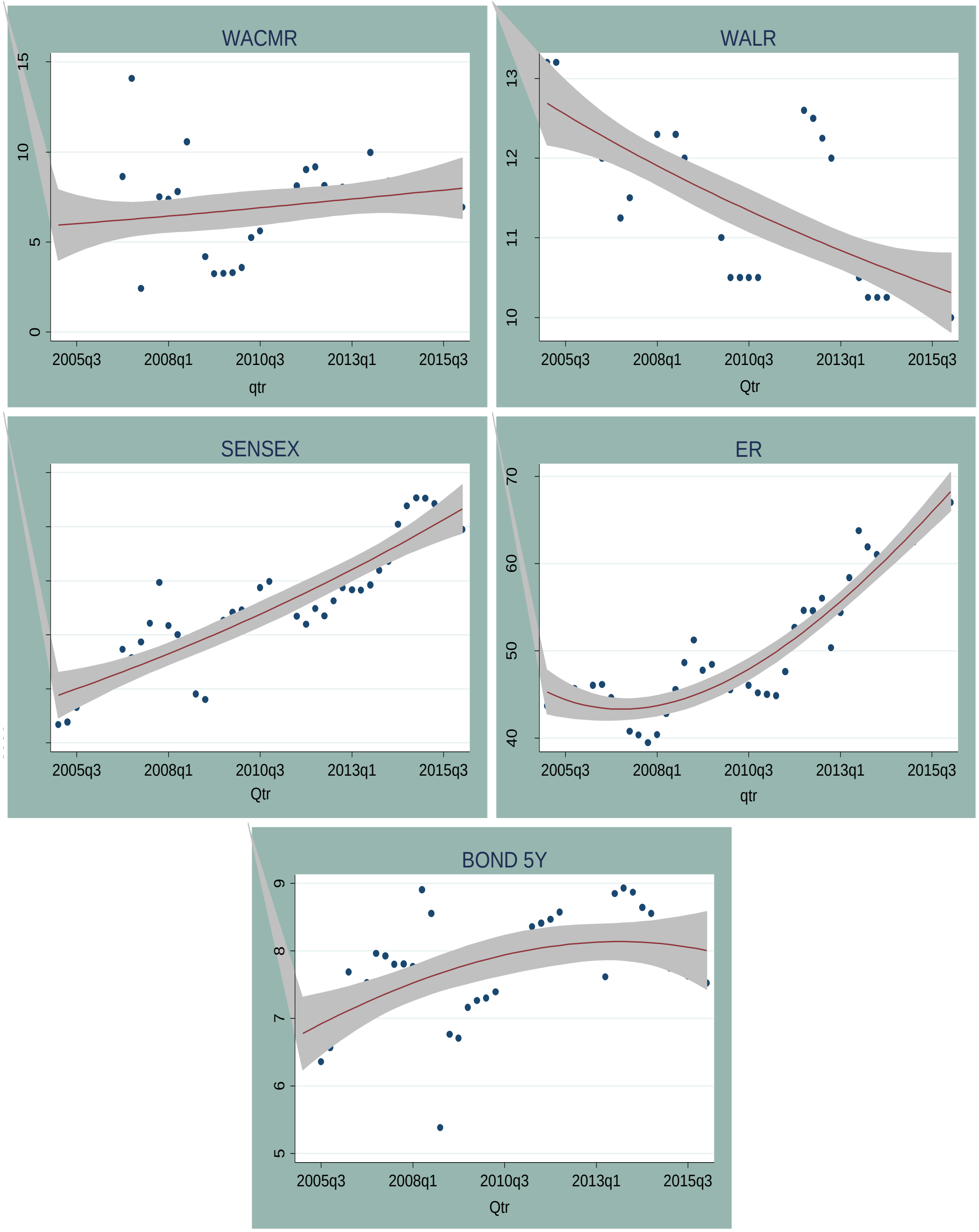
The VECM model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1. The WACMR, WALR, and BOND 5Y yield are expressed in percent and ER is the ratio of number of INR per each USD. SENSEX is expressed in the index numbers. Descriptive statistics in Table 5.2.16 reveals that BOND 5Y yield ranges from a minimum of 5.38 to a maximum of 8.93 with a mean value of 7.74.

Table 5.2.16: Descriptive Statistics

	WACMR	WALR	SENSEX	ER	BOND5Y
Mean	6.9253	11.3967	17295	50.9365	7.7499
Median	7.2300	11.4000	17299	47.6320	7.8050
Maximum	14.070	13.2000	27656	67.0219	8.9340
Minimum	2.4200	10.0000	6679	39.4400	5.3810
Std. Dev.	2.1380	0.9085	5693	8.2653	0.7525
Skewness	0.3591	0.1660	0.0872	0.5918	-0.7350
Kurtosis	4.6042	1.8515	2.4022	1.9829	3.7769
Jarque-Bera	5.7924	2.6800	0.7270	4.5670	5.1839
Probability	0.0552	0.2619	0.6952	0.1019	0.0749
Observations	45	45	45	45	45

The covariates of the model are presented in Figure 5.2.7.

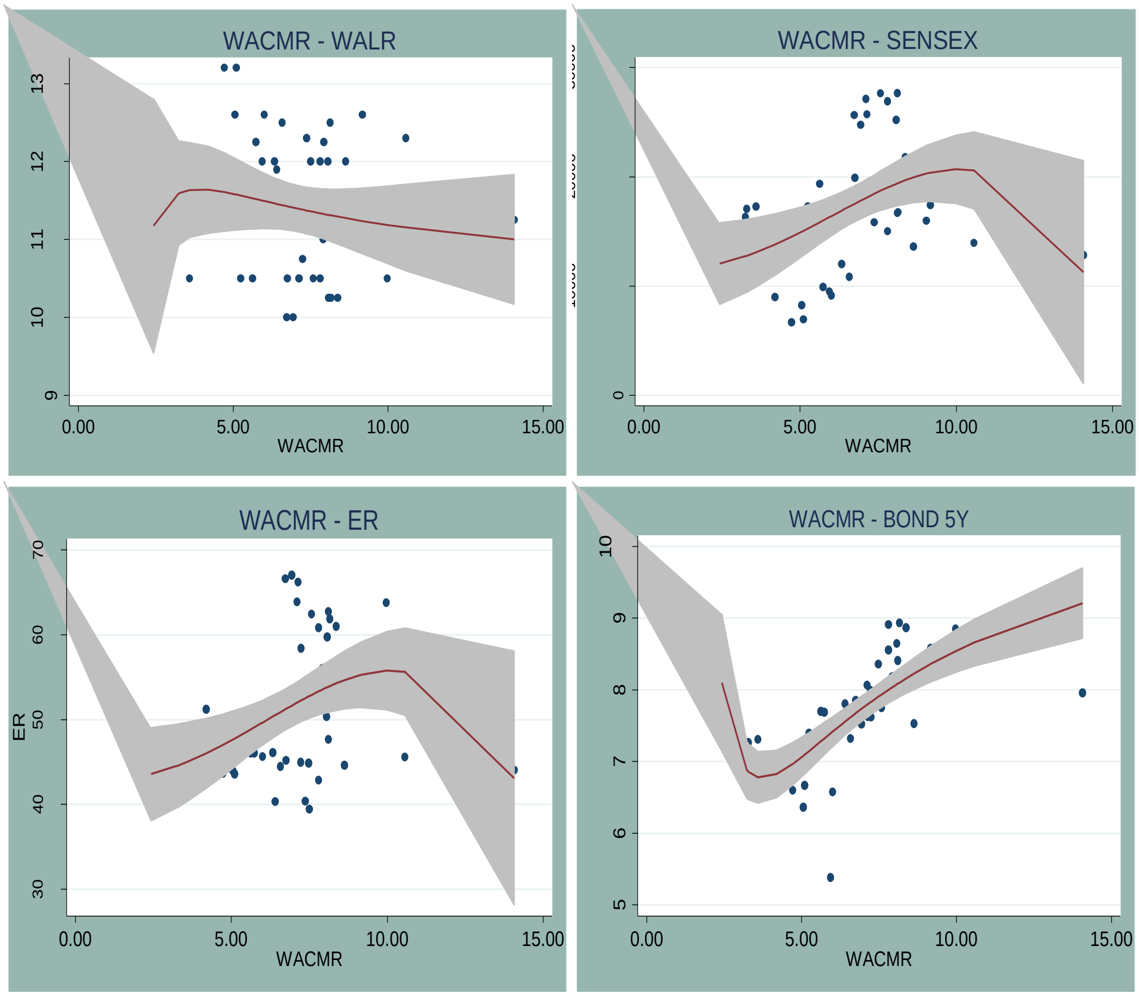
Figure 5.2.7: Covariates – WACMR, WALR, SENSEX, ER, BOND 5Y



Source: Reserve Bank of India database

The interactions of WACMR with other covariates are presented in Figure 5.2.8.

Figure 5.2.8: Interaction of covariates with WCMR (BOND 5Y model)



Source: Reserve Bank of India database

Lag Length Selection

We perform the sequentially modified likelihood ratio (LR) test using the criteria are discussed in Lutkepohl (1991, Section 4.3). The test computes various criteria to select the lag order of an unrestricted VAR. Table 5.2.17 displays various information criteria for all lags up to the specified maximum. The table indicates the selected lag from each column criterion by an asterisk "*". Four of the five available tests (Sequential modified LR test, Final prediction error, Akaike information criterion, Schwarz information criterion, and Hannan-Quinn criterion) select lag 1 order and hence there should be 1 lag included in the model. Therefore first lag is chosen for each endogenous variable in their autoregressive and distributed lag structures in the estimable VAR model.

Table 5.2.17: VAR Lag Order Selection Criteria

Endogenous variables: WACMR WALR BOND5Y ER SENSEX

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-738.5	NA	32800000	33.79	34.00	33.87
1	-601.6	236.45*	2045799*	28.71*	29.92*	29.16*

Included observations: 43
* indicates lag order selected by the criterion
LR: sequentially modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Estimates

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. The number of lags in the VAR is chosen considering several tests as detailed in the lag selection section of this report. Table 5.2.18 presents the vector autoregression estimates.

Table 5.2.18: Vector Autoregression Estimates

Standard errors in ( ) & t-statistics in [ ]

	WACMR	WALR	BOND5Y	ER	SENSEX
WACMR(-1)	-0.0782	0.0160	-0.0223	-0.1641	-178.4639
	-0.2258	-0.0406	-0.0703	-0.2460	-119.9940
	[-0.34611]	[0.39288]	[-0.31707]	[-0.66684]	[-1.48727]
WACMR(-2)	-0.1253	0.0713	0.0584	0.0434	-89.8889
	-0.2283	-0.0411	-0.0711	-0.2488	-121.3300
	[-0.54864]	[1.73537]	[0.82097]	[0.17435]	[-0.74087]
WACMR(-3)	-0.0500	0.0212	0.0317	0.0483	403.6137
	-0.2227	-0.0401	-0.0694	-0.2426	-118.3370
	[-0.22470]	[0.52817]	[0.45736]	[0.19927]	[3.41072]
WALR(-1)	0.3356	0.6770	-0.3299	-0.5108	-930.0240
	-1.0422	-0.1876	-0.3246	-1.1354	-553.7920
	[0.32203]	[3.60949]	[-1.01631]	[-0.44992]	[-1.67937]
WALR(-2)	-0.1413	0.1907	0.1731	0.9990	-294.4877
	-1.2122	-0.2181	-0.3776	-1.3206	-644.1200
	[-0.11656]	[0.87399]	[0.45844]	[0.75647]	[-0.45719]

WALR(-3)	0.9374	-0.3045	-0.1428	0.8595	-442.5748
	-0.9594	-0.1727	-0.2989	-1.0453	-509.8160
	[0.97699]	[-1.76369]	[-0.47778]	[0.82228]	[-0.86811]
BOND5Y(-1)	1.2889	-0.0476	0.5831	-0.4121	481.3064
	-0.7403	-0.1332	-0.2306	-0.8065	-393.3620
	[1.74119]	[-0.35749]	[2.52875]	[-0.51100]	[1.22357]
BOND5Y(-2)	0.5617	0.0168	-0.2613	1.4986	-778.1925
	-0.7674	-0.1381	-0.2390	-0.8361	-407.7850
	[0.73195]	[0.12136]	[-1.09300]	[1.79250]	[-1.90834]
BOND5Y(-3)	0.8228	-0.0801	0.1419	-0.8537	657.1476
	-0.7822	-0.1408	-0.2437	-0.8522	-415.6510
	[1.05191]	[-0.56933]	[0.58223]	[-1.00181]	[1.58101]
ER(-1)	0.0605	0.0577	-0.0137	1.0789	-7.1038
	-0.1893	-0.0341	-0.0590	-0.2063	-100.6020
	[0.31981]	[1.69355]	[-0.23190]	[5.23061]	[-0.07061]
ER(-2)	0.0624	-0.0886	0.0793	-0.0448	1.5572
	-0.2830	-0.0509	-0.0882	-0.3083	-150.3790
	[0.22066]	[-1.74004]	[0.89918]	[-0.14532]	[0.01036]
ER(-3)	-0.1878	-0.0091	-0.0914	-0.2016	149.4883
	-0.2343	-0.0422	-0.0730	-0.2553	-124.4970
	[-0.80142]	[-0.21696]	[-1.25277]	[-0.78983]	[1.20073]
SENSEX(-1)	0.0002	0.0001	0.0000	0.0001	0.6858
	-0.0003	-0.0001	-0.0001	-0.0003	-0.1524
	[0.75026]	[1.90199]	[-0.19032]	[0.29511]	[4.50020]
SENSEX(-2)	-0.0001	-0.0001	0.0002	0.0002	-0.0023
	-0.0004	-0.0001	-0.0001	-0.0004	-0.1873
	[-0.14442]	[-2.10072]	[1.43401]	[0.64597]	[-0.01254]
SENSEX(-3)	0.0000	0.0000	-0.0001	0.0001	-0.1745
	-0.0003	0.0000	-0.0001	-0.0003	-0.1412
	[-0.06682]	[0.59479]	[-1.67375]	[0.32236]	[-1.23615]
Intercept	-24.4357	7.0935	8.3218	-15.4011	17002.4900
	-14.0303	-2.5248	-4.3704	-15.2854	-7455.3800
	[-1.74163]	[2.80947]	[1.90416]	[-1.00757]	[2.28057]
R-squared	0.4034	0.8690	0.4591	0.9530	0.9712
Adj. R-squared	0.0592	0.7934	0.1471	0.9258	0.9546
Sum sq. resids	112.5109	3.6436	10.9167	133.5397	31768600
S.E. equation	2.0802	0.3743	0.6480	2.2663	1105
F-statistic	1.1721	11.4985	1.4715	35.1152	58.4492
Log likelihood	-80.2884	-8.2566	-31.3005	-83.8867	-343.85
Akaike AIC	4.5852	1.1551	2.2524	4.7565	17.1361
Schwarz SC	5.2471	1.8170	2.9144	5.4185	17.7981
Mean dependent	7.0660	11.2821	7.8361	51.4512	18010
S.D. dependent	2.1447	0.8236	0.7016	8.3211	5186
Determinant resid covariance (dof adj.)			635420		
Determinant resid covariance			57767		
Log likelihood			-528.22		
Akaike information criterion			28.9631		
Schwarz criterion			32.2729		

Causality Analysis

With a view to examining how changes in policy rate affect other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of other variables (Table 5.2.19). In this case, empirical results suggest a unidirectional causality running from changes in WALR to WACMR, ER, and SENSEX.

Table 5.2.19: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
WALR	0.2642	1	0.6072
BOND5Y	0.8885	1	0.3459
ER	0.0156	1	0.9007
SENSEX	0.3915	1	0.5315
All	1.7674	4	0.7784
Dependent variable: WALR			
Excluded	Chi-sq	df	Prob.
WACMR	3.1674	1	0.0751
BOND10Y	1.3670	1	0.2423
ER	4.1960	1	0.0405
SENSEX	2.9236	1	0.0873
All	6.4060	4	0.1708
Dependent variable: BOND5Y			
Excluded	Chi-sq	df	Prob.
WACMR	1.4859	1	0.2229
WALR	0.4588	1	0.4982
ER	0.0566	1	0.8119
SENSEX	0.0395	1	0.8425
All	2.4330	4	0.6567
Dependent variable: ER			
Excluded	Chi-sq	df	Prob.
WACMR	0.0215	1	0.8835
WALR	0.0147	1	0.9036
BOND10Y	1.2935	1	0.2554
SENSEX	0.8630	1	0.3529
All	4.1028	4	0.3923
Dependent variable: SENSEX			
Excluded	Chi-sq	df	Prob.
WACMR	0.1380	1	0.7103
WALR	1.5037	1	0.2201
BOND10Y	0.0035	1	0.9531
ER	0.0079	1	0.9290
All	1.8219	4	0.7685

Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.2.20, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.2.20: Cointegration Test Results

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.7427	119.6603	69.8189	0.0000
At most 1 *	0.6108	63.9974	47.8561	0.0008
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.7427	55.6629	33.8769	0.0000
At most 1	0.6108	38.6951	27.5843	0.0013
Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
1 Cointegrating Equation(s): Log likelihood = -508.8897 Normalized cointegrating coefficients (standard error in parentheses)				
WACMR	WALR	BOND5Y	ER	SENSEX
1	-0.1133	-4.7697	-0.4148	0.0007
	(0.4710)	(0.4356)	(0.0612)	(0.0001)

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.2.21, we show that WACMR and SENSEX have a negative error correction term (ECT) coefficient meaning that ER and SENSEX have a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. ECT coefficients for WALR, ER and BOND 5Y are statistically positive, which implies that these variables do not fit where they suffer a shock and do not adjust to restore their equilibrium. WALR depends negatively on BOND 5Y yield and SENSEX delayed by one period. The BOND 5Y yield depends negatively on WACMR, ER, SENSEX and positively on WALR. The ER depends positively on WALR, SENSEX and negatively on WACMR and BOND 5Y. The SENSEX depends positively on WACMR, WALR, BOND 5Y and negatively on ER.

Table 5.2.21: Vector Error Correction Estimates

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
WACMR(-1)	1
WALR(-1)	-0.5783
	-0.4116
	[-1.4050]
BOND5Y(-1)	-2.4710
	-0.3733
	[-6.6197]
ER(-1)	-0.1528
	-0.0410
	[-3.7287]
SENSEX(-1)	0.0002
	-0.0001
	[2.4880]
Intercept	22.8862

Error Correction:	D(WACMR)	D(WALR)	D(BOND5Y)	D(ER)	D(SENSEX)
CointEq1	-0.7323	0.1022	0.0885	0.0041	-427.7638
	-0.2790	-0.0553	-0.0889	-0.3024	-237.1830
	[-2.6244]	[1.8475]	[0.9960]	[0.0136]	[-1.8035]
D(WACMR(-1))	-0.0744	-0.0711	-0.0783	-0.0320	63.6749
	-0.2016	-0.0400	-0.0642	-0.2185	-171.3990
	[-0.3687]	[-1.7797]	[-1.2189]	[-0.1465]	[0.3715]
D(WALR(-1))	0.3999	0.0108	-0.1678	-0.1021	-810.9714
	-0.7780	-0.1543	-0.2478	-0.8433	-661.3400
	[0.5140]	[0.0700]	[-0.6773]	[-0.1210]	[-1.2262]
D(BOND5Y(-1))	-0.6121	0.1505	-0.0384	-0.8004	32.4352
	-0.6493	-0.1287	-0.2068	-0.7038	-551.9460
	[-0.9426]	[1.1692]	[-0.1856]	[-1.1373]	[0.0587]
D(ER(-1))	-0.0219	0.0713	-0.0133	0.0488	13.3036
	-0.1756	-0.0348	-0.0559	-0.1903	-149.2590
	[-0.1247]	[2.0484]	[-0.2379]	[0.2562]	[0.0891]
D(SENSEX(-1))	0.0001	0.0001	0.0000	-0.0002	0.0399
	-0.0002	0.0000	-0.0001	-0.0003	-0.1930
	[0.6256]	[1.7098]	[-0.1987]	[-0.9289]	[0.2068]
Intercept	0.0409	-0.1462	0.0255	0.6350	325.4713
	-0.3623	-0.0718	-0.1154	-0.3927	-307.9810
	[0.1130]	[-2.0357]	[0.2207]	[1.6169]	[1.0567]
R-squared	0.3587	0.1573	0.1085	0.1289	0.1783
Adj. R-squared	0.2518	0.0169	-0.0401	-0.0163	0.0413
Sum sq. resids	155.47	6.11	15.76	182.63	112000000
S.E. equation	2.0782	0.4120	0.6618	2.2524	1766.47
F-statistic	3.3554	1.1201	0.7304	0.8876	1.3019
Log likelihood	-88.65	-19.07	-39.44	-92.11	-378.69
Akaike AIC	4.4487	1.2124	2.1600	4.6097	17.9393
Schwarz SC	4.7354	1.4991	2.4468	4.8964	18.2260

Mean dependent	0.0426	-0.0744	0.0199	0.5450	414.36
S.D. dependent	2.4025	0.4155	0.6489	2.2342	1804.16
Determinant resid covariance (dof adj.)			2019297		
Determinant resid covariance			830559		
Log likelihood			-598.11		
Akaike information criterion			29.68		
Schwarz criterion			31.32		

The error correction coefficient for BOND 5Y was (0.0885) and carries the positive sign indicating a feedback effect of 8.85 percent from the previous quarter. The error correction term of SENSEX is found to be 427 points indicating that about 2.46 percent of disequilibrium is corrected each quarter by changes in SENSEX.

Table 5.2.22: VECM Regression Results

D(WACMR) = C(1)*(WACMR(-1) - 0.578278572247*WALR(-1) - 2.47101355124*BOND5Y(-1) - 0.152839349043*ER(-1) + 0.000213324101898*SENSEX(-1) + 22.8861499639) + C(2) *D(WACMR(-1)) + C(3)*D(WALR(-1)) + C(4)*D(BOND5Y(-1)) + C(5) *D(ER(-1)) + C(6)*D(SENSEX(-1)) + C(7)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.7323	0.2790	-2.6244	0.0127
C(2)	-0.0744	0.2016	-0.3688	0.7145
C(3)	0.3999	0.7780	0.5140	0.6104
C(4)	-0.6121	0.6493	-0.9426	0.3522
C(5)	-0.0219	0.1756	-0.1248	0.9014
C(6)	0.0001	0.0002	0.6257	0.5355
C(7)	0.0409	0.3623	0.1130	0.9107
R-squared	0.3587	Mean dependent var		0.0426
Adjusted R-squared	0.2518	S.D. dependent var		2.4025
S.E. of regression	2.0782	Akaike info criterion		4.4487
Sum squared resid	155.47	Schwarz criterion		4.7354
Log likelihood	-88.65	Hannan-Quinn criter.		4.5545
F-statistic	3.3554	Durbin-Watson stat		2.0566
Prob(F-statistic)	0.0099			

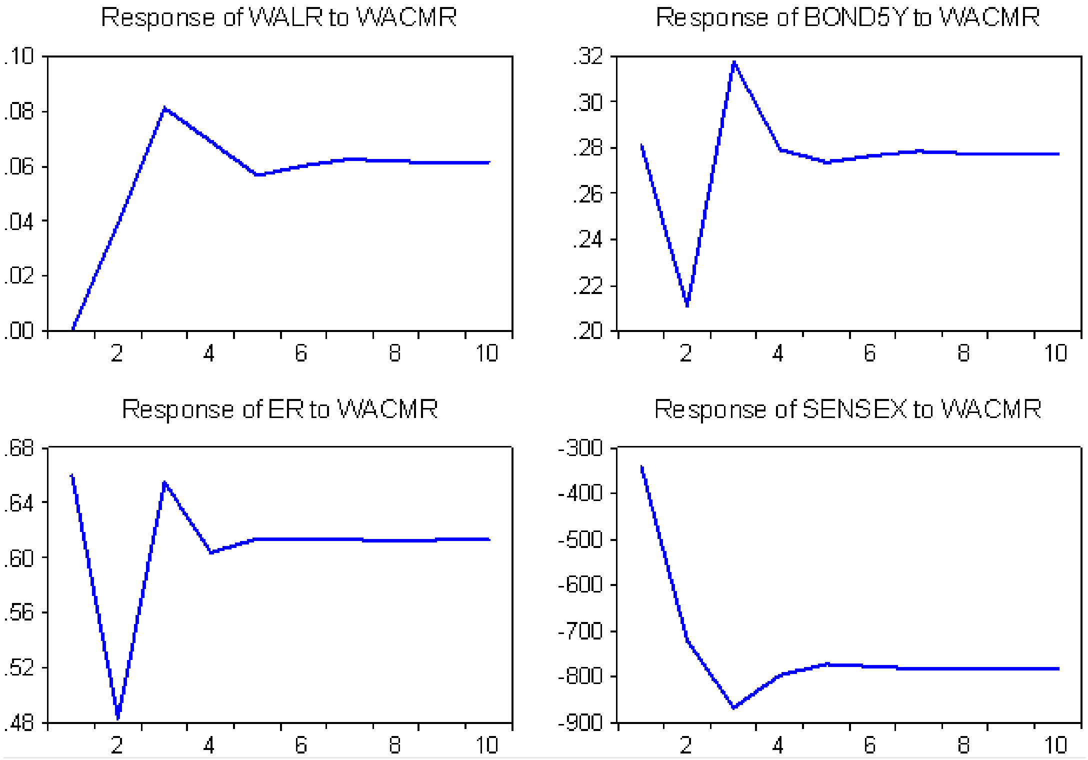
Table 5.2.22 contains the VECM and its coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2), C(3), C(4), C(5), C(6), and C(7) are short run coefficients. C(1) is

the speed of adjustment towards a long run equilibrium which is negative and significant; meaning WALR, BOND 5Y, ER, and SENSEX have long run influence on WACMR.

Impulse Responses

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.2.9.

Figure 5.2.9: Impulse Responses



The impulse responses show the effect of an unexpected 1 percentage point increase in WACMR on all other variables in the VECM. An unexpected rise in WACMR is associated with a rise in WALR by around 0.0003 in the first period and settles in the range of 0.0567 to 0.0625 during the 5th to 10th period (Table 5.2.23). An unexpected rise in WACMR is associated with a rise in BOND 5Y by around 0.2813 percent in the 1st period and reaches a peak of 0.3175 in the 3rd period. The rise continues to hover around a rise of 0.2738 to 0.2776 during the 5th to 10th period.

Table 5.2.23: Impulse Responses to One S.D. innovation in WACMR

Period	WALR	BOND5Y	ER	SENSEX
1	0.0003	0.2813	0.6601	-339.93
2	0.0393	0.2110	0.4833	-720.85
3	0.0811	0.3175	0.6551	-866.99
4	0.0690	0.2793	0.6038	-796.11
5	0.0567	0.2738	0.6139	-772.28
6	0.0601	0.2766	0.6136	-777.38
7	0.0625	0.2785	0.6132	-782.52
8	0.0617	0.2775	0.6125	-782.06
9	0.0614	0.2775	0.6131	-781.47
10	0.0616	0.2776	0.6131	-781.43

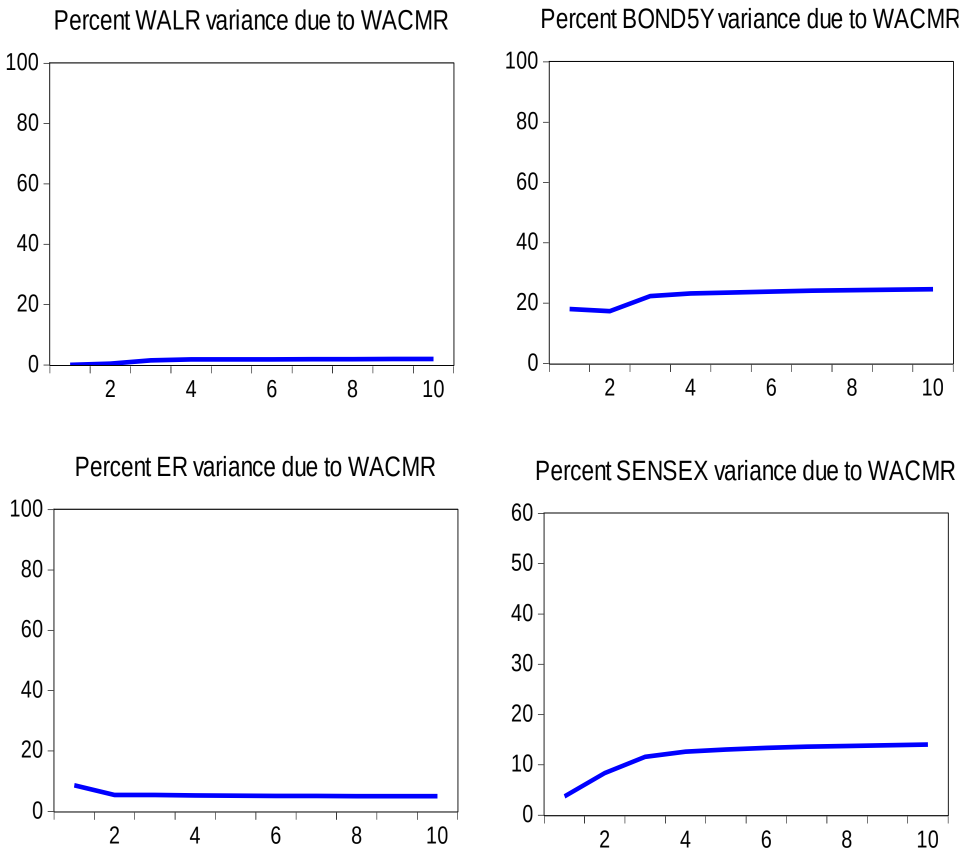
Cholesky Ordering: WACMR WALR BOND5Y ER SENSEX

A shocking rise in WACMR is associated with a rise in ER by 0.6601 in the 1st period and declines to 0.4833 in the 2nd period. The rise gradually slopes down to a level of 0.6131 by the 10th period. An unexpected rise in WACMR is associated with a decline in SENSEX around 339 points in the 1st period and reaches a peak of 867 points in the 3rd period. The rise continues to hover around a rise of 772 to 781 during the 5th to 10th period.

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.2.10: Variance Decompositions



The variance of decompositions is presented in Figure 5.2.10. We notice that at period 10, 13.01 percent of the errors in the forecast of WALR are attributed to WACMR (1.98 percent), BOND 5Y (1.45 percent), ER (1.44 percent), and SENSEX (8.11 percent) shocks in the recursive VAR (Table 5.2.24). Similarly, at period 10, 28.58 percent of the errors in the forecast of BOND 5Y yield are attributed to WACMR (24.59 percent), WALR (1.74 percent), ER (2.32 percent), and SENSEX (0.10 percent) shocks in the recursive VAR.

Table 5.2.24: Variance Decompositions

Variance Decomposition of WALR:

Period	S.E.	WACMR	WALR	BOND5Y	ER	SENSEX
1	2.0781	3.92E-05	99.9996	0.0000	0.0000	0.0000
2	2.3518	0.4371	93.8929	0.0007	0.7856	4.8834
3	2.6576	1.5484	89.9386	1.0662	0.9833	6.4632
4	2.9033	1.8247	88.7512	1.3244	1.0563	7.0431
5	3.1402	1.8192	88.2390	1.2971	1.1981	7.4463
6	3.3578	1.8599	87.8296	1.3396	1.2978	7.6728
7	3.5619	1.9106	87.5279	1.3919	1.3495	7.8199
8	3.7547	1.9407	87.3089	1.4186	1.3885	7.9430
9	3.9383	1.9619	87.1371	1.4377	1.4220	8.0411
10	4.1137	1.9801	86.9993	1.4549	1.4485	8.1170

Variance Decomposition of BOND5Y:

Period	S.E.	WACMR	WALR	BOND5Y	ER	SENSEX
1	0.4120	18.070	0.0572	81.8722	0.0000	0.0000
2	0.5939	17.407	1.4248	80.6747	0.4880	0.0050
3	0.7241	22.337	1.7458	74.5789	1.3272	0.0106
4	0.8403	23.243	1.6409	73.2868	1.7726	0.0559
5	0.9407	23.507	1.6560	72.8347	1.9194	0.0820
6	1.0295	23.840	1.7029	72.3253	2.0422	0.0885
7	1.1119	24.129	1.7194	71.9110	2.1466	0.0937
8	1.1889	24.319	1.7283	71.6301	2.2225	0.0993
9	1.2611	24.469	1.7383	71.4084	2.2805	0.1036
10	1.3293	24.592	1.7465	71.2257	2.3279	0.1068

Variance Decomposition of ER:

Period	S.E.	WACMR	WALR	BOND5Y	ER	SENSEX
1	0.6617	8.5899	0.1194	5.5100	85.7805	0.0000
2	0.8427	5.3938	0.2075	14.733	78.9272	0.7378
3	1.0024	5.4551	0.1308	17.742	75.7134	0.9584
4	1.1407	5.2637	0.0951	18.890	74.7918	0.9591
5	1.2670	5.1770	0.0746	19.523	74.2671	0.9574
6	1.3797	5.1190	0.0614	19.977	73.8779	0.9642
7	1.4841	5.0785	0.0522	20.280	73.6204	0.9682
8	1.5818	5.0472	0.0454	20.501	73.4352	0.9706
9	1.6737	5.0242	0.0402	20.673	73.2894	0.9727
10	1.7609	5.0060	0.0361	20.809	73.1739	0.9743

Variance Decomposition of SENSEX:

Period	S.E.	WACMR	WALR	BOND5Y	ER	SENSEX
1	2.2523	3.7031	0.5046	25.959	13.257	56.575
2	3.5227	8.3672	0.4530	38.925	8.0703	44.184
3	4.4873	11.5822	0.8431	43.707	6.5008	37.366
4	5.2719	12.6194	1.0517	45.738	6.1378	34.452
5	5.9613	13.0657	1.1181	46.781	6.0339	33.000
6	6.5800	13.3605	1.1518	47.497	5.9358	32.054
7	7.1446	13.5928	1.1820	48.020	5.8505	31.354
8	7.6678	13.7681	1.2066	48.411	5.7890	30.824
9	8.1576	13.9022	1.2249	48.713	5.7432	30.415
10	8.6196	14.0087	1.2393	48.954	5.7065	30.090

Cholesky Ordering: WACMR WALR BOND5Y ER SENSEX

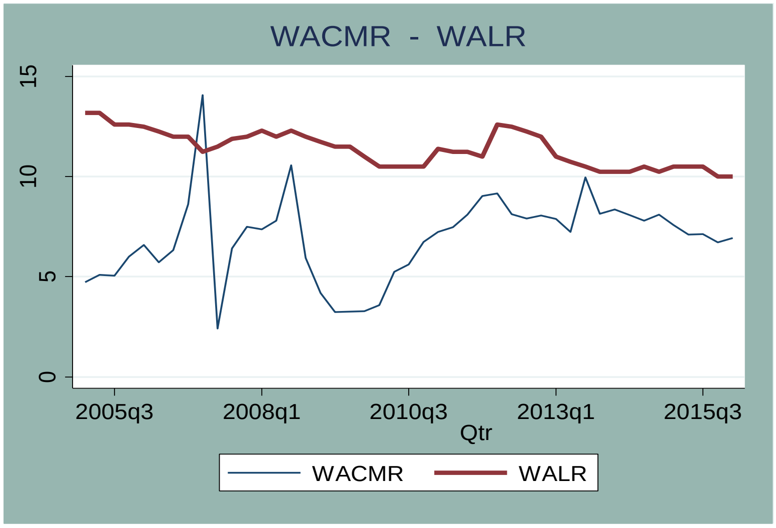
In the case of ER at the same 10th period, 26.83 percent of the error in the forecast is attributed to WACMR (5.00 percent), WALR (0.03 percent), BOND 5Y (20.80 percent), and SENSEX (0.91 percent) shocks in the recursive VAR. For SENSEX at the same 10th period, 69.91 percent of the error in the forecast is attributed to WACMR (14.00 percent), WALR (1.23 percent), BOND 5Y (48.95 percent), and ER (5.70 percent) shocks in the recursive VAR.

Findings:

Transmission to Lending Rate:

Literature shows that the monetary policy actions get transmitted to the credit market through the lending rate. The movement of WACMR and WALR during the sample period is presented in Figure 5.2.11. In Model I, the VECM results show an error correction term coefficient of -0.0473, indicating a feedback effect of 4.73 percent from WALR of the previous quarter. On the other hand, in Model II, the VECM results show an error correction term coefficient of -0.0885, indicating a feedback effect of 8.85 percent from WALR of the previous quarter. In the same order, in a period of one year, the transmission of call money rate to the lending rate is to the extent of 35.4 percent.

Figure 5.2.11: Call Money Rate and Lending Rate



Source: Reserve Bank of India database

In the model with BOND 10Y yield, an unexpected rise in WACMR is associated with a decline in WALR by around 0.1 in the first period, 0.14 in the 2nd period. The decline reaches its trough at 0.1559 in the 3rd period. From the 7th period onwards the decline stabilizes at 0.1496. However, considering the accumulated responses, a positive weighted average call money rate shock creates a 0.55 percent rise in WALR in the first year. At the end of the second year, only 1.15 percent of the effects of monetary policy tightening pass through the money market. After a period of 30 months, only 1.45 percent of the effects of monetary policy tightening pass through in the presence of long-term bond market (Table 5.2.25).

Table 5.2.25: Responses of Credit Market

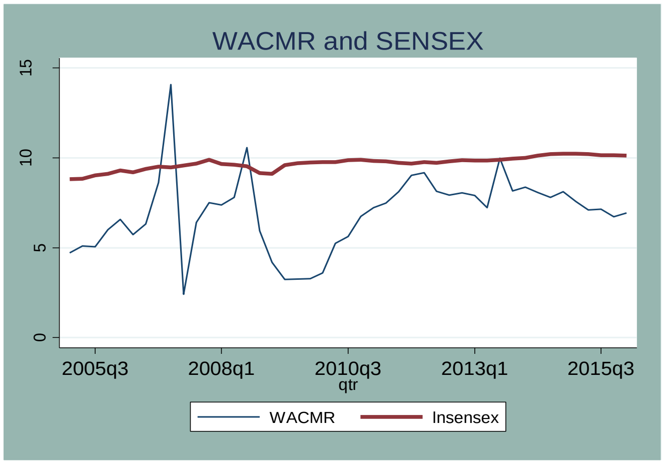
	WALR in the Model with Bond 10Y				WALR in the Model with Bond 5Y			
Period	WACMR	BOND10Y	SENSEX	ER	WACMR	ER	SENSEX	BOND5Y
1	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.24	0.06	0.08	0.09	0.04	0.05	0.13	0.00
3	0.40	0.17	0.12	0.18	0.12	0.10	0.26	-0.08
4	0.55	0.27	0.14	0.25	0.19	0.15	0.39	-0.14
5	0.70	0.38	0.18	0.32	0.25	0.21	0.51	-0.18
6	0.85	0.48	0.22	0.39	0.31	0.26	0.64	-0.24
7	1.00	0.59	0.25	0.47	0.37	0.32	0.76	-0.29
8	1.15	0.69	0.29	0.54	0.43	0.37	0.89	-0.34
9	1.30	0.80	0.32	0.61	0.49	0.42	1.01	-0.40
10	1.45	0.90	0.36	0.68	0.55	0.48	1.14	-0.45

An unexpected rise in WACMR is associated with a rise in WALR by around 0.0003 in the first period and settles in the range of 0.0567 to 0.0625 during the 5th to 10th period. On the other hand, considering the accumulated responses, a positive weighted average call money rate shock creates a 0.19 percent rise in WALR in the first year. At the end of the second year, only 0.43 percent of the effects of monetary policy tightening pass through the money market. After a period of 30 months, only 0.55 percent of the effects of monetary policy tightening pass through in the presence of 5-year bond yield (Table 5.2.25). The Pairwise Granger causality tests do not suggest the presence of significant causality running from call money rate to WALR.

Transmission to Asset Prices:

Theory suggests that monetary policy actions get transmitted through changes in financial prices (e.g. interest rates, exchange rates and asset prices) and financial quantities (e.g. money supply and credit aggregates), which in turn may influence the essential real variables, namely inflation and output. Monetary policy shocks are transmitted to asset prices. The degree of capital market development in a country can be examined by observing different parameters such as market capitalization of listed companies, listed stocks and trading volume. The correlation statistics reveal a positive relationship between WACMR and SENSEX (Figure 5.2.12).

Figure 5.2.12: Asset Price Channel

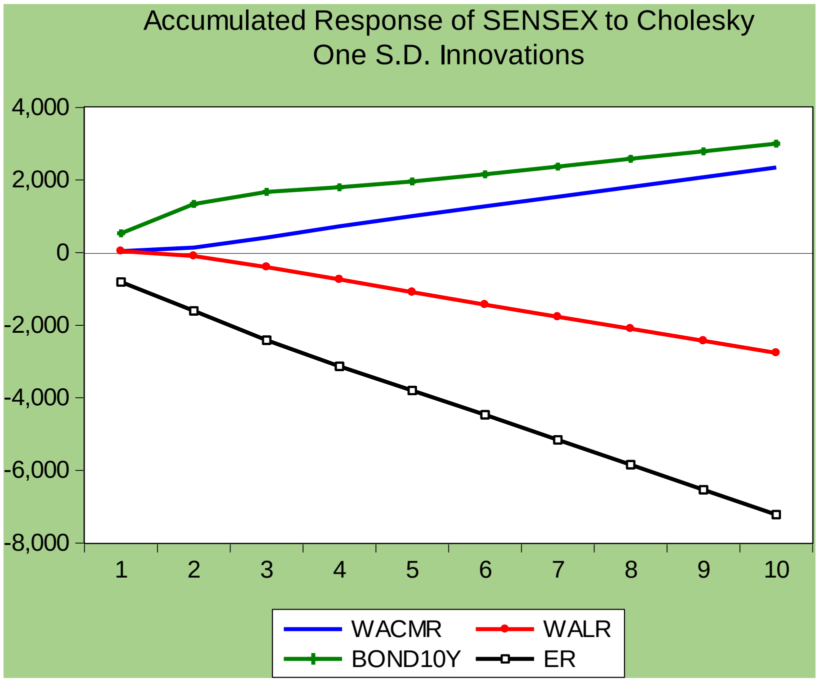


Source: Reserve Bank of India database

Figure 5.2.13 shows the accumulated response of SENSEX to Cholesky one S.D. innovations. A positive weighted average call money rate shock creates a 39 point rise in SENSEX in the first quarter. At the beginning of the second year, only 5.82 percent of the effects of monetary policy tightening pass through the asset prices. After a period of 2 years, only 10.45

percent of the effects of monetary policy tightening pass through the asset prices (Table 25.2.6). These results suggest that the asset price channel is not as effective as in the case of advanced economies in the transmission of monetary shocks in India. This supports the argument that monetary policy in India does not respond to asset prices, but the asset price channel of monetary policy does exist. Aleem (2010) also reports that the asset price channel is not important in the transmission of monetary policy shocks to the real sector in India.

Figure 5.2.13: Impulse response of SENSEX



We also notice that the credit market shock is weaker as the accumulated response of SENSEX to WALR is modest. A positive weighted average call money rate shock creates a -4.28 percent rise in SENSEX in the first year. At the end of the second year, only 12.13 percent of the effects of monetary policy tightening pass through the asset prices. After a period of 30 months, only 16 percent of the effects of monetary policy tightening pass through the asset prices (Table 5.2.26). The response of stock exchange index to credit market shocks evidences the presumed role of credit expansion in contributing to the asset price bubbles. The relative assessment of the impulse response functions suggests that monetary policy tightening leads to a moderation in credit demand over the medium-term, given the usual lags in the impact of monetary policy. The tightening of policy interest rates, which causes the call money rate to rise, thus, impacts the stock prices, as financing the leverage in the markets turns higher and costlier. The impact of the credit market channel on the asset price channel can also work through changes in market perception. As the credit conditions tighten, the perception about the overheating of the economy may get strengthened and accordingly the stock prices would adversely be affected.

Table 5.2.26: Accumulated Response of SENSEX

Quarters	WACMR	WALR	BOND10Y	ER
1	0.23	0.24	3.06	-4.68
2	0.80	-0.55	7.74	-9.28
3	2.40	-2.31	9.69	-13.94
4	4.20	-4.28	10.43	-18.12
5	5.82	-6.31	11.34	-21.96
6	7.36	-8.29	12.50	-25.85
7	8.90	-10.21	13.72	-29.81
8	10.45	-12.13	14.94	-33.79
9	12.01	-14.06	16.15	-37.77
10	13.56	-16.00	17.34	-41.75

Pairwise Granger causality tests suggest the presence of unidirectional causality running from call money rate to SENSEX (Table 5.2.27). However, the absence of the reverse causation from SENSEX to WACMR is not significant, suggesting the weaker feedback from the asset price channel of monetary policy transmission. The unidirectional causation running from monetary policy action through call money rate to asset prices through stock market index seems to weaker as this process looks just coincidental, not targeted. This is because the magnitude of the increase in the call money rate is not large enough to effectively pop up asset price bubbles.

The results seem to suggest that monetary policy does not respond to stock prices, though stock prices respond to monetary policy shocks. As suggested by (Kohn, 2008), our results provide evidence to the theory that the monetary policy actions should respond to asset prices only to the extent of their impact on growth, employment and inflation, which are the core objectives of monetary policy.

Table 5.2.27: Causal Relationship between Call Money Rate Changes in Stock Prices

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
SENSEX does not Granger Cause WACMR	42	2	0.9516	0.3954
WACMR does not Granger Cause SENSEX	42	2	10.6230	0.0002
BOND10Y does not Granger Cause WACMR	38	6	1.1643	0.3563
WACMR does not Granger Cause BOND10Y	38	6	6.25032	0.0004
BOND5Y does not Granger Cause WACMR	38	6	1.48003	0.2255
WACMR does not Granger Cause BOND5Y	38	6	4.46502	0.0033
BOND5Y does not Granger Cause SENSEX	33	12	2.80146	0.0757
SENSEX does not Granger Cause BOND5Y	33	12	1.15736	0.4302

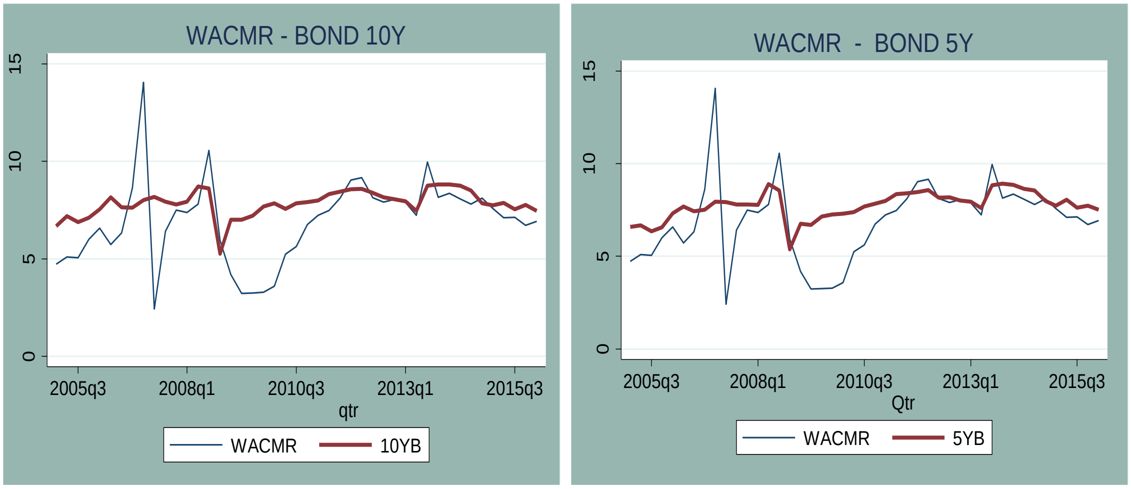
Greenspan orthodoxy on asset price build-up maintains that it is difficult to identify bubbles *ex ante* as central banks may not have better information than markets to influence asset prices. Bernanke and Gertler (2001) argued that central banks should disregard asset prices in their policy formulation as they found modest gains from allowing an independent response of central bank policy to the level of asset prices.

Transmission to Bond Market:

Theory suggests that monetary policy actions get transmitted through changes in the bond market which in turn may influence the essential real variables, namely inflation and output. Monetary policy shocks are transmitted to bond markets through the call money rate. The correlation statistics reveal a positive relationship between WACMR and BOND10Y (0.51*) and

BOND5Y (0.59*) (Figure 5.2.14). The VECM results suggest that the error correction coefficient for BOND 10Y was 0.1164 and carries the positive sign, indicating that there was a feedback of about 11.64 percent of the previous quarter. On the other hand, in Model II, the error correction term coefficient for BOND 5Y was 0.0885 and carries the positive sign indicating a feedback effect of 8.85 percent of the previous quarter.

Figure 5.2.14: Bond Market Channel



Source: Reserve Bank of India database

An unexpected rise in WACMR is associated with a rise in BOND 10Y yield by around 0.29 in the first period and reaches a peak of 0.33 in the 3rdnd period. Considering the accumulated responses, a positive weighted average call money rate shock creates a 1.17 percent rise in BOND 10Y yield in the first year. At the end of the second year, only 2.35 percent of the effects of monetary policy tightening pass through the bond market. After a period of 30 months, only 2.95 percent of the effects of monetary policy tightening pass through the long-term bond market (Table 5.2.28). Similarly, an unexpected rise in WACMR is associated with a rise in BOND 5Y yield by around 0.2813 percent in the 1st period and reaches a peak of 0.3175 in the 3rd period. Considering the accumulated responses of BOND 5Y yield, a positive weighted average call money rate shock creates a 1.09 percent rise in BOND 5Y yield in the first year. At the end of the second year, only 2.20 percent of the effects of monetary policy tightening pass through the bond market. After a period of 30 months, only 2.75 percent of the effects of monetary policy tightening pass through the long-term bond market.

Table 5.2.28: Responses of Bond Market

	Accumulated Response of Bond 10Y				Accumulated Response of Bond 5Y			
Period	WACMR	WALR	ER	SENSEX	WACMR	WALR	ER	SENSEX
1	0.30	0.12	0.00	0.00	0.28	-0.02	0.00	0.00
2	0.54	0.15	-0.05	-0.02	0.49	-0.12	-0.06	0.01
3	0.88	0.16	-0.05	-0.03	0.81	-0.20	-0.16	0.01
4	1.17	0.16	-0.03	-0.01	1.09	-0.26	-0.26	0.04
5	1.47	0.16	0.00	-0.01	1.36	-0.34	-0.34	0.06
6	1.76	0.17	0.02	-0.02	1.64	-0.41	-0.43	0.08
7	2.06	0.18	0.04	-0.02	1.92	-0.49	-0.53	0.10
8	2.35	0.19	0.06	-0.02	2.20	-0.56	-0.62	0.12
9	2.65	0.20	0.08	-0.02	2.47	-0.63	-0.71	0.14
10	2.95	0.21	0.10	-0.02	2.75	-0.71	-0.80	0.16

Pairwise Granger causality tests suggest the presence of unidirectional causality running from call money rate to BOND 10Y yield (Table 5.2.27). However, the absence of the reverse causation from BOND 10Y to WACMR is not significant suggesting the weaker feedback from the bond market channel of monetary policy transmission. Similarly, we notice a unidirectional causation running from call money rate to BOND 5Y yield. The unidirectional causation running from monetary policy action through call money rate to bond market seems to be weaker as this process looks just coincidental, not targeted.

Study 3: Examining the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel

India being a bank-dominant economy, the share of banks in domestic corporate borrowing continues to be high. Excessive dependence on bank finance makes the bank lending and the balance sheet channels exceptionally imperative for monetary transmission. We estimate using cointegrated models to pin down a long-run relationship of the policy interest rate with credit growth and lending rates. We examine the relationship employing the Granger causality test using a VAR framework using quarterly data from 2005 Q1 to 2016 Q1. We determine the asymmetry in transmission in different phases of monetary policy cycles to deposit and lending rates of banks.

We also propose to estimate the pass-through from monetary policy changes to bank interest rates in two steps:

(i) From the monetary policy rate to the interbank market rate that is the operating target of the framework; and then

(ii) From the target rate to bank interest rates (deposit and lending rates).

In each of the above steps, an error-correction model is used, which allows for the estimation of the long-run relationship between the policy and bank interest rates as well as the speed of adjustment to this long-run pass-through. The method also allows for the estimation of asymmetric adjustment parameters, to study whether there are differential responses to policy rate increases and decreases (Das, 2015).

3.1. Transmission from monetary policy rate to the inter-bank market rate

(Pass-through to WACMR (target rate) from Monetary Policy Repo Rate)

$$\boldsymbol{WACMR_t = \beta_0 + \beta_1 RepoRate_t + \varepsilon_t}$$

The identifying assumption that underlies this step of the empirical method is that the repo rate is weakly exogenous to the WACMR. That is, that there is no feedback to the repo rate from the WACMR. This is a reasonable assumption in that the repo rate is a policy rate decided by the central bank.

The Model

The baseline model includes five variables given in the order: WACMR and REPO. The estimation sample has been chosen so as to exclude any structural changes. We employ a VAR model of the form:

$$\boldsymbol{Z_t = A(L)Z_{t-1} + \mu + \varepsilon_t}$$

Z_t is a vector of endogenous variables, A(L) describes parameter matrices, μ is a vector of constant terms and ε_t is a vector of error terms that are assumed to be white noise. The vector Z_t comprises the following variables:

$$\boldsymbol{Z_t = (WACMR_t + REPO_t)}$$

Where, $WACMR_t$ – Weighted Average Call Money Rate

$REPO_t$ – Policy Repo Rate

A vector error correction model is estimated with the following cointegrating relationships

$$\boldsymbol{WACMR_t = \theta'_0 + \theta'_1 REPO_t + \varepsilon_{1t}}$$

The identifying assumption that underlies this step of the empirical method is that the lending rate is weakly exogenous to the REPO. The assumption is reasonable since changes in interest rates on bank loans, which will be of longer maturity, are unlikely to have feedback effects on overnight call money transactions. The coefficient on the first error correction term represents the speed of adjustment of WACMR to a deviation in the relationship between the WACMR rate and REPO.

The VECM model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1. The WACMR and REPO are expressed in the vector of constant terms comprises a linear trend and a constant. Choosing a lag length of one ensures that the error terms dismiss signs of autocorrelation and conditional heteroscedasticity.

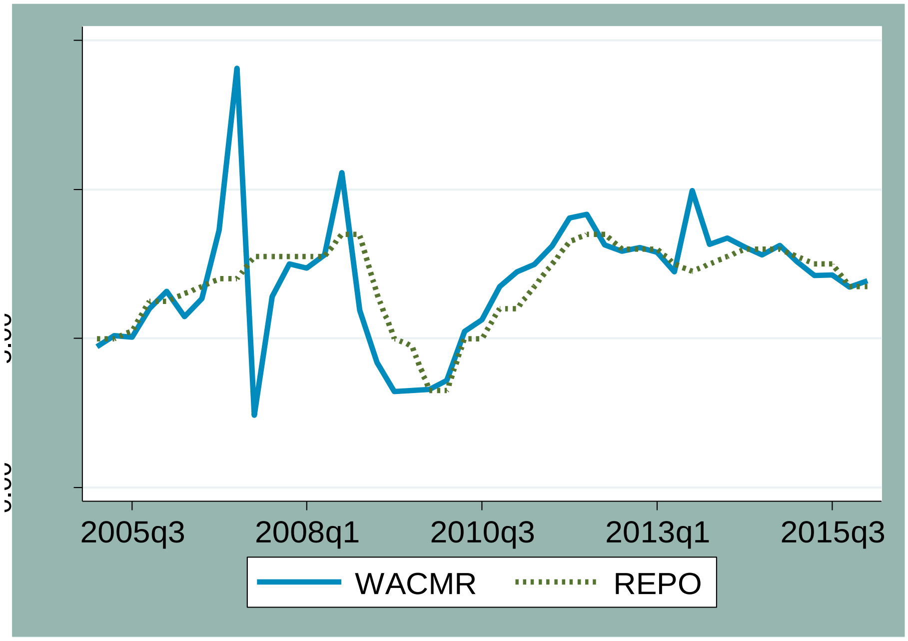
Table 5.3.1 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.93. REPO ranges from a minimum of 3.25 to a maximum of 8.50 with a mean value of 6.87.

Table 5.3.1: Descriptive Statistics

	WACMR	REPO
Mean	6.93	6.87
Median	7.23	7.50
Maximum	14.07	8.50
Minimum	2.42	3.25
Std. Dev.	2.14	1.36
Skewness	0.36	-1.00
Kurtosis	4.60	3.28
Jarque-Bera	5.79	7.65
Probability	0.06	0.02
Observations	45	45

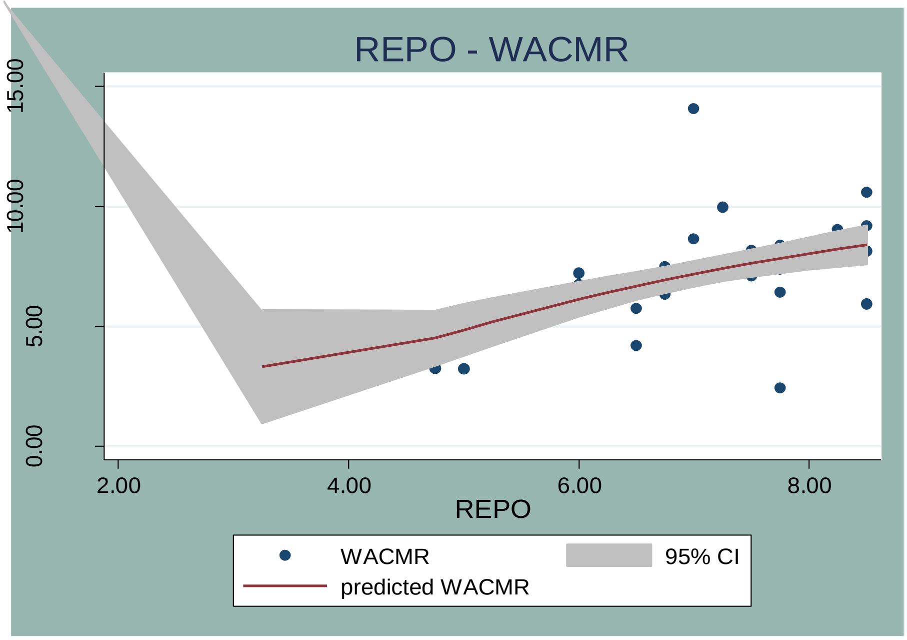
The covariates of the model are presented in Figure 5.3.1 and the interaction of WACMR and REPO are presented in Figure 5.3.2.

Figure 5.3.1: WACMR and REPO



Source: Reserve Bank of India database

Figure 5.3.2: Interaction of REPO and WACMR



Source: Reserve Bank of India database

Unit root tests

To estimate the VEC model, the first step is to test for stationarity. The stationarity properties in the time series are substantiated by performing the Augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979, 1981), Phillips-Perron (PP) (Phillips and Perron, 1988) KPSS (Kwiatkowski-Phillips-Schmidt-Shin, 1992) tests. To ensure that the spurious regression that Granger and Newbold (1974) identified would not be an issue for our models, we conducted ADF, PP, and KPSS unit root tests to confirm whether three variables are stationary. Test results are shown in Table 5.3.2. We notice that the t-statistic value is lesser than the critical values so that we do not accept the null that there is a unit root. On the other hand, we accept the alternate hypothesis that there is no unit root in the series at conventional test sizes. WACMR is found to stationary at the level form and REPO is first differenced to become stationary. The tests are conducted on the variables in levels and first differences.

Table 5.3.2: Unit root tests

We report the test statistics for ADF, PP, and KPSS Test. ***, **, * indicate the significance of the result at 1%, 5%, and 10% respectively. For KPSS test results, asymptotic critical values are provided as per Kwiatkowski-Phillips-Schmidt-Shin (1992, Table1). PP test, ADF test (H0: series has a unit root).

	Test Statistic at level form			Test Statistic at 1st diff.		
Variable	ADF Test	PP Test	KPSS Test	ADF Test	PP Test	KPSS Test
WACMR	-4.38***	-4.40***	0.24*	--	--	--
REPO	-2.57	-2.28	0.20*	-4.64***	-4.70***	0.08*

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. We determine the number of lags p of the VAR (p) model. Within the four usual criteria: Final prediction error (FPE), Akaike (AIC), Schwartz (SC) and Hannan-Quinn (HQ), Liew (2004) report that AIC and FPE are recommended to estimate autoregression Lag length. According to the previous study, we follow the result demonstrated by AIC criteria and the FPE criteria. Table 5.3.3 presents the output:

Table 5.3.3: VAR Lag Order Selection CriteriaEndogenous variables: WACMR REPO

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-149.2021	NA	5.4738	7.3757	7.4593	7.4062
1	-112.0983	68.777*	1.0894	5.7609	6.011*	5.8522*
2	-107.2793	8.4626	1.0487*	5.7209*	6.1389	5.8731
3	-105.8880	2.3076	1.1963	5.8482	6.4333	6.0613
4	-103.3881	3.9022	1.2971	5.9214	6.6737	6.1953

* indicates lag order selected by the criterion
LR: sequentially modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The number of lags in the VAR is chosen considering several tests as detailed in the lag selection section of this report. Table 5.3.4 presents the vector autoregression estimates.

A vector error correction model (VECM) with the order (p – 1):

$$\Delta Y_t = \alpha_1 + p_1 e_1 + \sum_{i=0}^{n} \beta_i \, \Delta Y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i Z_{t-i}$$

$$\Delta X_t = \alpha_2 + p_2 e_{i-1} + \sum_{i=0}^{n} \beta_i \, Y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \sum_{i=0}^{n} \gamma_i Z_{t-i}$$

The above described VECM is equivalent to a Vector Autoregression (VAR p) presentation of the levels X_t. In a VAR model each variable can be endogenous and the changes in a selected target variable in period t depend on the deviations from that specific equilibrium in the previous period and the short-run dynamics. Further, VECM allows for estimation of the long-run effects and to analyze the short-run adjustment process within one model. The variable vector X_t is assumed to be vector integrated of order 1 (I(1), i.e. ΔX_t is vector stationary.

Table 5.3.4: Vector Autoregression Estimates

Note: Standard errors in ( ) & t-statistics in [ ]

	WACMR	REPO
WACMR(-1)	0.049	0.1661
	(0.18)	(0.05)
	[0.2763]	[3.0270]
WACMR(-2)	-0.2293	0.0317
	(0.20)	(0.06)
	[-1.1694]	[0.5222]
REPO(-1)	1.8988	1.0379
	(0.57)	(0.18)
	[3.3105]	[5.8435]
REPO(-2)	-0.7182	-0.239
	(0.45)	(0.14)
	[-1.5884]	[-1.7066]
R-squared	0.2811	0.8203
Adj. R-squared	0.2258	0.8064
Sum sq. resids	138.43	13.276
S.E. equation	1.884	0.5835
F-statistic	5.0831	59.326
Log likelihood	-86.151	-35.747
Akaike AIC	4.1931	1.8487
Schwarz SC	4.3569	2.0126
Mean dependent	7.0191	6.9593
S.D. dependent	2.1412	1.3262
Determinant resid covariance (dof adj.)		0.9118
Determinant resid covariance		0.75
Log likelihood		-115.84
Akaike information criterion		5.7602
Schwarz criterion		6.0879

Robustness tests

We also perform the VAR Granger causality/block exogeneity Wald tests, residual normality tests, and VAR residual heteroskedasticity tests with without cross terms.

VAR Residual Normality Test

We perform the residual normality test and Table 5.3.5 reports the multivariate extensions of the Jarque-Bera residual normality test, which compares the third and fourth moments of the residuals to those from the normal distribution. The null hypothesis is about normality, and the acceptance of the hypothesis (because of an insignificant p-value) leads to the conclusion that the residuals are normally distributed.

Table 5.3.5: VAR Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	0.7005	3.5168	1	0.0608
2	-0.8103	4.7055	1	0.0301
Joint		8.2223	2	0.0164
Component	Kurtosis	Chi-sq	df	Prob.
1	6.9260	27.6159	1	0.0000
2	3.9502	1.6178	1	0.2034
Joint		29.2337	2	0.0000
Component	Jarque-Bera	df	Prob.	
1	31.1327	2.0000	0.0000	
2	6.3233	2.0000	0.0424	
Joint	37.4560	4.0000	0.0000	

Note: Null Hypothesis: residuals are multivariate normal
Orthogonalization: Cholesky (Lutkepohl)

Causality Analysis

The disadvantage of VECM model is that it does not allow us to detect the direction of causality between the variables. VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for the joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of REPO (Table 5.3.6). The results suggest a bidirectional causality running from changes in WACMR to REPO and vice versa.

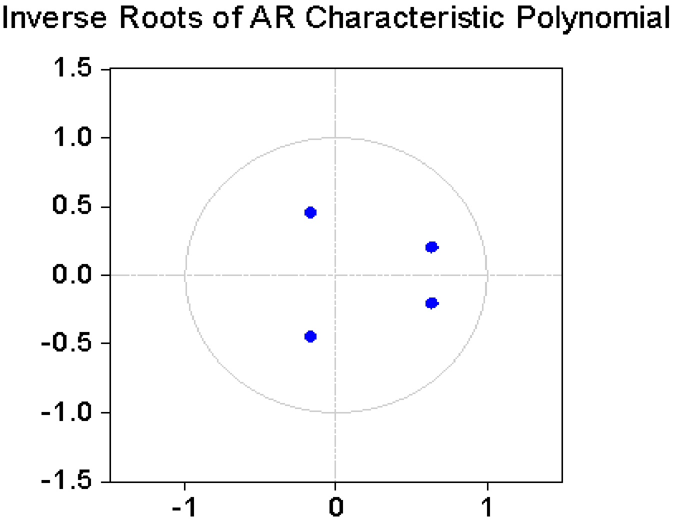
Table 5.3.6: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
REPO	8.5067	2	0.0142
All	8.5067	2	0.0142
Dependent variable: REPO			
Excluded	Chi-sq	df	Prob.
WACMR	10.7788	2	0.0046
All	10.7788	2	0.0046

Stability Condition Check

We perform the VAR stability condition check and we observe from Figure 5.3.3 that (a) values of the roots are less than unity (b) modulus values are also less than unity, and (c) the inverse roots of the AR Characteristic Polynomials lie within the Unit Circle. All these observations testify for the stability of the VAR model and thus, all these findings confirm that the estimated VAR model is stable.

Figure 5.3.3: VAR Stability Condition



Cointegration Test

To test the presence of cointegration between the variables investigated in this study, the Johansen’s approach is employed. The Johansen method uses a statistical model involving up to p lags as follows:

$$\boldsymbol{Y_t = \Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_p \Delta Y_{t-p} + \Pi \Delta Y_{t-p} + \varepsilon_t}$$

where Δ is the difference operator, Y_t is a vector of variables, Γ1,... Γp-1 represents the matrix of the short-run dynamics, Π=αβ’ with α and β are both matrices containing the adjustment coefficients and the cointegrating vector respectively and Π represents the long-run dynamics.

In order to identify the number of cointegration vectors, Johansen (1988) proposes the trace and maximum eigenvalue statistics while the trace statistic is designed for testing the null hypothesis of r cointegration vector, the maximum eigenvalue statistic tests for the null hypothesis of r cointegration vector against the alternative of r +1.

The trace test equation is established as:

$$\boldsymbol{\lambda_{\mathrm{trace}} = -T \sum_{j=r+1}^{n} \ln\left(1 - \lambda_{\mathrm{j}}\right)}$$

where T represents the number of observations and λ_j shows the estimated values of the roots.

In the second case, the eigenvalue test equation is presented as follow:

$$\boldsymbol{\lambda_{\max} = -T \ln\left(1 - \lambda_{\mathrm{j+1}}\right)}$$

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.3.7, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run. Johansen test of cointegration produces the *Trace* and *Maximum Eigenvalue* performed to determine the order of integration; which both indicates that we reject the null hypothesis that none of the variables is cointegrated since p-value 0.0000<0.05, but revealed that there is at most one cointegrating equation or error since p-values are greater than 0.05 for both trace and Max. Eigenvalue i.e. the variables have a long run relationship. The result of the normalized cointegrating coefficient is -1.1789 as the long run coefficient for REPO. Since the variables are cointegrated, we can now run the VECM model.

Table 5.3.7: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.4461	32.5013	15.4947	0.0001
r ≤1	r >1	At most 1 *	0.1674	7.6920	3.8415	0.0055
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r =0	None*	0.4461	24.8093	14.2646	0.0008
r =1	r =1	At most 1*	0.1674	7.6920	3.8415	0.0055

1 Cointegrating Equation(s): Log likelihood = -112.4623

Normalized cointegrating coefficients (standard error in parentheses)

WACMR	REPO
1.0000	-1.1789
	(0.1075)

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

VECM is an appropriate modeling strategy when the variables are cointegrated. It is suitable when the long-run forecast is desired; as VAR doesn't explicitly takes into account the long-run relationship. The VECM estimation method is used due to the presence of one cointegrating vector in the variables. The VEC specification is rather a vector autoregressive (VAR) specification augmented with an error-correction term highlighting the nature of convergence in short-run deviations in the co-integrated relation.

The vector error correction model (VECM) involves expressing an *n* x *1* vector of stationary time series (say y_t) in terms of constant, lagged values of itself and an error correction term. The standard VECM (p) model can be represented as,

$$\Delta \boldsymbol{Y_t} = \boldsymbol{C} + \boldsymbol{\varphi_1} \Delta \boldsymbol{Y_{t-1}} + \boldsymbol{\varphi_2} \Delta \boldsymbol{Y_{t-2}} + \cdots + \boldsymbol{\varphi_p} \Delta \boldsymbol{Y_{t-p}} + \boldsymbol{ECT} + \boldsymbol{\varepsilon_t}$$

where ECT refers to the Error Correction Term that is a product of an adjustment factor (α) and the cointegrating vector (β). The cointegrating vector shows the long-term equilibrium relationship between the concerned variables while the adjustment factors show the speed of adjustment towards equilibrium in case there is any deviation.

Table 5.3.8 shows the cointegrating vector along with the standard errors of the estimates in parentheses. We show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficient for WACMR is statistically negative which implies that this variable fit into the model and suffers a shock and adjusts to restore their equilibrium.

Table 5.3.8: Vector Error Correction Estimates

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
WACMR(-1)	1	
REPO(-1)	-1.18	
	(0.00)	
	[-8307.42]	
Intercept	1.1865	
Error Correction:	**D(WACMR)**	**D(REPO)**
CointEq1	-0.20	0.17
	(0.04)	(0.01)
	[-4.4690]	[14.3676]
D(WACMR(-4))	0.04	0.01
	(0.00)	(0.00)
	[36.96]	[40.28]
D(REPO(-4))	-0.02	0.01
	(0.00)	(0.00)
	[-6.42]	[12.58]
Intercept	0.04	0.03
	(0.00)	(0.00)
	[275.27]	[868.96]
R-squared	0.99	0.99
Adj. R-squared	0.99	0.99
Sum sq. resids	0.00	0.00
S.E. equation	0.00	0.00
F-statistic	1008.29	1406.11
Log likelihood	273.34	325.73
Akaike AIC	-13.47	-16.09
Schwarz SC	-13.30	-15.92
Mean dependent	0.04	0.03
S.D. dependent	0.00	0.00
Determinant resid covariance (dof adj.)		0.00
Determinant resid covariance		0.00
Log likelihood		605.22
Akaike information criterion		-29.76
Schwarz criterion		-29.34

The error correction coefficient for WACMR was (-0.20) and it measures the speed of adjustment of WACMR towards long run equilibrium. The coefficient carries the expected negative sign, significant at the 1 % level and less than one which is appropriate. The coefficient indicates a feedback of about 20% of the previous quarter's disequilibrium from the long run elasticity. About 20% percent of disequilibrium is "corrected" in each quarter by changes in WACMR.

Table 5.3.9: VECM Regression Results

D(WACMR) = C(1)*(WACMR(-1) - 1.17885647706*REPO(-1) + 1.1887271795) + C(2)*D(WACMR(-1)) + C(3)*D(WACMR(-2)) + C(4) *D(REPO(-1)) + C(5)*D(REPO(-2)) + C(6)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.1963	0.0439	-4.4690	0.0001
C(2)	0.0363	0.0010	36.9627	0.0000
C(3)	-0.0159	0.0025	-6.4215	0.0000
C(4)	0.0400	0.0001	275.2738	0.0000
R-squared	0.9882	Mean dependent var		0.0411
Adjusted R-squared	0.9873	S.D. dependent var		0.0024
S.E. of regression	0.0003	Akaike info criterion		-13.4672
Sum squared resid	0.0000	Schwarz criterion		-13.2983
Log likelihood	273.3438	Hannan-Quinn criteria.		-13.4061
F-statistic	1008.2920	Durbin-Watson stat		2.5428
Prob(F-statistic)	0.0000			

Table 5.3.9 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2), C(3), C(4), C(5), C(6), and C(7) are short run coefficients. C(1) is the speed of adjustment towards a long run equilibrium which is negative and significant; meaning REPO has a long run influence on WACMR. Thus, the VECM estimation shows that presence of a long-run relationship between WACMR and REPO with -0.20 as the speed of adjustment towards the equilibrium.

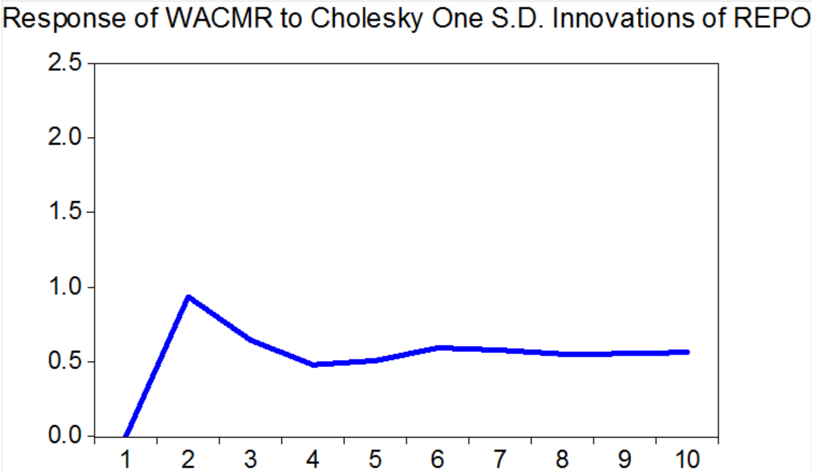
The coefficient of -0.1963 indicates that the WACMR adjusts by about 20 percent per time period towards the REPO after a deviation from equilibrium, resulting in 7.64 months to achieve the pass-through from a change in the REPO.

Impulse Responses

The study uses an impulse response function as an additional check of the Cointegration test's findings. Followed by Engle and Granger (1987), Cholesky type of contemporaneous identifying restrictions is employed to draw a meaningful interpretation. The recursive structure assumes that variables appearing first contemporaneously influence the latter variables but not vice versa. It is important to list the most exogenous looking variables earlier than the most endogenous looking variables.

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.3.4.

Figure 5.3.4: Impulse Responses



The impulse responses show the effect of an unexpected 1 percentage point increase in REPO on WACMR in the VECM. An unexpected rise in REPO is associated with a rise in WACMR by around 2.0356 in the 1st period and settles in the range of 0.9947 to 1.0297 during the 4th to the 10th period (Table 5.3.10). The response of WACMR to Cholesky one standard deviation of REPO is at its peak of 0.93 in the 2nd period. The response of WACMR settles at the level of 0.50 to 0.55 after the 5th period.

Table 5.3.10: Response of WACMR to Cholesky One S.D. Innovation of REPO

Period	WACMR	REPO
1	2.0356	0.0000
2	0.8011	0.9367
3	0.8044	0.6452
4	0.9947	0.4800
5	1.1314	0.5076
6	1.0285	0.5948
7	0.9986	0.5781
8	1.0237	0.5527
9	1.0390	0.5550
10	1.0297	0.5647

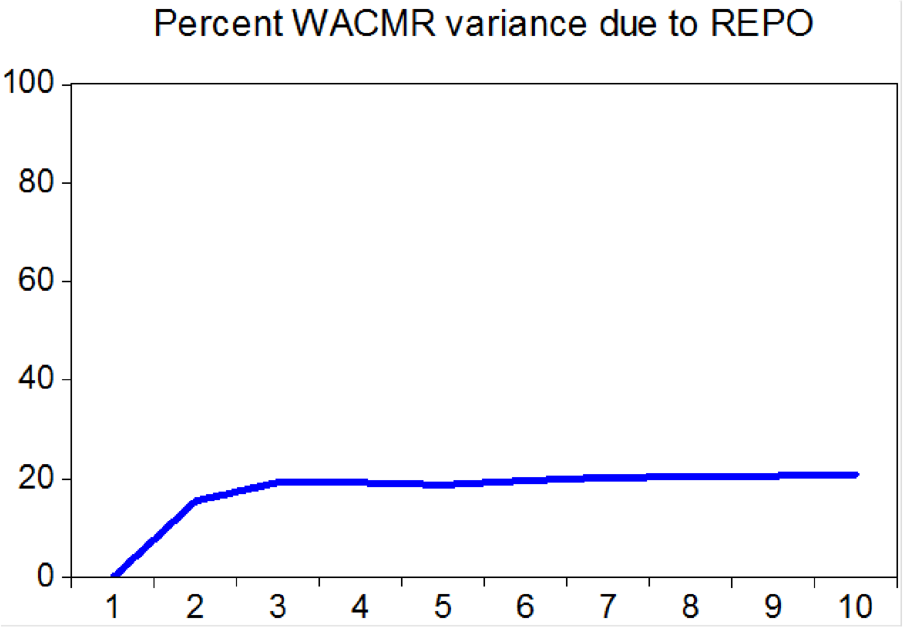
Cholesky Ordering: WACMR REPO

Variance Decompositions

While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. The variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.3.5: Variance Decompositions



The variance of decompositions is presented in Figure 5.3.5. Table 5.3.11 displays separate variance decomposition for each endogenous variable. The second column, labeled “SE”, contains the forecast error of the variable at the given forecast horizon. The source of this forecast error is the variation in the current and future values of the innovations to each endogenous variable in the VAR. The remaining columns give the percentage of the forecast variance due to each innovation, with each row adding up to 100. With the impulse responses, the variance decomposition based on the Cholesky factor can change dramatically if the ordering of the variables in the VAR is altered. For example, the first-period decomposition for the first variable in the VAR ordering is completely due to its own innovation.

We notice that at period 10, 20.81 percent of the errors in the forecast of WACMR are attributed to REPO shocks (Table 5.11). The variance decomposition in the 2nd period is observed to be 15.49 percent and stabilizes at an average level of 20.5 percent from the 5th period.

Table 5.3.11: Variance Decomposition of WACMR

Period	S.E.	WACMR	REPO
1	2.0356	100.0000	0.0000
2	2.3797	84.5066	15.4934
3	2.5935	80.7678	19.2322
4	2.8189	80.8205	19.1795
5	3.0796	81.2138	18.7862
6	3.3008	80.4007	19.5993
7	3.4967	79.8018	20.1982
8	3.6851	79.5655	20.4345
9	3.8688	79.4022	20.5978
10	4.0431	79.1894	20.8106

Cholesky Ordering: WACMR REPO

Forecasting of WACMR

The analysis provides a forecast based on the VECM model. State-of-the-art VAR forecasting systems contain more than three variables and allow for time-varying parameters to capture important drifts in coefficients (Sims, 1993). Multistep ahead forecasts, computed by iterating forward the recursive VAR, are presented in Table 5.3.12. The first two forecast error statistics largely depend on the scale of the dependent variable and are used as relative measures to compare forecasts for the same series across different models; the smaller the error, the better the forecasting ability of that model according to that criterion. Very low scores of root mean squared error (RMSE) and mean absolute error (MAE) for the forecasts indicate the strength and accuracy of the forecast based on the VAR model. The RMSE is computed using the formula:

$$\boldsymbol{RMSE = \sqrt{\frac{\sum(y-\hat{y})^2}{n-k-1}} = \sqrt{\frac{RSS}{n-k-1}}}$$

The remaining two statistics are scale invariant. The Theil inequality coefficient always lies between 0 and 1, where 0 indicates a perfect fit. Further, as the ultimate test of a forecasting model is its out-of-sample performance, Table VI focuses on pseudo out-of-sample forecasts[8] over the period 1996-2009 (Figure 5.3.6).

Table 5.3.12: Forecasting of WACMR

Forecast Statistics	WACMR
Root mean squared error[a]	0.1673
Mean absolute error[b]	0.1487
Mean absolute percentage error	2.6384
Theil inequality coefficient	0.0138
Bias proportion	0.7634
Variance proportion	0.1449
Covariance proportion	0.0916

Notes: [a] The mean squared forecast error is computed as the average squared value of the forecast error over the 1996-2009 out-of-sample period, and the resulting square root is the root mean squared forecast error reported in the table; root mean squared errors (RMSEs) are the errors squared before they are averaged and give a relatively high weight to large errors, which infers that RMSE is most useful when large errors are particularly undesirable.

[b] mean absolute error (MAE), which is a linear score (that all the individual differences are weighted equally in the average), measures the magnitude of the errors in a set of forecasts without considering their direction and measures accuracy for continuous variable; entries are the root mean square error of forecasts computed recursively for VARs.

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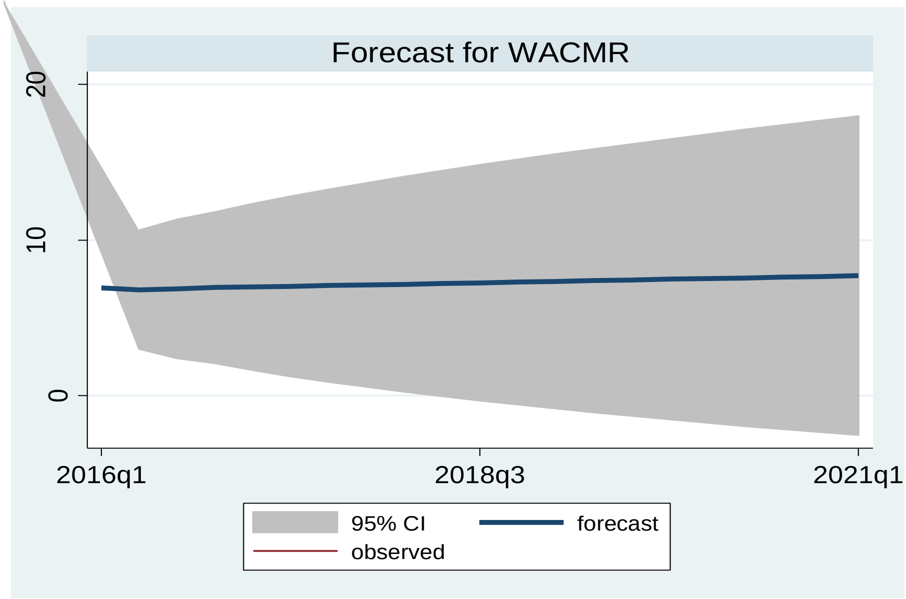
[8] Pseudo out-of-sample forecasts are often referred to as pseudo or "simulated" out-of-sample forecasts to emphasise that they simulate how these forecasts would have been computed in real time, although of course this exercise is conducted retrospectively, not in real time.

Figure 5.3.6: Forecasts of WACMR



Results from the above estimation exercise show that there is a cointegrating vector between the monetary policy rate and the operating target rate, i.e., WACMR.

3.2. Transmission from the inter-bank market rate to lending rate

The baseline model includes five variables given in the order: WALR and WACMR. The estimation sample has been chosen so as to exclude any structural changes. We employ a VAR model of the form:

$$\boldsymbol{Z_t = A(L)Z_{t-1} + \mu + \varepsilon_t}$$

Z_t is a vector of endogenous variables, $A(L)$ describes parameter matrices, μ is a vector of constant terms and ε_t is a vector of error terms that are assumed to be white noise. The vector Z_t comprises the following variables:

$$\boldsymbol{Z_t = (WALR_t + WACMR_t)}$$

Where, $WALR_t$ – Weighted Average Lending Rate (WALR) indicating credit market

$WACMR_t$ – Weighted Average Call Money Rate

A vector error correction model is estimated with the following cointegrating relationships

$$\boldsymbol{WALR_t = \theta'_0 + \theta'_1 WACMR_t + \varepsilon_{1t}}$$

The identifying assumption that underlies this step of the empirical method is that the lending rate is weakly exogenous to the WACMR. The assumption is reasonable since changes in interest rates on bank loans, which will be of longer maturity, are unlikely to have feedback effects on overnight call money transactions. The coefficient on the first error correction term represents the speed of adjustment of the lending rate to a deviation in the relationship between the lending rate and WACMR.

The VECM model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1. The WALR and WACMR are expressed in the vector of constant terms comprises a linear trend and a constant. Choosing a lag length of one ensures that the error terms dismiss signs of autocorrelation and conditional heteroscedasticity.

Table 5.3.13 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.93. WALR ranges from a minimum of 10.00 to a maximum of 13.20 with a mean value of 11.40.

Table 5.3.13: Descriptive Statistics

	WALR	WACMR
Mean	11.40	6.93
Median	11.40	7.23
Maximum	13.20	14.07
Minimum	10.00	2.42
Std. Dev.	0.91	2.14
Skewness	0.17	0.36
Kurtosis	1.85	4.60
Jarque-Bera	2.68	5.79
Probability	0.26	0.06
Observations	45.00	45.00

The covariates of the model are presented in Figure 5.3.7 and the interaction of WALR and WACMR are presented in Figure 5.3.8.

Figure 5.3.7: WALR and WACMR

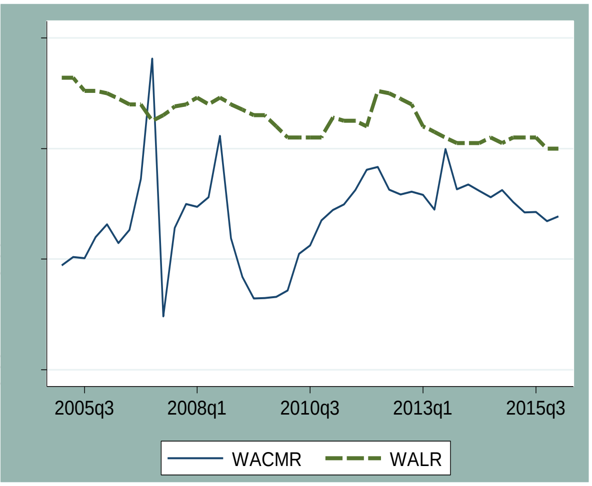
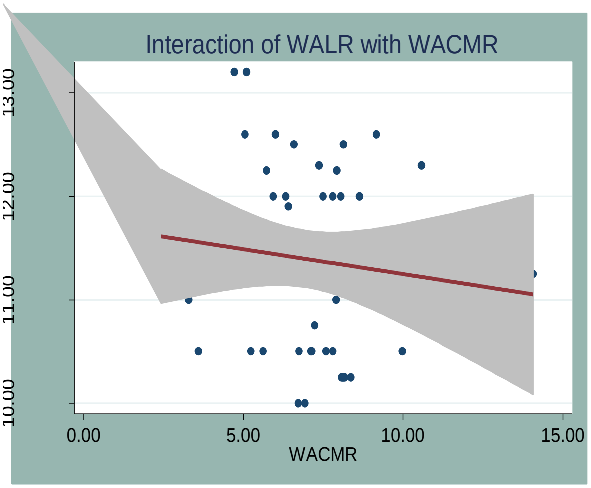


Figure 5.3.8: Interaction of WALR with WACMR



Source: Reserve Bank of India database

Unit Root Tests

To estimate the VEC model, the first step is to test for stationarity. The stationarity properties in the time series are substantiated by performing the Augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979, 1981), Phillips-Perron (PP) (Phillips and Perron, 1988) KPSS (Kwiatkowski-Phillips-Schmidt-Shin, 1992) tests. To ensure that the spurious regression that Granger and Newbold (1974) identified would not be an issue for our models, we conducted ADF, PP, and KPSS unit root tests to confirm whether three variables are stationary. Test results are shown in Table 14. We notice that the t-statistic value is lesser than the critical values so that we do not accept the null that there is a unit root. On the other hand, we accept the alternate hypothesis that there is no unit root in the series at conventional test sizes. WACMR is found to stationary at the level form and WALR is first differenced to become stationary. The tests are conducted on the variables in levels and first differences.

Table 14: Unit root tests

We report the test statistics for ADF, PP, and KPSS Test. ***, **, * indicate the significance of the result at 1%, 5%, and 10% respectively. For KPSS test results, asymptotic critical values are provided as per Kwiatkowski-Phillips-Schmidt-Shin (1992, Table1). PP test, ADF test (H0: series has a unit root).

	Test Statistic at level form			Test Statistic at 1st diff.		
Variable	ADF Test	PP Test	KPSS Test	ADF Test	PP Test	KPSS Test
WACMR	-4.38***	-4.40***	0.24*	--	--	--
WALR	-1.83	-1.84	0.64***	-6.54***	-6.54***	0.06***

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. The number of lags in the VAR is chosen considering several tests as detailed in the lag selection section of this report. Table 15 presents the vector autoregression estimates.

Table 15: Vector Autoregression Estimates

Standard errors in ( ) & t-statistics in [ ]

	WALR	WACMR
WALR(-1)	0.9313	1.0392
	-0.1580	-0.7712
	[5.8941]	[1.3475]
WALR(-2)	0.0317	-0.7333
	-0.1550	-0.7565
	[0.2047]	[-0.9693]
WACMR(-1)	0.0185	0.3519
	-0.0318	-0.1552
	[0.5823]	[2.2677]
WACMR(-2)	0.0302	0.1600
	-0.0315	-0.1537
	[0.9596]	[1.0410]
R-squared	0.7693	0.1577
Adj. R-squared	0.7516	0.0929
Sum sq. resids	6.8080	162.18
S.E. equation	0.4178	2.0393
F-statistic	43.351	2.4346
Log likelihood	-21.387	-89.556
Akaike AIC	1.1808	4.3515
Schwarz SC	1.3447	4.5153
Mean dependent	11.312	7.0191
S.D. dependent	0.8382	2.1412
Determinant resid covariance (dof adj.)		0.7250
Determinant resid covariance		0.5964
Log likelihood		-110.91
Akaike information criterion		5.5309
Schwarz criterion		5.8586

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out Pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the $\chi2$ statistic for joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WALR and the second block consisting of WACMR

(Table 16). The results suggest a unidirectional causality running from changes in WACMR to WALR.

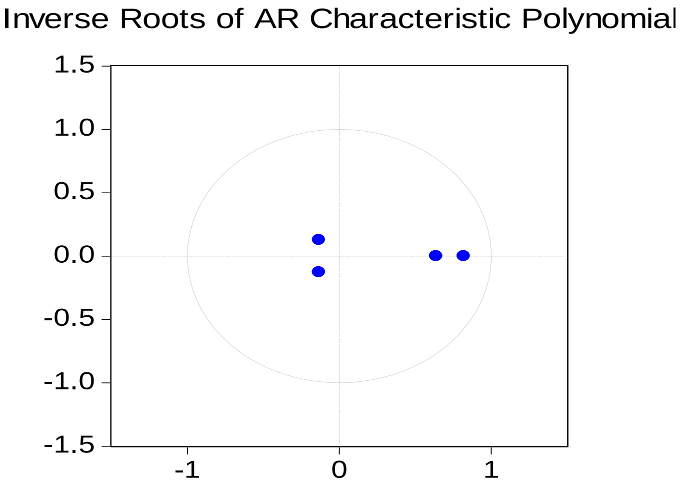
Table 16: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WALR			
Excluded	Chi-sq	df	Prob.
WACMR	2.1799	2	0.3362
All	2.1799	2	0.3362
Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
WALR	9.4077	2	0.0091
All	9.4077	2	0.0091

Stability Condition Check

We perform the VAR stability condition check and we observe from Figure 9 that (a) values of the roots are less than unity (b) modulus values are also less than unity, and (c) the inverse roots of the AR Characteristic Polynomials lie within the Unit Circle. All these observations testify for the stability of the VAR model and thus, all these findings confirm that the estimated VAR model is stable.

Figure 5.3.9: VAR Stability Condition



Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.3.17, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.3.17: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.1681	10.8502	15.4947	0.2209
r ≤1	r >1	At most 1 *	0.0716	3.1184	3.8415	0.0774
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r =0	None*	0.1681	7.7317	14.2646	0.4066
r =1	r =1	At most 1*	0.0716	3.1184	3.8415	0.0774

1 Cointegrating Equation(s): Log likelihood = -108.0946

Normalized cointegrating coefficients (standard error in parentheses)

WALR	WACMR
1.0000	-9.2380
	(3.4456)

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values

The presence of a cointegrating vector implies that the covariates are related strongly in the long run. Johansen test of cointegration produces the *Trace* and *Maximum Eigenvalue* performed to determine the order of integration; which both indicates that we reject the null hypothesis that none of the variables is cointegrated since p-value 0.0000<0.05, but revealed that there is at most one cointegrating equation or error since p-values are greater than 0.05 for both trace and Max. Eigenvalue i.e. the variables have a long run relationship. The result of the normalized cointegrating coefficient is -9.2380 as the long run coefficient for WACMR. Since the variables are cointegrated, we can now run the VECM model.

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.3.18, we show that WALR has a negative error correction term (ECT) coefficient meaning that WALR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficient for WALR is statistically negative which implies that this variable fit into the model and suffers a shock and adjusts to restore their equilibrium.

Table 5.3.18: Vector Error Correction Estimates [WALR, WACMR]

Cointegrating Eq:	CointEq1	
WALR(-1)	1	
WACMR(-1)	1.17	
	(0.37)	
	[3.14]	
Intercept	-18.34	
Error Correction:	D(WALR)	D(WACMR)
CointEq1	-0.37	0.00
	(0.13)	(0.00)
	[-2.9465]	[0.2590]
D(WALR(-1))	0.17	0.00
	(0.16)	(0.00)
	[1.0742]	[0.0078]
D(WALR(-2))	0.25	0.00
	(0.16)	(0.00)
	[1.5772]	[-0.5713]
D(WACMR(-1))	2.75	0.33
	(8.70)	(0.07)
	[0.3163]	[4.5071]
D(WACMR(-2))	1.21	0.26
	(2.77)	(0.02)
	[0.4355]	[11.3120]
Intercept	-0.20	0.02
	(0.48)	(0.00)
	[-0.4226]	[4.0969]
R-squared	0.20	0.91
Adj. R-squared	0.09	0.89
Sum sq. resids	5.56	0.00
S.E. equation	0.39	0.00
F-statistic	1.82	69.50
Log likelihood	-17.14	183.59
Akaike AIC	1.10	-8.46
Schwarz SC	1.35	-8.21
Mean dependent	-0.06	0.04
S.D. dependent	0.41	0.01
Determinant resid covariance (dof adj.)		0.00

Determinant resid covariance	0.00
Log likelihood	166.50
Akaike information criterion	-7.26
Schwarz criterion	-6.68

Note: Standard errors in ( ) & t-statistics in [ ]

The error correction coefficient for WALR was (-0.37) and it measures the speed of adjustment of WALR towards long run equilibrium. The coefficient carries the expected negative sign. The coefficient indicates a feedback of about 37% of the previous quarter's disequilibrium from the long run elasticity. About 37% percent of disequilibrium is "corrected" in each quarter by changes in WACMR.

Table 5.3.19: VECM Regression Results

D(WALR) = C(1)*(WALR(-1) + 0.030377273419*WACMR(-1) - 11.5677429451) + C(2)*D(WALR(-1)) + C(3)*D(WACMR(-1)) + C(4)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.1322	0.0793	-1.6676	0.1034
C(2)	0.0440	0.1550	0.2837	0.7781
C(3)	-0.9287	1.2105	-0.7672	0.4476
C(4)	-0.0261	0.0865	-0.3022	0.7641
R-squared	0.1039	Mean dependent var		-0.0744
Adjusted R-squared	0.0349	S.D. dependent var		0.4155
S.E. of regression	0.4082	Akaike info criterion		1.1343
Sum squared resid	6.4985	Schwarz criterion		1.2981
Log likelihood	-20.3875	Hannan-Quinn criter.		1.1947
F-statistic	1.5070	Durbin-Watson stat		1.9993
Prob(F-statistic)	0.2278			

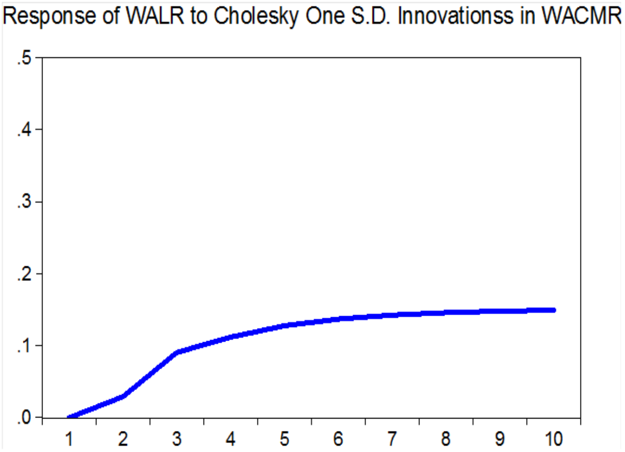
Table 5.3.19 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2), C(3), C(4), C(5), C(6), and C(7) are short run coefficients. C(1) is the speed of adjustment towards a long run equilibrium which is negative; meaning WACMR has a long run influence on WAR.

The coefficient of -0.37 indicates that the lending rate adjusts by 37 percent per time period towards the WACMR after a deviation from equilibrium, resulting in 8.1 months to achieve the pass-through from a change in the WACMR.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.3.10.

Figure 5.3.10: Impulse Responses



The impulse responses show the effect of an unexpected 1 percentage point increase in WACMR on WALR in the VECM. An unexpected rise in WACMR is associated with a rise in WALR by around 0.4237 in the 1st period and settles in the range of 0.4248 to 0.4308 during the 4th to the 10th period (Table 5.3.20).

Table 5.3.20: Response of WALR to Cholesky One S.D. Innovation of Repo

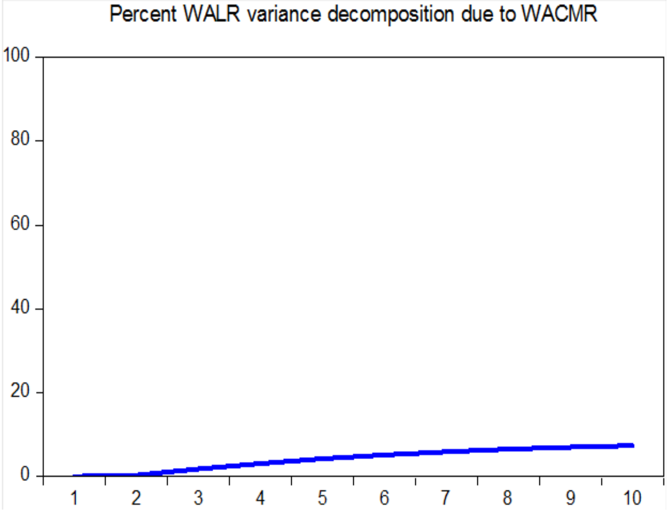
Period	WALR	WACMR
1	0.4237	0.0000
2	0.4054	0.0292
3	0.4109	0.0906
4	0.4216	0.1119
5	0.4248	0.1278
6	0.4275	0.1371
7	0.4290	0.1426
8	0.4299	0.1460
9	0.4305	0.1480
10	0.4308	0.1492

Cholesky Ordering: WACMR REPO

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.3.11: Variance Decompositions



The variance of decompositions is presented in Figure 5.3.11. We notice that at period 10, 7.3625 percent of the errors in the forecast of WALR are attributed to WACMR (Table 5.3.21).

Table 5.3.21: Variance Decomposition of WALR

Period	S.E.	WALR	WACMR
1	0.4237	100.0000	0.0000
2	0.5871	99.7533	0.2467
3	0.7223	98.2631	1.7369
4	0.8438	96.9684	3.0316
5	0.9533	95.8280	4.1720
6	1.0537	94.8928	5.1072
7	1.1466	94.1396	5.8604
8	1.2332	93.5326	6.4674
9	1.3145	93.0405	6.9595
10	1.3913	92.6375	7.3625

Cholesky Ordering: WACMR REPO

3.3. Transmission from the inter-bank market rate to deposit rate

The baseline model includes five variables given in the order: DR and WACMR. The estimation sample has been chosen so as to exclude any structural changes. We employ a VAR model of the form:

$$\boldsymbol{Z_t = A(L)Z_{t-1} + \mu + \varepsilon_t}$$

Z_t is a vector of endogenous variables, A(L) describes parameter matrices, μ is a vector of constant terms and ε_t is a vector of error terms that are assumed to be white noise. The vector Z_t comprises the following variables:

$$\boldsymbol{Z_t = (DR_t + WACMR_t)}$$

Where, DR_t – Deposit Rate in the bank market

$WACMR_t$ – Weighted Average Call Money Rate

A vector error correction model is estimated with the following cointegrating relationships

$$\boldsymbol{DR_t = \theta_0' + \theta_1' WACMR_t + \varepsilon_{1t}}$$

The identifying assumption that underlies this step of the empirical method is that the deposit rate is weakly exogenous to the WACMR. The assumption is possibly more difficult in that an increase in the cost of deposits could make raising funds in the overnight market more attractive. With a preference for more stable and longer-maturity deposit funding, however, any feedback effects are likely small. The assumption is reasonable since changes in interest rates on bank loans, which will be of longer maturity, are unlikely to have feedback effects on overnight call money transactions. The coefficient on the first error correction term represents the speed of adjustment of the lending rate to a deviation in the relationship between the lending rate and WACMR.

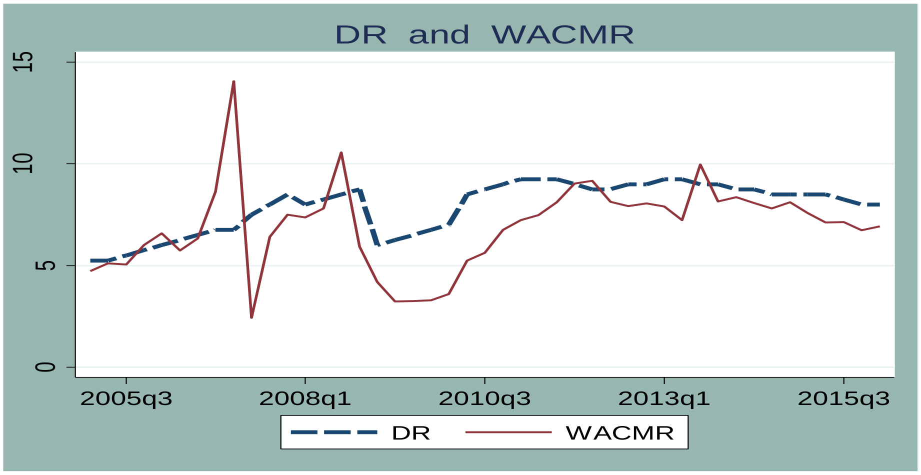
The VECM model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1. The DR and WACMR are expressed in the vector of constant terms comprises a linear trend and a constant. Choosing a lag length of one ensures that the error terms dismiss signs of autocorrelation and conditional heteroscedasticity. Table 5.3.22 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.93. DR ranges from a minimum of 5.25 to a maximum of 9.25 with a mean value of 7.88.

Table 5.22: Descriptive Statistics

	DR	WACMR
Mean	7.8833	6.9253
Median	8.5000	7.2300
Maximum	9.2500	14.0700
Minimum	5.2500	2.4200
Std. Dev.	1.2563	2.1380
Skewness	-0.7589	0.3591
Kurtosis	2.1706	4.6042
Jarque-Bera	5.6097	5.7924
Probability	0.0605	0.0552
Observations	45	45

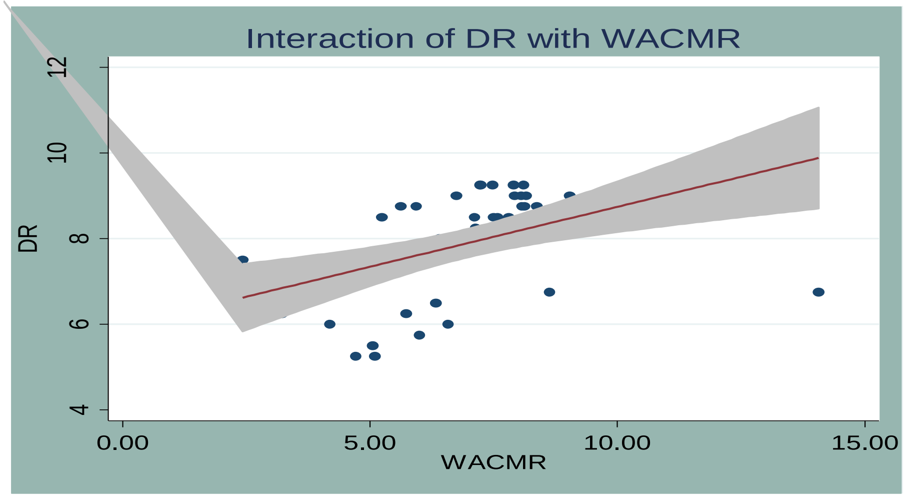
The covariates of the model are presented in Figure 5.3.12 and the interaction of DR and WACMR are presented in Figure 5.3.13.

Figure 5.3.12: DR and WACMR



Source: Reserve Bank of India database

Figure 5.3.13: Interaction of DR with WACMR



Source: Reserve Bank of India database

Unit root tests

To estimate the VEC model, the first step is to test for stationarity. The stationarity properties in the time series are substantiated by performing the Augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979, 1981), Phillips-Perron (PP) (Phillips and Perron, 1988) KPSS (Kwiatkowski-Phillips-Schmidt-Shin, 1992) tests. To ensure that the spurious regression that Granger and Newbold (1974) identified would not be an issue for our models, we conducted ADF, PP, and KPSS unit root tests to confirm whether three variables are stationary. Test results are shown in Table 5.3.23. We notice that the t-statistic value is lesser than the critical values so that we do not accept the null that there is a unit root. On the other hand, we accept the alternate hypothesis that there is no unit root in the series at conventional test sizes. WACMR is found to stationary at the level form and DR is first differenced to become stationary. The tests are conducted on the variables in levels and first differences.

Table 5.3.23: Unit root tests

We report the test statistics for ADF, PP, and KPSS Test. ***, **, * indicate the significance of the result at 1%, 5%, and 10% respectively. For KPSS test results, asymptotic critical values are provided as per Kwiatkowski-Phillips-Schmidt-Shin (1992, Table1). PP test, ADF test (H0: series has a unit root).

	Test Statistic at level form			Test Statistic at 1st diff.		
Variable	ADF Test	PP Test	KPSS Test	ADF Test	PP Test	KPSS Test
WACMR	-4.38***	-4.40***	0.24*	--	--	--
DR	-2.28	-2.28	0.58*	-6.23***	-6.23***	0.19*

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. The number of lags in the VAR is chosen considering several tests as detailed in the lag selection section of this report. Table 5.3.24 presents the vector autoregression estimates.

Table 5.3.24: Vector Autoregression Estimates

Standard errors in ( ) & t-statistics in [ ]

	DR	WACMR
DR(-1)	0.9862	0.6955
	-0.0398	-0.1358
	[24.7629]	[5.1199]
WACMR(-1)	0.0206	0.2135
	-0.0439	-0.1496
	[0.4695]	[1.4276]
R-squared	0.7984	0.2543
Adj. R-squared	0.7936	0.2366
Sum sq. resids	12.571	146.26
S.E. equation	0.5471	1.8662
F-statistic	166.33	14.326
Log likelihood	-34.872	-88.860
Akaike AIC	1.6760	4.1300
Schwarz SC	1.7571	4.2111
Mean dependent	7.9432	6.9755
S.D. dependent	1.2042	2.1358
Determinant resid covariance (dof adj.)		1.0352
Determinant resid covariance		0.9432
Log likelihood		-123.58
Akaike information criterion		5.7991
Schwarz criterion		5.9613

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out Pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for the joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block of DR and the second block consisting of WACMR (Table 5.3.25). The results suggest a unidirectional causality running from changes in WACMR to DR and vice versa.

Table 5.3.25: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: DR			
Excluded	Chi-sq	df	Prob.
WACMR	0.2204	1	0.6387
All	0.2204	1	0.6387
Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
DR	26.2135	1	0.0000
All	26.2135	1	0.0000

Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.3.26, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.3.26: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.1927	8.9022	15.4947	0.3745
r ≤1	r >1	At most 1 *	0.0030	0.1246	3.8415	0.7241
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r =0	None*	0.1927	8.7776	14.2646	0.3051
r =1	r =1	At most 1*	0.0030	0.1246	3.8415	0.7241

1 Cointegrating Equation(s): Log likelihood = 171.35

Normalized cointegrating coefficients (standard error in parentheses)

DR	WACMR
1	-0.7487
	-0.5818

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The presence of a cointegrating vector implies that the covariates are related strongly in the long run. Johansen test of cointegration produces the *Trace* and *Maximum Eigenvalue* performed to determine the order of integration; which both indicates that we reject the null hypothesis that none of the variables is cointegrated since p-value 0.0000<0.05, but revealed that there is at most one cointegrating equation or error since p-values are greater than 0.05 for both trace and Max. Eigenvalue i.e. the variables have a long run relationship. The result of the normalized cointegrating coefficient is -0.7487 as the long run coefficient for WACMR. Since the variables are cointegrated, we can now run the VECM model.

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.3.27, we show that DR has a negative error correction term (ECT) coefficient meaning that DR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficient for DR is statistically negative which implies that this variable fit into the model and suffers a shock and adjusts to restore their equilibrium.

Table 5.3.27: Vector Error Correction Estimates [DR, WACMR]

Cointegrating Eq:	CointEq1	
DR(-1)	1	
WACMR(-1)	-0.75	
	(0.58)	
	[-1.28]	
Intercept	-3.59	
Error Correction:	D(DR)	D(WACMR)
CointEq1	-0.34	0.00
	(0.13)	(0.00)
	[-2.65]	[-0.72]
D(DR(-1))	0.17	0.00
	(0.17)	(0.00)
	[1.002]	[0.36]
D(DR(-2))	0.15	0.00
	(0.17)	(0.00)
	[0.90]	[0.42]
D(DR(-3))	0.10	0.00
	(0.17)	(0.00)
	[0.59]	[0.23]
D(WACMR(-1))	2.60	0.52
	(27.83)	(0.10)
	[0.09]	[5.15]
D(WACMR(-2))	-12.92	-0.08
	(17.11)	(0.06)
	[-0.75]	[-1.29]
D(WACMR(-3))	-5.31	-0.11
	(8.83)	(0.03)
	[-0.60]	[-3.35]
Intercept	0.70	0.03
	(0.90)	(0.00)
	[0.77]	[8.31]
R-squared	0.19	0.52
Adj. R-squared	0.01	0.41
Sum sq. resids	10.11	0.00
S.E. equation	0.55	0.00
F-statistic	1.09	5.02
Log likelihood	-29.48	200.72
Akaike AIC	1.83	-9.40
Schwarz SC	2.16	-9.07
Mean dependent	0.05	0.04
S.D. dependent	0.56	0.00
Determinant resid covariance (dof adj.)		0.00
Determinant resid covariance		0.00
Log likelihood		171.36
Akaike information criterion		-7.48
Schwarz criterion		-6.73

The error correction coefficient for DR was (-0.34). The coefficient indicates a feedback of about 34% of the previous quarter’s disequilibrium from the long run elasticity.

Table 5.3.28: VECM Regression Results

D(DR) = C(1)*(DR(-1) - 0.74870477298*WACMR(-1) - 3.58578049825) + C(2)*D(DR(-1)) + C(3)*D(DR(-2)) + C(4)*D(DR(-3)) + C(5)*D(WACMR(-1)) + C(6)*D(WACMR(-2)) + C(7)*D(WACMR(-3)) + C(8)

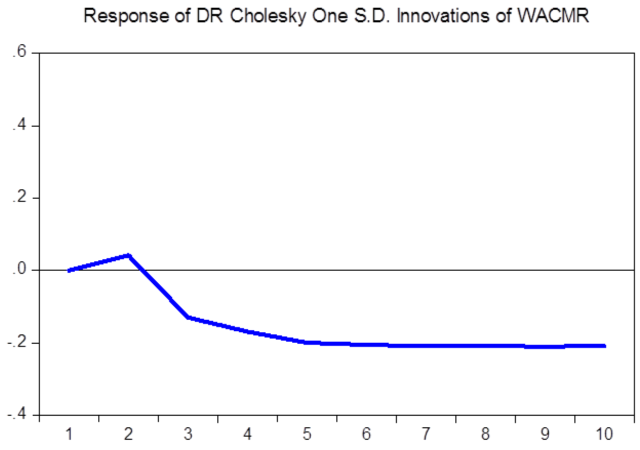
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.3431	0.1294	-2.6509	0.0122
C(2)	0.1692	0.1687	1.0030	0.3232
C(3)	0.1516	0.1671	0.9073	0.3708
C(4)	0.0990	0.1662	0.5957	0.5554
C(5)	2.6004	27.8342	0.0934	0.9261
C(6)	-12.9238	17.1136	-0.7552	0.4555
C(7)	-5.3122	8.8302	-0.6016	0.5516
C(8)	0.6982	0.9027	0.7735	0.4448
R-squared	0.1872	Mean dependent var		0.0549
Adjusted R-squared	0.0148	S.D. dependent var		0.5577
S.E. of regression	0.5535	Akaike info criterion		1.8281
Sum squared resid	10.1100	Schwarz criterion		2.1624
Log likelihood	-29.4756	Hannan-Quinn criter.		1.9498
F-statistic	1.0860	Durbin-Watson stat		2.1058
Prob(F-statistic)	0.3944			

Table 5.3.28 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with DR as the dependent variable while C(2), C(3), and C(4) are short run coefficients. The long run coefficient of the model -0.3431 is statistically significant at the 5 percent level of significance indicating the speed of adjustment of DR with WACMR at a level of 34.31% per period.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.3.14.

Figure 5.3.14: Impulse Responses



The impulse responses show the effect of an unexpected 1 percentage point increase in WACMR on DR in the VECM. An unexpected rise in WACMR is associated with a rise in DR by around 0.0422 in the 2nd period and settles in the range of 0.2093 to 0.2095 during the 8th to the 10th period (Table 5.3.29).

Table 5.3.29: Response of DR to Cholesky One S.D. Innovation of Repo

Period	DR	WACMR
1	0.5347	0.0000
2	0.5484	0.0422
3	0.5719	-0.1296
4	0.5592	-0.1690
5	0.5580	-0.1998
6	0.5554	-0.2055
7	0.5551	-0.2089
8	0.5548	-0.2093
9	0.5547	-0.2095
10	0.5547	-0.2095

Cholesky Ordering: WACMR REPO

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.3.15: Variance Decompositions

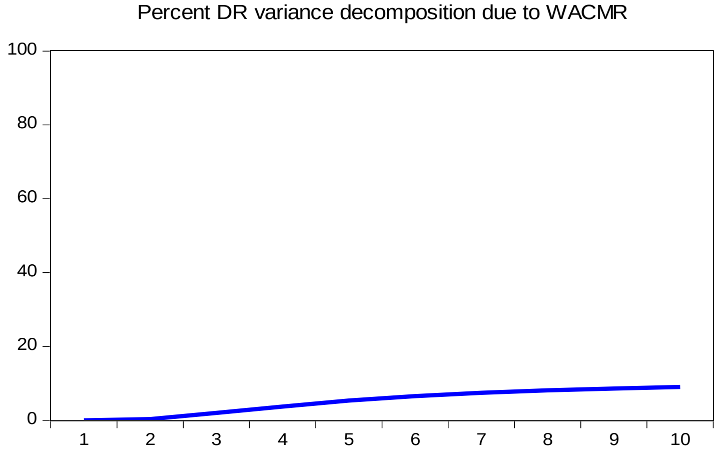


Table 5.3.30: Variance Decomposition of DR

Period	S.E.	DR	WACMR
1	0.5347	100.0000	0.0000
2	0.7671	99.6969	0.3031
3	0.9656	98.0073	1.9927
4	1.1285	96.2982	3.7018
5	1.2747	94.6420	5.3580
6	1.4056	93.4550	6.5450
7	1.5256	92.5689	7.4311
8	1.6367	91.9096	8.0904
9	1.7408	91.4001	8.5999
10	1.8390	90.9968	9.0032

Cholesky Ordering: WACMR REPO

The variance of decompositions is presented in Figure 5.3.15. We notice that at period 10, 9.0032 percent of the errors in the forecast of DR are attributed to WACMR (Table 5.3.30). The deposit rate adjusts to deviations between the deposit rate and WACMR more quickly, with the coefficient of -0.3431 indicating 4.3 months to achieve 50 percent of pass-through.

Findings:

Transmission to the Inter-Bank Market Rate

Monetary economics literature shows that the monetary policy actions get transmitted to the real economy through the inter-bank market rate. The market interest rate targeted by the monetary policy framework is the weighted average call money rate (WACMR). The correlation statistics reveal a positive significant relationship between REPO rate and WACMR at the level of 0.69* during the sample period. The Pairwise Granger causality tests suggest the presence of significant causality running from REPO rate and WACMR and also the reverse. There is strong bidirectional causality between the policy rate and the call money rate (Table 5.3.31).

Table 5.331: Causal Relationship between REPO rate and WACMR

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
REPO does not Granger Cause WACMR	43	2	319.86	0.0000
WACMR does not Granger Cause REPO	43	2	31250.60	0.0000

The VECM results show that there is a cointegrating vector between the monetary policy repo rate and the operating target rate (WACMR). The coefficient on the repo rate 1.18 indicates a long-run elasticity between the REPO rate and WACMR. Further, the results suggest that the error correction coefficient for WACMR was (-0.20) and it measures the speed of adjustment of WACMR towards long run equilibrium. The results indicate a feedback of about 20 percent of the previous quarter's disequilibrium from the long run elasticity. In simpler terms, about 20 percent of disequilibrium is "corrected" in each quarter by changes in WACMR.

The impulse responses show that the effect of an unexpected 1 percentage point increase in REPO is associated with a rise in WACMR by around 2.0356 in the 1st period and settles in the range of 0.9947 to 1.0297 during the 4th to the 10th period. The response of WACMR settles at the level of 0.50 to 0.55 after the 5th period. The variance decompositions suggest that at end of 10 quarters, 20.81 percent of the errors in the forecast of WACMR are attributed to REPO shocks. The variance decomposition in the 2nd quarter is observed to be 15.49 percent and stabilizes at an average level of 20.5 percent from the 5th quarter. These results thus, show that there is significant, albeit slow, pass-through of policy changes to inter-bank call money rate.

Transmission from Call Money Rate to the Lending Rate

Theory suggests that the monetary policy actions get transmitted to the credit market through the lending rate from the inter-bank call money rate. The correlation statistics reveal a relationship between WACMR and WALR at the level of -0.11 during the sample period. The long-run results of the VECM show the presence of the cointegrating vector between the lending rate and the WACMR. The elasticity of the lending rate with respect to the WACMR is 0.37, meaning that, on average, only 37% of a change in the WACMR gets passed on to the lending rate. The error correction coefficient for WALR was -0.37 and it measures the speed of adjustment of WALR towards long run equilibrium. The coefficient indicates a feedback of about 37% of the previous quarter's disequilibrium from the long run elasticity. The coefficient of -0.37 indicates that the lending rate adjusts by 37 percent per time period towards the

WACMR after a deviation from equilibrium, resulting in 8.1 months to achieve the pass-through from a change in the WACMR.

The impulse responses reveal that an unexpected rise in WACMR is associated with a rise in WALR by around 0.4237 in the 1st quarter and settles in the range of 0.4248 to 0.4308 during the 4th to the 10th quarter. The variance decompositions show that at the 10th quarter, 7.3625 percent of the errors in the forecast of WALR are attributed to WACMR. The results thus suggest a weak pass-through of monetary policy to the lending rate from the inter-bank call money rate in India.

Transmission from Call Money Rate to the Deposit Rate

Monetary policy literature suggests that the monetary policy actions get transmitted to the bank channel through the deposit rates as well via the inter-bank call money rate. The correlation statistics reveal a positive significant relationship between WACMR and DR at the level of 0.48* during the sample period.

Table 5.3.32: Causal Relationship between WACMR and DR

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
DR does not Granger Cause WACMR	36	8	1.4338	0.2458
WACMR does not Granger Cause DR	36	8	9.2550	0.0000

The Pairwise Granger causality tests suggest the presence of unidirectional causality running from the call money rate at the deposit rate (Table 5.3.32). However, the absence of the reverse causation from deposit rate to call money rate is not significant, suggesting the weaker feedback from deposit (liquidity) channel of monetary policy transmission. The unidirectional causation running from monetary policy action through call money rate at a deposit rate seems to be weaker as this process looks just coincidental, not targeted.

The long run coefficient of -0.3431 indicates the speed of adjustment of DR with WACMR at a level of 34.31% per period. The impulse responses show that an unexpected one percentage point rise in the call money rate is associated with a rise in deposit rate by around 0.0422 in the 2nd quarter and settles in the range of 0.2093 to 0.2095 during the 8th to the 10th quarter. The variance decompositions suggest that at the 10th quarter, 9.0032 percent of the errors in the forecast of deposit rate are attributed to the call money rate. Thus, the results indicate that the extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate.

Study 4: Assessing the Pass-through to call money rate from Monetary Policy

The pass-through to call money rate from the monetary policy repo rate is now assessed using an error correction model which has two stages, corresponding to the long-run pass-through and short-run dynamics, is estimated as follows in section 4.1. The identifying assumption that underlies this step of the empirical method is that the repo rate is weakly exogenous to the WACMR. That is, that there is no feedback to the repo rate from the WACMR. This is a reasonable assumption in that the repo rate is a policy rate decided by the central bank. Further, we estimate the pass-through using an alternate specification in section 4.2 to account for the effective policy rate depending on the liquidity situation; a specification is estimated where both the reverse repo rate and the repo rate are included in the long-run stage.

4.1 Assessing the pass-through from LAF Net Injection to Call Money Rate

The estimation sample has been chosen so as to exclude any structural changes. We employ a VAR model of the form:

$$\boldsymbol{Z_t = A(L)Z_{t-1} + \mu + \varepsilon_t}$$

Z_t is a vector of endogenous variables, $A(L)$ describes parameter matrices, μ is a vector of constant terms and ε_t is a vector of error terms that are assumed to be white noise. An error correction model (Das, 2015) which has two stages, corresponding to the long-run pass-through and short-run dynamics is estimated as follows:

$$\boldsymbol{WACMR_t = \beta_0 + \beta_1 REPO_t + \varepsilon_t}$$

------ LR Eqn

$$\Delta WACMR_t = \alpha ECT_0 + \sum_{K=1}^{K} \delta_{2K}\, \Delta WACMR_{t-k} + \delta_{3k}\Delta(LAFNI/NDTL)_{t-k} + v_t$$

------ SR Eqn

where the error correction term:

$$ECT_t = WACMR_{t-1} - \widehat{\beta}_0 - \widehat{\beta}_1 REPO_{t-1}$$

is the residual from the LR equation, which measures period t-1 deviations from the long-run stationary relationship.

Where, $REPO_t$ – Policy REPO Rate

$WACMR_t$ – Weighted Average Call Money Rate

$LAFNI_t$ – Liquidity adjustment facility net injection

$NDTL_t$ – Net Demand and Time Liabilities

ECT_t – the Error Correction Term

The VECM model is estimated by using quarterly data over the period from 2005Q1 to 2016Q1.

The short-run equation is further written as:

$$WACMRD = \alpha ECT + SUMDELTAWACMRDLAG + DELTALAFNITONDTL + \mathcal{V}_t$$

- WACMRD is the delta WACMR (change in WACMR)
- ECT is the error correction term meaning the difference between WACMR and REPO.
- SUMDELTAWACMRLAG is $\sum_{K=1}^{K} \Delta WACMR_{t-k}$
- DELTALAFNITONDTL is $\Delta(LAFNI/NDTL)_{t-k}$

Table 5.4.1 provides the descriptive statistics of the variables. WACMRD rate ranges from a minimum of -11.650 to a maximum of 5.440 with a mean value of 0.0503.

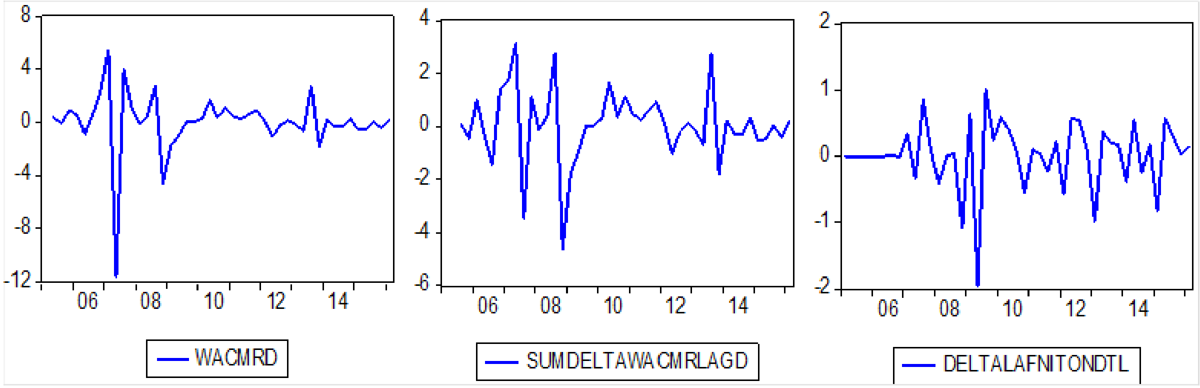
SUMDELTAWACMRLAGD ranges from a minimum of -2.19 to a maximum of 5.15 with a mean value of 1.3173. DELTALAFNITONDTL has a mean value of 0.0153 and it ranges from a minimum of -1.9585 and maximum of 1.0005.

Table 5.4.1: Descriptive Statistics

	WACMRD	SUMDELTAWACMRLAGD	DELTALAFNITONDTL
Mean	0.0503	1.3173	0.0153
Median	0.1717	1.7650	0.0482
Maximum	5.4400	5.1500	1.0005
Minimum	-11.650	-2.1900	-1.9585
Std. Dev.	2.3749	1.9073	0.5339
Skewness	-2.5348	-0.2652	-1.3019
Kurtosis	15.315	2.3218	6.0102
Observations	44	44	44

The covariates of the model are presented in Figure 5.4.1.

Figure 5.4.1: Covariates



Source: Reserve Bank of India database

The next step in our analysis was to check the simple correlations between variables under study. Presenting the correlation instead of covariance makes it easier to see that whether the variables are correlated. Table 5.4.2 presents the Pearson’s correlations (δ) with significance levels (two-tailed) as well as the standard errors with the bootstrap results. The correlations of the covariates suggest that WACMRD and ECT are strongly correlated.

Table 5.4.2: Correlations

	WACMRD	ECT	SUMDELTAWACMRLAGD	DELTALAFNITONDTL
WACMRD	1.0000			
ECT	-0.6150	1.0000		
SUMDELTAWACMRLAGD	-0.0980	0.4416	1.0000	
DELTALAFNITONDTL	0.2736	-0.2158	-0.0459	1.0000

Unit root tests

To estimate the VEC model, the first step is to test for stationarity. The stationarity properties in the time series are substantiated by performing the Augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979, 1981), Phillips-Perron (PP) (Phillips and Perron, 1988) KPSS (Kwiatkowski-Phillips-Schmidt-Shin, 1992) tests. To ensure that the spurious regression that Granger and Newbold (1974) identified would not be an issue for our models, we conducted ADF, PP, and KPSS unit root tests to confirm whether three variables are stationary. Table 5.4.3 reports the results of the unit root tests.

Table 5.4.3: Unit root tests

We report the test statistics for ADF, PP, and KPSS Test. ***, **, * indicate the significance of the result at 1%, 5%, and 10% respectively. For KPSS test results, asymptotic critical values are provided as per Kwiatkowski-Phillips-Schmidt-Shin (1992, Table1). PP test, ADF test (H0: series has a unit root).

	Test Statistic at level form		
Variable	ADF Test	PP Test	KPSS Test
WACMRD	-9.8450***	-12.3341***	0.1489
ECT	-6.7682***	-6.8341***	0.1116
SUMDELTAWACMRLAGD	-7.6111**	-7.7766***	0.0710
DELTALAFNITONDTL	-10.1025***	-11.8356***	0.2339

We notice that the t-statistic value is lesser than the critical values so that we do not accept the null that there is a unit root. On the other hand, we accept the alternate hypothesis that there is no unit root in the series at conventional test sizes. All the three variables are found to be stationary at the level form in the three types of unit root tests.

We estimate an unrestricted VAR model and apply Cholesky decomposition to the VAR specification. We determine the number of lags p of the VAR (p) model. Within the four usual criteria: Final prediction error (FPE), Akaike (AIC), Schwartz (SC) and Hannan-Quinn (HQ), Liew (2004) report that AIC and FPE are recommended to estimate autoregression Lag length. According to the previous study, we follow the result demonstrated by AIC criteria and the FPE criteria. Table 5.4.4 presents the output:

Table 5.4.4: VAR Lag Order Selection Criteria   Endogenous variables: WACMR REPO

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-181.0930	NA	2.1382*	9.2728*	9.6489*	9.4098*
1	-174.6547	10.9923	2.4364	9.3978	10.1501	9.6717

* indicates lag order selected by the criterion
LR: sequentially modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The Table 5.4.5 presents the vector autoregression estimates.

Table 5.4.5: Vector Autoregression Estimates

Standard errors in ( ) & t-statistics in [ ]

	WACMRD	SUMDELTAWACMRLAGD	DELTALAFNITONDTL
WACMRD(-1)	-0.6255	0.3251	-0.0587
	(0.19)	(0.11)	(0.04)
	[-3.22]	[2.91]	[-1.34]
WACMRD(-2)	-0.4630	0.1916	-0.0423
	(0.26)	(0.15)	(0.06)
	[-1.78]	[1.28]	[-0.72]
WACMRD(-3)	-0.1788	0.0945	-0.0319
	(0.23)	(0.13)	(0.05)
	[-0.78]	[0.72]	[-0.62]
SUMDELTAWACMRLAGD(-1)	0.2301	-0.3915	0.0379
	(0.35)	(0.20)	(0.08)
	[0.66]	[-1.97]	[0.48]
SUMDELTAWACMRLAGD(-2)	-0.0601	-0.1721	0.1310
	(0.35)	(0.20)	(0.08)
	[-0.17]	[-0.85]	[1.66]

SUMDELTAWACMRLAGD(-3)	0.1204	-0.0887	-0.0253
	(0.28)	(0.16)	(0.06)
	[0.42]	[-0.55]	[-0.40]
DELTALAFNITONDTL(-1)	0.1822	0.4383	-0.3410
	(0.83)	(0.48)	(0.19)
	[0.21]	[0.92]	[-1.83]
DELTALAFNITONDTL(-2)	0.5905	0.1863	-0.0758
	(0.87)	(0.50)	(0.20)
	[0.67]	[0.37]	[-0.38]
DELTALAFNITONDTL(-3)	0.9473	0.4432	-0.1985
	(0.79)	(0.45)	(0.18)
	[1.20]	[0.98]	[-1.12]
R-squared	0.3018	0.3267	0.3072
Adj. R-squared	0.1216	0.1529	0.1284
Sum sq. resids	168.44	55.544	8.4908
S.E. equation	2.3310	1.3386	0.5234
F-statistic	1.6750	1.8801	1.7182
Log likelihood	-85.511	-63.323	-25.759
Akaike AIC	4.7256	3.6162	1.7380
Schwarz SC	5.1056	3.9962	2.1180
Mean dependent	0.0088	0.0390	0.0168
S.D. dependent	2.4872	1.4544	0.5606
Determinant resid covariance (dof adj.)		1.7444	
Determinant resid covariance		0.8120	
Log likelihood		-166.10	
Akaike information criterion		9.6554	
Schwarz criterion		10.7954	

Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.4.6, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.4.6: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.5682	63.4339	29.7971	0.0000
r ≤1	r >1	At most 1 *	0.3541	30.6838	15.4947	0.0001
r ≤2	r >2	At most 2 *	0.2950	13.6343	3.8415	0.0002
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.5682	32.7501	21.1316	0.0008
r ≤1	r >1	At most 1 *	0.3541	17.0496	14.2646	0.0177

r ≤2	r >2	At most 2 *	0.2950	13.6343	3.8415	0.0002

1 Cointegrating Equation(s): Log likelihood = -171.7574

Normalized cointegrating coefficients (standard error in parentheses)

WACMRD	SUMDELTAWACMRLAGD	DELTALAFNITONDTL
1	-1.5755	2.7912
	-0.2141	-0.7201

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.47, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficient for WACMRD is statistically negative which implies that this variable fit into the model and suffers a shock and adjusts to restore their equilibrium.

Table 5..7: Vector Error Correction Estimates
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
WACMRD(-1)	1		
SUMDELTAWACMRLAGD(-1)	-1.5755		
	(0.21)		
	[-7.35]		
DELTALAFNITONDTL(-1)	2.7912		
	(0.72)		
	[3.87]		
Intercept	0.0137		
Error Correction:	D(WACMRD)	D(SUMDELTAWACMRLAGD)	D(DELTALAFNITONDTL)
CointEq1	-0.3157	1.2964	-0.2445
	(0.72)	(0.35)	(0.15)
	[-0.43]	[3.70]	[-1.58]
D(WACMRD(-1))	-0.8884	-0.8910	0.1817
	(0.68)	(0.33)	(0.14)
	[-1.31]	[-2.70]	[1.25]
D(WACMRD(-2))	-0.7322	-0.5206	0.1137
	(0.50)	(0.24)	(0.11)
	[-1.46]	[-2.14]	[1.06]
D(WACMRD(-3))	-0.3346	-0.2262	0.0407
	(0.27)	(0.13)	(0.06)
	[-1.24]	[-1.72]	[0.70]
D(SUMDELTAWACMRLAGD(-1))	-0.3442	0.5947	-0.2838
	(0.89)	(0.43)	(0.19)
	[-0.38]	[1.36]	[-1.48]

D(SUMDELTAWACMRLAGD(-2))	-0.5128	0.3777	-0.0496
	(0.61)	(0.30)	(0.13)
	[-0.83]	[1.26]	[-0.37]
D(SUMDELTAWACMRLAGD(-3))	-0.2480	0.1133	0.0059
	(0.32)	(0.16)	(0.07)
	[-0.76]	[0.71]	[0.08]
D(DELTALAFNITONDTL(-1))	0.6108	-2.6624	-0.4607
	(1.69)	(0.82)	(0.36)
	[0.36]	[-3.23]	[-1.27]
D(DELTALAFNITONDTL(-2))	0.4338	-1.9078	-0.2756
	(1.33)	(0.65)	(0.29)
	[0.32]	[-2.93]	[-0.96]
D(DELTALAFNITONDTL(-3))	0.6200	-0.7299	-0.2177
	-0.8605	-0.4192	-0.1843
	[0.72]	[-1.74]	[-1.18]
Intercept	-0.0390	0.0226	0.0075
	(0.47)	(0.23)	(0.10)
	[-0.08]	[0.09]	[0.07]
R-squared	0.6494	0.7087	0.6860
Adj. R-squared	0.5242	0.6046	0.5738
Sum sq. resids	237.72	56.427	10.902
S.E. equation	2.9138	1.4196	0.6240
F-statistic	5.1868	6.8109	6.1163
Log likelihood	-90.586	-62.542	-30.484
Akaike AIC	5.2096	3.7714	2.1274
Schwarz SC	5.6788	4.2406	2.5966
Mean dependent	0.0271	0.0146	0.0038
S.D. dependent	4.2243	2.2577	0.9558
Determinant resid covariance (dof adj.)		3.6274	
Determinant resid covariance		1.3424	
Log likelihood		-171.7574	
Akaike information criterion		10.6542	
Schwarz criterion		12.1898	

We provide the estimates of the adjustment parameters and short-run coefficients by running the VECM of the short run (SR) equation of the model in Table 5.4.8. We find an estimate of the coefficient of ECT equal to -0.3157 indicating that when there is a deviation from the equilibrium between the WACMR and the repo rate, the WACMR adjusts by 31.5 percent per time period towards the repo rate to re-establish equilibrium. At this rate, it would take 4.76 months to achieve fifty percent of the pass-through from an increase in the repo rate. Thus, the repo rate appears to sufficiently capture the monetary policy stance of the RBI.

Table 5.4.8: VECM Regression Results

Dependent Variable: D(WACMRD)

D(WACMRD) = C(1)*(WACMRD(-1) - 1.57553524922*SUMDELTAWACMRLAGD(-1) + 2.79122213569*DELTALAFNITONDTL(-1) + 0.0137214560066) + C(2)*D(WACMRD(-1)) + C(3)*D(WACMRD(-2)) + C(4)*D(WACMRD(-3)) + C(5)*D(SUMDELTAWACMRLAGD(-1)) + C(6) *D(SUMDELTAWACMRLAGD(-2)) + C(7)*D(SUMDELTAWACMRLAGD(-3)) + (8)*D(DELTALAFNITONDTL(-1)) + C(9)*D(DELTALAFNITONDT L(-2)) + C(10)*D(DELTALAFNITONDTL(-3)) + C(11)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.3157	0.7190	-0.4391	0.6640
C(2)	-0.8884	0.6754	-1.3154	0.1991
C(3)	-0.7322	0.4982	-1.4698	0.1528
C(4)	-0.3346	0.2687	-1.2453	0.2233
C(5)	-0.3442	0.8920	-0.3859	0.7025
C(6)	-0.5128	0.6115	-0.8385	0.4088
C(7)	-0.2480	0.3235	-0.7667	0.4497
C(8)	0.6108	1.6875	0.3620	0.7201
C(9)	0.4338	1.3326	0.3255	0.7472
C(10)	0.6200	0.8605	0.7205	0.4772
C(11)	-0.0390	0.4673	-0.0835	0.9341

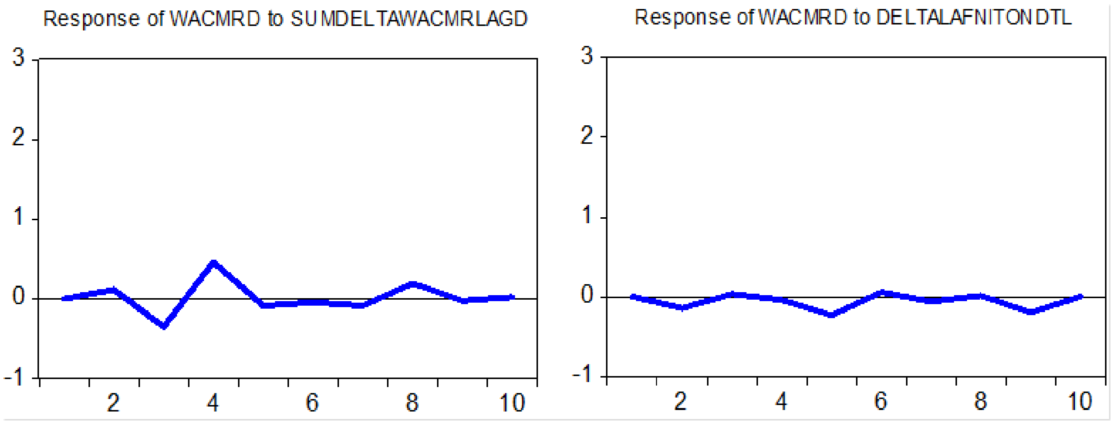
R-squared	0.2842	Mean dependent var	0.0426
Adjusted R-squared	0.2088	S.D. dependent var	2.4025
S.E. of regression	2.1370	Akaike info criterion	4.4656
Sum squared resid	173.5335	Schwarz criterion	4.6704
Log likelihood	-91.0105	Hannan-Quinn criter.	4.5411
F-statistic	3.7712	Durbin-Watson stat	2.1654
Prob(F-statistic)	0.0112		

Table 54.8 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with other variables of the model as the dependent variable while C(2) to C(11) are the short run coefficients.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The accumulated impulse responses for the recursive VAR are plotted in Figure 5.4.2.

Figure 5.4.2: Accumulated impulse responses



The impulse responses show the effect of an unexpected 1 percentage point increase in SUMDELTAWACMRLAGD and DELTALAFNITONDTL on WACMRD in the VECM. An unexpected one standard deviation shock in SUMDELTAWACMRLAGD and DELTALAFNITONDTL is associated with a change in WACMR by around 0.2567 in the 2nd period and crosses the 100 percent in between the 3rd and 4th periods (Table 5.4.9). The results suggest that the complete transmission of the monetary policy through SUMDELTAWACMRLAGD and DELTALAFNITONDTL happens around 9 months. These results support our results of the earlier analysis involving repo rate in determining the transmission to call money rate.

Table 5.4.9: Accumulated Impulse Responses

Period	WACMRD	SUMDELTAWACMRLAGD	DELTALAFNITONDTL
1	2.9138	0.0000	0.0000
2	-0.5447	0.1156	-0.1411
3	0.6212	-0.3526	0.0330
4	1.0003	0.4586	-0.0411
5	0.9687	-0.0871	-0.2327
6	0.4234	-0.0454	0.0587
7	0.7631	-0.0876	-0.0604

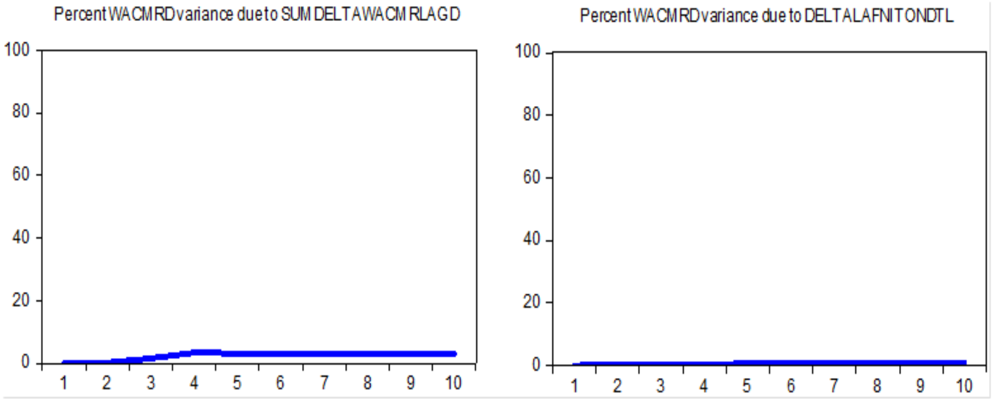
8	0.9358	0.1917	0.0128
9	0.5921	-0.0241	-0.1964
10	0.7189	0.0184	0.0016

Cholesky Ordering: WACMRD SUMDELTAWACMRLAGD DELTALAFNITONDTL

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.4.3: Variance decompositions



The variance of decompositions is presented in Figure 5.4.3. We notice that (in Table 5.4.10) at period 2, 0.1516 percent of the errors in the forecast of WACMRD are attributed to SUMDELTAWACMRLAGD, and 0.2257 percent of the errors in the forecast or WACMRD are attributed to DELTALAFNITONDTL. However, at period 10, 2.8493 percent of the errors in the forecast of WACMR are attributed to SUMDELTAWACMRLAGD. Similarly, 0.8673 percent of the errors in the forecast or WACMR are attributed to DELTALAFNITONDTL.

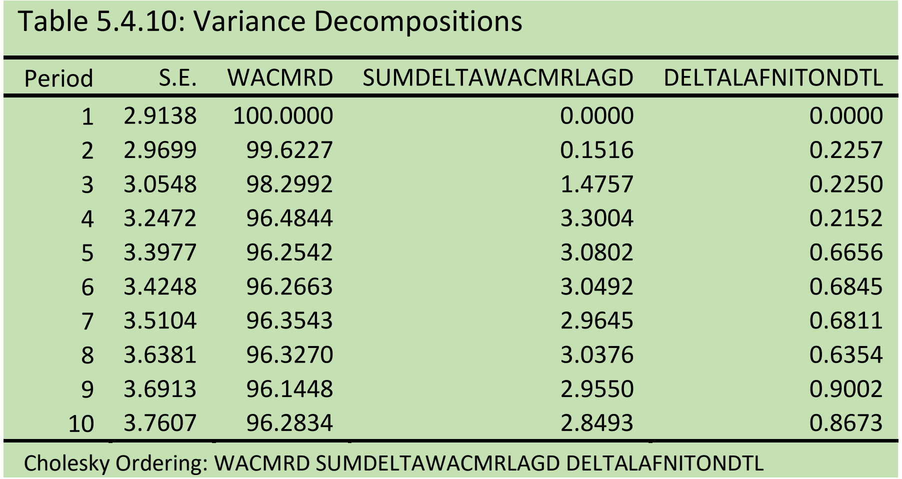


Table 5.4.10: Variance Decompositions

Period	S.E.	WACMRD	SUMDELTAWACMRLAGD	DELTALAFNITONDTL
1	2.9138	100.0000	0.0000	0.0000
2	2.9699	99.6227	0.1516	0.2257
3	3.0548	98.2992	1.4757	0.2250
4	3.2472	96.4844	3.3004	0.2152
5	3.3977	96.2542	3.0802	0.6656
6	3.4248	96.2663	3.0492	0.6845
7	3.5104	96.3543	2.9645	0.6811
8	3.6381	96.3270	3.0376	0.6354
9	3.6913	96.1448	2.9550	0.9002
10	3.7607	96.2834	2.8493	0.8673

Cholesky Ordering: WACMRD SUMDELTAWACMRLAGD DELTALAFNITONDTL

Forecasting WACMRD

Multistep ahead forecasts, computed by iterating forward the recursive model, are presented in Table 5.4.11. The first two forecast error statistics largely depend on the scale of the dependent variable and are used as relative measures to compare forecasts for the same series across different models; the smaller the error, the better the forecasting ability of that model according to that criterion. Very low scores of root mean squared error (RMSE) and mean absolute error (MAE) for the forecasts indicate the strength and accuracy of the forecast based on the VAR model. The RMSE is computed using the formula:

$$\boldsymbol{RMSE = \sqrt{\frac{\sum(y-\hat{y})^2}{n-k-1}} = \sqrt{\frac{RSS}{n-k-1}}}$$

The remaining two statistics are scale invariant. The Theil inequality coefficient always lies between 0 and 1, where 0 indicates a perfect fit. Further, as the ultimate test of a forecasting model is its out-of-sample performance, Table VI focuses on pseudo out-of-sample forecasts[9] over the period 1996-2009 (Figure 5.4.9).

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[9] Pseudo out-of-sample forecasts are often referred to as pseudo or “simulated” out-of-sample forecasts to emphasise that they simulate how these forecasts would have been computed in real time, although of course this exercise is conducted retrospectively, not in real time.

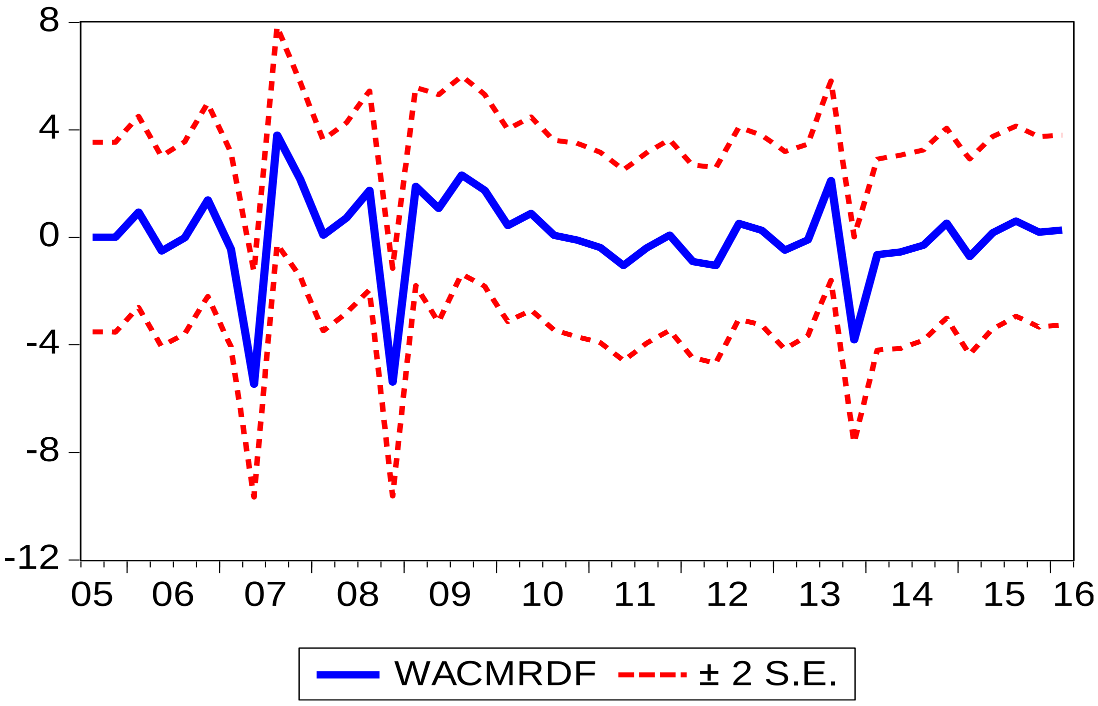
Table 5.4.11: Forecasting of WACMR

Forecast Statistics	WACMR
Root mean squared error[a]	1.7781
Mean absolute error[b]	1.1944
Mean absolute percentage error	493.43
Theil inequality coefficient	0.4580
Bias proportion	0.0079
Variance proportion	0.2169
Covariance proportion	0.7751

Notes: [a]The mean squared forecast error is computed as the average squared value of the forecast error over the 1996-2009 out-of-sample period, and the resulting square root is the root mean squared forecast error reported in the table; root mean squared errors (RMSEs) are the errors squared before they are averaged and give a relatively high weight to large errors, which infers that RMSE is most useful when large errors are particularly undesirable.

[b]mean absolute error (MAE), which is a linear score (that all the individual differences are weighted equally in the average), measures the magnitude of the errors in a set of forecasts without considering their direction and measures accuracy for continuous variable; entries are the root mean square error of forecasts computed recursively for VARs.

Figure 5.4.4: Forecasts of WACMR



4.2 Alternate Specification:

In theory, the repo rate is an important policy rate which signals the stance of monetary policy, with the reverse repo rate being a fixed distance under the repo rate and the marginal standing facility (MSF) rate being a fixed distance above the repo rate. Before the liquidity adjustment facility (LAF) became consistently operated in deficit mode, two effective policy rates depending on the liquidity situation were considered to be:

- Reverse repo rate when in a liquidity surplus (LAFnetinj < 0)
- Repo rate when in a liquidity deficit (LAFnetinj > 0)

To account for the effective policy rate depending on the liquidity situation, a specification is estimated where both the reverse repo rate and the repo rate are included in the long-run stage

$$\boldsymbol{\Delta WACMR_t = \beta_{0+}\beta_{11} ReverseRepoRate_t \times LiquidityDeficit_t + \beta_{12}\ RepoRate_t \times LiquidityDeficit_t + \varepsilon_t}$$

where

$$\boldsymbol{LiquidityDeficit_t = \begin{cases} 0 & if \quad Liquidity\ Adjustment\ Facility\ net\ injection < 0 \\ 1 & if \quad Liquidity\ Adjustment\ Facility\ net\ injection > 0 \end{cases}}$$

The specification is rewritten as

$$\boldsymbol{\Delta WACMR_t = \beta_{0+}\beta_{11} RRRLIQDEF_t + \beta_{12}\ RRLIQDEF_t + \varepsilon_t}$$

The above specification allows us to capture the effects of policy rate changes throughout the sample period. It does not miss the information from focusing on the repo rate which is the most important policy rate in India. Table 5.4.12 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.9. RRRLIQDEF ranges from a minimum of 0.00 to a maximum of 7.25 with a mean value of 4.15. RRLIQDEF ranges from a minimum of 0.00 to a maximum of 8.50 with a mean value of 5.0556.

Table 5.4.12: Descriptive Statistics

	WACMR	RRRLIQDEF	RRLIQDEF
Mean	6.9253	4.1500	5.0556
Median	7.2300	5.7500	6.7500
Maximum	14.0700	7.2500	8.5000
Minimum	2.4200	0.0000	0.0000
Std. Dev.	2.1380	2.8070	3.3676
Skewness	0.3591	-0.6691	-0.7394
Kurtosis	4.6042	1.7111	1.7651
Jarque-Bera	5.7924	6.4725	6.9594
Probability	0.0552	0.0393	0.0308
Observations	45	45	45

The covariates of the model are presented in Figure 5.4.5.

Figure 5.4.5: Covariates

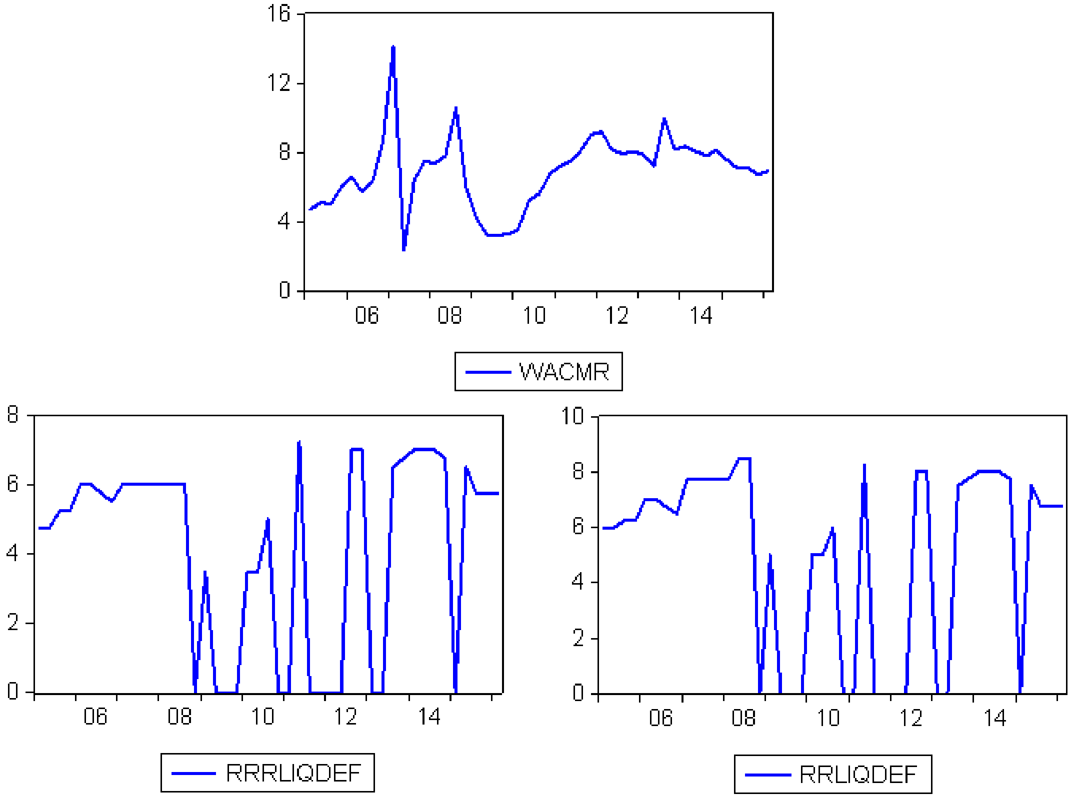
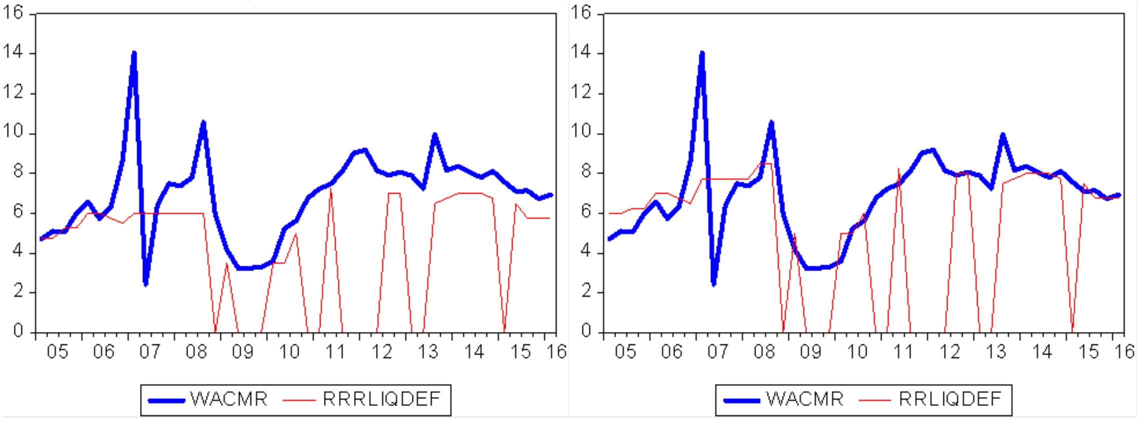


Figure 5.4.6: WACMR and RRLIQDEF, RRRLIQDEF



Unit root tests

To estimate the VEC model, the first step is to test for stationarity. The stationarity properties in the time series are substantiated by performing the Augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979, 1981), Phillips-Perron (PP) (Phillips and Perron, 1988) KPSS (Kwiatkowski-Phillips-Schmidt-Shin, 1992) tests. To ensure that the spurious regression that Granger and Newbold (1974) identified would not be an issue for our models, we conducted ADF, PP, and KPSS unit root tests to confirm whether three variables are stationary. Table 5.4.13 reports the results of the unit root tests.

Table 5.4.13: Unit root tests

We report the test statistics for ADF, PP, and KPSS Test. ***, **, * indicate the significance of the result at 1%, 5%, and 10% respectively. For KPSS test results, asymptotic critical values are provided as per Kwiatkowski-Phillips-Schmidt-Shin (1992, Table1). PP test, ADF test (H0: series has a unit root).

	Test Statistic at level form		
Variable	ADF Test	PP Test	KPSS Test
WACMR	-4.38***	-4.40***	0.24
RRRLIQDEF	-4.37***	-4.33***	0.18
RRLIQDEF	-4.37***	-4.36***	0.19

We notice that the t-statistic value is lesser than the critical values so that we do not accept the null that there is a unit root. On the other hand, we accept the alternate hypothesis that there is no unit root in the series at conventional test sizes. All the three variables are found to be stationary at the level form in the three types of unit root tests.

Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.4.14, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.4.14: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.2989	31.5644	29.7971	0.0310
r ≤1	r >1	At most 1 *	0.2181	16.2944	15.4947	0.0378
r ≤2	r >2	At most 2 *	0.1245	5.7149	3.8415	0.0168
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.2989	15.2700	21.1316	0.2704
r ≤1	r >1	At most 1 *	0.2181	10.5794	14.2646	0.1766
r ≤2	r >2	At most 2 *	0.1245	5.7149	3.8415	0.0168
		1 Cointegrating Equation(s):		Log likelihood = -211.5211		
		Normalized cointegrating coefficients (standard error in parentheses)				
		WACMR	RRRLIQDEF	RRLIQDEF		
		1	-3.2074	2.0201		
			-1.7154	-1.4265		

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.4.15, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in

the short-run to restore long-run equilibrium. The ECT coefficient for WACMR is statistically negative which implies that this variable fit into the model and suffers a shock and adjusts to restore their equilibrium.

Table 5.4.15: Vector Error Correction Estimates

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
WACMR(-1)	1		
RRRLIQDEF(-1)	-3.21		
	(1.72)		
	[-1.86979]		
RRLIQDEF(-1)	2.02		
	(1.43)		
	[1.41617]		
Intercept	-3.92		
Error Correction:	D(WACMR)	D(RRRLIQDEF)	D(RRLIQDEF)
CointEq1	-0.36	0.45	0.51
	(0.14)	(0.20)	(0.25)
	[-2.49]	[2.22]	[2.05]
D(WACMR(-1))	-0.25	-0.33	-0.39
	(0.16)	(0.22)	(0.26)
	[-1.59]	[-1.51]	[-1.48]
D(RRRLIQDEF(-1))	-0.67	0.09	0.39
	(1.07)	(1.50)	(1.80)
	[-0.62]	[0.05]	[0.21]
D(RRLIQDEF(-1))	0.46	-0.17	-0.46
	(0.88)	(1.24)	(1.49)
	[0.51]	[-0.13]	[-0.30]
Intercept	0.06	0.04	0.03
	(0.33)	(0.46)	(0.55)
	[0.18]	[0.08]	[0.06]
R-squared	0.28	0.21	0.20
Adj. R-squared	0.21	0.13	0.12
Sum sq. resids	173.53	342.36	497.61
S.E. equation	2.14	3.00	3.62
F-statistic	3.77	2.57	2.42
Log likelihood	-91.01	-105.62	-113.66
Akaike AIC	4.47	5.15	5.52
Schwarz SC	4.67	5.35	5.72
Mean dependent	0.04	0.02	0.02
S.D. dependent	2.40	3.22	3.86
Determinant resid covariance (dof adj.)		5.45	
Determinant resid covariance		3.76	
Log likelihood		-211.52	
Akaike information criterion		10.68	
Schwarz criterion		11.41	

The long-run elasticity of WACMR with respect to the reverse repo rate is 0.45 and the elasticity with respect to the repo rate is 0.51, which together come to about the same elasticity with the WACMR as the repo rate does in the first specification. Thus, the repo rate appears to sufficiently capture the monetary policy stance of the RBI.

The coefficient of -0.45 indicates that the WACMR adjusts by about 45 percent per time period towards the RRRLIQDIF after a deviation from equilibrium, resulting in 6.66 months to achieve the pass-through from a change in the RRLIQDIF. Similarly, the coefficient of -0.51 indicates that the WACMR adjusts by about 51 percent per time period towards the RRLIQDIF after a deviation from equilibrium, resulting in 5.88 months to achieve the pass-through from a change in the RRLIQDIF.

Table 5.4.16: VECM Regression Results

Dependent Variable: D(WACMR)

D(WACMR) = C(1)*(WACMR(-1) - 3.20740484365*RRRLIQDEF(-1) + 2.0201385658*RRLIQDEF(-1) - 3.91880537934) + C(2)*D(WACMR(-1)) + C(3)*D(RRRLIQDEF(-1)) + C(4)*D(RRLIQDEF(-1)) + C(5)

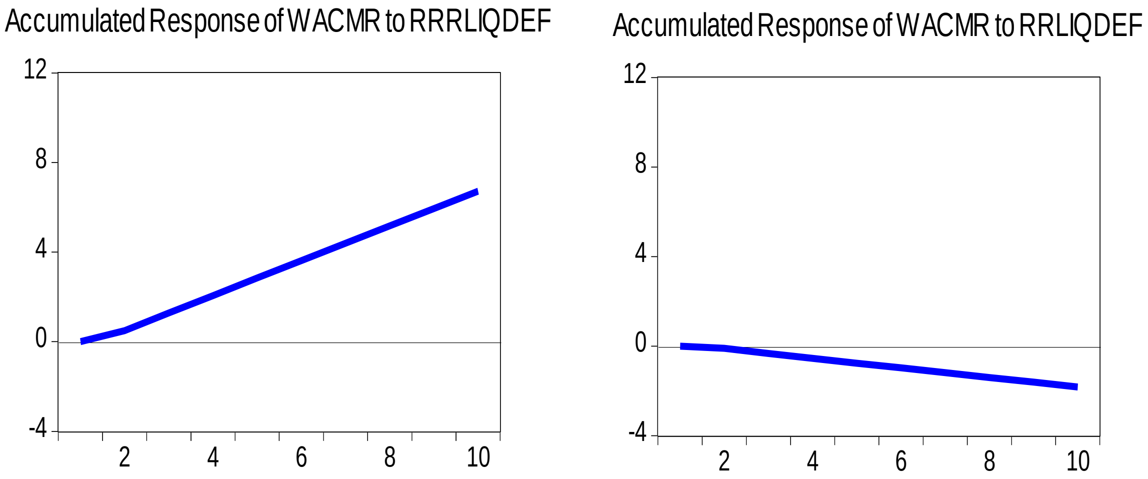
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.3620	0.1449	-2.4983	0.0169
C(2)	-0.2493	0.1564	-1.5938	0.1193
C(3)	-0.6651	1.0654	-0.6243	0.5361
C(4)	0.4575	0.8813	0.5191	0.6067
C(5)	0.0617	0.3261	0.1892	0.8509
C(1)	-0.3620	0.1449	-2.4983	0.0169
R-squared	0.2842	Mean dependent var		0.0426
Adjusted R-squared	0.2088	S.D. dependent var		2.4025
S.E. of regression	2.1370	Akaike info criterion		4.4656
Sum squared resid	173.53	Schwarz criterion		4.6704
Log likelihood	-91.010	Hannan-Quinn criter.		4.5411
F-statistic	3.7712	Durbin-Watson stat		2.1654
Prob(F-statistic)	0.0112			

Table 5.4.16 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WALR as the dependent variable while C(2) to C(8) are the short run coefficients.

Impulse Responses

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The accumulated impulse responses for the recursive VAR are plotted in Figure 5.4.7.

Figure 5.4.7: Accumulated Response of WACMR to RRRLIQDEF and RRLIQDEF



Accumulated Response of WACMR to RRRLIQDEF

Accumulated Response of WACMR to RRLIQDEF

The impulse responses show the effect of an unexpected 1 percentage point increase in RRRLIQDEF and RRLIQDEF on WACMR in the VECM. An unexpected one standard deviation shock in RRRLIQDEF and RRLIQDEF is associated with a change in WACMR by around 0.5930 in the 2nd period and crosses the 100 percent in between the 2nd and 3rd periods (Table 5.4.17). The results suggest that the complete transmission of the monetary policy through REPO and REVERSEREPO happens around 8 to 9months. These results support our results of the earlier analysis involving repo rate in determining the transmission to call money rate.

Table 5.4.17: Accumulated Impulse Responses

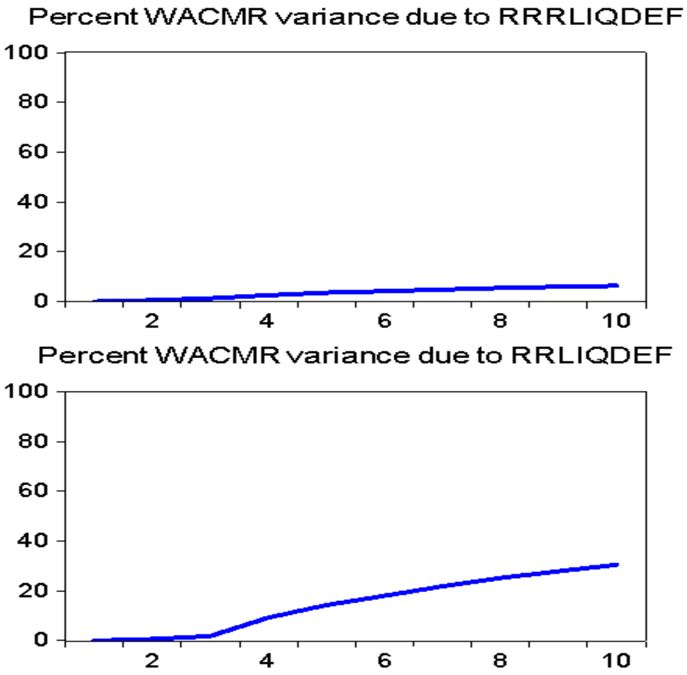
Period	WACMR	RRRLIQDEF	RRLIQDEF
1	2.1370	0.0000	0.0000
2	3.0831	0.4901	-0.1030
3	4.1769	1.2764	-0.3372
4	5.1537	2.0597	-0.5452
5	6.1755	2.8417	-0.7640
6	7.1852	3.6179	-0.9762
7	8.2002	4.3943	-1.1905
8	9.2133	5.1706	-1.4039
9	10.2271	5.9471	-1.6177
10	11.2406	6.7235	-1.8314

Cholesky Ordering: WACMR RRRLIQDEF RRLIQDEF

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.4.8: Variance decompositions



The variance of decompositions is presented in Figure 5.4.8. We notice that (in Table 5.4.18) at period 2, 4.20 percent of the errors in the forecast of WACMR are attributed to RRRLIQDEF, and 0.18 percent of the errors in the forecast or WACMR are attributed to RRLIQDEF. However, at period 10, 26.45 percent of the errors in the forecast of WACMR are attributed to RRRLIQDEF. Similarly, 1.99 percent of the errors in the forecast or WACMR are attributed to RRLIQDEF.

Table 5.4.18: Variance Decompositions

Period	S.E.	WACMR	RRRLIQDEF	RRLIQDEF
1	2.1370	100.0000	0.0000	0.0000
2	2.3901	95.6089	4.2053	0.1858
3	2.7536	87.8140	11.3229	0.8631
4	3.0320	82.8050	16.0122	1.1827
5	3.3010	79.4415	19.1214	1.4371
6	3.5445	77.0158	21.3794	1.6048
7	3.7739	75.1703	23.0917	1.7380
8	3.9896	73.7103	24.4484	1.8414
9	4.1945	72.5287	25.5455	1.9258
10	4.3897	71.5524	26.4524	1.9952

Cholesky Ordering: WACMR RRRLIQDEF RRLIQDEF

From the estimates of this specification, where the effective policy rate is the reverse repo rate when there is a liquidity surplus and the repo rate when there is a liquidity deficit, we find that both the rates are part of a cointegrating relationship with WACMR. The long-run elasticity of WACMR with respect to the reverse repo rate in liquidity surplus situation is 0.45 and the elasticity with respect to the repo rate in liquidity deficit situation is 0.51. Thus, the repo rate appears to appropriately capture the monetary policy stance of the RBI.

Conclusion

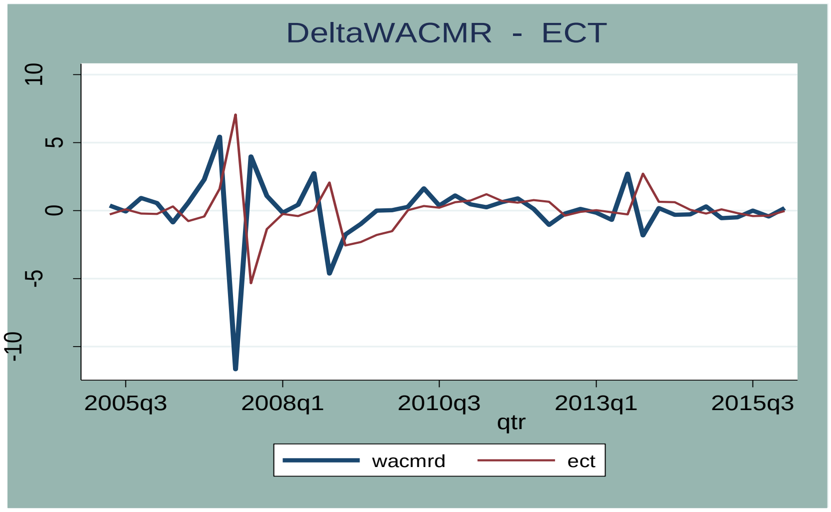
From the estimates of the alternate specification, where the effective policy rate is the reverse repo rate when there is a liquidity surplus and the repo rate when there is a liquidity deficit, we see that both rates are part of a cointegrating relationship with WACMR. The long-run elasticity of WACMR with respect to the reverse repo rate is 0.66 and the elasticity with respect to the repo rate is 0.45, which together come to about the same elasticity with the WACMR as the repo rate does in the first specification. Thus, the repo rate appears to sufficiently capture the monetary policy stance of the RBI.

Findings:

Transmission to Call Money Rate:

In specification 1, the correlation statistics reveal a statistically significant correlation of 0.61 between WACMRD and ECT. The Comovement of the covariates ΔWACMR and ECT are presented in Figure 5.4.9.

Figure 5.4.9: Comovement of ΔWACMR and ECT



The Pairwise Granger causality tests suggest the presence of unidirectional causality running from ECT to ΔWACMR (Table 5.4.19). The unidirectional causation running from ECT to the change in call money rate suggests the presence of a string feedback effect.

Table 5.4.19: Causal Relationship between ΔWACMR and the ECT

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
ECT does not Granger Cause ΔWACMR	32	2	131.76	0.0000
DELTALAFNITONDTL does not Granger Cause ΔWACMR	32	2	1.9549	0.1581
SUMDELTAWACMRLAGD does not Granger Cause ΔWACMR	32	2	3.4727	0.0432

The VECM results show an error correction term coefficient of -0.3157 for ECT, indicating a feedback effect of 31.57 percent from the equilibrium between the WACMR and the repo rate of the previous quarter. That is when there is a deviation from the equilibrium between the WACMR and the repo rate, the WACMR adjusts by 31.5 percent per time period towards the repo rate to re-establish equilibrium. These results suggest that it takes 9.5 months for the complete pass-through from the policy repo rate to call money rate. At this rate, it would take

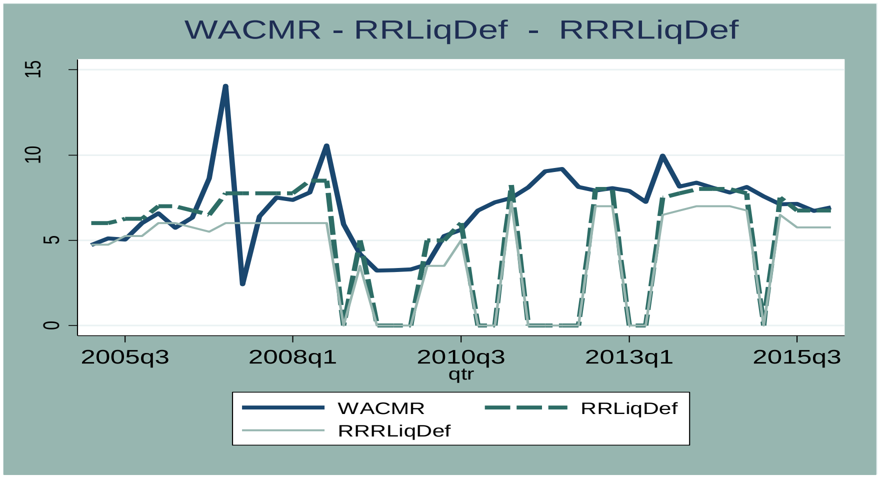
4.76 months to achieve fifty percent of the pass-through from an increase in the repo rate. Thus, the repo rate appears to sufficiently capture the monetary policy stance of the RBI.

The impulse responses show that an unexpected one standard deviation shock in total change in the lagged WACMR and the change in LAFNITONDTL is associated with a change in WACMR by around 0.2567 in the 2nd period and crosses the 100 percent in between the 3rd and 4th periods. The results suggest that the complete transmission of the monetary policy happens around 9 months. Thus, the above results support our results of the earlier analysis involving repo rate in determining the transmission to call money rate.

Transmission to Call Money Rate in the Alternate Specification:

The alternate specification accounts for the effective policy rate depending on the liquidity situation, where both the reverse repo rate and the repo rate are included in the long-run stage. In the alternate specification, the correlation statistics reveal a positive correlation between WACMR, RRLiqDef and RRRLiqDef. The Comovement of the covariates WACMR, RRLiqDef and RRRLiqDef are presented in Figure 5.4.10.

Figure 5.4.10: Comovement of WACMR, RRLiqDef and RRRLiqDef



The VECM results show an error correction term coefficient of -0.36 for WACMR indicating a feedback effect of 36 percent from the equilibrium between the WACMR and the reverse repo rate and the repo rate in the previous quarter. That is when there is a deviation from the equilibrium between the WACMR and the repo rate and the reverse repo rate depending upon their effects, the WACMR adjusts by 36 percent per time period to re-establish equilibrium. These results suggest that it takes 8.3 months for the complete pass-through from the policy repo rate to call money rate. At this rate, it would take 4.16 months to achieve fifty percent of the pass-through from an increase in the repo rate. Thus, the repo rate appears to sufficiently capture the monetary policy stance.

The impulse responses that an unexpected one standard deviation shock in RRRLIQDEF and RRLIQDEF is associated with a change in WACMR by around 0.5930 in the 2nd period and crosses the 100 percent in between the 2nd and 3rd periods. These results suggest that the complete transmission of the monetary policy through REPO and REVERSEREPO happens in around 8 to 9 months. Thus the alternate specification results also support our results of the earlier analysis involving repo rate in determining the transmission to call money rate.

Study 5: Assessing the Pass-through to Bank Interest Rates from Call Money Rate

Monetary policy operates not only through the conventional money channel but also, and more importantly, through the bank lending channel. The monetary policy shocks impact credit supply independently of influencing credit demand, and hence the there is a need to examine the effectiveness of transmission through the bank lending channel. The effectiveness of monetary policy transmission is also influenced by the way bank credit is deployed.

The pass-through of the monetary policy rates to bank interest rates is an important subject matter because it measures the effectiveness of monetary policy to control inflation or stabilize the economy. Monetary policy is effective when a change in policy rate is transmitted to bank lending rates, which in turn influence aggregate domestic demand, investment, and eventually output (Xu & Chen, 2012). Monetary economics literature suggests that monetary policy as the first line of defense against economic slowdowns, especially if quick action is needed to stabilize the economy. However, how fast economic stability is achieved depends on the pass-through to bank lending rate and financial market development among others. This section of the study investigates the long-run interest rate pass-through of the money market rate to the bank lending rate and the deposit rate.

5.1 Pass-through to Bank Lending Rate

In this section, we assess the pass-through to the bank lending rate from the call money rate. The assumption is that the changes in interest rates on bank loans, which will be of longer maturity, are unlikely to have feedback effects on overnight call money transactions. Further, it is probably intricate that a rise in the cost of deposits could make the cost of funds in the overnight market more attractive. In view of this, with a preference for more stable and longer-maturity deposit funding, however, feedback effects are perhaps likely to be small.

Bank lending channel (Kashyap and Stein, 1995) through the credit channel emphasizes the role of changes in banks' balance sheet items, i.e., in deposits and loans as conduits for monetary policy transmission. The credit availability under this bank lending channel can be demonstrated as below:

$$M \downarrow \Longrightarrow Bank\_Deposits \downarrow \Rightarrow Bank\_Loans \downarrow \Rightarrow Investment \downarrow \Rightarrow Output \downarrow$$

The banking channel has two distinct parts: (i) bank credit channel and (ii) bank deposit channel, as there is no close substitute for bank loans, both on the asset side of banks' balance sheets and on the liability side of borrowers.

A vector error correction model is estimated with the following cointegrating relationships:

$$\boldsymbol{LendingRate_t = \theta_1^l + \theta_1^l WACMR_t + \varepsilon_{1t}}$$

$$\boldsymbol{\Delta WALR_t = \Delta REPO_t + \Delta WACMR_t + \Delta Loans/assets_t + v_{lt}}$$

$$\boldsymbol{DepositRate_t = \theta_1^d + \theta_1^d WACMR_t + \varepsilon_{2t}}$$

$$\boldsymbol{\Delta DR_t = \Delta REPO_t + \Delta WACMR_t + \Delta Loans/assets_t + v_{dt}}$$

Where, ΔDR_t – Change in the deposit rate

$REPO_t$ – Monetary Policy Repo Rate

$WACMR_t$ – Weighted Average Call Money Rate

$WALR_t$ – Weighted average lending rate (WALR) indicating credit market

$\Delta LOANS/ASSETS_t$ – Change in the bank loans to assets ratio

We propose the following identifying assumptions that underlie this step of the empirical method are:

(i) That the lending rate is weakly exogenous to the Weighted Average Call Money Rate

(ii)That the deposit rate is weakly exogenous to the Weighted Average Call Money Rate

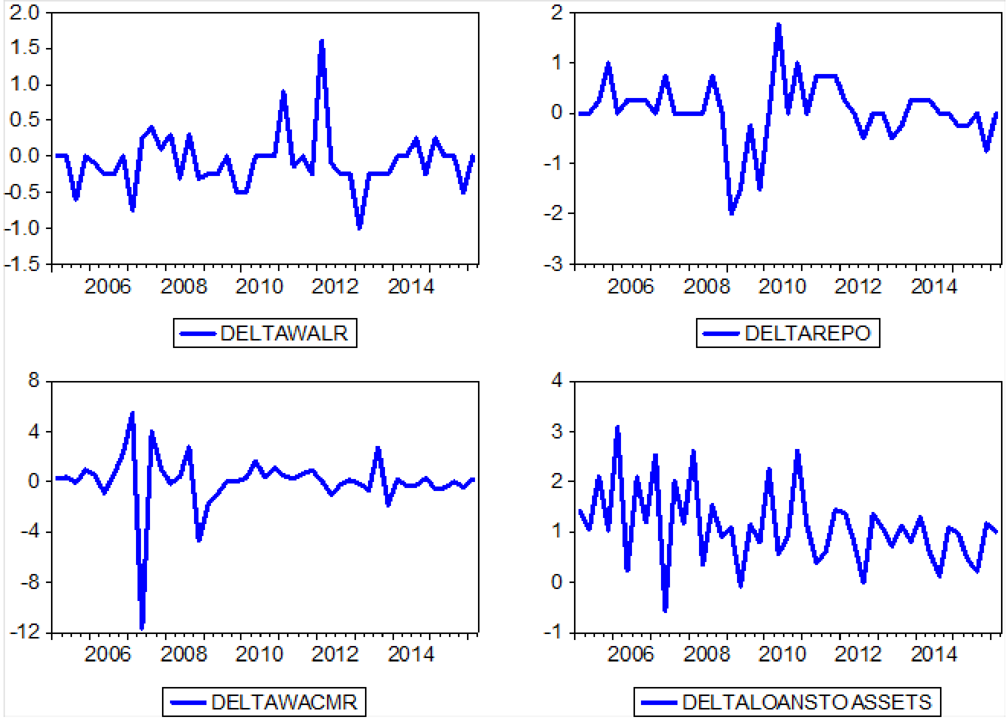
Table 5.5.1 provides the descriptive statistics of the variables. ΔWALR rate ranges from a minimum of -1.00 to a maximum of 1.60 with a mean value of -0.0711. ΔREPO ranges from a minimum of -2.00 to a maximum of 1.75 with a mean value of 0.0389. ΔWACMR ranges from a minimum of -11.65 to a maximum of 5.44 with a mean value of 0.0558. ΔLOANS/ASSETS ranges from a minimum of –0.56 to a maximum of 3.0883 with a mean value of 1.1079.

Table 5.5.1: Descriptive Statistics

	ΔWALR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS
Mean	-0.0711	0.0389	0.0558	1.1079
Median	0.0000	0.0000	0.2062	1.0666
Maximum	1.6000	1.7500	5.4400	3.0883
Minimum	-1.0000	-2.0000	-11.6500	-0.5600
Std. Dev.	0.4063	0.6417	2.3481	0.7670
Skewness	1.4780	-0.6964	-2.5696	0.5271
Kurtosis	8.4993	5.5724	15.6798	3.2541
Observations	45	45	45	45

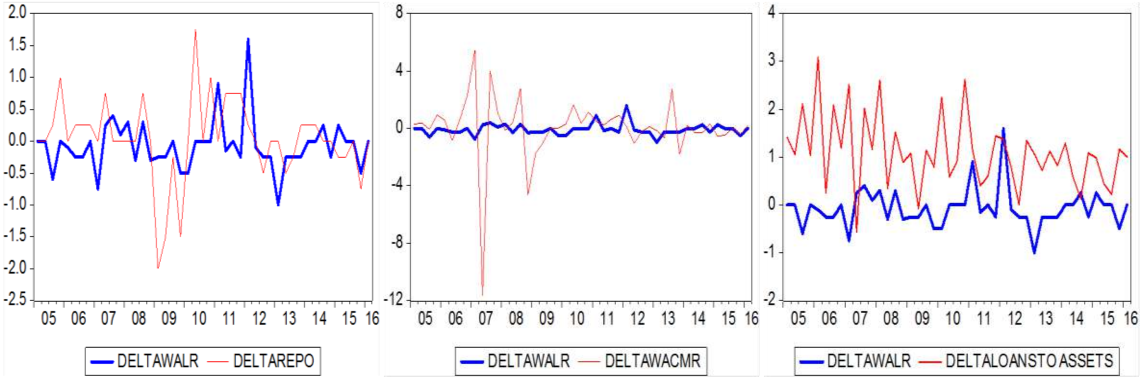
The correlation statistics reveal a positive relationship between ΔWALR and ΔREPO at the level of 0.22 during the sample period. However, there is a significant positive correlation (0.49) between ΔWALR and ΔLOANS/ASSETS at 5-percent significance level. On the other hand, ΔWALR has a negative correlation (-0.0475) with ΔWACMR and ΔLOANS/ASSETS (-0.0398). The covariates of the model are presented in Figure 5.5.1.

Figure 5.5.1: Covariates



Source: Reserve Bank of India database

Figure 5.5.2: ΔWALR with ΔREPO, ΔWACMR, and ΔLOANS/ASSETS



Source: Reserve Bank of India database

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WALR and the second block consisting of ΔREPO, ΔWACMR, ΔLOANS/ASSETS (Table 5.5.2). The results suggest a bidirectional causality running from changes in ΔWALR to other set of variables, ΔREPO and other set of variables, ΔLOANS/ASSETS and other set of variables.

Table 5.5.2: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(ΔWALR)			
Excluded	Chi-sq	df	Prob.
D(ΔREPO)	10.7128	5.0000	0.0574
D(ΔWACMR)	6.0730	5.0000	0.2992
D(ΔLOANS/ASSETS)	5.7458	5.0000	0.3317
All	22.6403	15.0000	0.0921
Dependent variable: D(ΔREPO)			
Excluded	Chi-sq	df	Prob.
D(ΔWALR)	5.3283	5.0000	0.3771
D(ΔWACMR)	9.0758	5.0000	0.1061
D(ΔLOANS/ASSETS)	6.3426	5.0000	0.2743
All	23.4988	15.0000	0.0741
Dependent variable: D(ΔWACMR)			
Excluded	Chi-sq	df	Prob.
D(ΔWALR)	1.8376	5.0000	0.8711
D(ΔREPO)	8.2966	5.0000	0.1406
D(ΔLOANS/ASSETS)	9.3691	5.0000	0.0952
All	21.1030	15.0000	0.1336
Dependent variable: D(ΔLOANS/ASSETS)			
Excluded	Chi-sq	df	Prob.
D(ΔWALR)	7.9091	5.0000	0.1613
D(ΔREPO)	25.9492	5.0000	0.0001
D(ΔWACMR)	10.5168	5.0000	0.0618
All	55.5018	15.0000	0.0000

Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.5.3, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.5.3: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.8697	157.9497	47.8561	0.0000
r ≤1	r >1	At most 1 *	0.7129	80.5144	29.7971	0.0000
r ≤2	r >2	At most 2 *	0.4327	33.0903	15.4947	0.0001
r ≤3	r >3	At most 3 *	0.2621	11.5522	3.8415	0.0007
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.8697	77.4352	27.5843	0.0000
r ≤1	r >1	At most 1 *	0.7129	47.4242	21.1316	0.0000
r ≤2	r >2	At most 2 *	0.4327	21.5381	14.2646	0.0030
r ≤3	r >3	At most 3 *	0.2621	11.5522	3.8415	0.0007
		1 Cointegrating Equation(s):	Log likelihood = -97.01981			
		Normalized cointegrating coefficients (standard error in parentheses)				
		ΔWALR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS	
		1	0.1704	-0.3019	0.0025	
			-0.1543	-0.0404	-0.1750	

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.5.4, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficient for WACMR is statistically negative which implies that this variable fit into the model and suffers a shock and adjusts to restore their equilibrium.

Table 5.5.4: Vector Error Correction Estimates

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1			
ΔWALR(-1)	1.0000			
ΔREPO(-1)	0.1704			
	-0.1543			
	[1.10432]			
ΔWACMR(-1)	-0.3019			
	-0.0404			
	[-7.46614]			
ΔLOANS/ASSETS(-1)	0.0025			
	-0.1750			
	[0.01447]			
Intercept	0.0633			
Error Correction:	D(ΔWALR)	D(ΔREPO)	D(ΔWACMR)	D(ΔLOANS/ASSETS)
CointEq1	-0.3877	-0.0488	3.4510	0.3676
	-0.1714	-0.2120	-0.7575	-0.1686
	[-2.26202]	[-0.22991]	[4.55566]	[2.18062]
R-squared	0.6381	0.6658	0.8529	0.8998
Adj. R-squared	0.1632	0.2272	0.6599	0.7684
Sum sq. resids	5.0898	7.7900	99.4217	4.9225
S.E. equation	0.5640	0.6978	2.4928	0.5547
F-statistic	1.3436	1.5180	4.4187	6.8447
Log likelihood	-15.7232	-23.8095	-72.1936	-15.0881
Akaike AIC	1.9854	2.4110	4.9576	1.9520
Schwarz SC	2.9335	3.3591	5.9056	2.9001
Mean dependent	0.0066	-0.0066	-0.0104	-0.0286
S.D. dependent	0.6166	0.7937	4.2745	1.1525
Determinant resid covariance (dof adj.)		0.0617		
Determinant resid covariance		0.0019		
Log likelihood		-97.0198		
Akaike information criterion		9.9484		
Schwarz criterion		13.9131		

The error correction coefficient for ΔWALR was (-0.3877). The coefficient indicates a feedback of about 38.77% of the previous quarter's disequilibrium from the long run elasticity.

Table 5.5.5: VECM Regression Results

Dependent Variable: D(ΔWALR)

D(ΔWALR) = C(1)*(ΔWALR(-1) + 0.17037417807*ΔREPO(-1) - 0.301856825314*ΔWACMR(-1) + 0.00253258728663*ΔLOANS/ASSETS(-1) + 0.0633389901209) + C(2) *D(ΔWALR(-2)) + C(3)*D(ΔWALR(-3)) + C(4) *D(ΔWALR(-4)) + C(5)*D(ΔWALR(-5)) + C(6) *D(ΔWALR(-6)) + C(7)*D(ΔREPO(-2)) + C(8) *D(ΔREPO(-3)) + C(9)*D(ΔREPO(-4)) + C(10) *D(ΔREPO(-5)) + C(11)*D(ΔREPO(-6)) + C(12) *D(ΔWACMR(-2)) + C(13)*D(ΔWACMR(-3)) + C(14) *D(ΔWACMR(-4)) + C(15)*D(ΔWACMR(-5)) + C(16) *D(ΔWCMR(-6)) + C(17)*D(ΔLOANS/ASSETS(-2)) + C(18)*D(ΔLOANS/ASSETS(-3)) + C(19)*D(ΔLOANS/ASSETS (-4)) + C(20)*D(ΔLOANS/ASSETS (-5)) + C(21) *D(ΔLOANS/ASSETS (-6)) + C(22)

	Coefficient	Std. Error	t-Statistic	Prob.

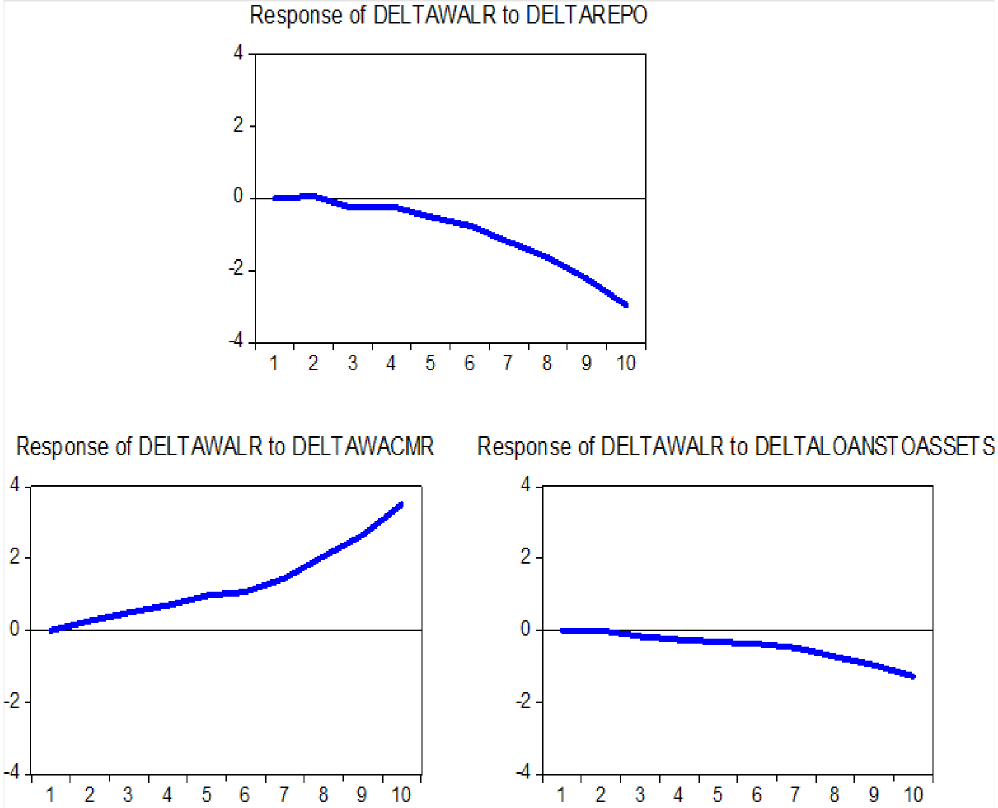
C(1)	-0.3877	0.1714	-2.2620	0.0380
C(2)	0.1112	0.2788	0.3989	0.6952
C(3)	0.4708	0.3535	1.3318	0.2016
C(4)	0.0648	0.3059	0.2119	0.8348
C(5)	0.1397	0.2795	0.4996	0.6241
C(6)	0.0886	0.2211	0.4005	0.6941
C(7)	-0.2020	0.2257	-0.8948	0.3841
C(8)	0.1268	0.2117	0.5991	0.5575
C(9)	-0.0018	0.2219	-0.0082	0.9936
C(10)	0.0670	0.2465	0.2717	0.7893
C(11)	-0.4991	0.2005	-2.4889	0.0242
C(12)	0.1079	0.0686	1.5720	0.1355
C(13)	0.1793	0.1141	1.5721	0.1355
C(14)	0.1822	0.1387	1.3132	0.2076
C(15)	0.0642	0.1158	0.5539	0.5873
C(16)	0.0314	0.0717	0.4378	0.6674
C(17)	-0.5848	0.3508	-1.6672	0.1149
C(18)	-0.5993	0.5264	-1.1386	0.2716
C(19)	-0.4439	0.5723	-0.7756	0.4493
C(20)	-0.2223	0.5399	-0.4117	0.6860
C(21)	0.0856	0.2890	0.2961	0.7710
C(22)	-0.0429	0.1035	-0.4141	0.6843
R-squared	0.6381	Mean dependent var		0.0066
Adjusted R-squared	0.1632	S.D. dependent var		0.6166
S.E. of regression	0.5640	Akaike info criterion		1.9854
Sum squared resid	5.0898	Schwarz criterion		2.9335
Log likelihood	-15.7232	Hannan-Quinn criter.		2.3227
F-statistic	1.3436	Durbin-Watson stat		2.2559
Prob(F-statistic)	0.2761			

Table 5.5.5 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WALR as the dependent variable while C(2) to C(22) are the short run coefficients.

Impulse Responses

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. The impulse responses for the recursive VAR are plotted in Figure 5.5.2.

Figure 5.5.2: Impulse Responses of ΔWALR to ΔREPO, ΔWACMR, and ΔLOANS/ASSETS



The impulse responses show the effect of an unexpected 1 percentage point increase in ΔREPO, ΔWACMR, and ΔLOANS/ASSETS on ΔWALR in the VECM. An unexpected rise in ΔREPO is associated with a rise in ΔWALR by around 0.0619 in the 2nd period and settles in the range of -0.2696 to -2.9738 during the 3rd to the 10th period (Table 5.5.6). An unexpected rise in ΔWACMR is associated with a rise in ΔWALR by around 0.2692 in the 2nd period and settles in the range of 1.0756 to 3.5060 during the 6th to 10th period. An unexpected rise in ΔLOANS/ASSETS is associated with a decline in ΔWALR by around -0.0003 in the 2nd period and settles in the range of -0.1615 to -1.2710 during the 3rd to 10th period.

Table 5.5.6: Impulse Responses

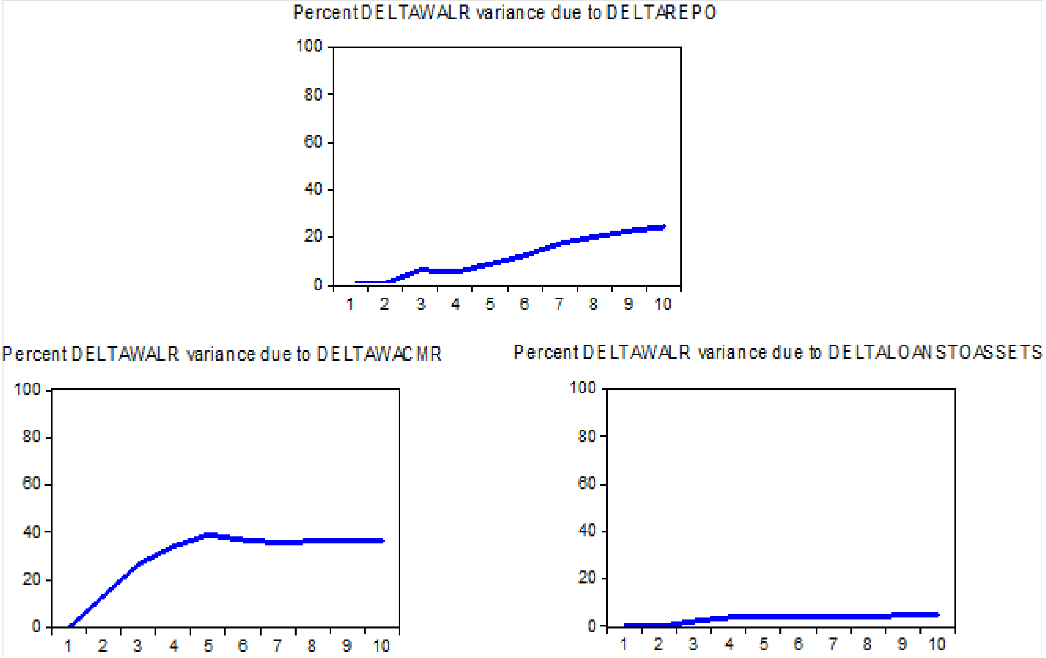
Period	ΔWALR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS
1	0.5640	0.0000	0.0000	0.0000
2	0.3816	0.0619	0.2692	-0.0003
3	0.5556	-0.2696	0.4963	-0.1615
4	0.7585	-0.2290	0.7028	-0.2554
5	0.8959	-0.5194	0.9729	-0.3216
6	1.2299	-0.7601	1.0756	-0.3650
7	1.5321	-1.2102	1.4533	-0.4852
8	1.9895	-1.6482	2.0589	-0.7270
9	2.4752	-2.2331	2.6540	-0.9667
10	3.2275	-2.9738	3.5060	-1.2710

Cholesky Ordering: ΔWALR ΔREPO ΔWACMR ΔLOANS/ASSETS

Variance Decompositions

The variance of decompositions is presented in Figure 5.5.3. We notice that (in Table 5.5.7) at period 10, 24.42 percent of the errors in the forecast of ΔWALR are attributed to ΔREPO. Similarly, 36.79 percent of the errors in the forecast or ΔWALR are attributed to ΔWACMR and 4.68 percent of the errors in the forecast of ΔLOANS/ASSETS.

Figure 5.5.3: Variance decompositions


Percent DELTAWALR variance due to DELTAREPO

Percent DELTAWALR variance due to DELTAWACMR

Percent DELTAWALR variance due to DELTALOANSTOASSETS

Source: Reserve Bank of India database

Table 5.5.7: Variance decompositions

Period	S.E.	ΔWALR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS
1	0.5640	100.000	0.0000	0.0000	0.0000
2	0.7349	85.8723	0.7097	13.4180	0.0000
3	1.0926	64.7007	6.4112	26.7038	2.1842
4	1.5430	56.6083	5.4174	34.1380	3.8362
5	2.1221	47.7519	8.8557	39.0674	4.3250
6	2.8078	46.4641	12.3861	36.9892	4.1606
7	3.7474	42.8004	17.3822	35.8056	4.0117
8	5.0483	39.1145	20.2377	36.3633	4.2845
9	6.6766	36.1060	22.7574	36.5910	4.5457
10	8.8173	34.1009	24.4236	36.7913	4.6842

Cholesky Ordering: ΔWALR ΔREPO ΔWACMR ΔLOANS/ASSETS

The long-run results of the VECM estimated show the cointegrating vector between the lending rate and the WACMR. The elasticity of the lending rate with respect to the WACMR is 0.3877, meaning that, on average, only 38.77% of a change in the WACMR gets passed on to the lending rate. It further suggests that it would take 7.7 months for complete transmission of the change in WACMR to the lending rate.

5.2 The Pass-through to Bank Deposit Rate

A monetary tightening is believed to drain the deposits from the banking system. As such, the banks have to readjust their portfolio by reducing their supply of loans, given the imperfect substitutability between loans and other assets. Accordingly, the loan supply being reduced, banks hike their lending rate or reduce their loans. Consequently, a reduction in the supply of loans leads to a rise in the external finance premium for bank-dependent borrowers whose activity is reduced. Accordingly, credit allocated to bank-dependent borrowers may fall causing these borrowers to curtail their spending. The identifying assumptions that underlie this step of the empirical method are that the deposit rate is weakly exogenous to the weighted average call money rate. The deposit rate has a feedback effect from the changes in repo rate, call money rate and the rate of change in bank loans to assets. Accordingly, the specification for estimation is as below:

$$\boldsymbol{DepositRate_t = \theta_1^d + \theta_1^d WACMR_t + \varepsilon_{2t}}$$

$$\boldsymbol{\Delta DR_t = \Delta REPO_t + \Delta WACMR_t + \Delta Loans/assets_t + v_{dt}}$$

Where, ΔDR_t – Change in the deposit rate

$REPO_t$ – Monetary Policy Repo Rate

$WACMR_t$ – Weighted Average Call Money Rate

$\Delta LOANS/ASSETS_t$ – Change in the bank loans to assets ratio

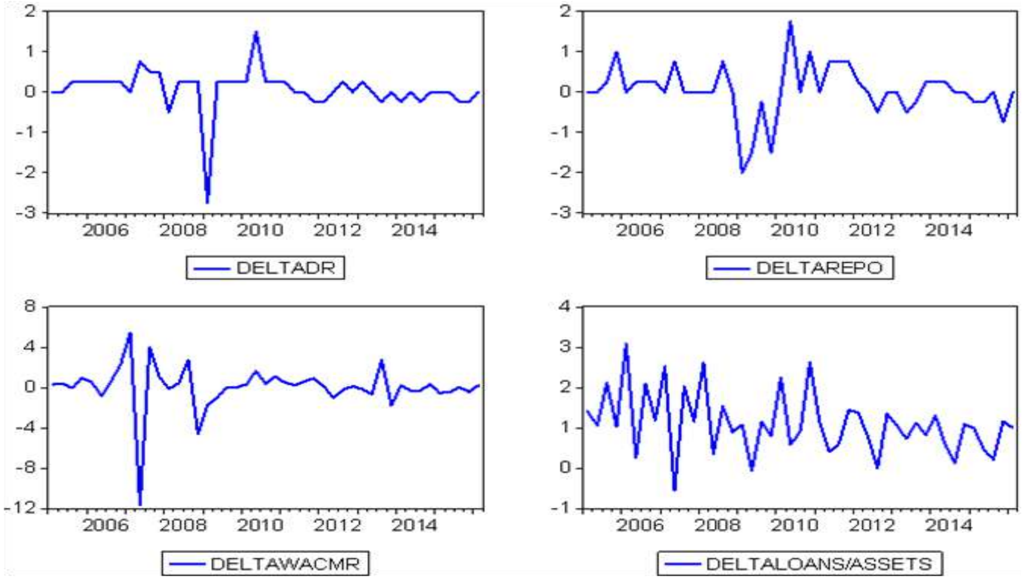
Table 5.5.8 provides the descriptive statistics of the variables. DR ranges from a minimum of 5.25 to a maximum of 9.25 with a mean value of 7.88. ΔREPO ranges from a minimum of -2.00 to a maximum of 1.75 with a mean value of 0.0389. ΔWACMR ranges from a minimum of -11.65 to a maximum of 5.44 with a mean value of 0.0558. ΔLOANS/ASSETS ranges from a minimum of –0.56 to a maximum of 3.0883 with a mean value of 1.1079.

Table 5.5.8: Descriptive Statistics

	DR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS
Mean	0.0611	0.0389	0.0558	1.1079
Median	0.0000	0.0000	0.2062	1.0666
Maximum	1.5000	1.7500	5.4400	3.0883
Minimum	-2.7500	-2.0000	-11.6500	-0.5600
Std. Dev.	0.5334	0.6417	2.3481	0.7670
Skewness	-2.8786	-0.6964	-2.5696	0.5271
Kurtosis	19.2995	5.5724	15.6798	3.2541
Observations	45	45	45	45

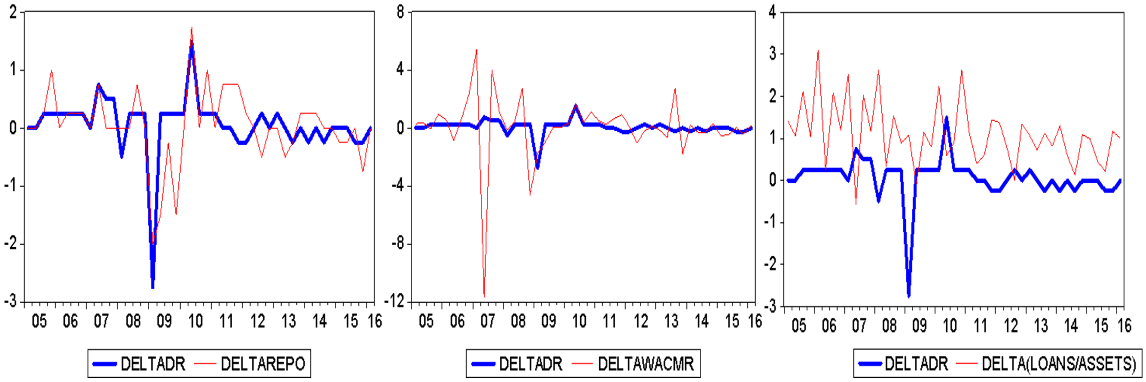
The covariates of the model are presented in Figure 5.5.4.

Figure 5.5.4: Covariates



Source: Reserve Bank of India database

Figure 5.5.5: ΔDR with ΔREPO, ΔWACMR, and ΔLOANS/ASSETS



Source: Reserve Bank of India database

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for the joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WALR and the second block consisting of ΔREPO, ΔWACMR, ΔLOANS/ASSETS (Table 5.5.9). The results suggest a bidirectional causality running from changes in ΔWALR to other set of variables, ΔREPO and other set of variables, ΔLOANS/ASSETS and other set of variables.

Table 5.5.9: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(ΔDR)			
Excluded	Chi-sq	df	Prob.
D(ΔDR)	9.5114	4	0.0495
D(ΔWACMR)	3.2853	4	0.5113
D(ΔLOANS/ASSETS)	3.1650	4	0.5306
All	16.7098	12	0.1608
Dependent variable: D(ΔREPO)			
Excluded	Chi-sq	df	Prob.
D(ΔWALR)	13.2427	4	0.0101
D(ΔWACMR)	4.2707	4	0.3706
D(ΔLOANS/ASSETS)	8.3288	4	0.0803
All	34.9839	12	0.0005
Dependent variable: D(ΔWACMR)			
Excluded	Chi-sq	df	Prob.
D(ΔDR)	17.9650	4	0.0013
D(ΔREPO)	15.1354	4	0.0044
D(ΔLOANS/ASSETS)	8.5942	4	0.0721
All	29.5676	12	0.0032
Dependent variable: D(ΔLOANS/ASSETS)			
Excluded	Chi-sq	df	Prob.
D(ΔWALR)	5.5967	4	0.2314
D(ΔREPO)	12.4812	4	0.0141
D(ΔWACMR)	14.8326	4	0.0051
All	35.6529	12	0.0004

Cointegration Test

We test the models with lag interval (1, 1) by employing JJ cointegration test. In Table 5.5.10, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.5.10: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.5245	61.2450	47.8561	0.0017
r ≤1	r >1	At most 1 *	0.4072	31.5056	29.7971	0.0315
r ≤2	r >2	At most 2 *	0.1830	10.5905	15.4947	0.2380
r ≤3	r >3	At most 3 *	0.0607	2.5049	3.8415	0.1135
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.5245	29.7393	27.5843	0.0260
r ≤1	r >1	At most 1 *	0.4072	20.9152	21.1316	0.0536
r ≤2	r >2	At most 2 *	0.1830	8.0855	14.2646	0.3701
r ≤3	r >3	At most 3 *	0.0607	2.5049	3.8415	0.1135
		1 Cointegrating Equation(s): Log likelihood = -111.9257 Normalized cointegrating coefficients (standard error in parentheses)				
		ΔDR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS	
		1	0.4859	-0.7666	-0.3914	
			-0.2604	-0.2007	-0.2324	

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.5.11, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficients for ΔDR and ΔREPO are statistically negative which implies that these variables fit into the model and suffer a shock and adjust to restore their equilibrium.

Table 5.5.11: Vector Error Correction Estimates

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2		
ΔDR(-1)	1.00	0.00		
ΔREPO(-1)	0.00	1.00		
ΔWACMR(-1)	-0.07	-0.81		
	(0.07)	(0.14)		
	[-0.90]	[-5.66]		
ΔLOANS/ASSETS (-1)	-0.66	-0.36		
	(0.15)	(0.29)		
	[-4.41]	[-1.25]		
Intercept	0.67	0.39		
Error Correction:	D(ΔDR)	D(ΔREPO)	D(ΔWACMR)	D(ΔLOANS/ASSETS)
CointEq1	-0.67	0.53	0.93	1.42
	(0.34)	(0.41)	(1.52)	(0.45)
	[-1.94]	[1.28]	[0.60]	[3.13]
CointEq2	-0.11	-0.58	2.16	0.24
	(0.17)	(0.20)	(0.73)	(0.22)
	[-0.66]	[-2.96]	[2.95]	[1.11]
D(ΔDR (-1))	-0.05	-0.06	-0.25	-0.86
	(0.28)	(0.33)	(1.22)	(0.36)
	[-0.17]	[-0.19]	[-0.20]	[-2.37]
D(ΔDR (-2))	0.09	-0.18	0.04	-0.25
	(0.20)	(0.24)	(0.89)	(0.27)
	[0.46]	[-0.76]	[0.04]	[-0.94]
D(ΔREPO (-1))	0.07	-0.39	-1.11	-0.22
	(0.16)	(0.20)	(0.73)	(0.22)
	[0.42]	[-2.01]	[-1.52]	[-1.01]
D(ΔREPO (-2))	-0.30	-0.35	-0.75	-0.14
	(0.17)	(0.20)	(0.74)	(0.22)
	[-1.74]	[-1.73]	[-1.01]	[-0.62]
D(ΔWACMR (-1))	-0.07	-0.26	0.40	0.23
	(0.09)	(0.11)	(0.40)	(0.12)
	[-0.73]	[-2.39]	[0.99]	[1.91]
D(ΔWACMR (-2))	-0.06	-0.11	-0.01	0.13
	(0.05)	(0.06)	(0.23)	(0.07)
	[-1.17]	[-1.70]	[-0.03]	[1.86]
D(ΔLOANS/ASSETS (-1))	-0.37	-0.01	0.83	-0.17
	(0.17)	(0.20)	(0.74)	(0.22)
	[-2.21]	[-0.06]	[1.11]	[-0.75]
D(ΔLOANS/ASSETS (-2))	-0.21	-0.13	0.77	0.00
	(0.12)	(0.15)	(0.54)	(0.16)
	[-1.70]	[-0.87]	[1.43]	[0.01]
Intercept	-0.01	-0.02	0.01	-0.03
	(0.08)	(0.10)	(0.37)	(0.11)
	[-0.13]	[-0.23]	[0.03]	[-0.28]
R-squared	0.62	0.48	0.74	0.76
Adj. R-squared	0.50	0.31	0.65	0.68
Sum sq. resids	9.19	12.99	179.05	15.94
S.E. equation	0.54	0.65	2.40	0.72

F-statistic	5.10	2.85	8.70	9.72
Log likelihood	-27.68	-34.95	-90.05	-39.25
Akaike AIC	1.84	2.19	4.81	2.39
Schwarz SC	2.30	2.64	5.27	2.85
Mean dependent	-0.01	-0.01	0.01	-0.03
S.D. dependent	0.77	0.78	4.08	1.27
Determinant resid covariance (dof adj.)		0.12		
Determinant resid covariance		0.04		
Log likelihood		-168.69		
Akaike information criterion		10.51		
Schwarz criterion		12.66		

The error correction coefficient for ΔDR was (-0.67). The coefficient indicates a feedback of about 67% of the previous quarter's disequilibrium from the long run elasticity.

Table 5.5.12: VECM Regression Results

Dependent Variable: D(ΔDR)

D(ΔDR) = C(1)*(ΔDR (-1) - 0.0680436687756*ΔWACMR (-1) - 0.663351594648*DELTALOANSTOASSETS(-1) + 0.669732319839) + C(2)*(ΔREPO(-1) - 0.809939608724 *DELTAWACMR(-1) - 0.360611019481*ΔLOANS/ASSETS(-1) + 0.387923086999) + C(3)*D(ΔDR (-1)) + C(4)*D(ΔDR (-2)) + C(5)*D(ΔREPO (-1)) + C(6)*D(ΔREPO (-2)) + C(7) *D(ΔWACMR (-1)) + C(8)*D(ΔWACMR (-2)) + C(9) *D(ΔLOANS/ASSETS (-1)) + C(10)*D(ΔLOANS/ASSETS (-2)) + C(11)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.6705	0.3442	-1.9483	0.0605
C(2)	-0.1099	0.1657	-0.6630	0.5122
C(3)	-0.0490	0.2754	-0.1780	0.8599
C(4)	0.0927	0.2013	0.4608	0.6481
C(5)	0.0694	0.1646	0.4219	0.6760
C(6)	-0.2951	0.1687	-1.7490	0.0902
C(7)	-0.0669	0.0912	-0.7332	0.4690
C(8)	-0.0620	0.0530	-1.1710	0.2505
C(9)	-0.3724	0.1684	-2.2110	0.0345
C(10)	-0.2078	0.1220	-1.7032	0.0985
C(11)	-0.0110	0.0841	-0.1313	0.8964

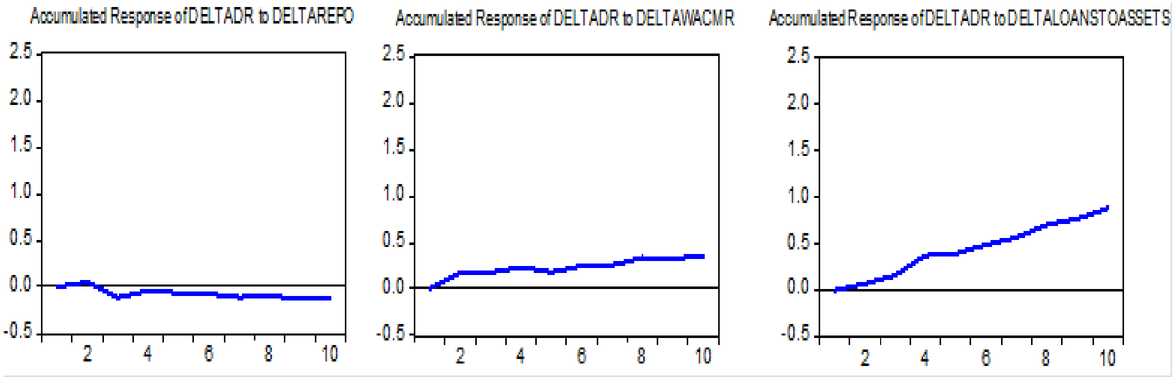
R-squared	0.6221	Mean dependent var	0.0000
Adjusted R-squared	0.5002	S.D. dependent var	0.7742
S.E. of regression	0.5444	Akaike info criterion	1.9020
Sum squared resid	9.1862	Schwarz criterion	2.6620
Log likelihood	-27.6762	Hannan-Quinn criter.	2.1768
F-statistic	5.1040	Durbin-Watson stat	1.7098
Prob(F-statistic)	0.0002		

Table 5.5.12 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with ΔREPO as the dependent variable while C(2) to C(18) are the short run coefficients.

Impulse Responses

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.5.6.

Figure 5.5.6: Impulse Responses of ΔDR to ΔREPO, ΔWACMR, and ΔLOANS/ASSETS



Source: Reserve Bank of India database

The impulse responses show the effect of an unexpected 1 percentage point increase in ΔREPO, ΔWACMR, and ΔLOANS/ASSETS on ΔDR in the VECM. An unexpected rise in ΔREPO is associated with a decline in ΔDR by around -0.11 in the 3rd period and settles in the range of -0.0411 to -0.1374 during the 4th to the 10th period (Table 5.5.13). An unexpected rise in ΔWACMR is associated with a rise in ΔDR by around 0.1742 in the 2nd period and settles in the range of 0.1749 to 0.3619 during the 3rd to 10th period. An unexpected rise in ΔLOANS/ASSETS is associated with a decline in ΔDR by around 0.0718 in the 2nd period and settles in the range of 0.1626 to 0.8811 during the 3rd to 10th period.

Table 5.5.13: Impulse Responses

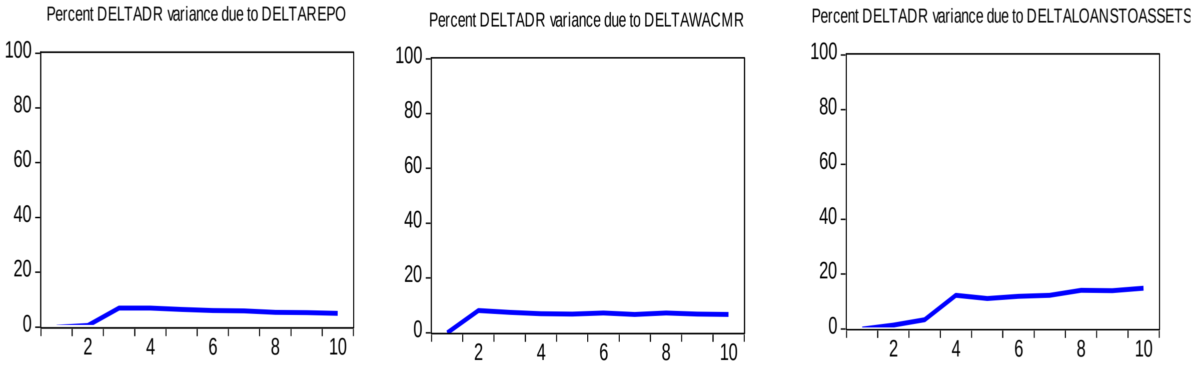
Period	ΔDR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS
1	0.5444	0.0000	0.0000	0.0000
2	0.7401	0.0465	0.1742	0.0718
3	0.7859	-0.1159	0.1749	0.1626
4	0.9395	-0.0411	0.2367	0.3783
5	1.1633	-0.0674	0.1822	0.3979
6	1.3141	-0.0781	0.2465	0.4901
7	1.4822	-0.1122	0.2556	0.5705
8	1.6515	-0.0997	0.3357	0.7057
9	1.8193	-0.1294	0.3196	0.7686
10	1.9919	-0.1374	0.3619	0.8811

Cholesky Ordering: ΔWALR ΔREPO ΔWACMR ΔLOANS/ASSETS

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.5.7: Variance decompositions



The variance of decompositions is presented in Figure 5.5.7. We notice that (in Table 5.5.14) at period 10, 4.98 percent of the errors in the forecast of ΔDR are attributed to ΔREPO. Similarly, 6.67 percent of the errors in the forecast or ΔDR are attributed to ΔWACMR and 14.78 percent of the errors in the forecast of ΔLOANS/ASSETS.

Table 5.5.14: Variance decompositions

Period	S.E.	ΔDR	ΔREPO	ΔWACMR	ΔLOANS/ASSETS
1	0.5444	100.0000	0.0000	0.0000	0.0000
2	0.6102	89.8881	0.5809	8.1463	1.3846
3	0.6395	82.3333	6.9734	7.4155	3.2778
4	0.6989	73.7665	6.9817	6.9896	12.2621
5	0.7366	75.6390	6.4129	6.8380	11.1101
6	0.7603	74.9303	6.0391	7.1321	11.8985
7	0.7836	75.1421	5.8744	6.7280	12.2555
8	0.8171	73.4127	5.4267	7.1492	14.0115
9	0.8372	73.9478	5.2951	6.8469	13.9102
10	0.8632	73.5504	4.9888	6.6794	14.7815

Cholesky Ordering: ΔDR ΔREPO ΔWACMR ΔLOANS/ASSETS

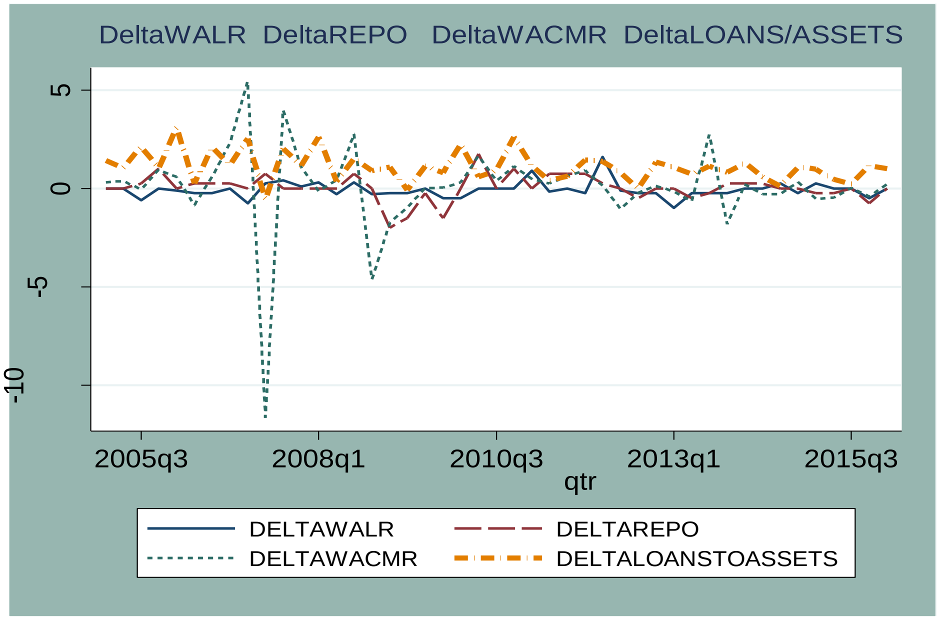
The long-run results of the VECM estimated show the cointegrating vector between the deposit rate and the WACMR. The elasticity of the deposit rate with respect to the WACMR is -0.67, meaning that, on average, only 67% of a change in the WACMR gets passed on to the deposit rate. It further suggests that it would take around 4.47 months for complete transmission of the change in WACMR to the deposit rate.

Findings:

Pass-through to Bank Lending Rate

For monetary policy to operate through a credit channel, not only must there be bank dependent borrowers, but monetary policy must also directly affect banks' willingness to lend. The correlation statistics reveal a significant positive correlation (0.49) between ΔWACMR and ΔLOANS/ASSETS at 5-percent significance level. On the other hand, ΔWALR has a negative correlation (-0.0475) with ΔWACMR and ΔLOANS/ASSETS (-0.0398). The movement of the covariates is presented in Figure 5.5.8.

Figure 5.5.8: Movement of the covariates



Source: Reserve Bank of India database

The Pairwise Granger causality tests suggest the presence of unidirectional causality running from the change in repo rate to the change in lending rate; from the change in call money rate to the change in the ratio of loans to assets; and from the change in the ratio of loans to assets to the change in the lending rate (Table 5.5.15). The direction of causality evidences the dominant presence of the bank lending channel of monetary policy transmission in India.

Table 5.5.15: Causal Relationship between ΔWALR and the covariates

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
ΔREPO does not Granger Cause ΔWALR	36	8	3.29976	0.0494
ΔWACMR does not Granger Cause ΔLOANSTOASSETS	36	8	3.69654	0.0361
ΔLOANSTOASSETS does not Granger Cause ΔWALR	36	8	3.34395	0.0476

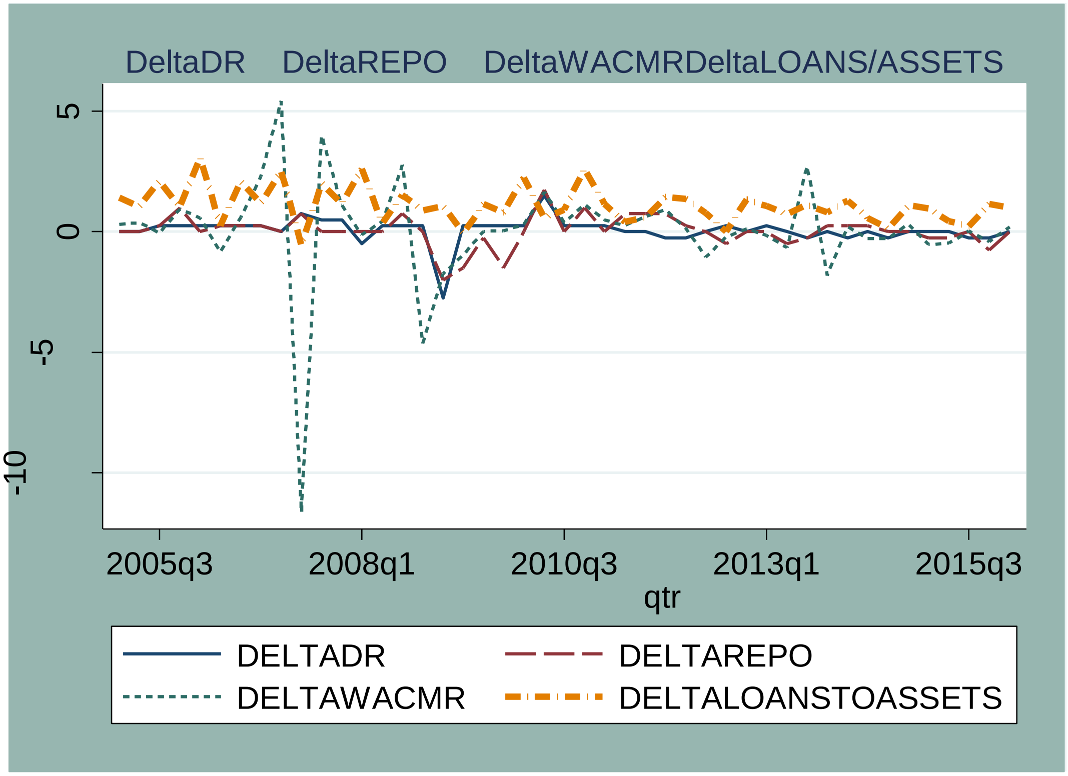
The long-run results of the VECM show the presence of the cointegrating vector between the lending rate and the other covariates. The error correction coefficient for ∆WALR was -0.3877 and it measures the speed of adjustment of WALR towards long run equilibrium. The coefficient indicates a feedback of about 38.77% of the previous quarter's disequilibrium from the long run elasticity resulting in 7.74 months to achieve the complete pass-through.

The impulse responses show that an unexpected rise in ∆REPO is associated with a rise in ∆WALR by around 0.0619 in the 2nd period and settles in the range of -0.2696 to -2.9738 during the 3rd to the 10th period. An unexpected rise in ∆WACMR is associated with a rise in ∆WALR by around 0.2692 in the 2nd period and settles in the range of 1.0756 to 3.5060 during the 6th to 10th period. An unexpected rise in ∆LOANS/ASSETS is associated with a decline in ∆WALR by around -0.0003 in the 2nd period and settles in the range of -0.1615 to -1.2710 during the 3rd to 10th period. The variance of decompositions shows that at period 10, 24.42 percent of the errors in the forecast of ∆WALR are attributed to ∆REPO. Similarly, 36.79 percent of the errors in the forecast or ∆WALR are attributed to ∆WACMR and 4.68 percent of the errors in the forecast of ∆LOANS/ASSETS.

The Pass-through to Bank Deposit Rate

The correlation statistics reveal a significant positive correlation (0.56) between ∆DR and ∆REPO at 5-percent significance level. On the other hand, ∆DR has a negative correlation (-0.075) with ∆LOANS/ASSETS. The movement of the covariates is presented in Figure 5.5.9.

Figure 5.5.9: The covariates: ΔDR, ΔREPO, ΔWACMR, ΔLOANS/ASSETS



Source: Reserve Bank of India database

The Pairwise Granger causality tests suggest the presence of unidirectional causality running from the change in repo rate to the change in call money rate; the change in call money rate to the change in deposit rate; and from the change in the repo rate to the change in the ratio of loans to assets (Table 5.5.16). The direction of causality evidences the prevalence of the bank lending channel of monetary policy transmission in India.

Table 5.5.16: Causal Relationship between ΔDR and the covariates

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
ΔWACMR does not Granger Cause ΔREPO	37	8	3.5265	0.0105
ΔWACMR does not Granger Cause ΔDR	36	8	9.5230	0.0000
ΔREPO does not Granger Cause ΔLOANSTOASSETS	41	4	2.2536	0.0852

The impulse responses show that an unexpected rise in ΔREPO is associated with a decline in ΔDR by around -0.11 in the 3rd period and settles in the range of -0.0411 to -0.1374 during the 4th to the 10th period. An unexpected rise in ΔWACMR is associated with a rise in ΔDR by around 0.1742 in the 2nd period and settles in the range of 0.1749 to 0.3619 during the 3rd to 10th period. An unexpected rise in ΔLOANS/ASSETS is associated with a decline in ΔDR by around 0.0718 in the 2nd period and settles in the range of 0.1626 to 0.8811 during the 3rd to 10th period. The variance of decompositions shows that at period 10, about 4.98 percent of the errors in the forecast of ΔDR are attributed to ΔREPO. Similarly, 6.67 percent of the errors in the forecast of ΔDR are attributed to ΔWACMR and 14.78 percent of the errors in the forecast of ΔLOANS/ASSETS.

The long-run results of the VECM show the presence of the cointegrating vector between the lending rate and the other covariates. The error correction coefficient for ΔDR of -0.67 measures the speed of adjustment of ΔDR towards long run equilibrium. The coefficient indicates a feedback of about 67% of the previous quarter's disequilibrium from the long run elasticity, resulting in 4.48 months to achieve the complete pass-through.

Study 6: Examining the co-integrating relationship of monetary policy rate movements with Call Money Rate

6.1 Pass-through to WACMR from CRR

The effect of CRR as a policy instrument (on the quantity front) is estimated in the stated specification. A positive (negative) shock to CRR corresponds to contractionary (expansionary) monetary policy shock. The CRR is considered for assessment of the effectiveness of policy transmission as its medium-term impact on bank lending can be expected to be direct and fairly quick.

While using economic data, endogeneity and exogeneity of variables are not always clear, to examine the plausibility and effectiveness of these two instruments, it is appropriate to use a VAR framework. In monetary policy transmission, in particular, there is bound to be a feedback and in presence of feedback, intervention and transfer function analyses are inappropriate. A VAR analysis treats all variables as jointly endogenous (Enders, 1995). Singh (2011), Mohanty (2012) and Sengupta (2014) use a vector autoregression (VAR) to study the various channels of monetary transmission in India.

A vector error correction model is estimated with the following cointegrating relationships.

$$\boldsymbol{WACMR_t = \beta_0 + \beta_1 CRR_t + \varepsilon_t}$$

Where, WACMRt – Weighted Average Call Money Rate

CRR_t – Monetary Policy Cash Reserve Ratio

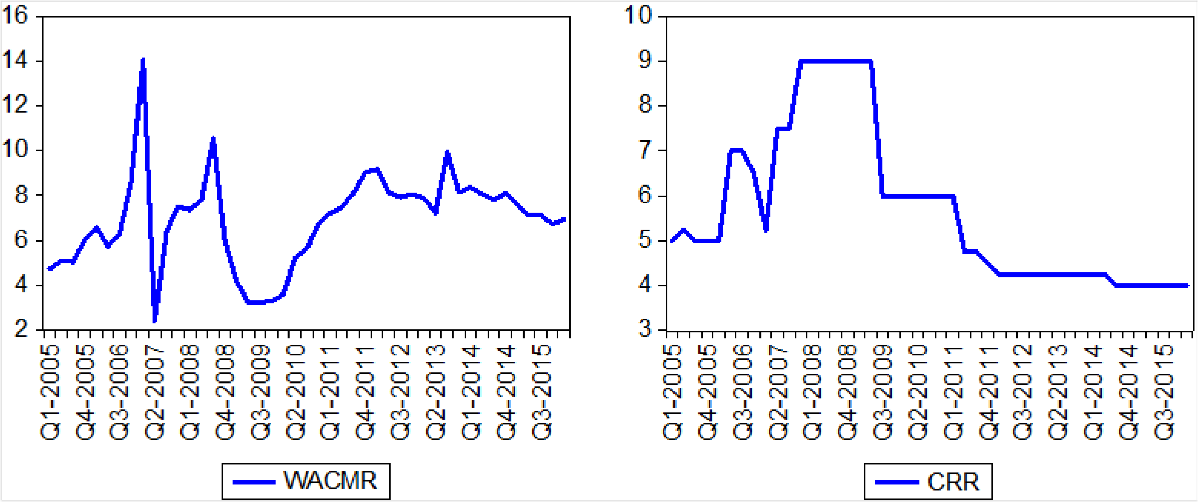
Table 5.6.1 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.92. CRR ranges from a minimum of 4.00 to a maximum of 9.00 with a mean value of 5.67. The correlation statistics reveal a negative correlation (0.29) between CRR and WACMR.

Table 5.6.1: Descriptive Statistics

	WACMR	CRR
Mean	6.9253	5.6778
Median	7.2300	5.0000
Maximum	14.0700	9.0000
Minimum	2.4200	4.0000
Std. Dev.	2.1380	1.7464
Skewness	0.3591	0.8949
Kurtosis	4.6042	2.4555
Jarque-Bera	5.7924	6.5617
Probability	0.0552	0.0376
Observations	45	45

The covariates of the model are presented in Figure 5.6.1.

Figure 5.6.1: Covariates: WACMR and SLR



Source: Reserve Bank of India database

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out Pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of CRR (Table 5.6.2). The results do not suggest a bidirectional causality running from changes in CRR to WACMR. However, the causality runs from changes in CRR to WACMR.

Table 5.6.2: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
CRR	17.8077	3	0.0005
All	17.8077	3	0.0005
Dependent variable: CRR			
Excluded	Chi-sq	df	Prob.
WACMR	2.2425	3	0.5236
All	2.2425	3	0.5236

Cointegration Test

We test the models with lag interval (1, 2) by employing JJ Cointegration test. In Table 5.6.3, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of Cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.6.3: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.2518	14.5647	15.4947	0.0687
r ≤1	r >1	At most 1 *	0.0551	2.3792	3.8415	0.1230
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.2518	12.1855	14.2646	0.1039
r ≤1	r >1	At most 1 *	0.0551	2.3792	3.8415	0.1230
		1 Cointegrating Equation(s):	Log likelihood = -126.3014			
		Normalized cointegrating coefficients (standard error in parentheses)				

WACMR	CRR
1	0.5155
	-0.2629

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.6.4, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium.

Table 5.6.4: Vector Error Correction Estimates
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
WACMR(-1)	1.0000	
CRR(-1)	0.5155	
	(0.26)	
	[1.96094]	
Intercept	-9.9825	
Error Correction:	D(WACMR)	D(CRR)
CointEq1	-0.6837	0.0887
	(0.20)	(0.08)
	[-3.46977]	[1.12469]
D(WACMR(-1))	-0.0655	0.0255
	(0.19)	(0.08)
	[-0.34178]	[0.33248]
D(WACMR(-2))	0.0284	-0.0326
	(0.17)	(0.07)
	[0.17076]	[-0.49007]
D(CRR(-1))	0.6954	-0.0155
	(0.46)	(0.18)
	[1.52334]	[-0.08476]
D(CRR(-2))	0.8616	-0.0590
	(0.47)	(0.19)
	[1.84708]	[-0.31590]
Intercept	0.0869	-0.0248
	(0.30)	(0.12)
	[0.28985]	[-0.20650]
R-squared	0.4411	0.0898
Adj. R-squared	0.3635	-0.0366
Sum sq. resids	135.4791	21.7089
S.E. equation	1.9399	0.7765
F-statistic	5.6829	0.7105
Log likelihood	-84.1895	-45.7365
Akaike AIC	4.2947	2.4636
Schwarz SC	4.5430	2.7119

Mean dependent	0.0448	-0.0238
S.D. dependent	2.4316	0.7627
Determinant resid covariance (dof adj.)		1.9096
Determinant resid covariance		1.4030
Log likelihood		-126.3014
Akaike information criterion		6.6810
Schwarz criterion		7.2602

The error correction coefficient for WACMR was (-0.6837). The coefficient indicates a feedback of about 68.37% of the previous quarter's disequilibrium from the long run elasticity. However, the error correction coefficient for CRR was (-0.0887). The coefficient indicates a feedback of about 8.87% of the previous quarter's disequilibrium from the long run elasticity.

Table 5.6.5: VECM Regression Results

Dependent Variable: D(WACMR)
D(WACMR) = C(1)*(WACMR(-1) + 0.51554712309*CRR(-1) - 9.98249336775) + C(2)*D(WACMR(-1)) + C(3)*D(WACMR(-2)) + C(4) *D(CRR(-1)) + C(5)*D(CRR(-2)) + C(6)

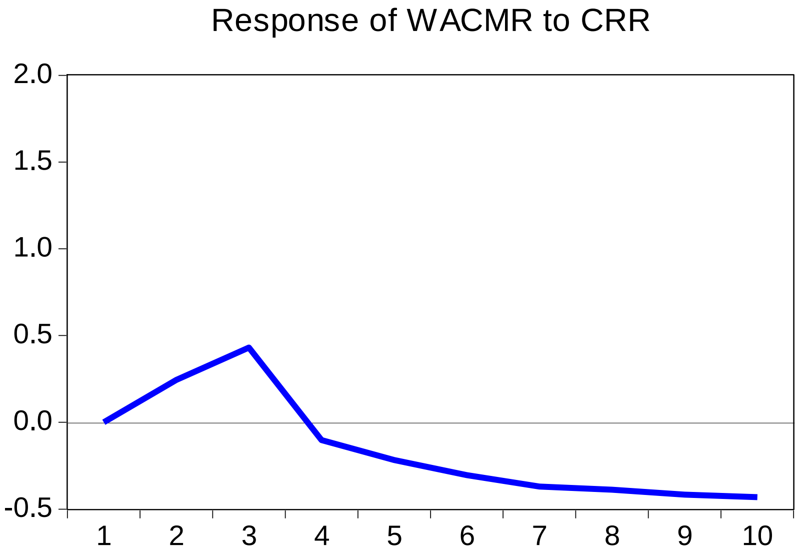
	Coefficient		Std. Error	t-Statistic	Prob.
C(1)	-0.6837		0.1970	-3.4698	0.0014
C(2)	-0.0655		0.1916	-0.3418	0.7345
C(3)	0.0284		0.1660	0.1708	0.8654
C(4)	0.6954		0.4565	1.5233	0.1364
C(5)	0.8616		0.4665	1.8471	0.0730
C(6)	0.0869		0.2999	0.2899	0.7736
R-squared	0.4411	Mean dependent var			0.0448
Adjusted R-squared	0.3635	S.D. dependent var			2.4316
S.E. of regression	1.9399	Akaike info criterion			4.2947
Sum squared resid	135.47	Schwarz criterion			4.5430
Log likelihood	-84.189	Hannan-Quinn criter.			4.3857
F-statistic	5.6829	Durbin-Watson stat			2.2998
Prob(F-statistic)	0.0006				

Table 5.6.5 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2) to C(8) are the short run coefficients.

Impulse Responses

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.6.2.

Figure 5.6.2: Impulse Response of WACMR



The impulse responses show the effect of an unexpected 1 percentage point increase in CRR on WACMR in the VECM. An unexpected rise in CRR is associated with a rise in WACMR by around 0.2442 in the 2nd period and hits a peak of 0.4314 in the 3rd period. From the 4th period onwards, the response turns negative in the range of -0.1025 in the 4th period to -0.4314 in the 10th period (Table 5.6.6).

Table 5.6.6: Impulse Responses

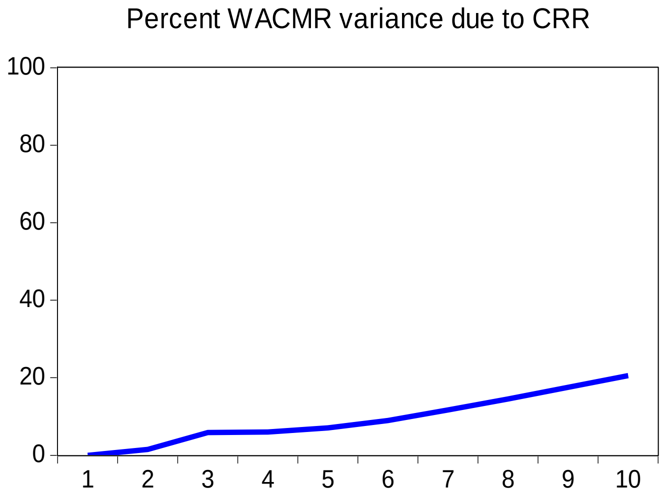
Period	WACMR	CRR
1	1.9399	0.0000
2	0.3806	0.2442
3	0.1928	0.4314
4	0.2260	-0.1025
5	0.0835	-0.2178
6	0.1226	-0.3050
7	0.0825	-0.3702
8	0.0619	-0.3879
9	0.0579	-0.4166
10	0.0476	-0.4314

Cholesky Ordering: WACMR CRR

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.6.3: Variance decompositions



The variance of decompositions is presented in Figure 5.6.3. We notice that (in Table 5.6.7) at period 10, 20.55 percent of the errors in the forecast of WACMR are attributed to CRR.

Table 5.6.7: Variance decompositions

Period	S.E.	WACMR	CRR
1	1.9399	100.0000	0.0000
2	1.9919	98.4965	1.5035
3	2.0472	94.1369	5.8631
4	2.0622	93.9750	6.0250
5	2.0753	92.9497	7.0503
6	2.1012	91.0149	8.9851
7	2.1352	88.2928	11.7072
8	2.1710	85.4838	14.5162
9	2.2114	82.4600	17.5400
10	2.2536	79.4461	20.5540

Cholesky Ordering: WACMR CRR

To conclude, we show in the analysis that the elasticity of the CRR with respect to the WACMR is 0.0887 meaning that, on average, only 8.87% of a change in the CRR gets passed on to the WACMR in a period of three months. This suggests that for the transmission from CRR to WACMR is relatively weaker compared that from REPO to WACMR.

6.2 Pass-through to WACMR from SLR

The liquidity adjustment facility (LAF) since November 2004 is operated using overnight fixed rate repos and reverse repos with banks. The LAF has been a major component in the operating framework of the RBI and is intended to operate in a deficit liquidity mode to ensure more effective monetary transmission. Banks in India are subject to a statutory liquidity ratio — a certain percent of net total time and demand liabilities that banks must invest in gold and/or government approved securities. Banks pledge government securities as collateral, most of which should be over and above the securities they must hold to comply with liquidity (SLR) regulations. The effect of SLR as a policy instrument (on the quantity front) is estimated in the specification stated below. A positive (negative) shock to SLR corresponds to contractionary (expansionary) monetary policy shock. The SLR is considered for assessment of the effectiveness of policy transmission as its medium-term impact on bank lending can be expected to be direct and rather swift.

A vector error correction model is estimated with the following cointegrating relationships

$$\boldsymbol{WACMR_t = \beta_0 + \beta_1 SLR_t + \varepsilon_t}$$

Where, WACMRt – Weighted Average Call Money Rate

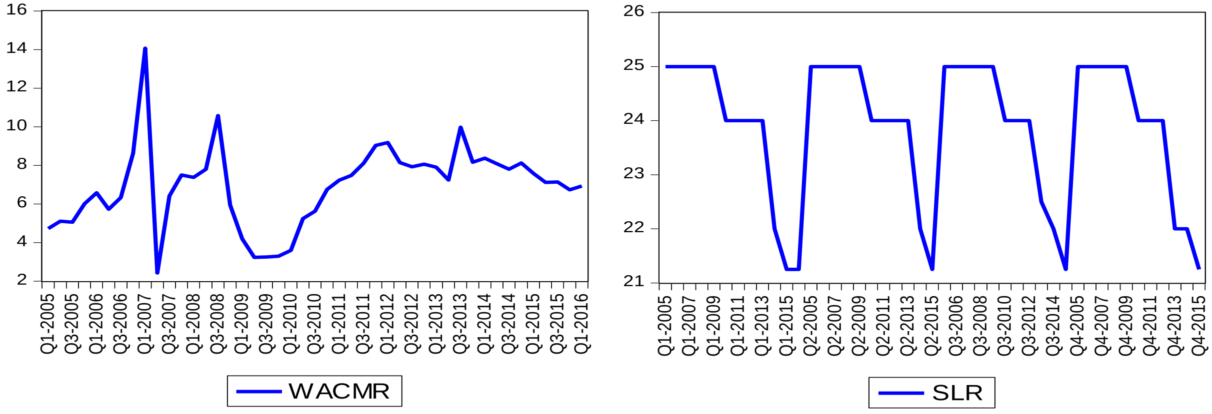
SLR_t – Monetary Policy Statutory Liquidity Ratio

Table 5.6.8 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.92. SLR ranges from a minimum of 21.25 to a maximum of 25.00 with a mean value of 23.88. The covariates of the model are presented in Figure 5.6.4. The correlation statistics suggest that the correlation between WACMR and SLR was -0.26 during the sample period.

Table 5.6.8: Descriptive Statistics

	WACMR	SLR
Mean	6.9253	23.8833
Median	7.2300	24.0000
Maximum	14.0700	25.0000
Minimum	2.4200	21.2500
Std. Dev.	2.1380	1.3438
Skewness	0.3591	-0.9423
Kurtosis	4.6042	2.4103
Jarque-Bera	5.7924	7.3120
Probability	0.0552	0.0258
Observations	45	45

Figure 5.6.4: Covariates: WACMR and SLR



Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out Pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of SLR

(Table 5.6.9). The results do not suggest a bidirectional causality running from changes in SLR to WACMR.

Table 5.6.9: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
SLR	0.0554	1	0.8140
All	0.0554	1	0.8140
Dependent variable: SLR			
Excluded	Chi-sq	df	Prob.
WACMR	0.0659	1	0.7974
All	0.0659	1	0.7974

Cointegration Test

We test the models with lag interval (1, 2) by employing JJ cointegration test. In Table 5.6.10, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of Cointegration between models. The presence of a cointegrating vector implies that the covariates are related in the long run.

Table 5.6.10: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.2127	10.3269	15.4947	0.2564
r ≤1	r >1	At most 1 *	0.0010	0.0413	3.8415	0.8389
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.2127	10.2856	14.2646	0.1938
r ≤1	r >1	At most 1 *	0.0010	0.0413	3.8415	0.8389
		1 Cointegrating Equation(s):		Log likelihood = -97.1093		
		Normalized cointegrating coefficients (standard error in parentheses)				
		WACMR	SLR			
		1	0.3538			
			-0.4278			

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.6.11, we show that WACMR has a negative error correction term

(ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium.

Table 5.6.11: Vector Error Correction Estimates [WACMR, SLR]
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
WACMR(-1)	1	
SLR(-1)	0.3538	
	-0.4278	
	[0.82699]	
Intercept	-15.4394	
Error Correction:	D(WACMR)	D(SLR)
CointEq1	-0.5890	0.0112
	-0.1815	-0.0275
	[-3.2450]	[0.4066]
D(WACMR(-1))	-0.1119	-0.0062
	-0.1586	-0.0241
	[-0.7060]	[-0.2567]
D(SLR(-1))	0.2477	0.1095
	-1.0526	-0.1597
	[0.2353]	[0.6859]
Intercept	0.0694	-0.0774
	-0.3216	-0.0488
	[0.2158]	[-1.5854]
R-squared	0.3421	0.0170
Adj. R-squared	0.2915	-0.0586
Sum sq. resids	159.49	3.6719
S.E. equation	2.0223	0.3068
F-statistic	6.7587	0.2250
Log likelihood	-89.197	-8.1139
Akaike AIC	4.3348	0.5634
Schwarz SC	4.4986	0.7273
Mean dependent	0.0426	-0.0872
S.D. dependent	2.4025	0.2982
Determinant resid covariance (dof adj.)		0.3815
Determinant resid covariance		0.3138
Log likelihood		-97.109
Akaike information criterion		4.9818
Schwarz criterion		5.3914

The error correction coefficient for WACMR was (-0.5890). The coefficient indicates a feedback of about 58.90% of the previous quarter’s disequilibrium from the long run elasticity. The error correction coefficient for SLR was (-0.0112). The coefficient indicates a feedback of about 1.12% of the previous quarter’s disequilibrium from the long run elasticity.

Table 5.6.12 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2) to C(4) are the short run coefficients.

Table 5.6.12: VECM Regression Results

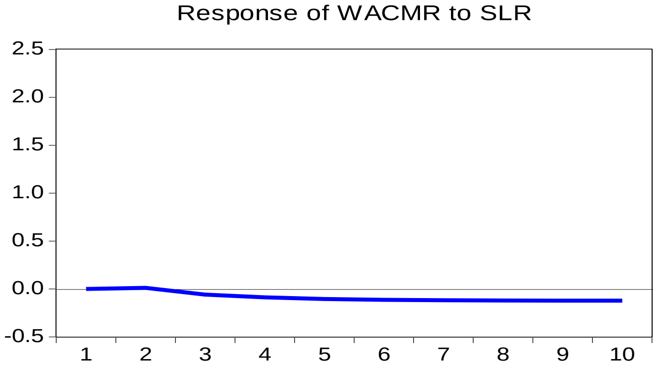
Dependent Variable: D(WACMR)
D(WACMR) = C(1)*(WACMR(-1) + 0.353822228731*SLR(-1) - 15.4394218663) + C(2)*D(WACMR(-1)) + C(3)*D(SLR(-1)) + C(4)

	Coefficient		Std. Error	t-Statistic	Prob.
C(1)	-0.5890		0.1815	-3.2450	0.0024
C(2)	-0.1119		0.1586	-0.7060	0.4844
C(3)	0.2477		1.0526	0.2353	0.8152
C(4)	0.0694		0.3216	0.2158	0.8302
R-squared	0.3421	Mean dependent var			0.0426
Adjusted R-squared	0.2915	S.D. dependent var			2.4025
S.E. of regression	2.0223	Akaike info criterion			4.3348
Sum squared resid	159.49	Schwarz criterion			4.4986
Log likelihood	-89.19	Hannan-Quinn criter.			4.3952
F-statistic	6.7587	Durbin-Watson stat			2.0227
Prob(F-statistic)	0.0009				

Impulse Responses

Any shocks to the ith variable not only directly affect the respective variable ith variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.6.5.

Figure 5.6.5: Impulse Response of WACMR



The impulse responses show the effect of an unexpected 1 percentage point increase in SLR on WACMR in the VECM. An unexpected rise in SLR is associated with a decline in WACMR by around -0.0587 in the 3rd period and settles in the range of -0.1044 to -0.1226 during the 5th to the 10th period (Table 5.6.13).

Table 5.6.13: Impulse Responses

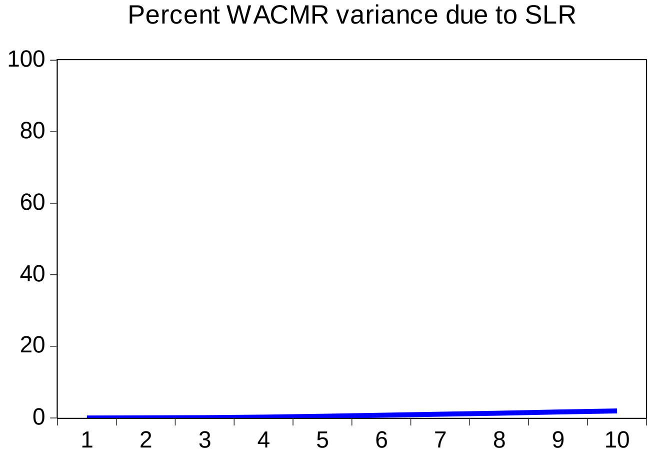
Period	WACMR	SLR
1	2.0223	0.0000
2	0.6036	0.0120
3	0.4134	-0.0587
4	0.1966	-0.0869
5	0.1068	-0.1044
6	0.0539	-0.1132
7	0.0271	-0.1180
8	0.0126	-0.1205
9	0.0050	-0.1218
10	0.0010	-0.1226

Cholesky Ordering: WACMR CRR

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.6.6: Variance decompositions



The variance of decompositions is presented in Figure 5.6.6. We notice that (in Table 5.6.14) at period 10, 1.95 percent of the errors in the forecast of WACMR are attributed to SLR.

Table 5.6.14: Variance decompositions

Period	S.E.	WACMR	SLR
1	2.0223	100.0000	0.0000
2	2.1105	99.9968	0.0032
3	2.1514	99.9225	0.0775
4	2.1621	99.7618	0.2382
5	2.1673	99.5307	0.4693
6	2.1709	99.2601	0.7399
7	2.1743	98.9678	1.0322
8	2.1776	98.6647	1.3353
9	2.1810	98.3568	1.6432
10	2.1845	98.0472	1.9528

Cholesky Ordering: WACMR SLR

The above analysis shows that the elasticity of the SLR with respect to the WACMR is 0.0112 meaning that, on average, only 1.12% of a change in the SRR gets passed on to the WACMR in a period of three months. This suggests that for the transmission from SLR to WACMR is relatively weaker compared that from REPO to WACMR.

6.3 Pass-through to WACMR from Bank Rate

The effect of BR as a price instrument is estimated in the stated specification. Compared to CRR (the quantitative instrument), the Bank Rate may not be capable of equilibrating the demand and supply positions in a financial market which is not only imperfectly competitive but whose sub-markets are less than perfectly integrated. A positive (negative) shock to BR corresponds to contractionary (expansionary) monetary policy shock. The BR is considered for assessment of the effectiveness of policy transmission as its medium-term impact on bank lending can be expected to be direct and fairly quick.

A vector error correction model is estimated with the following cointegrating relationships

$$WACMR_t = \beta_0 + \beta_1 BR_t + \varepsilon_t$$

Where, $WACMR_t$ – Weighted Average Call Money Rate

BR_t – Monetary Policy Bank Rate

Table 5.6.15 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.92. BR ranges from a minimum of 4.75 to a maximum of 9.50 with a mean value of 6.62.

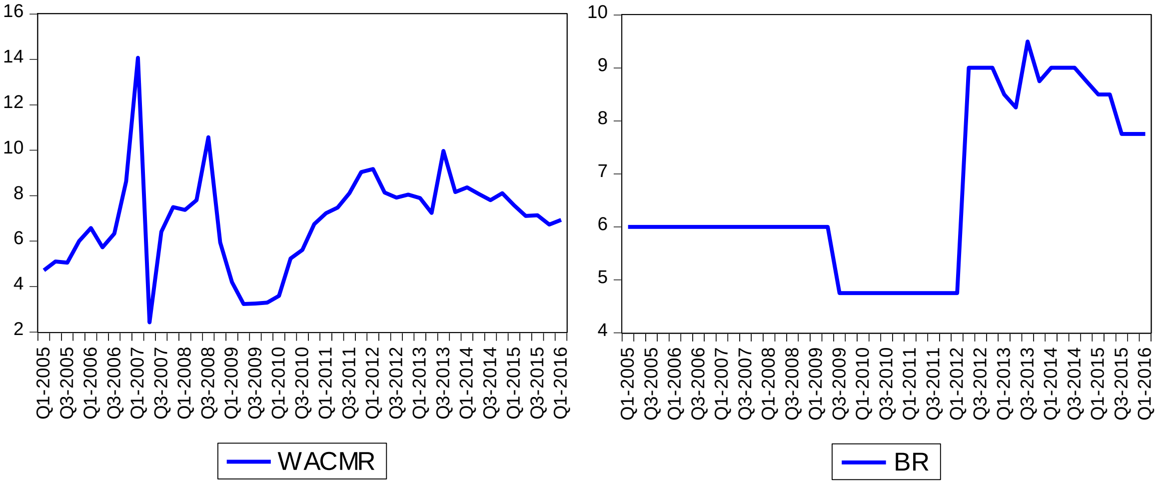
Table 5.6.15: Descriptive Statistics

	WACMR	BR
Mean	6.9253	6.6278
Median	7.2300	6.0000
Maximum	14.0700	9.5000
Minimum	2.4200	4.7500
Std. Dev.	2.1380	1.6084
Skewness	0.3591	0.4078
Kurtosis	4.6042	1.6905
Jarque-Bera	5.7924	4.4623

Probability	0.0552	0.1074
Observations	45	45

The covariates of the model are presented in Figure 5.6.7.

Figure 5.6.7: Covariates: WACMR and BR



Source: Reserve Bank of India database

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for the joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of SLR (Table 5.6.16). The results suggest a bidirectional causality running from changes in BR to WACMR.

Table 5.6.16: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
BR	4.6505	2	0.0978
All	4.6505	2	0.0978
Dependent variable: CRR			
Excluded	Chi-sq	df	Prob.
WACMR	8.0527	2	0.0178
All	8.0527	2	0.0178

Cointegration Test

We test the models with lag interval (1, 2) by employing JJ cointegration test. In Table 5.6.17, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.6.17: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.2803	16.4761	15.4947	0.0355
r ≤1	r >1	At most 1 *	0.0614	2.6621	3.8415	0.1028
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.2803	13.8141	14.2646	0.0588
r ≤1	r >1	At most 1 *	0.0614	2.6621	3.8415	0.1028
		1 Cointegrating Equation(s):	Log likelihood = -130.3996			
		Normalized cointegrating coefficients (standard error in parentheses)				
		WACMR	BR			
		1	-0.6067			
			-0.2312			

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.6.18, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in

the short-run to restore long-run equilibrium. The ECT coefficients for WACMR is statistically negative which implies that these variables fit into the model and suffer a shock and adjust to restore their equilibrium.

Table 5.6.18: Vector Error Correction Estimates
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
WACMR(-1)	1	
BR(-1)	-0.6067	
	-0.2312	
	[-2.6246]	
Intercept	-2.9983	
Error Correction:	D(WACMR)	D(BR)
CointEq1	-0.5555	0.2148
	-0.2491	-0.0849
	[-2.2298]	[2.5316]
D(WACMR(-1))	-0.1362	-0.1388
	-0.2277	-0.0776
	[-0.5981]	[-1.7899]
D(WACMR(-2))	-0.0546	-0.0507
	-0.1798	-0.0612
	[-0.3036]	[-0.8282]
D(BR(-1))	-0.0372	-0.1021
	-0.4515	-0.1538
	[-0.0823]	[-0.6636]
D(BR(-2))	0.0078	-0.0439
	-0.4513	-0.1537
Intercept	0.0544	0.0560
	-0.3311	-0.1128
	[0.1644]	[0.4968]
R-squared	0.3235	0.1634
Adj. R-squared	0.2295	0.0472
Sum sq. resids	163.9910	19.0250
S.E. equation	2.1343	0.7270
F-statistic	3.4431	1.4058
Log likelihood	-88.200	-42.965
Akaike AIC	4.4857	2.3317
Schwarz SC	4.7340	2.5799
Mean dependent	0.0448	0.0417
S.D. dependent	2.4316	0.7447
Determinant resid covariance (dof adj.)		2.3211
Determinant resid covariance		1.7053
Log likelihood		-130.39
Akaike information criterion		6.8762
Schwarz criterion		7.4554

The error correction coefficient for WACMR was (-0.5555). The coefficient indicates a feedback of about 55.55% of the previous quarter's disequilibrium from the long run elasticity. However, the error correction coefficient for BR was (0.2148). The coefficient indicates a feedback of about 21.48% of the previous quarter's disequilibrium from the long run elasticity.

Table 5.6.19: VECM Regression Results

Dependent Variable: D(WACMR)
D(WACMR) = C(1)*(WACMR(-1) - 0.606673567277*BR(-1) - 2.99834260746) + C(2)*D(WACMR(-1)) + C(3)*D(WACMR(-2)) + C(4) *D(BR(-1)) + C(5)*D(BR(-2)) + C(6)

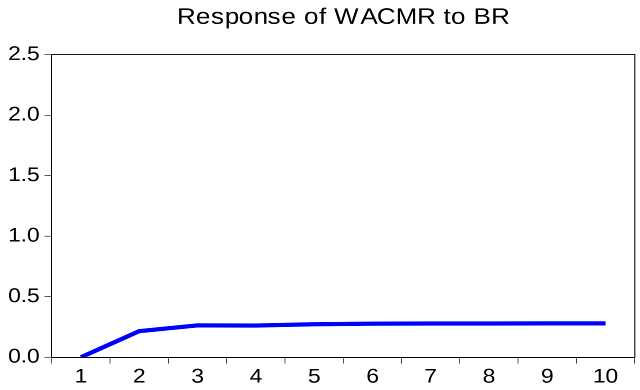
	Coefficient		Std. Error	t-Statistic	Prob.
C(1)	-0.5555		0.2491	-2.2298	0.0321
C(2)	-0.1362		0.2277	-0.5981	0.5535
C(3)	-0.0546		0.1798	-0.3037	0.7631
C(4)	-0.0372		0.4515	-0.0823	0.9349
C(5)	0.0078		0.4513	0.0172	0.9864
C(6)	0.0544		0.3311	0.1644	0.8703
R-squared	0.3235	Mean dependent var			0.0448
Adjusted R-squared	0.2295	S.D. dependent var			2.4316
S.E. of regression	2.1343	Akaike info criterion			4.4857
Sum squared resid	163.99	Schwarz criterion			4.7340
Log likelihood	-88.200	Hannan-Quinn criter.			4.5767
F-statistic	3.4431	Durbin-Watson stat			1.9926
Prob(F-statistic)	0.0121				

Table 5.6.19 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2) to C(6) are the short run coefficients.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.6.8.

Figure 5.6.8: Impulse Response of WACMR



The impulse responses show the effect of an unexpected 1 percentage point increase in BR on WACMR in the VECM. An unexpected rise in BR is associated with a decline in WACMR by around 0.2141 in the 2nd period and settles in the range of 0.2624 to 0.2790 during the 3rd to the 10th period (Table 5.6.20).

Table 5.6.20: Impulse Responses

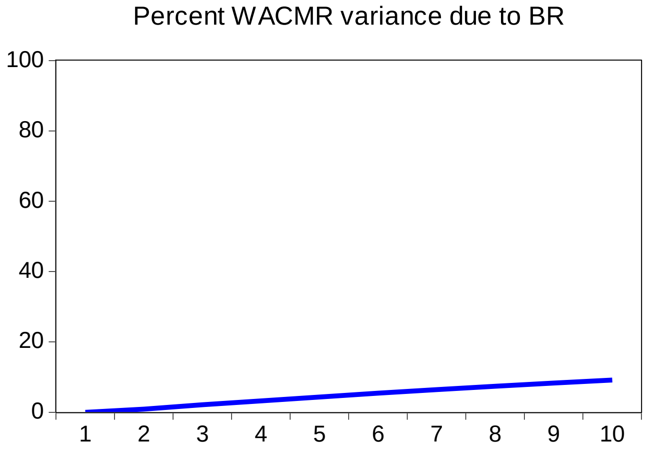
Period	WACMR	BR
1	2.1343	0.0000
2	0.6992	0.2141
3	0.4762	0.2624
4	0.4677	0.2609
5	0.4125	0.2715
6	0.3918	0.2764
7	0.3839	0.2777
8	0.3799	0.2784
9	0.3781	0.2788
10	0.3772	0.2790

Cholesky Ordering: WACMR BR

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.6.9: Variance decompositions



The variance of decompositions is presented in Figure 5.6.9. We notice that (in Table 5.6.21) at period 10, about 9.14 percent of the errors in the forecast of WACMR are attributed to BR.

Table 5.6.21: Variance decompositions

Period	S.E.	WACMR	BR
1	2.1343	100.0000	0.0000
2	2.2561	99.0999	0.9001
3	2.3207	97.8712	2.1288
4	2.3817	96.7790	3.2210
5	2.4324	95.6662	4.3338
6	2.4792	94.5857	5.4144
7	2.5240	93.5663	6.4337
8	2.5676	92.6070	7.3930
9	2.6102	91.7056	8.2944
10	2.6520	90.8588	9.1412

Cholesky Ordering: WACMR SLR

The above analysis shows that the elasticity of the BR with respect to the WACMR is 0.02148 meaning that, on average, only 21.48% of a change in the BR gets passed on to the WACMR in a period of three months. This suggests that for the transmission from BR to WACMR is relatively weaker compared that from REPO to WACMR.

6.4 Pass-through to WACMR from Reverse Repo Rate

Reverse repo rate (RRP) is a framework for monetary policy within which '*constrained discretion*' is exercised by monetary policymakers (Bernanke et al., 1999). The RRP rate is either reduced or kept steady when the inflation outlook is below or within the target range, respectively. In India, the LAF operates through daily repo and reverse repo auctions, thereby setting a corridor for the short-term interest rate consistent with policy objectives. The daily net injection by the RBI to banks through the LAF is equal to the amount lent through the overnight repo facility (amount outstanding on a given day), plus the amount lent through the term repo facility, less the amount borrowed through the reverse repo facility. The pass-through to call money rate from the reverse repo rate is estimated using the VECM as detailed here below.

A vector error correction model is estimated with the following cointegrating relationships

$$\boldsymbol{WACMR_t = \beta_0 + \beta_1 RRR_t + \varepsilon_t}$$

Where, WACMR$_t$ – Weighted Average Call Money Rate

RRR$_t$ – Monetary Policy Reverse Repo Rate

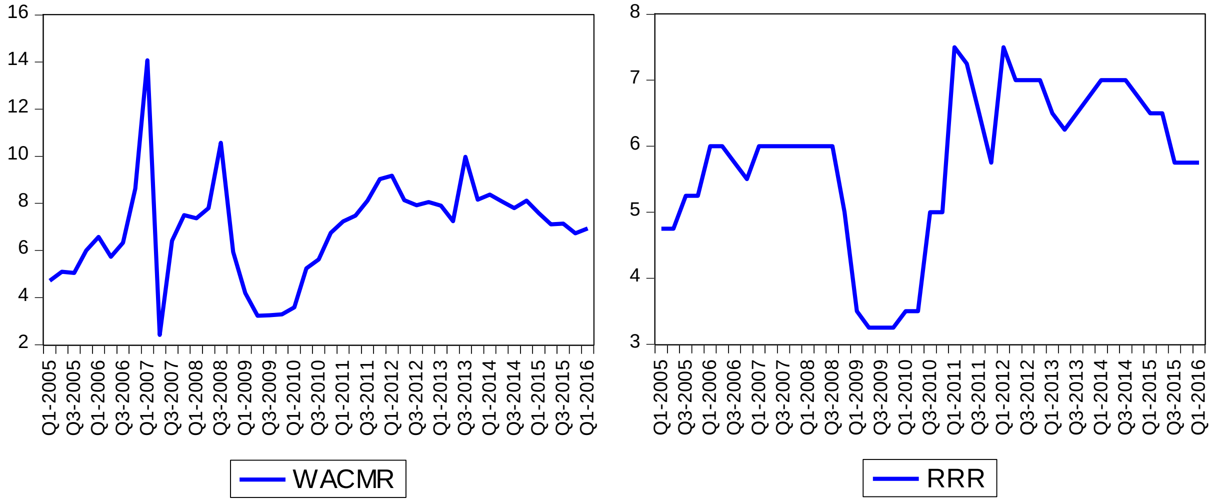
Table 5.6.22 provides the descriptive statistics of the variables. WACMR rate ranges from a minimum of 2.42 to a maximum of 14.07 with a mean value of 6.92. RRR ranges from a minimum of 3.25 to a maximum of 7.50 with a mean value of 5.77. The correlation statistics suggest a statistically significant positive correlation between WACMR and SLR was 0.66 during the sample period.

Table 5.6.22: Descriptive Statistics

	WACMR	RRR
Mean	6.9253	5.7778
Median	7.2300	6.0000
Maximum	14.0700	7.5000
Minimum	2.4200	3.2500
Std. Dev.	2.1380	1.1825
Skewness	0.3591	-0.8273
Kurtosis	4.6042	2.9198
Jarque-Bera	5.7924	5.1451
Probability	0.0552	0.0763
Observations	45	45

The covariates of the model are presented in Figure 5.6.10.

Figure 5.6.10: Covariates: WACMR and RRR



Source: Reserve Bank of India database

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation. With a view to examining how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WACMR and the second block consisting of RRR (Table 5.6.23). The results suggest a unidirectional causality running from changes in RRR to WACMR.

Table 5.6.23: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: WACMR			
Excluded	Chi-sq	df	Prob.
RRR	14.3694	2	0.0008
All	14.3694	2	0.0008
Dependent variable: RRR			
Excluded	Chi-sq	df	Prob.
WACMR	1.6179	2	0.4453
All	1.6179	2	0.4453

Cointegration Test

We test the models with lag interval (1, 2) by employing JJ cointegration test. In Table 5.6.24, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.6.24: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.4526	30.6101	15.4947	0.0001
r ≤1	r >1	At most 1 *	0.1186	5.3005	3.8415	0.0213
		Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
r =0	r >0	None *	0.4526	25.3097	14.2646	0.0006
r ≤1	r >1	At most 1 *	0.1186	5.3005	3.8415	0.0213
		1 Cointegrating Equation(s):		Log likelihood = -116.7877		
		Normalized cointegrating coefficients (standard error in parentheses)				
		WACMR	RRR			
		1	-1.3267			
			-0.1339			

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.6.25, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in the short-run to restore long-run equilibrium. The ECT coefficients for WACMR and ΔREPO are statistically negative which implies that these variables fit into the model and suffer a shock and adjust to restore their equilibrium.

Table 5.6.25: Vector Error Correction Estimates [WACMR, RRR]

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
WACMR(-1)	1	
RRR(-1)	-1.3267	
	-0.1339	
	[-9.9102]	
Intercept	0.7098	
	D(WACMR)	D(RRR)
CointEq1	-1.5919	0.0547
	-0.3415	-0.1332
	[-4.6611]	[0.4103]
D(WACMR(-1))	0.4863	0.0322
	-0.2562	-0.0999
	[1.8981]	[0.3220]
D(WACMR(-2))	0.2152	0.0038
	-0.1756	-0.0685
	[1.2256]	[0.0551]
D(RRR(-1))	-1.1252	-0.0096
	-0.5340	-0.2083
	[-2.1071]	[-0.0460]
D(RRR(-2))	-0.4808	0.1338
	-0.4595	-0.1792
	[-1.0464]	[0.7468]
Intercept	0.0518	0.0075
	-0.2752	-0.1073
	[0.1883]	[0.0697]
R-squared	0.5291	0.0612
Adj. R-squared	0.4637	-0.0692
Sum sq. resids	114.14	17.362
S.E. equation	1.7806	0.6945
F-statistic	8.0910	0.4693
Log likelihood	-80.591	-41.044
Akaike AIC	4.1234	2.2402
Schwarz SC	4.3716	2.4885
Mean dependent	0.0448	0.0119
S.D. dependent	2.4316	0.6716
Determinant resid covariance (dof adj.)		1.2139

Determinant resid covariance	0.8919
Log likelihood	-116.78
Akaike information criterion	6.2280
Schwarz criterion	6.8072

The error correction coefficient for RRR was (-0.0547). The coefficient indicates a feedback of about 5.47% of the previous quarter's disequilibrium from the long run elasticity.

Table 5.6.26: VECM Regression Results

Dependent Variable: D(WACMR)

D(WACMR) = C(1)*(WACMR(-1) - 1.32665622428*RRR(-1) + 0.709765068846) + C(2)*D(WACMR(-1)) + C(3)*D(WACMR(-2)) + C(4)*D(RRR(-1)) + C(5)*D(RRR(-2)) + C(6)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.5919	0.3415	-4.6611	0.0000
C(2)	0.4863	0.2562	1.8982	0.0657
C(3)	0.2152	0.1755	1.2256	0.2283
C(4)	-1.1252	0.5340	-2.1071	0.0421
C(5)	-0.4808	0.4594	-1.0464	0.3023
C(6)	0.0518	0.2752	0.1884	0.8517

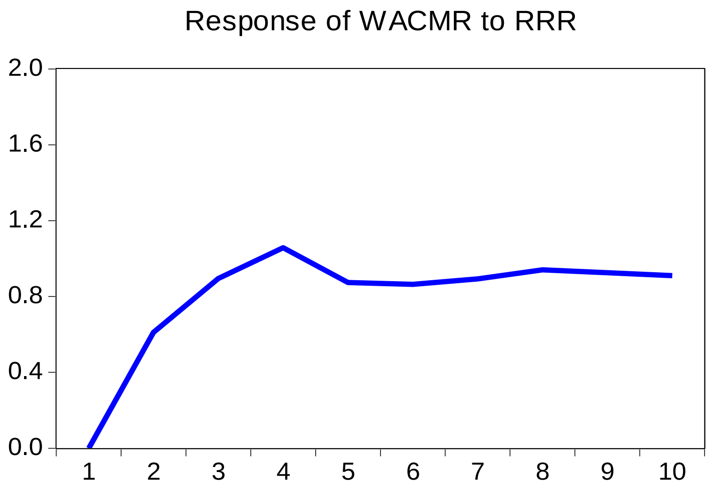
R-squared	0.5291	Mean dependent var	0.0448
Adjusted R-squared	0.4637	S.D. dependent var	2.4316
S.E. of regression	1.7806	Akaike info criterion	4.1234
Sum squared resid	114.1436	Schwarz criterion	4.3716
Log likelihood	-80.5910	Hannan-Quinn criter.	4.2144
F-statistic	8.0910	Durbin-Watson stat	2.0913
Prob(F-statistic)	0.0000		

Table 5.6.26 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2) to C(6) are the short run coefficients.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.6.11.

Figure 5.6.11: Impulse Response of WACMR



The impulse responses show the effect of an unexpected 1 percentage point increase in BR on WACMR in the VECM. An unexpected rise in RRR is associated with a rise in WACMR by around 0.6106 in the 2nd period and settles in the range of 0.8947 to 0.9104 during the 3rd to the 10th period (Table 5.6.27).

Table 5.6.27: Impulse Responses

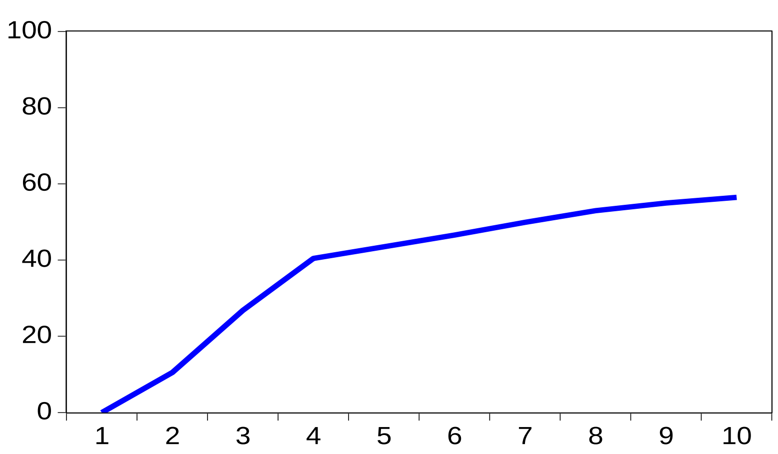
Period	WACMR	RRR
1	1.7806	0.0000
2	0.1231	0.6106
3	0.1456	0.8947
4	0.4133	1.0578
5	0.7676	0.8735
6	0.6293	0.8643
7	0.5079	0.8931
8	0.4964	0.9411
9	0.5676	0.9254
10	0.5825	0.9104

Cholesky Ordering: WACMR BR

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 12: Variance decompositions


Percent WACMR variance due to RRR

The variance of decompositions is presented in Figure 12. We notice that (in Table 5.6.28) at period 10, 56.46 percent of the errors in the forecast of WACMR are attributed to RRR.

Table 5.6.28: Variance decompositions

Period	S.E.	WACMR	RRR
1	1.7806	100.0000	0.0000
2	1.8864	89.5247	10.4753
3	2.0929	73.2158	26.7842
4	2.3811	59.5751	40.4249
5	2.6499	56.4933	43.5067
6	2.8575	53.4350	46.5650
7	3.0365	50.1156	49.8844
8	3.2175	47.0160	52.9840
9	3.3957	45.0049	54.9951
10	3.5636	43.5370	56.4630

Cholesky Ordering: WACMR SLR

The error correction coefficient for RRR was (0.0547). The coefficient indicates a feedback of about 5.47% of the previous quarter's disequilibrium from the long run elasticity. The above analysis shows that the elasticity of the RRR with respect to the WACMR is 0.0547 meaning that, on average, only 5.47% of a change in the RRR gets passed on to the WACMR in a period of three months. This suggests that for the transmission from RRR to WACMR is relatively weaker compared that from REPO to WACMR.

6.5 Integrated Model: Monetary Policy Pass-through to WACMR from the Policy Rates

In this section of the study, an integrated specification is estimated for assessing the monetary policy transmission in India. The specification includes the repo rate, reverse repo rate, cash reserve ratio, statutory liquidity ratio, bank rate with the control variables like inflation and output growth.

A vector error correction model is estimated with the following cointegrating relationships:

$$\begin{aligned} WACMR_t = \beta_0 + \beta_1 RR_t + \beta_2 RRR_t + \beta_3 CRR_t + \beta_4 SLR_t + \beta_5 BR_t \\ + \beta_6 INFL_t + \beta_7 GDPGR_t + \varepsilon_t \end{aligned}$$

Where, $WACMR_t$ – Weighted Average Call Money Rate

RR_t – Monetary Policy Repo Rate

RRR_t – Monetary Policy Reverse Repo Rate

CRR_t – Monetary Policy Cash Reserve Ratio

SLR_t – Monetary Policy Statutory Liquidity Ratio

BR_t – Monetary Policy Bank Rate

$INFL_t$ – Inflation rate

$GDPGR_t$ – Economic output growth rate

Table 5.6.29 provides the descriptive statistics of the variables Repo Rate (RR), Reverse Repo Rate (RRR), Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), Bank Rate (BR), Inflation (INFL), and GDP Growth Rate (GDPGR). Table 2 provides the statistics of the correlations of the variables.

Table 5.6.29: Descriptive Statistics

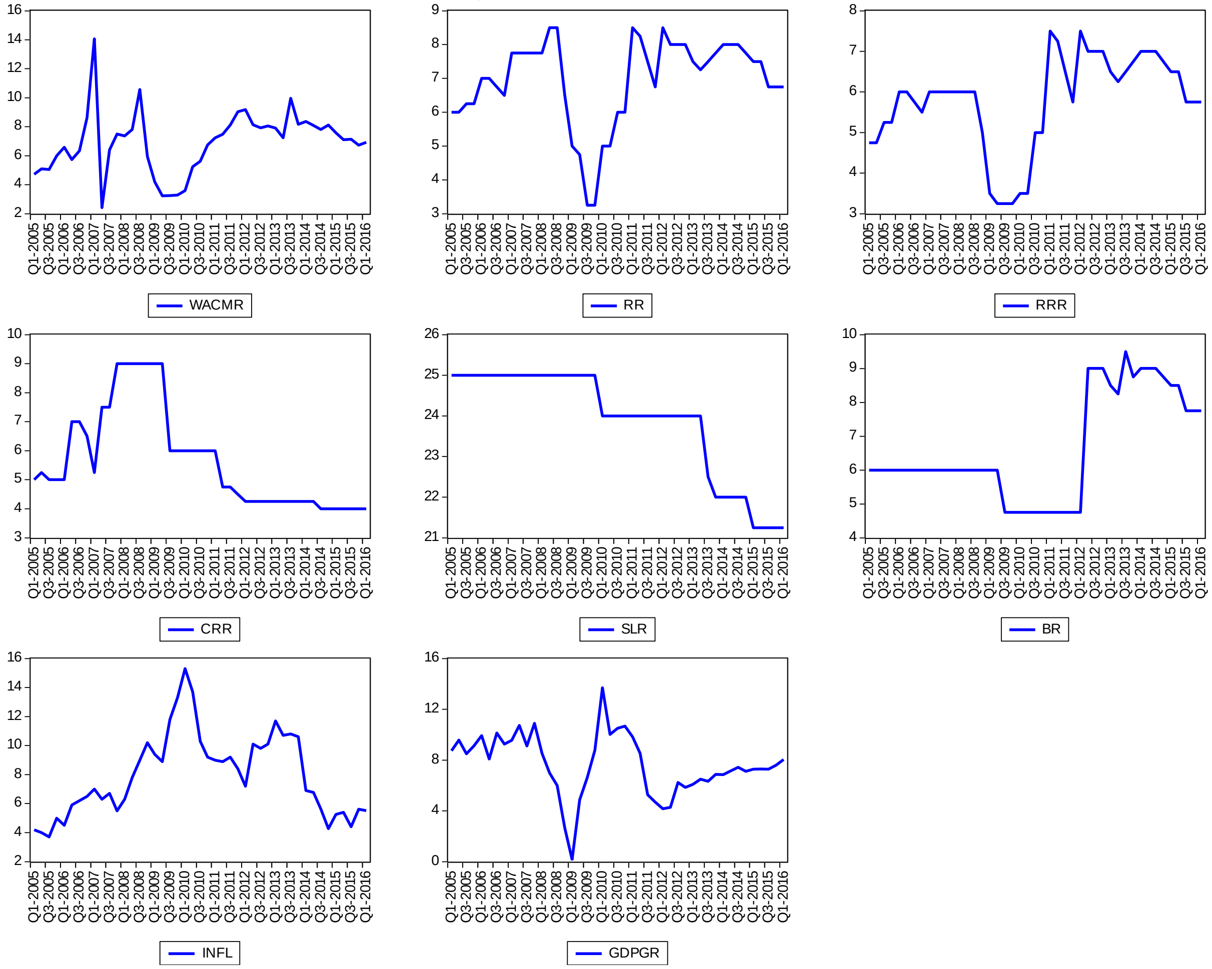
	WACMR	RR	RRR	CRR	SLR	BR	INFL	GDPGR
Mean	6.9253	6.9500	5.7778	5.6778	23.8833	6.6278	7.9324	7.6415
Median	7.2300	7.5000	6.0000	5.0000	24.0000	6.0000	7.2000	7.4308
Maximum	14.070	8.5000	7.5000	9.0000	25.0000	9.5000	15.300	13.697
Minimum	2.4200	3.2500	3.2500	4.0000	21.2500	4.7500	3.7000	0.1639
Std. Dev.	2.1380	1.2865	1.1825	1.7464	1.3438	1.6084	2.8255	2.4236
Skewness	0.3591	-1.1879	-0.8273	0.8949	-0.9423	0.4078	0.5281	-0.4604
Kurtosis	4.6042	4.0900	2.9198	2.4555	2.4103	1.6905	2.6194	4.0957
Jarque-Bera	5.7924	12.8119	5.1451	6.5617	7.3120	4.4623	2.3634	3.8409
Probability	0.0552	0.0017	0.0763	0.0376	0.0258	0.1074	0.3068	0.1465
Observations	45	45	45	45	45	45	45	45

Table 5.6.30: Correlations

	WACMR	RR	RRR	CRR	SLR	BR	INFL	GDPGR
WACMR	1							
RR	0.6899*	1						
RRR	0.6677*	0.9337*	1					
CRR	-0.2921	-0.1793	-0.4344*	1				
SLR	-0.2615	-0.2688	-0.4020*	0.6579*	1			
BR	0.3455*	0.4343*	0.5156*	-0.4952*	-0.6482*	1		
INFL	-0.1371	-0.3403*	-0.3244*	0.1034	0.1634	-0.1786	1	
GDPGR	-0.1772	-0.0990	-0.1217	-0.0045	0.1038	-0.3001*	-0.0988	1

The covariates of the model are presented in Figure 5.6.13.

Figure 5.6.13: Covariates



Source: Reserve Bank of India database

Causality Analysis

VAR Granger Causality/Block Exogeneity Wald Tests Carry out Pairwise Granger causality tests and tests whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2 statistic for joint significance of all other lagged endogenous variables in the equation. With a view to examine how changes in policy rate affect the other set of variables, block exogeneity test was performed with the first block as WAMCR and the second block consisting of Repo

Rate (RR), Reverse Repo Rate (RRR), Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), Bank Rate (BR), Inflation (INFL), and GDP Growth Rate (GDPGR) (Table 5.6.31). The results suggest a unidirectional causality running from changes in CRR to other variables, INFL to other variables, and GDPGR to other variables.

Table 5.6.31: VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(WACMR)				Dependent variable: D(RR)			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
D(RR)	1.4914	2	0.4744	D(WACMR)	2.4401	2	0.2952
D(RRR)	4.3328	2	0.1146	D(RRR)	6.2618	2	0.0437
D(CRR)	0.8124	2	0.6662	D(CRR)	2.6719	2	0.2629
D(SLR)	0.4524	2	0.7975	D(SLR)	1.3580	2	0.5071
D(BR)	0.4770	2	0.7878	D(BR)	1.7165	2	0.4239
D(INFL)	0.8279	2	0.6610	D(INFL)	3.5032	2	0.1735
D(GDPGR)	1.3798	2	0.5016	D(GDPGR)	5.8873	2	0.0527
All	7.9445	14	0.8922	All	19.0830	14	0.1618
Dependent variable: D(RRR)				Dependent variable: D(CRR)			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
D(WACMR)	0.5301	2	0.7672	D(WACMR)	8.9661	2	0.0113
D(RR)	0.5193	2	0.7713	D(RR)	8.4348	2	0.0147
D(CRR)	3.5603	2	0.1686	D(RRR)	13.3281	2	0.0013
D(SLR)	1.0508	2	0.5913	D(SLR)	0.1526	2	0.9265
D(BR)	0.9235	2	0.6302	D(BR)	0.1899	2	0.9094
D(INFL)	6.4851	2	0.0391	D(INFL)	6.2961	2	0.0429
D(GDPGR)	0.5479	2	0.7604	D(GDPGR)	2.6933	2	0.2601
All	14.5845	14	0.4071	All	26.9106	14	0.0198
Dependent variable: D(SLR)				Dependent variable: D(BR)			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
D(WACMR)	0.1797	2	0.9140	D(WACMR)	2.1432	2	0.3425
D(RR)	0.4823	2	0.7857	D(RR)	5.1595	2	0.0758
D(RRR)	0.1563	2	0.9248	D(RRR)	6.1872	2	0.0453
D(CRR)	1.2382	2	0.5384	D(CRR)	3.9430	2	0.1392
D(BR)	1.6866	2	0.4303	D(SLR)	0.3712	2	0.8306
D(INFL)	2.6170	2	0.2702	D(INFL)	1.3687	2	0.5044
D(GDPGR)	0.3536	2	0.8379	D(GDPGR)	6.4901	2	0.0390
All	8.5943	14	0.8561	All	14.9141	14	0.3841
Dependent variable: D(INFL)				Dependent variable: D(GDPGR)			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
D(WACMR)	7.3008	2	0.0260	D(WACMR)	23.6872	2	0.0000
D(RR)	0.5283	2	0.7679	D(RR)	3.0746	2	0.2150
D(RRR)	1.8255	2	0.4014	D(RRR)	0.4264	2	0.8080
D(CRR)	0.2434	2	0.8854	D(CRR)	10.3342	2	0.0057
D(SLR)	22.7908	2	0.0000	D(SLR)	6.9988	2	0.0302
D(BR)	3.1618	2	0.2058	D(BR)	0.2476	2	0.8836
D(GDPGR)	12.6644	2	0.0018	D(INFL)	7.2076	2	0.0272
All	65.7806	14	0.0000	All	58.3796	14	0.0000

Cointegration Test

We test the models with lag interval (1, 2) by employing JJ cointegration test. In Table 5.6.32, the JJ Cointegration trace and Max test results of all the models of analysis are furnished. Both the test results indicate that there is an evidence of cointegration between models. The presence of a cointegrating vector implies that the covariates are related strongly in the long run.

Table 5.6.32: Johansen Cointegration Test Results

H_0	H_a	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Trace)						
r =0	r >0	None *	0.7854	219.3689	159.5297	0.0000
r ≤1	r >1	At most 1 *	0.7018	153.1885	125.6154	0.0004
r ≤2	r >2	At most 2 *	0.6174	101.1627	95.7537	0.0201
r ≤3	r >3	At most 3 *	0.4592	59.8546	69.8189	0.2398
r ≤4	r >4	At most 4 *	0.2873	33.4261	47.8561	0.5334
r ≤5	r >5	At most 5 *	0.2201	18.8621	29.7971	0.5029
r ≤6	r >6	At most 6 *	0.1488	8.1726	15.4947	0.4471
r ≤7	r >7	At most 6 *	0.0286	1.2463	3.8415	0.2643
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)						
r =0	r >0	None *	0.7854	66.1805	52.3626	0.0011
r ≤1	r >1	At most 1 *	0.7018	52.0258	46.2314	0.0108
r ≤2	r >2	At most 2 *	0.6174	41.3081	40.0776	0.0362
r ≤3	r >3	At most 3 *	0.4592	26.4286	33.8769	0.2952
r ≤4	r >4	At most 4 *	0.2873	14.5639	27.5843	0.7818
r ≤5	r >5	At most 5 *	0.2201	10.6896	21.1316	0.6782
r ≤6	r >6	At most 6 *	0.1488	6.9263	14.2646	0.4979
r ≤7	r >7	At most 6 *	0.0286	1.2463	3.8415	0.2643

1 Cointegrating Equation(s): Log likelihood -342.9144
2 Cointegrating Equation(s): Log likelihood -316.9015
Normalized cointegrating coefficients (standard error in parentheses)

WACMR	RR	RRR	CRR	SLR	BR	INFL	GDPGR
1	0	-2.2281	-0.1303	-0.3791	-0.5299	-0.2714	-1.7111
		-0.5432	-0.3419	-0.5181	-0.4307	-0.1699	-0.2208
0	1	-1.0254	-0.1853	-0.0194	-0.1398	-0.0106	-0.1279
		-0.0517	-0.0326	-0.0493	-0.0410	-0.0162	-0.0210

Trace test indicates 2 cointegrating Eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The VECM estimation method is used due to the presence of one cointegrating vector in the variables. From the Table 5.6.33, we show that WACMR has a negative error correction term (ECT) coefficient meaning that WACMR has a feedback to long-run equilibrium: adjusting in

the short-run to restore long-run equilibrium. The ECT coefficients for WACMR, RR, RRR, and CRR are statistically negative which implies that these variables suffer a shock and adjust to restore their equilibrium.

Table 5.6.33: Vector Error Correction Estimates
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2						
WACMR(-1)	1	0						
RR(-1)	0	1						
RRR(-1)	-2.23	-1.03						
	-0.54	-0.05						
	[-4.10]	[-19.8]						
CRR(-1)	-0.13	-0.19						
	-0.34	-0.03						
	[-0.38]	[-5.69]						
SLR(-1)	-0.38	-0.02						
	-0.52	-0.05						
	[-0.73]	[-0.39]						
BR(-1)	-0.53	-0.14						
	-0.43	-0.04						
	[-1.23]	[-3.40]						
INFL(-1)	-0.27	-0.01						
	-0.17	-0.02						
	[-1.59]	[-0.65]						
GDPGR(-1)	-1.71	-0.13						
	-0.22	-0.02						
	[-7.75]	[-6.08]						
C	34.48	2.48						
Error Correction:	D(WACMR)	D(RR)	D(RRR)	D(CRR)	D(SLR)	D(BR)	D(INF)	D(GDPGR)
CointEq1	-0.20	0.04	-0.01	-0.06	-0.03	0.05	0.13	0.45
	-0.14	-0.05	-0.04	-0.05	-0.02	-0.04	-0.08	-0.08
	[-1.45]	[0.73]	[-0.2]	[-1.3]	[-1.4]	[1.18]	[1.53]	[5.35]
CointEq2	-1.30	-1.57	-0.40	0.28	0.42	0.16	-0.22	-4.26
	-1.44	-0.49	-0.45	-0.51	-0.21	-0.4	-0.88	-0.88
	[-0.90]	[-3.20]	[-0.9]	[0.5]	[2.0]	[0.3]	[-0.2]	[-4.84]
R-squared	0.37	0.35	0.19	0.18	0.15	0.30	0.27	0.56
Adj. R-squared	0.17	0.14	-0.07	-0.07	-0.11	0.08	0.04	0.42
Sum sq. resids	153.3	17.9	15.2	19.6	3.2	15.9	57.0	57.4
S.E. equation	2.19	0.75	0.69	0.78	0.31	0.71	1.33	1.34
F-statistic	1.86	1.69	0.73	0.71	0.58	1.37	1.17	4.09
Log likelihood	-88.3	-42.2	-38.7	-44.1	-4.9	-39	-67.1	-67.2
Akaike AIC	4.62	2.48	2.31	2.56	0.74	2.36	3.63	3.64
Schwarz SC	5.07	2.93	2.76	3.01	1.19	2.81	4.08	4.09
Mean dependent	0.04	0.02	0.02	-0.03	-0.09	0.04	0.04	-0.04
S.D. dependent	2.40	0.81	0.67	0.75	0.30	0.74	1.36	1.77
Determinant resid covariance (dof adj.)		0.00						
Determinant resid covariance		0.00						
Log likelihood		-316.90						

Akaike information criterion	19.58
Schwarz criterion	23.84

The error correction coefficient for WACMR of -0.20 indicates a feedback of about 20% of the previous quarter’s disequilibrium from the long run elasticity. Similarly, the ECT coefficient for RR indicates a feedback of 4%, and that of RRR indicates a feedback of 1%. The CRR and SLR are observed to indicate a feedback of 6% and 3% respectively.

Table 5.6.34: VECM Regression Results

Dependent Variable: D(WACMR)

D(WACMR) = C(1)*(WACMR(-1) + 0.7963*SLR(-1) + 2.4371*BR(-1) + 0.1726*INFL(-1) + 3.1967*GDPGR(-1) - 67.7876) + C(2)*(RR(-1) - 0.0606*SLR(-1) + 0.3601*BR(-1) + 0.1732*INFL(-1) + 1.1031*GDPGR(-1) - 17.6942) + C(3)*(RRR(-1) - 0.1458*SLR(-1) + 0.2306*BR(-1) + 0.3265*INFL(-1) + 1.3200*GDPGR(-1) - 16.5201) + C(4)*(CRR(-1) + 1.13152*SLR(-1) + 2.8176*BR(-1) - 0.7116*INFL(-1) + 0.5851*GDPGR(-1) - 50.0707) + C(5)*D(WACMR(-1)) + C(6)*D(WACMR(-2)) + C(7)*D(RR(-1)) + C(8)*D(RR(-2)) + C(9) *D(RRR(-1)) + C(10)*D(RRR(-2)) + C(11)*D(CRR(-1)) + C(12)*D(CRR(-2)) + C(13)*D(SLR(-1)) + C(14)*D(SLR(-2))+C(15)*D(BR(-1)) + C(16)*D(BR(-2)) + C(17)*D(INFL(-1)) + C(18)*D(INFL(-2)) + C(19)*D(GDPGR(-1)) + C(20)*D(GDPGR(-2))+C(21)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.1181	0.3887	-2.8766	0.0090
C(2)	-3.7560	1.9460	-1.9301	0.0672
C(3)	5.7213	1.9487	2.9360	0.0079
C(4)	1.0456	0.4235	2.4690	0.0222
C(5)	0.0669	0.3133	0.2136	0.8330
C(6)	0.0608	0.2332	0.2606	0.7970
C(7)	2.2017	1.8136	1.2140	0.2382
C(8)	1.3195	1.6471	0.8011	0.4321
C(9)	-3.5837	1.7826	-2.0104	0.0574
C(10)	-2.4931	1.7072	-1.4603	0.1590
C(11)	-0.5955	0.7964	-0.7478	0.4629
C(12)	0.1912	0.7074	0.2703	0.7895
C(13)	0.7386	1.3013	0.5676	0.5763
C(14)	0.3180	1.3004	0.2446	0.8092
C(15)	0.4243	0.6171	0.6876	0.4992
C(16)	0.0353	0.4879	0.0723	0.9430
C(17)	-0.2257	0.3078	-0.7331	0.4716
C(18)	-0.1257	0.3033	-0.4145	0.6827
C(19)	-0.4034	0.3546	-1.1378	0.2680
C(20)	-0.1511	0.3681	-0.4104	0.6856
C(21)	0.1677	0.3634	0.4615	0.6492

R-squared	0.6107	Mean dependent var	0.0448
Adjusted R-squared	0.2400	S.D. dependent var	2.4316
S.E. of regression	2.1198	Akaike info criterion	4.6473
Sum squared resid	94.3622	Schwarz criterion	5.5162
Log likelihood	-76.5943	Hannan-Quinn criter.	4.9658
F-statistic	1.6474	Durbin-Watson stat	2.3341
Prob(F-statistic)	0.1322		

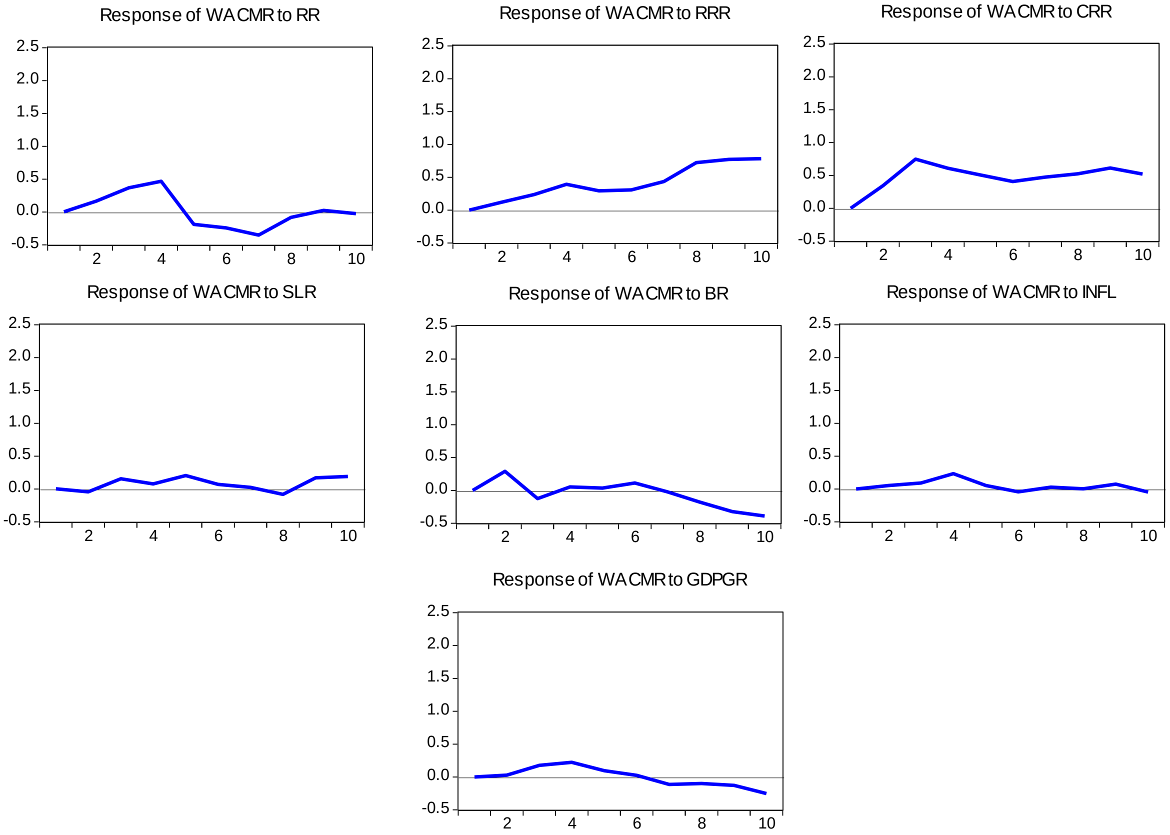
Table 5.6.34 contains the VECM regression coefficients as well as their t-statistic and p-value. C(1) is the coefficient of the cointegrated model (long run) with WACMR as the dependent variable while C(2) to C(2) are the short run coefficients.

Impulse Responses

Any shocks to the i^{th} variable not only directly affect the respective variable i^{th} variable only, but also it would be transmitted to all of the endogenous variables in the model through the dynamic (lag) structure of VAR. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In view of this feature, impulse response function in VAR System is widely used in describing the dynamic behaviors of variables in the system related to shocks in the residual of the time series under study. The impulse responses for the recursive VAR are plotted in Figure 5.6.14.

The impulse responses show the effect of an unexpected 1 percentage point increase in the policy rates on WACMR in the VECM. An unexpected rise in RR is associated with a rise in WACMR by around 0.1638 in the 2nd period and declines in the range of -0.1912 to -0.0257 during the 5th to the 10th period (Table 5.6.35). Similarly, an unexpected rise in RRR is associated with a rise in WACMR by around 0.1201 in the 2nd period and settles in the range of 0.2341 to 0.7810 during the 3rd to 10th period. An unexpected rise in CRR is associated with a rise in WACMR by around 0.3434 in the 2nd period and settles in the range of 0.7481 to 0.5183 during the 3rd to 10th period. A shock in SLR by a percentage point causes a rise in WACMR by around 0.1542 during the 3rd period and the impact settles in the range of 0.0755 to 0.1904 during the 4th to 10th period.

Figure 5.6.14: Impulse Responses



Source: Reserve Bank of India database

Table 5.6.35: Impulse responses

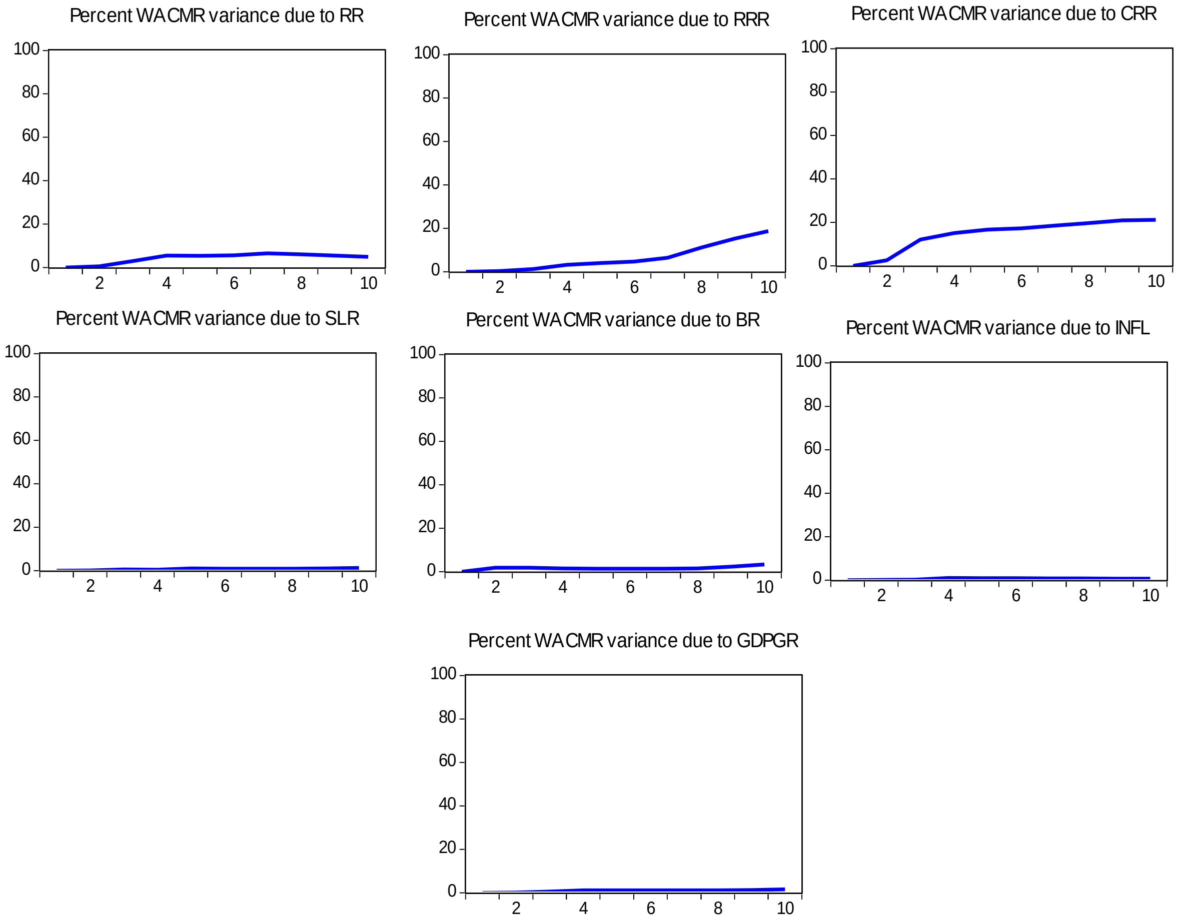
Period	WACMR	RR	RRR	CRR	SLR	BR	INFL	GDPGR
1	2.1198	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0089	0.1638	0.1201	0.3434	-0.0456	0.2893	0.0526	0.0263
3	0.2128	0.3677	0.2341	0.7481	0.1542	-0.1253	0.0892	0.1750
4	0.7166	0.4677	0.3916	0.6081	0.0755	0.0524	0.2319	0.2211
5	0.6649	-0.1912	0.2912	0.5068	0.2027	0.0351	0.0519	0.0938
6	0.5694	-0.2446	0.3061	0.4065	0.0704	0.1119	-0.0453	0.0247
7	0.3189	-0.3526	0.4343	0.4742	0.0216	-0.0221	0.0264	-0.1158
8	0.1243	-0.0848	0.7217	0.5227	-0.0845	-0.1783	0.0035	-0.1025
9	0.2287	0.0238	0.7717	0.6110	0.1696	-0.3260	0.0727	-0.1302
10	0.0932	-0.0257	0.7810	0.5183	0.1904	-0.3912	-0.0479	-0.2547

Cholesky Ordering: WACMR RR RRR CRR SLR BR INFL GDPGR

Variance Decompositions

The impulse responses (IRS) discover the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However, it is also required to know the magnitude of shocks in the system. To overcome this problem, a variance decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR system. So, the variance decomposition is applied in the model to find out the information about the relative importance of every random innovation in the question of its effects on the variables concerned in the VAR system.

Figure 5.6.15: Variance decompositions



Source: Reserve Bank of India database

The variance of decompositions is presented in Figure 5.6.15. We notice that (in Table 5.6.36) at period 1, 0.56 percent of the errors in the forecast of WACMR are attributed to RR, 0.30 percent to RRR, 2.48 percent to CRR, 0.04 percent to SLR, and 1.76 percent to BR. At the end of period 10, 4.93 percent of the errors in the forecast of WACMR are attributed to RR, 18.73 percent to RRR, 21.10 percent to CRR, 1.21 percent to SLR, and 3.29 percent to BR.

Table 5.6.36: Variance decompositions

Period	S.E.	WACMR	RR	RRR	CRR	SLR	BR	INFL	GDPGR
1	2.1198	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	2.1776	94.7620	0.5656	0.3042	2.4866	0.0439	1.7648	0.0583	0.0146
3	2.3696	80.8348	2.8853	1.2325	12.0684	0.4605	1.7699	0.1909	0.5577
4	2.6422	72.3676	5.4535	3.1877	15.0035	0.4520	1.4628	0.9241	1.1489
5	2.8028	69.9422	5.3122	3.9127	16.6037	0.9248	1.3157	0.8556	1.1331
6	2.9187	68.3034	5.6013	4.7080	17.2507	0.9110	1.3604	0.8131	1.0521
7	3.0287	64.5383	6.5569	6.4284	18.4707	0.8511	1.2686	0.7627	1.1233
8	3.1685	59.1243	6.0628	11.0614	19.5989	0.8488	1.4758	0.6970	1.1310
9	3.3494	53.3766	5.4307	15.2080	20.8670	1.0159	2.2679	0.6709	1.1632
10	3.5161	48.5062	4.9333	18.7336	21.1081	1.2152	3.2960	0.6273	1.5803

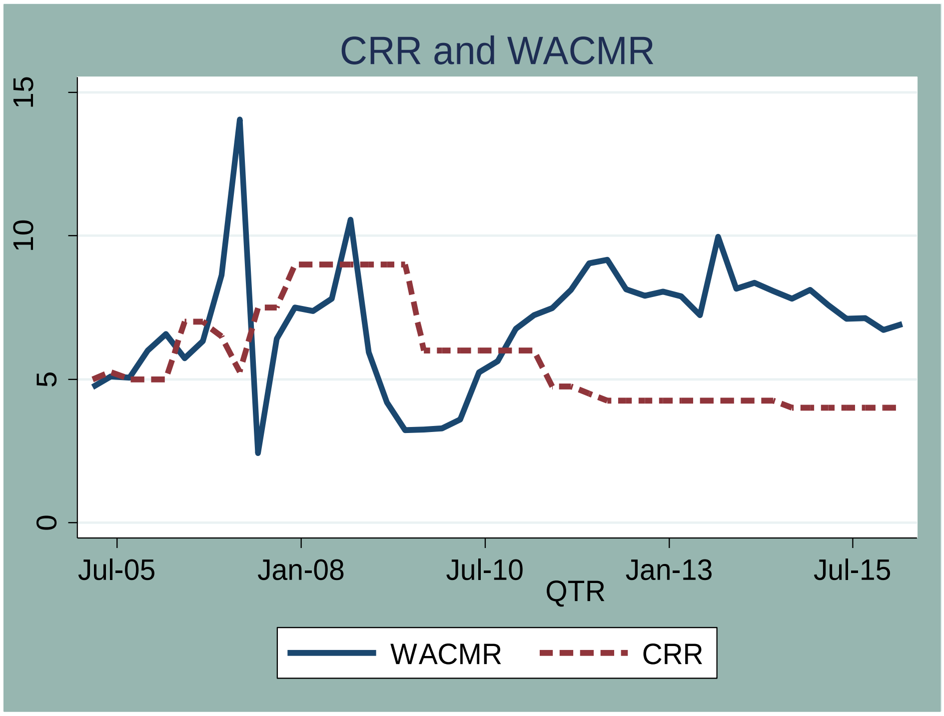
Cholesky Ordering: WACMR RR RRR CRR SLR BR INFL GDPGR

Findings:

Pass-through to WACMR from CRR:

The correlation statistics reveal a negative correlation (0.29) between CRR and WACMR. The movement of the covariates CRR and WACMR is presented in Figure 5.6.16.

Figure 5.6.16: The covariates – CRR and WACMR



Source: Reserve Bank of India database

The Pairwise Granger causality tests suggest the presence of unidirectional causality running from the cash reserve rate to the call money rate (Table 5.6.37). The direction of causality evidences the prevalence of the bank lending channel of monetary policy transmission in India.

Table 5.6.37: Causal Relationship between CRR and WACMR

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
WACMR does not Granger Cause CRR	41	4	1.9314	0.1292
CRR does not Granger Cause WACMR	41	4	4.7080	0.0042

The impulse responses show that an unexpected rise in CRR is associated with a rise in WACMR by around 0.2442 in the 2nd period and hits a peak of 0.4314 in the 3rd period. From the 4th period onwards, the response turns negative in the range of -0.1025 in the 4th period to -

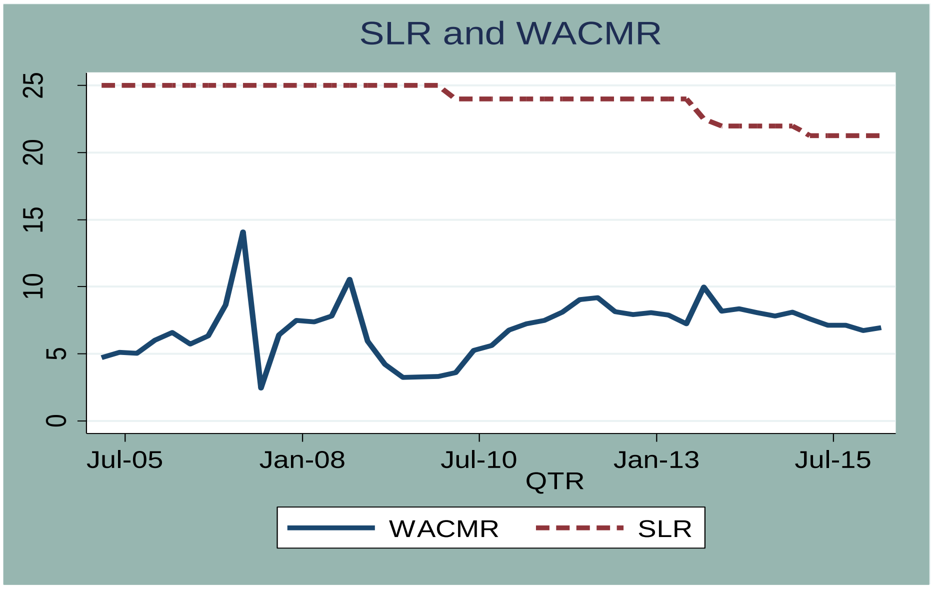
0.4314 in the 10th period. The variance of decompositions shows that at period 10, about 20.55 percent of the errors in the forecast of WACMR are attributed to CRR.

The long-run results of the VECM show the presence of the cointegrating vector between the CRR and WACMR. The error correction coefficient for WACMR of -0.6837 measures the speed of adjustment of WACMR towards long run equilibrium with CRR. The coefficient indicates a feedback of about 68.37% of the previous quarter's disequilibrium from the long run elasticity resulting in 4.38 months to achieve the complete pass-through.

Pass-through to WACMR from SLR:

The correlation statistics reveal a negative correlation (-0.26) between SLR and WACMR. The movement of the covariates CRR and WACMR is presented in Figure 5.6.17.

Figure 5.6.17: The Covariates – SLR and WACMR



Source: Reserve Bank of India database

The impulse responses indicate that an unexpected rise in SLR is associated with a decline in WACMR by around -0.0587 in the 3rd period and settles in the range of -0.1044 to -

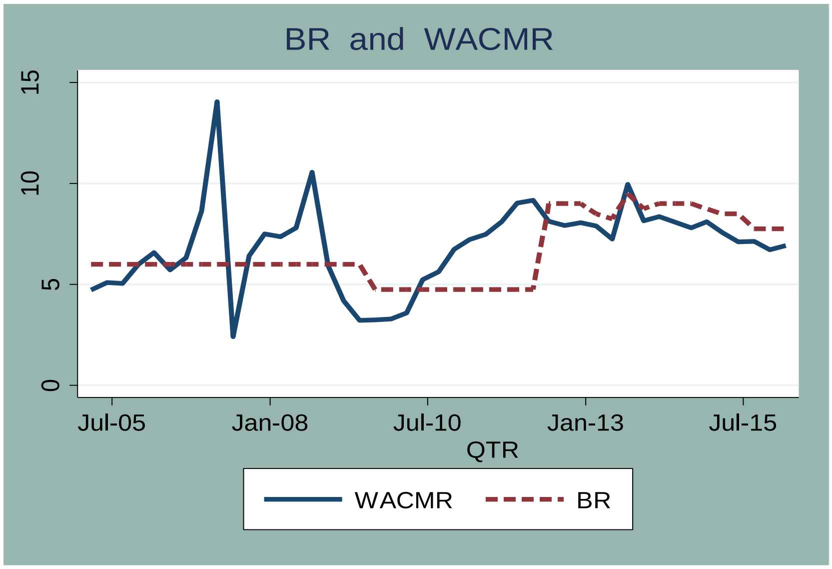
0.1226 during the 5th to the 10th period. The variance of decompositions indicates that at period 10, about 1.95 percent of the errors in the forecast of WACMR are attributed to SLR.

The long-run results of the VECM show the presence of the cointegrating vector between the SLR and WACMR. The error correction coefficient for WACMR of -0.5890 measures the speed of adjustment of WACMR towards long run equilibrium with SLR. The coefficient indicates a feedback of about 58.90% of the previous quarter's disequilibrium from the long run elasticity resulting in 5.09 months to achieve the complete pass-through.

Pass-through to WACMR from BR:

The correlation statistics reveal a statistically significant positive correlation (0.34) between BR and WACMR. The movement of the covariates CRR and WACMR is presented in Figure 5.6.18.

Figure 5.6.18: The Covariates BR and WACMR



Source: Reserve Bank of India database

The Pairwise Granger causality tests suggest the presence of unidirectional causality running from the bank rate to call money rate (Table 5.6.38). The direction of causality evidences the prevalence of the bank lending channel of monetary policy transmission in India.

Table 5.6.38: Causal Relationship between BR and WACMR

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
WACMR does not Granger Cause BR	43	12	0.3540	0.9487
BR does not Granger Cause WACMR	43	12	2.7073	0.0825

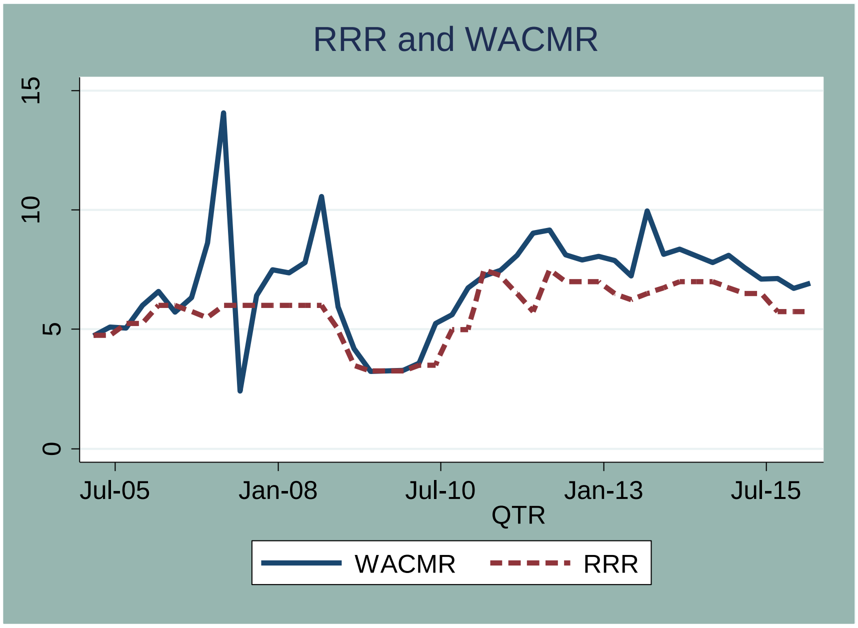
The impulse responses show that an unexpected rise in BR is associated with a decline in WACMR by around 0.21 in the 2nd period and settles in the range of 0.26 to 0.28 during the 3rd to the 10th period. The variance of decompositions shows that at period 10, about 9.14 percent of the errors in the forecast of WACMR are attributed to BR.

The long-run results of the VECM show the presence of the cointegrating vector between the BR and WACMR. The error correction coefficient for WACMR of -0.5555 measures the speed of adjustment of WACMR towards long run equilibrium with BR. The coefficient indicates a feedback of about 55.55% of the previous quarter's disequilibrium from the long run elasticity resulting in 5.4 months to achieve the complete pass-through.

Pass-through to WACMR from RRR:

The correlation statistics reveal a statistically significant positive correlation (0.66) between RRR and WACMR. The movement of the covariates RRR and WACMR is presented in Figure 5.6.19.

Figure 5.6.19: The covariates – RRR and WACMR



Source: Reserve Bank of India database

The Pairwise Granger causality tests suggest the presence of unidirectional causality running from the reverse repo rate to call money rate (Table 5.6.39). The direction of causality evidences the prevalence of the bank lending channel of monetary policy transmission in India.

Table 5.6.39: Causal Relationship between BR and WACMR

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.
WACMR does not Granger Cause RRR	43	2	0.8090	0.4528
RRR does not Granger Cause WACMR	43	2	7.1847	0.0023

The impulse responses show that an unexpected rise in the reverse repo rate is associated with a rise in the call money rate by around 0.61 in the 2nd period and settles in the range of 0.89 to 0.91 during the 3rd to the 10th period. The variance of decompositions shows that at period 10, about 56.46 percent of the errors in the forecast of WACMR are attributed to RRR.

The long-run results of the VECM show the presence of the cointegrating vector between the RRR and WACMR. The error correction coefficient for WACMR of 0.0547 measures the speed of adjustment of WACMR towards long run equilibrium with RRR. The above analysis shows that the elasticity of the RRR with respect to the WACMR is 0.0547 meaning that, on average, only 5.47% of a change in the RRR gets passed on to the WACMR in a period of three months. This suggests that for the transmission from RRR to WACMR is relatively weaker compared that from REPO to WACMR.

Chapter 6

Conclusion

This study provides a comprehensive analysis of the effectiveness of the monetary policy transmission in India. Essentially, it sheds more light on the specific questions such as: (i) How is the efficiency of the transmission of monetary policy rates to the real economy? (ii) How is the co-integrating relationship of monetary policy interest rate movements with rates across financial markets? (iii) How is the co-integrating relationship of monetary policy interest rate movements with credit growth, the lending rate in the bank lending channel? (iv) How is the pass-through to call money rate from monetary policy and then how is the pass-through to bank interest rates from call money rate?

The study analysed the different models of monetary policy transmission models and underscore the importance of lending model in the context of banking dominated financial system of an economy. The efficacy of monetary policy largely depends on the channels of its transmission. The study analysed six channels of monetary policy transmission: (i) the interest rate channel, (ii) exchange rate channel, (iii) bank lending channel, (iv) balance sheet channel, (v) asset price channel, and (vi) expectation channel. Though all of these channels are active in advanced economies, only a few are prominent in the developing countries. The effectiveness of these channels mostly depends on the stage of development of the economy and the structure of its financial system. A sound and stable financial system is indispensable for an objective and efficient implementation of monetary policy. A fragmented and fragile financial sector poses several challenges in the smooth conduct of monetary policy, as the interest rate channel may not have the targeted outcome. Thus, a country's financial structure has a strong influence on the monetary policy transmission.

This study estimates the efficiency of monetary policy transmission in India in *five* separate *sub-studies*. Study 1 reports the estimation of the impulse responses of macroeconomic indicators to the policy repo rate shocks in India. Following a quarterly structural vector auto-regression (SVAR) model, the study finds evidence that policy rate increases have a negative effect on output growth with a lag of two-quarters and a moderating impact on inflation with a lag of three-quarters. The commodity price inflation experiences a negative impact for the first shock in monetary policy repo rate in 10–12 months by 3 percent. However, during the 13th to 15th months, there is a spurt in the CPI, leading us to observe the presence of a "price puzzle". The impulse response functions imply that increase in policy *Repo Rate* is associated with a maximum decline in short-term lending rate (-5.27) that occurs with a lag of ten quarters with the overall impact continuing through 4–10 quarters.

The analysis shows that a hike in the monetary policy repo rate is associated with an appreciation of the exchange rate by 0.17 for the first shock in the 3rd quarter. In response to the first shock, the maximum decline (appreciation) in the exchange rate (-7.09) occurs with a lag of nine quarters with the overall impact continuing through 3–9 quarters. However, the depreciation of the exchange rate persists in the 6th, 8th and 10th period. I notice that the domestic currency appreciates initially (during the 1st and 2nd periods) in response to a positive shock to policy repo rate and subsequently depreciates. The possible reason could be: the exchange rate channel is rather weak due to the fact that India remained characterised by a low degree of de facto capital mobility during the sample period, at least when compared to other emerging markets. Further, a possibility is that the RBI's intervention in the foreign exchange market has tended to mute the exchange rate response to monetary policy. This explains the possibly weak exchange rate channel.

The estimation of the impact of monetary policy shocks on the economic output growth shows that a hike in the monetary policy repo rate is associated with a decline in real GDP growth rate by -1.06 for the first shock in the 6th quarter. The real GDP growth responds to the policy repo rate shock with a lag of three-quarters. In response to the first shock, the maximum decline in GDP growth (-4.3) occurs with a lag of eight quarters with the overall impact continuing through 6–8 quarters. The results are consistent with a broad class of theories and suggest that monetary policy has a limited sharp influence on real variables, such as real output. However, the results underscore the importance of interest rate as a potent monetary policy tool.

Study 2 reports the estimation of the cointegrating relationship of the monetary policy repo rate movements with the rates across the financial markets in India. Assessing the transmission to lending rate, in Model I, the VECM results show an error correction term coefficient of -0.05, indicating a feedback effect of 4.7 percent from a weighted average lending rate of the previous quarter. Alternatively, in Model II, the VECM results show an error correction term coefficient of -0.09, indicating a feedback effect of 8.85 percent from a weighted average lending rate of the previous quarter. In the same order, in a period of one year, the transmission of call money rate to the lending rate is to the extent of 35.4 percent.

In the model with BOND 10Y yield, an unexpected rise in WACMR is associated with a decline in the weighted average lending rate of around 0.1 in the first period, 0.14 in the 2nd period. The decline reaches its trough of 0.1559 in the 3rd period. From the 7th period onwards the decline stabilizes at 0.15. However, considering the accumulated responses, a positive weighted average call money rate shock creates a 0.55 percent rise in the weighted average lending rate in the first year. At the end of the second year, only 1.15 percent of the effects of monetary policy tightening pass through the money market. After a period of 30 months, only 1.45 percent of the effects of monetary policy tightening pass through in the presence of a long-term bond market.

An unexpected rise in WACMR is associated with a rise in the weighted average lending rate by around 0.0003 in the first period and settles in the range of 0.0567 to 0.0625 during the 5th to 10th period. On the other hand, considering the accumulated responses, a positive weighted average call money rate shock creates a 0.19 percent rise in the weighted average lending rate in the first year. At the end of the second year, only 0.43 percent of the effects of monetary policy tightening pass through the money market. After a period of 30 months, only 0.55 percent of the effects of monetary policy tightening pass through in the presence of 5-year bond yield. The Pairwise Granger causality tests do not suggest the presence of significant causality running from call money rate to weighted average lending rate.

Assessing the transmission to asset prices, the study finds that a positive weighted average call money rate shock creates a 39 point rise in SENSEX in the first quarter. At the beginning of the second year, only 5.8 percent of the effects of monetary policy tightening pass through the asset prices. After a period of 2 years, only 10.45 percent of the effects of monetary policy tightening pass through the asset prices. These results suggest that the asset price channel is not as effective as in the case of advanced economies in the transmission of monetary shocks in India. This supports the argument that monetary policy in India does not respond to asset prices, but the asset price channel of monetary policy does exist.

It is also noticed that the credit market shock is weaker as the accumulated response of SENSEX to weighted average lending rate is modest. A positive weighted average call money rate shock creates a -4.28 percent rise in SENSEX in the first year. At the end of the second year, only 12 percent of the effects of monetary policy tightening pass through the asset prices. After a period of 30 months, only 16 percent of the effects of monetary policy tightening pass through the asset prices. The response of stock exchange index to credit market shocks evidences the presumed role of credit expansion in contributing to the asset price bubbles. The results suggest that monetary policy does not respond to stock prices, though stock prices respond to monetary policy shocks

Assessing the transmission to the bond market, the VECM results suggest that the error correction coefficient for BOND 10Y was 0.12 and carries the positive sign, indicating that there was a feedback of about 12 percent in the previous quarter. On the other hand, in Model II, the error correction term coefficient for BOND 5Y was 0.09 and carries the positive sign indicating a feedback effect of 9 percent of the previous quarter. An unexpected rise in WACMR is associated with a rise in BOND 10Y yield by around 0.29 in the first period and reaches a peak of 0.33 in the 3rd period. Considering the accumulated responses, a positive weighted average call money rate shock creates a 1.17 percent rise in BOND 10Y yield in the first year. At the end of the second year, only 2.35 percent of the effects of monetary policy tightening pass through the bond market. After a period of 30 months, only 2.95 percent of the effects of monetary policy tightening pass through the long-term bond market. Similarly, an unexpected rise in WACMR is associated with a rise in BOND 5Y yield by around 0.2813 percent in the 1st period and reaches a peak of 0.3175 in the 3rd period. Considering the accumulated responses of BOND 5Y, A positive weighted average call money rate shock creates a 1.09 percent rise in BOND 5Y yield in the first year. At the end of the second year, only 2.20 percent of the effects of monetary policy tightening pass through the bond market. After a period of 30 months, only 2.75 percent of the effects of monetary policy tightening pass through the long-term bond market. Pairwise Granger causality tests suggest the presence of unidirectional causality running from call money rate to BOND 10Y. However, the absence of the reverse causation from BOND 10Y to WACMR is not significant, suggesting the weaker feedback from the bond market channel of monetary policy transmission. Similarly, we notice a unidirectional causation running from call money rate to BOND 5Y. The unidirectional causation running from monetary policy action through call money rate to bond market seems to be weaker as this process looks just coincidental, not targeted.

Study 3 reports the examination of the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel. Assessing the transmission to the Inter-Bank Market Rate, the VECM results show that there is a cointegrating vector between the monetary policy repo rate and the operating target rate (weighted average call money rate – WACMR). The coefficient on the repo rate 1.18 indicates a long-run elasticity between the REPO rate and weighted average call money rate. Further, the results suggest that the error correction coefficient for weighted average call money rate was (-0.20) and it measures the speed of adjustment of weighted average call money rate towards long run equilibrium. The results indicate a feedback of about 20 percent of the previous quarter's disequilibrium from the long run elasticity. In simpler terms, about 20 percent of disequilibrium is "corrected" in each quarter by changes in weighted average call money rate. The impulse responses show that the effect of an unexpected 1 percentage point increase in REPO is associated with a rise in weighted average call money rate of around 2.04 in the 1st period and settles in the range of 0.99 to 1.03 during the 4th to the 10th period. The response of weighted average call money rate settles at the level of 0.50 to 0.55 after the 5th period. The variance decompositions suggest that at the end of 10 quarters, 20.81 percent of the errors in the forecast of weighted average call money rate are attributed to repo rate shocks. The variance decomposition in the 2nd quarter is observed to be 15.49 percent and stabilizes at an average level of 20.5 percent from the 5th quarter. These results thus, show that there is significant, albeit slow, pass-through of policy changes to inter-bank call money rate.

Assessing the transmission to the lending rate, the long-run results of the VECM show the presence of the cointegrating vector between the lending rate and the WACMR. The elasticity of the lending rate with respect to the WACMR is 0.37, meaning that, on average, only 37% of a change in the WACMR gets passed on to the lending rate. The error correction coefficient for WALR was -0.37 and it measures the speed of adjustment of WALR towards long run equilibrium. The coefficient indicates a feedback of about 37% of the previous quarter's disequilibrium from the long run elasticity. The coefficient of -0.37 indicates that the lending rate adjusts by 37 percent per time period towards the WACMR after a deviation from equilibrium, resulting in 8.1 months to achieve the pass-through from a change in the WACMR. The impulse responses reveal that an unexpected rise in WACMR is associated with a rise in WALR by around 0.42 in the 1st quarter and settles in the range of 0.4248 to 0.4308 during the 4th to the 10th quarter. The variance decompositions show that at the 10th quarter, 7.4 percent of the errors in the forecast of WALR are attributed to WACMR.

Assessing the transmission to the Deposit Rate, the impulse responses show that an unexpected one percentage point rise in the call money rate is associated with a rise in deposit rate by around 0.0422 in the 2nd quarter and settles in the range of 0.2093 to 0.2095 during the 8th to the 10th quarter. The variance decompositions suggest that at the 10th quarter, 9.0032 percent of the errors in the forecast of deposit rate are attributed to the call money rate. Thus, the results indicate that the extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate.

Study 4 reports the estimation of the pass-through to call money rate from monetary policy. Assessing the transmission to Call Money Rate, the VECM results show an error correction term coefficient of -0.3157 for ECT, indicating a feedback effect of 31.57 percent from the equilibrium between the WACMR and the repo rate of the previous quarter. That is when there is a deviation from the equilibrium between the WACMR and the repo rate, the WACMR adjusts by 31.5 percent per time period towards the repo rate to re-establish equilibrium. These results suggest that it takes 9.5 months for the complete pass-through from the policy repo rate to call money rate. At this rate, it would take 4.76 months to achieve fifty percent of the pass-through from an increase in the repo rate. Thus, the repo rate appears to sufficiently capture the monetary policy stance of the RBI. The impulse responses show that an unexpected one standard deviation shock in a total change in the lagged WACMR and the change in LAFNITONDTL is associated with a change in WACMR by around 0.2567 in the 2nd period and crosses the 100 percent in between the 3rd and 4th periods. The results suggest that the complete transmission of the monetary policy happens around 9 months. Thus, the above results support our results of the earlier analysis involving repo rate in determining the transmission to call money rate.

Assessing the transmission to Call Money Rate in the alternate specification, the VECM results show an error correction term coefficient of -0.36 for WACMR indicating a feedback effect of 36 percent from the equilibrium between the WACMR and the reverse repo rate and the repo rate in the previous quarter. That is when there is a deviation from the equilibrium between the WACMR and the repo rate and the reverse repo rate depending upon their effects, the WACMR adjusts by 36 percent per time period to re-establish equilibrium. These results suggest that it takes 8.3 months for the complete pass-through from the policy repo rate to call money rate. At this rate, it would take 4.16 months to achieve fifty percent of the pass-through from an increase in the repo rate. Thus, the repo rate appears to sufficiently capture the monetary policy stance.

The impulse responses that an unexpected one standard deviation shock in RRRLIQDEF and RRLIQDEF is associated with a change in WACMR by around 0.5930 in the 2nd period and crosses the 100 percent in between the 2nd and 3rd periods. These results suggest that the complete transmission of the monetary policy through REPO and REVERSEREPO happens around 8 to 9 months. Thus the alternate specification results also support our results of the earlier analysis involving repo rate in determining the transmission to call money rate.

Study 5 reports the estimation of the pass-through to bank interest rates from call money rate. Assessing the pass-through to Bank Lending Rate, the long-run results of the VECM show the presence of the cointegrating vector between the lending rate and the other covariates. The error correction coefficient for ΔWALR was -0.3877 and it measures the speed of adjustment of WALR towards long run equilibrium. The coefficient indicates a feedback of about 38.77% of the previous quarter's disequilibrium from the long run elasticity, resulting in 7.74 months to achieve the complete pass-through.

The impulse responses show that an unexpected rise in ΔREPO is associated with a rise in ΔWALR by around 0.0619 in the 2nd period and settles in the range of -0.27 to -2.97 during the 3rd to the 10th period. An unexpected rise in ΔWACMR is associated with a rise in ΔWALR by around 0.2692 in the 2nd period and settles in the range of 1.07 to 3.50 during the 6th to 10th period. An unexpected rise in ΔLOANS/ASSETS is associated with a decline in ΔWALR by around -0.0003 in the 2nd period and settles in the range of -0.16 to -1.27 during the 3rd to 10th period. The variance of decompositions shows that at period 10, 24.42 percent of the errors in the forecast of ΔWALR are attributed to ΔREPO. Similarly, 36.79 percent of the errors in the forecast or ΔWALR are attributed to ΔWACMR and 4.68 percent of the errors in the forecast of ΔLOANS/ASSETS.

Assessing the pass-through to bank deposit rate, the long-run results of the VECM show the presence of the cointegrating vector between the lending rate and the other covariates. The error correction coefficient for ΔDR of -0.67 measures the speed of adjustment of ΔDR towards long run equilibrium. The coefficient indicates a feedback of about 67% of the previous quarter's disequilibrium from the long run elasticity, resulting in 4.48 months to achieve the complete pass-through. The impulse responses show that an unexpected rise in ΔREPO is associated with a decline in ΔDR by around -0.11 in the 3rd period and settles in the range of -0.04 to -0.14 during the 4th to the 10th period. An unexpected rise in ΔWACMR is associated with a rise in ΔDR by around 0.1742 in the 2nd period and settles in the range of 0.17 to 0.36 during the 3rd to 10th period. An unexpected rise in ΔLOANS/ASSETS is associated with a decline in ΔDR by around 0.0718 in the 2nd period and settles in the range of 0.16 to 0.88 during the 3rd to 10th period. The variance of decompositions shows that at period 10, about 4.98 percent of the errors in the forecast of ΔDR are attributed to ΔREPO. Similarly, 6.67 percent of the errors in the forecast of ΔDR are attributed to ΔWACMR and 14.78 percent of the errors in the forecast of ΔLOANS/ASSETS.

Finally, Study 6 reports the estimation of the cointegrating relationship of monetary policy rate movements with call money rate. Assessing the pass-through to WACMR from CRR, the long-run results of the VECM show the presence of the cointegrating vector between the CRR and WACMR. The error correction coefficient for WACMR of -0.68 measures the speed of adjustment of WACMR towards long run equilibrium with CRR. The coefficient indicates a feedback of about 68.37% of the previous quarter's disequilibrium from the long run elasticity, resulting in 4.38 months to achieve the complete pass-through. The impulse responses show that an unexpected rise in CRR is associated with a rise in WACMR by around 0.24 in the 2nd period and hits a peak of 0.43 in the 3rd period. From the 4th period onwards, the response turns negative in the range of -0.10 in the 4th period to -0.43 in the 10th period. The variance of decompositions shows that at period 10, about 20.55 percent of the errors in the forecast of WACMR are attributed to CRR.

Assessing the pass-through to WACMR from SLR, the long-run results of the VECM show the presence of the cointegrating vector between the SLR and WACMR. The error correction coefficient for WACMR of -0.5890 measures the speed of adjustment of WACMR towards long run equilibrium with an SLR. The coefficient indicates a feedback of about 59% of the previous quarter’s disequilibrium from the long run elasticity, resulting in 5.09 months to achieve the complete pass-through. The impulse responses indicate that an unexpected rise in an SLR is associated with a decline in WACMR by around -0.06 in the 3rd period and settles in the range of -0.10 to -0.12 during the 5th to the 10th period. The variance of decompositions indicates that at period 10, about 1.95 percent of the errors in the forecast of WACMR are attributed to SLR.

Assessing the pass-through to WACMR from bank rate, the long-run results of the VECM show the presence of the cointegrating vector between the bank rate and WACMR. The error correction coefficient for WACMR of -0.55 measures the speed of adjustment of WACMR towards long run equilibrium with bank rate. The coefficient indicates a feedback of about 55% of the previous quarter’s disequilibrium from the long run elasticity, resulting in 5.4 months to achieve the complete pass-through. The impulse responses show that an unexpected rise in bank rate is associated with a decline in WACMR by around 0.21 in the 2nd period and settles in the range of 0.26 to 0.28 during the 3rd to the 10th period. The variance of decompositions shows that at period 10, about 9.14 percent of the errors in the forecast of WACMR are attributed to the bank rate.

Assessing the pass-through to WACMR from reverse repo rate, the long-run results of the VECM show the presence of the cointegrating vector between the reverse repo rate and WACMR. The error correction coefficient for WACMR of 0.0547 measures the speed of adjustment of WACMR towards long run equilibrium with the reverse repo rate. The above analysis shows that the elasticity of the reverse repo rate with respect to the WACMR is 0.0547 meaning that, on average, only 5.47% of a change in the reverse repo rate gets passed on to the WACMR in a period of three months. This suggests that for the transmission from reverse repo rate to WACMR is relatively weaker compared that from repo rate to WACMR. The impulse responses show that an unexpected rise in the reverse repo rate is associated with a rise in the call money rate by around 0.61 in the 2nd period and settles in the range of 0.89 to 0.91 during the 3rd to the 10th period. The variance of decompositions shows that at period 10, about 56.46 percent of the errors in the forecast of WACMR are attributed to reverse repo rate.

To conclude, the study 1 finds that the time lag for complete transmission of the pass-through from Repo Rate to Commodity Price Inflation is about 8 quarters. The time lag for the complete pass-through from Repo Rate to Short-Term Lending Rate is about 4 quarters. The transmission lag for the complete pass-through from Repo Rate to Exchange Rate is 9 quarters. However, for the transmission from Repo Rate to Output Growth is 3 quarters.

Study 2 observes that time lag for the transmission from Call Money Rate to Lending Rate is 2.82 quarters; from Call Money Rate to Asset Prices it is 8-10 quarters, and from Call Money Rate to Bond Market, it is 9 quarters.

Study 3, examining the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel observes that the transmission lag for the complete pass-through from Repo Rate to Call Money Rate is about 5 quarters; and from Call Money Rate to Lending Rate (alternate specification) is about 2.7 quarters; from Call Money Rate to Bank Deposit Rate it is 2.9 quarters.

Study 4, assessing the pass-through to call money rate from Monetary Policy finds that the time lag in complete transmission from Repo Rate to Call Money Rate is 3.17 quarters; From Repo Rate to Call Money Rate (alternate Specification) is 2.76 quarters.

Study 5, assessing the Pass-through to Bank Interest Rates from Call Money Rate shows that the time lag in the transmission from Repo Rate to Lending Rate is about 2.58 quarters and from Repo Rate to Bank Deposit Rate it is 1.49 quarters.

Study 6, examining the co-integrating relationship of monetary policy rates movements with Call Money Rate reveals that the time lag in the transmission from Cash Reserve Ratio to Call Money Rate is 1.46 quarters; from Statutory Liquidity Ratio to Call Money Rate it is 1.69 quarters; from Bank Rate to Call Money Rate, it is 1.8 quarters; and from Reverse Repo Rate to Call Money Rate, it is 9 quarters.

Notable Observations:

- The unidirectional causation running from monetary policy action through call money rate to asset prices through stock market index seems to be weaker as this process looks just coincidental, not targeted. This is because the magnitude of the increase in the call money rate is not large enough to effectively pop up asset price bubbles.

- The response of stock exchange index to credit market shocks evidences the presumed role of credit expansion in contributing to the asset price bubbles. The monetary policy tightening leads to a moderation in credit demand over the medium-term, given the usual lags in the impact of monetary policy. The tightening of policy interest rates, which causes the call money rate to rise, impacts the stock prices, as financing the leverage in the markets turns higher and costlier. The impact of the credit market channel on the asset price channel can also work through changes in market perception. As the credit conditions tighten, the perception about the overheating of the economy may get strengthened and accordingly the stock prices would adversely be affected.

- There is strong bidirectional causality between the policy rate and the call money rate. However, there is significant, albeit slow, pass-through of policy changes to inter-bank call money rate. Similarly, there is a weak pass-through of monetary policy to the lending rate from the inter-bank call money rate.

- Though there exists a unidirectional causality running from the call money rate at the deposit rate, there is a weaker feedback from deposit (liquidity) channel of monetary policy transmission. The unidirectional causation running from monetary policy action through call money rate to deposit rate seems to be weaker as this process looks just coincidental, not targeted. Further, the extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate.

- There is a unidirectional causality running from the change in the repo rate to the change in lending rate; from the change in the call money rate to the change in the ratio of loans to assets; and from the change in the ratio of loans to assets to the change in the lending rate. The direction of causality evidences the dominant presence of the bank lending channel of monetary policy transmission in India.

- There is a unidirectional causality running from the cash reserve rate to the call money rate; from the bank rate to call money rate; from the reverse repo rate to call money rate. The direction of causality evidences the predominance of the bank lending channel of monetary policy transmission in India.

- The transmission from reverse repo rate to call money rate is relatively weaker compared that from repo rate to call money rate. The repo rate appears to sufficiently capture the monetary policy stance.

Policy Implications

It is important to note that since food and fuel account for more than 57 percent of the CPI on which the immediate impact of monetary policy is limited, the commitment to the nominal anchor needs to be established by the timely monetary policy response to risks from second round effects and inflation expectations in response to shocks to food and fuel. Administered prices, wages, and directed interest rates continue to be the significant impediments to monetary policy transmission and the achievement of the price stability objective.

The real GDP growth responds to the policy repo rate shock with a lag of three-quarters. The biggest impediment to monetary targeting is the lack of control over RBI’s credit to the central government, which accounts for the bulk of reserve money creation. Persistent fiscal dominance continues to interrupt monetary policy efficacy as open market operations are intermittently employed to ‘manage yields’ in the context of large government borrowings. Further, there is a need to delink the open market operations from fiscal operations and instead linked solely to liquidity management.

In view of the implementation of Basel III framework, it is desirable to reduce the SLR to a level in consonance with the liquidity coverage ratio (LCR).

The transmission of monetary policy to deposit and lending rates is sensitive to liquidity conditions prevailing at the time of a policy rate change and during the period thereafter. There is a need to fine tune RBI’s liquidity management operations in order to ensure consistency with the monetary policy stance. Every increase in the policy rate (conveying an anti-inflation policy stance) should be accompanied by liquidity tightening measures through the liquidity management operations to enable efficient transmission.

In the transmission of the monetary policy to the lending rate, continued time-lags are also due to the imperfectness in the financial system structures and incompletely integrated market segments.

There is a need to develop a more competitive and dynamic banking structure that can facilitate faster re-pricing of deposit and lending rates, in response to RBI’s monetary policy actions.

The higher cost of funds for the banks and related banking system inefficiencies cause a significant impediment in the efficient transmission of the monetary policy through the banking channel.

Asset quality of the banks affects their margins and impedes the efficient transmission of the reduction in the policy rates to the real sector. Banks’ reluctance to pass on the benefits of the favourable monetary policy measures to the real sector are perhaps due to the attempt by the banks to cover their shrinking margins due to the deteriorating asset quality.

Monetary policy transmission mechanism in India, an emerging economy, is found to be weaker compared to the advanced economies. The possible reasons could be: first that the small size of the formal financial sector in India would tend to undermine the effects on bank lending rates on aggregate demand. With the expansion of domestic financial markets and gradual deregulation of interest rates, monetary policy operating procedure in India in the recent years has evolved towards greater reliance on interest rates to signal the stance of monetary policy. This process is bolstered by significant evidence that policy rate changes transmit through the term structure of interest rates, though the intensity of transmission differs across markets. The monetary policy transmission mechanism in India is felt to be weak.

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About the Researcher:

Brief Bio: Dr. Vighneswara Swamy

Dr. Vighneswara Swamy is currently Professor at IBS-Hyderabad and has been teaching students of the MBA program. Dr. Vighneswara possesses a good blend of industry experience and meritorious educational background. Academically, he has specialized in Economics in the master's program and holds his Doctoral degree in Economics from the University of Mysore. He is a Post-Doc Fellow in Financial Economics. Further, he is the holder of the distinction as one amongst the toppers in the University Grants Commission-National Entrance Test for UGC Lecturership. Dr. Swamy was associated with Institute of Economic Growth as ***Senior Fellow***.

His research interests include financial economics involving banking and finance, International economics, macroeconomics, and development economics. He has published in globally reputed journals such as World Development (a top rated economics journal). One of his research papers published in the International Journal of Banking and Finance is listed in the most popular papers category of the journal. He has authored a customized textbook titled "Risk Management in Financial Institutions" published by McGraw-Hill custom publishing.

Some of his accomplishments in economic research include several awards and recognitions like; *UGC Post-Doctoral Research Award*, *IIBF Macro Research Award 2012*, *Sir Ratan Tata Trust Research Fellowship* 2012-14 at ISEC, B'lore, *SANEI Regional Research Fellowship 2013*, *IIBF Macro Research Award* 2015-16, and *SANEI Regional Research Fellowship* 2015. Professor Swamy was felicitated at 2nd International Conference 'Reshaping Organizations to Develop Responsible Global Leadership' organized by Nepalese Academy of Management held in March 2013 as the Plenary Speaker and was also invited to chair a session. He was the Conference Chair of the 9th International Conference on Business & Finance (ICBF) – 2012 held on January 6 and 7, 2012 at Hyderabad, India.

Contact details:

Dr. Vighneswara Swamy
Professor,
IBS-Hyderabad,
Dontanapally, Shankarapally Road,
HYDERABAD – 501204
E-Mail: vighneswar@ibsindia.org
vighnesh.ibs@gmail.com
Mobile, +91 9705096919
Office, +91 8417-236660 to 65 extn. 6109

Policy Brief
to
Reserve Bank of India

The Effectiveness of Transmission of Monetary Policy Rates in India

This study provides new evidence on the effectiveness of monetary policy transmission in India.

Issues:

In the context of the intense debate on the concerns of the slower pace of transmission, this study sheds more light on the timely questions such as: (i) What are the extent and speed of pass-through from monetary policy to inter-bank money market rate and short-term market rate? (ii) What are the extent and speed of pass-through from monetary policy rate to deposit and lending rates, and the real credit to the private sector? (iii) What are the impacts of policy repo rate change in inflation, investment, and gross domestic product? and (iv) Is the pass-through symmetric? Or do the episodes of monetary contraction and expansion have different influences on bank interest rates?

Approach:

The effectiveness of monetary policy actions lies in the speed and magnitude of the transmission process. Like other empirical studies in emerging countries have established the importance of the bank lending channel and the interest rate channel, this study finds the predominance of the banking channel in the transmission of the monetary policy in

India. The study analyzed six channels of monetary policy transmission: (i) the interest rate channel, (ii) exchange rate channel, (iii) bank lending channel, (iv) balance sheet channel, (v) asset price channel, and (vi) expectation channel

Results at a Glance:

The results of the study are presented here below in a nutshell for easy and quick comprehension.

	Transmission	*Complete Pass-through*
Study 1: *Estimating Impulse Responses of macroeconomic Indicators*		
1	From Repo Rate to Commodity Price Inflation	8 quarters
2	From Repo Rate to Short-Term Lending Rate	4 quarters
3	From Repo Rate to Exchange Rate	9 quarters
4	From Repo Rate to Output Growth	3 quarters
Study 2: *Examining the Co-integrating Relationship of Monetary Policy Interest Rate Movements with Rates across Financial Markets*		
5	From Call Money Rate to Lending Rate	2.82 quarters
6	From Call Money Rate to Asset Prices	8-10 quarters
7	From Call Money Rate to Bond Market	9 quarters
Study 3: *Examining the cointegrating relationship of monetary policy interest rate movements with bank interest rates in the bank lending channel*		
8	From Repo Rate to Call Money Rate	5 quarters
9	From Call Money Rate to Lending Rate (alternate specification)	2.7 quarters
10	From Call Money Rate to Bank Deposit Rate	2.9 quarters
Study 4: *Assessing the Pass-through to call money rate from Monetary Policy*		
11	From Repo Rate to Call Money Rate	3.17 quarters
12	From Repo Rate to Call Money Rate (alternate Specification)	2.76 quarters
Study 5: *Assessing the Pass-through to Bank Interest Rates from Call Money Rate*		
13	From Repo Rate to Lending Rate	2.58 quarters
14	From Repo Rate to Bank Deposit Rate	1.49 quarters
Study 6: *Examining the co-integrating relationship of monetary policy rates movements with Call Money Rate*		
15	From Cash Reserve Ratio to Call Money Rate	1.46 quarter
16	From Statutory Liquidity Ratio to Call Money Rate	1.69 quarter
17	From Bank Rate to Call Money Rate	1.8 quarter
18	From Reverse Repo Rate to Call Money Rate	9 quarters

Notable Observations:

1. The unidirectional causation running from monetary policy action through call money rate to asset prices through stock market index seems to be weaker as this process looks just coincidental, not targeted. This is because the magnitude of the increase in the call money rate is not large enough to effectively pop up asset price bubbles.

2. The response of stock exchange index to credit market shocks evidence the presumed role of credit expansion in contributing to the asset price bubbles. The monetary policy tightening leads to a moderation in credit demand over the medium-term, given the usual lags in the impact of monetary policy. The tightening of policy interest rates, which causes the call money rate to rise, impacts the stock prices, as financing the leverage in the markets turns higher and costlier. The impact of the credit market channel on the asset price channel can also work through changes in market perception. As the credit conditions tighten, the perception about the overheating of the economy may get strengthened and accordingly the stock prices would adversely be affected.

3. There is strong bidirectional causality between the policy rate and the call money rate. However, there is significant, albeit slow, pass-through of policy changes to inter-bank call money rate. Similarly, there is a weak pass-through of monetary policy to the lending rate from the inter-bank call money rate.

4. Though there exists a unidirectional causality running from the call money rate at the deposit rate, there is a weaker feedback from deposit (liquidity) channel of monetary policy transmission. The unidirectional causation running from monetary policy action through call money rate to deposit rate seems to be weaker as this process looks just coincidental, not targeted. Further, the extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate.

5. There is a unidirectional causality running from the change in the repo rate to the change in lending rate; from the change in the call money rate to the change in the ratio of loans to assets; and from the change in the ratio of loans to assets to the change in the lending rate. The direction of causality evidences the dominant presence of the bank lending channel of monetary policy transmission in India.

6. There is a unidirectional causality running from the cash reserve rate to the call money rate; from the bank rate to call money rate; from the reverse repo rate to call money rate. The direction of causality evidences the predominance of the bank lending channel of monetary policy transmission in India.

7. The transmission from reverse repo rate to call money rate is relatively weaker compared that from repo rate to call money rate. The repo rate appears to sufficiently capture the monetary policy stance.

Policy Implications:

It is important to note that since food and fuel account for more than 57 percent of the CPI on which the immediate impact of monetary policy is limited, the commitment to the nominal anchor needs to be established by the timely monetary policy response to risks from second round effects and inflation expectations in response to shocks to food and fuel. Administered prices, wages, and directed interest rates continue to be the significant impediments to monetary policy transmission and the achievement of the price stability objective.

The real GDP growth responds to the policy repo rate shock with a lag of three-quarters. The biggest impediment to monetary targeting is the lack of control over RBI's credit to the central government, which accounts for the bulk of reserve money creation. Persistent fiscal dominance continues to interrupt monetary policy efficacy as open market operations are intermittently employed to 'manage yields' in the context of large government borrowings. Further, there is a need to delink the open market operations from fiscal operations and instead linked solely to liquidity management.

In view of the implementation of Basel III framework, it is desirable to reduce the SLR to a level in consonance with the liquidity coverage ratio (LCR).

The transmission of monetary policy to deposit and lending rates is sensitive to liquidity conditions prevailing at the time of a policy rate change and during the period thereafter. There is a need to fine tune RBI's liquidity management operations in order to ensure consistency with the monetary policy stance. Every increase in the policy rate (conveying an anti-inflation policy stance) should be accompanied by liquidity tightening measures through the liquidity management operations to enable efficient transmission.

In the transmission of the monetary policy to the lending rate, continued time-lags are also due to the imperfectness in the financial system structures and incompletely integrated market segments.

There is a need to develop a more competitive and dynamic banking structure that can facilitate faster re-pricing of deposit and lending rates, in response to RBI’s monetary policy actions.

The higher cost of funds to the banks and related banking system inefficiencies cause a significant impediment in the efficient transmission of the monetary policy through the banking channel.

Asset quality of the banks affects their margins and impedes the efficient transmission of the reduction in the policy rates to the real sector. Banks’ reluctance to pass on the benefits of the favorable monetary policy measures to the real sector are perhaps due to the attempt by the banks to cover their shrinking margins due to the deteriorating asset quality.

Monetary policy transmission mechanism in India, an emerging economy, is found to be weaker compared to the advanced economies. The possible reasons could be: first that the small size of the formal financial sector in India would tend to undermine the effects on bank lending rates on aggregate demand. With the expansion of domestic financial markets and gradual deregulation of interest rates, monetary policy operating procedure in India in the recent years has evolved towards greater reliance on interest rates to signal the stance of monetary policy. This process is bolstered by significant evidence that policy rate changes transmit through the term structure of interest rates, though the intensity of transmission differs across markets. The monetary policy transmission mechanism in India is felt to be weak.
