

Chapter 1

Introduction

An important question is how monetary policy affect output and inflation? The monetary policy framework of a ce ntral bank aims to attain the desired objectives of policy in terms of inflation and growth. Typically, central banks exercise control over the monetary base and/or short term interest rates such as the rate at which the central bank supplies or absorbs reserves to/from the banking system in the economy. How these interest rate actions and liquidity operations of the central banks impact the end-objectives depends on the underlying monetary transmission, which in turn depends on structure of the economy and the state of development in financial markets.

1.1 Transmission Channels

Monetary transmission refers to a process through which changes in the policy get translated into the ultimate objectives of inflation and growth passing through some intermediate process. Traditionally, four key channels of monetary policy transmission have been identified in literature viz., (i) money or interest rate channel; (ii) credit or balance sheet channel; (iii) exchange rate channel; and (iv) asset price channel. In recent years, a fifth channel, i.e., expectations channel has assumed increased prominence in the conduct of forward-looking monetary policy.

Interestingly, the channels of monetary transmission are often referred to 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. This is because not only different channels of monetary transmission tend to operate at the same time but they also change over time.

As Bernanke and Gertler (1995) observed: To a large extent, empirical analysis of the effects of monetary policy has treated monetary transmission mechanism itself as a “black box”. As a result, questions remain: does monetary policy affect the real economy? If so, what is the transmission mechanism by which these effects take place? Monetary policy changes affect market interest rates such as bank lending and bank deposit rates in varying degrees over time.

In general, transmission mechanism is largely conditioned by the monetary policy framework, structure and depth of the financial system in which the central bank operates and the state of real economy. While there is vast empirical literature on monetary policy transmission for advanced economies, only a limited number of empirical studies have examined the monetary transmission mechanisms in emerging markets and developing economies (EMDEs). This is understandable given the underdeveloped nature of financial markets and rapid structural changes in EMDEs. However, since the 2000s, analysis of monetary transmission mechanisms in EMDEs, including India, has gained prominence due to structural and economic reforms and subsequent transitions to market oriented policy regimes. Literature on monetary transmission in India is still in a nascent stage.

An effective implementation of monetary policy needs an assessment of how the monetary policy changes propagate through the financial markets and then the broader economy. In general, monetary policy gets transmitted to final objectives of inflation and growth through two stages. In the first stage, policy changes transmit through the financial system by altering financial prices and quantities. In the second stage, financial prices and quantities influence the real economy by altering aggregate spending decisions of households and firms, and hence the aggregate demand and inflation. Nonetheless, whether monetary policy actions influence the spectrum of market interest rates would *inter alia* depend upon the level of development of various segments of financial markets. Cross-country studies suggest that as domestic financial markets grow, transmission of monetary policy through financial channels becomes better.

1.2 Evolution of Monetary Framework in India

In India, the depth and width of financial markets expanded significantly since the 1990s following wide-ranging financial sector reforms. Alongside, the market discovery of prices of financial instruments was buttressed by progressive deregulation of interest rates. Various measures were taken to facilitate the process of price discovery in different segments of financial markets which *inter alia* included deregulation of interest rates; auction-based market borrowing programme of the government; development of short-term money markets through introduction of money market instruments; discontinuation of automatic monetisation by phasing out of *ad hoc* Treasury Bills; replacing cash credit with term loans, and reduction in statutory reserve requirements. These reforms facilitated a shift in the operating framework for monetary management from direct instruments to

interest rate based indirect instruments. Even though the financial reforms began in the early 1990s, the impact became evident from the late 1990s.

Financial markets in India have developed significantly since the financial sector reforms in the early 1990s. Integrated financial markets are important for different reasons like transmission of monetary policy signals (Reddy, 2003), a medium to provide economic growth through promoting financial savings and investment (Mohan, 2004), contribute to financial stability (Trichet, 2005), improve financial services (Giannetti, et al., 2005) and encourages market discipline and informational efficiency (RBI, 2006). Further, the interest rate based monetary policy transmission framework is dependent upon the extent and speed with which changes in the policy rate are transmitted to the market interest rates and exchange rate and onward to the real sector (Mohan, 2007). A well-integrated market, makes it easier for central bank to manage demand in the economy and attain its objective of low inflation and sustained growth (Pétursson, 2001).

The Reserve Bank of India (RBI) was established in 1935. Since the formative years during 1935–1950, 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). During the development phase during 1951–1970, monetary policy was geared towards supporting plan financing, 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.

The development of the financial market and understanding the inter-linkages among various segments of the financial market is important for the central bank to evolve a framework for monetary policy which is consistent with its stated objectives. Based on the recommendations of Chakravarty Committee (1985), a monetary targeting framework was adopted by the Reserve Bank in the mid-1980s, with reserve money as the operating target and broad money (M3) as an intermediate target for monetary operations.

In the 1990s, the increasing market orientation of the financial system and greater capital inflows imparted instability to the money demand function. Consequently, there was a shift to multiple indicators approach in the late 1990s. Under this approach, interest

rates or rates of return in different markets along with movements in currency, credit, fiscal position, trade, capital flows, inflation rate, exchange rate, refinancing and transactions in foreign exchange – available on a high frequency basis – were juxtaposed with output data for drawing policy perspectives. The multiple indicators approach continued to evolve and was augmented by forward looking indicators and a panel of parsimonious time series models. The forward looking indicators were drawn from the Reserve Bank’s industrial outlook survey, capacity utilization survey, professional forecasters’ survey and inflation expectations survey. The assessment from these indicators and models feed into the projection of growth and inflation (Mohanty *et al.*).

Along with this, following the recommendation of Narasimham Committee II (1998) the operating procedure of monetary policy was also changed by introducing the Interim Liquidity Adjustment Facility (ILAF) in April 1999. Over time the ILAF developed into a full-fledged liquidity adjustment facility (LAF) based on the development and deepening of financial markets. The LAF was operated through overnight fixed rate repo (used for injection of liquidity) and reverse repo (used for absorption of liquidity) from November 2004, which provided an informal corridor for the interbank overnight call money rate. Thus RBI slowly moved towards interest rate as the key instrument of monetary transmission.

In May 2011 RBI moved into a new operating procedure for monetary policy with the weighted average overnight call money rate as the operating target of monetary policy. The repo rate was made the key policy instrument with a new Marginal Standing Facility (MSF) under which banks could borrow overnight at 100 basis points above the repo rate. The reverse repo rate was placed at 100 basis points below repo rate defining a corridor with a fixed width of 200 basis points (RBI, 2011).

Following the recommendation of the Urjit Patel Committee (RBI, 2014) while weighted average call rate continues to be the the operating target, there is a greater reliance on term-repo under the RBI’s LAF operations for liquidity management. Also the RBI switched wholesale price inflation (WPI) to consumer price inflation (CPI) as the nominal anchor for monetary policy. Further, the Monetary Policy Framework Agreement was signed by the Government of India and the Reserve Bank in February 2015 with the objective “to primarily maintain price stability while keeping in mind the objective of

growth” (Government of India, 2015). Reserve bank will look to contain inflation at 4 per cent with a tolerance band of +/- 2 per cent in the medium term.

The RBI Working Group on Money Supply (Chairman: Y.V. Reddy, 1998) pointed to some evidence of interest rate channel of monetary transmission. RBI (2005) using a VAR framework for the period 1994-95 to 2003-04 found that monetary tightening through a positive shock to the Bank Rate had the expected negative effect on output and prices with the peak effect occurring after six months. Monetary easing through a positive shock to broad money had a positive effect on output and prices with peak effect occurring after about two years and one year, respectively. Further, exchange rate depreciation led to increase in prices with the peak effect after six months and a positive impact on output.

A number of studies have also examined the importance of different channels of monetary policy transmission in India. Al-Mashat (2003) using a structural VECM model for the period 1980:Q1 to 2002:Q4 found interest rate and exchange rate channels to be important in the transmission of monetary policy shocks on key macroeconomic variables. Bank lending was not an important channel due to presence of directed lending under priority sector. On the other hand, Aleem (2010) studying credit channel, asset price channel and exchange rate channel of monetary policy transmission using VAR models for the period 1996:Q4 to 2007:Q4 found the credit channel to be the only important channel of monetary transmission in India.

Using cointegrated VAR approach, Singh and Kalirajan (2007) showed the significance of interest rate as the major policy variable for conducting monetary policy in the post-liberalised Indian economy, with CRR playing a complementary role. Patra and Kapur (2010) also found that aggregate demand responds to interest rate changes with a lag of at least three quarters. However, they pointed out that the presence of institutional impediments in the credit market such as administered interest rates could lead to persistence of the impact of monetary policy up to two years. Bhaumik *et al.* [2010] highlighted the importance of bank ownership in monetary policy transmission through the credit channel. Pandit and Vashisht (2011) found that policy rate channel of transmission mechanism, a hybrid of the traditional interest rate channel and credit channel, works in India, as in other six EMEs considered by them. Mohanty (2014) found 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.

1.3 Chapter Scheme

Against this background, in this thesis we examine three questions: (i) development and extent of integration in the domestic financial market in India, (ii) evidence of interest rate channel of monetary transmission, and (iii) the impact of liquidity on the interest rate channel of monetary transmission. The thesis is organised into 6 chapters including this introductory chapter. The chapter scheme is as follows:

Chapter 1: Introduction

It sets the context by briefly tracing the evolution of the monetary policy framework since the mid-1980s and how interest rate has formally evolved as the operating target of monetary policy since the 2000s. This is in a way predicated on the understanding that interest rate is a key factor in monetary policy transmission to the broader economy. Thus the proposed research has policy relevance.

Chapter 2: Development of Financial Markets

In the context of reforms in the 1990s and following the implementation of recommendation of several committees – particularly Chakravarty Committee (1985), Vaghul Committee (1987), Rangrajan Committee (1991) and Narasimham Committee (1998) – various segments of the financial market were developed. The chapter captures these developments with a greater emphasis on the money, government securities and credit markets. The analysis shows how the transition from a regulated interest rate regime to a largely deregulated interest rate regime was effected. This is crucial for monetary transmission. The chapter ends with a stylised illustration of the current operating procedure of monetary policy as this is the crucial first step in monetary transmission.

Chapter 3: Integration of Financial Markets

In this chapter we empirically test for the integration across segments of the financial market encompassing money, government securities and credit markets. We provide analysis on the basis of monthly data on interest rate/yield in these segments of the market for a period of 17 years from March 1998 to March 2015 broadly coinciding with the period of gradual interest rate liberalisation and market developments. Apart from correlation, we perform cointegration analysis to formally test for long-term equilibrium relationship among key interest rate.

We additionally test for the stability in the cointegrating relationship by estimating a short-term vector error correction model (VECM).

Chapter 4: Review of Literature on Monetary Transmission

In this chapter we review both theoretical and empirical literature on monetary transmission with an emphasis on the interest rate channel. We particularly focus on Emerging Markets and Developing Economies (EMDEs) including India. This chapter also presents the stylised facts on monetary policy in India for the period 1997-98 to 2014-15 coinciding with reforms to develop the interest rate instrument of monetary policy.

Chapter 5: Empirical Model on Interest Rate Channel

In this chapter we set out an empirical model first in an unstructured Vector Auto Regression (VAR) framework and then proceed to develop a structural VAR (SVAR) with an overlay of liquidity to examine the interest rate channel of monetary policy and the impact of liquidity on it. We estimate a quarterly model for the 16 year period from 1999-2000:Q₁ to 2014-15:Q₄ coinciding with the period of gradual adoption of interest rate as the key operating instrument of monetary policy in India. Another consideration for the time period was the fact that quarterly gross domestic product (GDP) data are available only towards the latter part of the 1990s. Our representative economy-wide model is specified in three variables: (i) policy rate, (ii) GDP growth rate and (iii) headline inflation rate broadly in a New Keynesian framework. In the model, we additionally try to control for liquidity as an exogenous dummy variable to show the efficacy of transmission under varying liquidity conditions.

Chapter 6: Conclusions

This chapter gives the conclusions of the research undertaken.

Chapter 2

Development of Financial Markets

In this chapter we capture the development of various segments of the financial markets: money, foreign exchange, debt and credit market. We conclude the chapter with a discussion on the monetary operating procedure of the Reserve Bank of India (RBI), which has a direct bearing on monetary policy transmission.

Financial markets are important to monetary policy formulation, as monetary policy is mainly implemented through these markets, which then propagate to the real sector in the process achieving policy objectives. The transmission of monetary policy to financial markets could be viewed as an intermediate step or the first step in the overall transmission process. The efficacy of the monetary policy transmission therefore depends to a large extent on the degree of integration of the financial markets.

In India, the depth and width of financial markets expanded significantly since the 1990s following wide-ranging financial sector reforms. Alongside, the market discovery of prices of financial instruments was supported by progressive deregulation of interest rates. These developments enabled the monetary policy operating framework to evolve from predominantly a quantity-based operation to an interest rate-based operation.

Against this background, this chapter briefly captures the development of money, foreign exchange and credit markets in India. We also capture the evolution of monetary operating procedures in India and see how interest rate evolved as the principal operating instrument. This has a critical bearing on the interest rate channel of monetary transmission.

Adoption of interest rate as the principal monetary instrument is, however, no assurance for monetary transmission unless the other segments of the financial markets respond to the interest rate signal from the RBI. This requires that price discovery in the different segments of the market should largely be market determined, and various frictions in the market ought to be minimised. This indeed is a long process. We capture this process of financial marker developments from the late 1990s.

2.1 Financial Markets Evolution in India

Financial markets in India have developed significantly since the financial sector reforms in the early 1990s. Integrated financial markets are important for different reasons like transmission of monetary policy signals (Reddy, 2003), medium to provide economic growth through promoting financial savings and investment (Mohan, 2004), contribute to financial stability (Trichet, 2005), improves financial services (Giannetti, et al. 2005) and encourages market discipline and informational efficiency (RBI, 2006). Further, the interest rate based monetary policy transmission framework is dependent upon the extent and speed with which changes in the policy rate are transmitted to the market interest rates and exchange rate and onward to the real sector (Mohan, 2007). A well-integrated market makes it easier for central bank to manage demand in the economy and attain its objective of low inflation and sustained growth (Pétursson, 2001).

2.2 Role of Money Market in Monetary Transmission

Money market can be defined as a market for short-term funds with maturities ranging from overnight to one year and includes financial instruments that are considered to be close substitutes of money. It provides an equilibrating mechanism for demand and supply of short-term funds and in the process provides an avenue for central bank intervention in influencing both the quantum and cost of liquidity in the financial system, consistent with the overall stance of monetary policy. In the process, money market plays a central role in the monetary policy transmission mechanism by providing a key link in the operations of monetary policy to financial markets and ultimately, to the real economy. In fact, money market is the first and the most important stage in the chain of monetary policy transmission.

Typically, the monetary policy instrument, effectively the price of central bank liquidity, is directly set by the central bank. In view of limited control over long-term interest rates, central banks adopt a strategy to exert direct influence on short-term interest rates. Changes in the short-term policy rate provide signals to financial markets, whereby different segments of the financial system respond by adjusting their rates of return on various instruments, depending on their sensitivity and the efficacy of the transmission mechanism. How quickly and effectively the monetary policy actions influence the

spectrum of market interest rates depends upon the level of development of various segments of financial markets, particularly the money market to some extent. Cross-country studies suggest that as domestic financial markets grow, transmission of monetary policy through various channels improve.

As a crucial initial link in the chain through which monetary policy aims at achieving ultimate goals relating to inflation and growth, money market developments are closely monitored and influenced by central banks. Besides expecting money market rates to respond to policy rate changes in a well anchored manner, central banks aim at ensuring appropriate liquidity conditions through discretionary liquidity management operations so that money market functions normally. Money market is also an important funding market for banks and financial institutions, and at times, even for corporates. Stressed conditions in the money markets could increase moral hazard with banks expecting the central bank to function as the lender of first resort.

2.2.1 Financial crisis and global money markets

Following the recent global financial crisis, money market funding for the financial systems effectively got replaced with central bank funding in advanced countries. Money market rates (like LIBOR and EURIBOR) are standard benchmarks for pricing of bonds, loans and other financial products. Market manipulation of this key benchmark – as reportedly happened to LIBOR recently - though undermined the faith in money market. A sound money market would have to ensure conditions where banks can conduct business safely.

Money market transactions could be both secured and unsecured, *i.e.*, without collaterals. What does one expect from the secured and unsecured markets? The unsecured market should primarily promote market discipline. Loans being uncollateralised in this market, lenders are directly exposed to the risk of non-repayment. This works as an incentive for them to address information asymmetry by collecting information about borrowers. It is the constant peer monitoring that promotes market discipline.

In the secured segment of the money market, the lender may address credit risk concerns by asking for sound collaterals and also applying some haircuts, but the peer monitoring could potentially then be less emphasised. Conditions of market stress can lead

to collateral scarcity and falling value of collaterals, which could stifle even the secured money market. Illiquidity spiral from the financial markets, *i.e.* when financial instruments held as assets turn illiquid, may lead to a situation where central banks would be required to dilute the collateral standards for liquidity injection, and even exchange good quality securities against securities facing illiquidity risks. This becomes necessary to unfreeze the markets in general. After the global crisis, asset quality, particularly liquidity, has received greater policy focus.

Money market rates also reflect market expectations of how the policy rate could evolve in the near term. As per standard expectations hypothesis, money market rates for different time duration should equal expected future short-term rates, plus term premium and risk premium. Bernanke (2004) had examined how expectations of the likely future course of the federal funds rate respond to Fed's policy actions and statements and noted that "...Our findings support the view that FOMC statements have proven a powerful tool for affecting market expectations about the future course of the federal funds rate".

Empirical research suggests that if the shortest end of the money market, which is influenced the most by policy rate, is stable, or less volatile, then it may help in keeping term premium lower, compared to a period when volatile short rates get transmitted to the entire money market and simultaneously the term premium rises.

With the sophistication of financial markets rendering the money, output and price relationship unstable, by the early 1980s, major central banks began to emphasise on the price channel, *i.e.*, policy interest rate for monetary policy transmission. As a result, the role of money market became all the more important for signalling and transmission of monetary policy. Thus, the development of money markets across countries in terms of instruments and participants with varying risk profiles has necessitated changes in the operating procedures of monetary policy.

In the case of India, the ultimate goals of monetary policy, *i.e.*, price stability and growth, have remained unchanged over the years. However, operational and intermediate objectives of monetary policy have undergone periodic changes in response to changes in the economic and financial environment. The development of the money market over the years and relative stability in the call money market enabled the Reserve Bank to move away from quantity-based instruments to price-based instruments under its multiple

indicators approach adopted since 1998. Accordingly, the overnight call rate, which was used implicitly as operating target since the institution of liquidity adjustment facility (LAF) in 2000, became explicit after the adoption of a new operating procedure in May 2011. However, this has been a long and gradual process. As the money market gained in depth it was feasible to make the transition to a market-based approach in which the central bank has less direct control unlike in a quantity- based approach.

2.3 Development of Money Market in India

Financial reforms in India began in the early 1990s. However, various segments of the domestic financial market, *viz.*, money market, debt market and forex market underwent significant shifts mainly from the late 1990s. Earlier, the Indian money market was characterised by paucity of instruments, lack of depth and distortions in the market microstructure. It mainly consisted of uncollateralised call market, treasury bills, commercial bills and participation certificates.

2.3.1 Reforms in the Indian money market

Following the recommendations of Chakravarty Committee (1985), the Reserve Bank adopted a monetary targeting framework. At the same time, efforts were made to develop the money market following the recommendations of Vaghul Committee (1987). In this regard, important developments were: (i) setting up of the Discount and Finance House of India (DFHI) in 1988 to impart liquidity to money market instruments and help the development of secondary markets in such instruments; (ii) introduction of instruments such as certificate of deposits (CDs) in 1989 and commercial papers in 1990 and inter-bank participation certificates with and without risk in 1988 to increase the range of instruments; and (iii) freeing of call money rates by May 1989 to enable price discovery.

While a number of instruments were introduced in the late 1980s, the money market lacked depth. The functioning of the market continued to be hamstrung by a number of structural rigidities such as skewed distribution of liquidity and the prevalence of administered deposit and lending rates of banks. Recognising these rigidities, the pace of reforms in money market was speeded up in the late 1990s.

Following the recommendations of an Internal Working Group (1997) of the RBI and the Narasimham Committee (1998), a comprehensive set of measures were undertaken by the Reserve Bank to develop the money market. First, the interest rate ceiling in the money market was withdrawn. This prompted the market participants to study the market behaviour and develop their own capability to bid for liquidity in the market. In the process it encouraged banks to improve their own liquidity management. Second, auctions in treasury bills were introduced. This motivated banks to develop their own treasury capabilities. Another broader macro-objective was that it would also improve the discipline of government borrowings. Third, maturities of other existing instruments such as CP and CDs were also gradually shortened to encourage wider participation.

Fourth, the credit market was dominated by a cash credit system under which firms were given a credit limit and they drew cash as per their requirement. This imparted considerable uncertainty to banks' credit portfolio. In a way banks ended up doing the cash flow management of corporates. Steps were initiated to gradually move away from the cash credit system to a loan-based system.

Finally and most importantly, the *ad hoc* treasury bills were abolished in 1997 thereby putting a stop to the practice of automatic monetisation of fiscal deficit. In the pre-1997 period the government had unfettered access to direct central bank funding through the instrumentality of *ad hoc* treasury bills at a fixed rate. The intention was to provide short-term accommodation as the government's cash flow was unpredictable. It was intended to be the usual relationship between a banker and its client as RBI by statute is the debt manager of the government.

In this case the banker happened to be the central bank, i.e., the RBI and its client was the government. The RBI has the unlimited capacity to print money against the backing of government securities. As *ad hoc* treasury bills piled up in the books of the RBI, the government converted those to long dated unmarketable securities. This turned out to be the main source of money creation hampering the RBI's ability to control money supply. In addition, this practice was certainly not conducive to development of a government securities market.

The practice of automatic monetisation of government deficits was finally abandoned in 1997, and was the most important reform in developing a market-based interest rate system. This also enhanced the instrument independence of the Reserve Bank. In other words, the RBI got the flexibility to use interest rate for monetary management rather than for neutralising the monetary impact of large government borrowings.

Thus the developments in the various segments of the money market can be seen to be complementing one another in the process of developing a market determined interest rate structure. A snapshot of major developments in the money market is given in (Table 2.1).

2.3.2 Prudential measures in the Indian money market

Another key development was that, efforts were made to transform the call money market into primarily an inter-bank market. At the same time other market participants were encouraged to migrate towards the collateralised segments of the market. These processes once complete left the more stringently regulated banks in the uncollateralised segment of the market, thus enhancing overall market stability and facilitating diversification.

In order to facilitate the phasing out of corporate and the non-banks from the call money market, new instruments such as market repos and collateralised borrowing and lending obligations (CBLO) were introduced to provide avenues for managing their short-term liquidity. CBLO is a money market instrument offered by the Clearing Corporation of India Limited (CCIL). It is in the nature of a tripartite repo between the borrower and the lender with the intermediation of CCIL for the custody and management of collateral and settlement. With the availability of alternative instruments, non-bank entities completely exited the call money market by August 2005.

Table 2.1 : Major Developments in Money Market since the 1990s

1. Abolition of <i>ad hoc</i> treasury bills in April 1997
2. Full-fledged LAF in June 2000.
3. CBLO for corporate and non-bank participants introduced in 2003
4. Minimum maturity of CPs shortened by October 2004
5. Prudential limits on exposure of banks and PDs to call/notice market in April 2005
6. Maturity of CDs gradually shortened by April 2005
7. Transformation of call money market into a pure inter-bank market by August 2005
8. Widening of collateral base by making state government securities (SDLs) eligible for LAF operations since April 2007
9. Operationalisation of a screen-based negotiated system (NDS-CALL) for all dealings in the call/notice and the term money markets in September 2006. The reporting of all such transactions made compulsory through NDS-CALL in November 2012.
10. Repo in corporate bonds allowed in March 2010.
11. Operationalisation of a reporting platform managed by FIMMNDIA for secondary market transactions in CPs and CDs in July 2010.
12. In November 2011, direct access to Negotiated Dealing System-Order Matching (NDS-OM) was extended to licensed urban co-operative banks and systemically important non-deposit taking non-banking financial companies (NBFCND-SI).
13. To facilitate direct participation by retail and mid-segment investors in government securities auctions, web-based access to the negotiated dealing system (NDS) auction was allowed. A similar web-based access to the NDS-OM system for secondary market transactions was permitted in June 2012.
14. The period of short sale in government securities was extended from five days to three months in February 2012.
15. Buyback of CPs by issuers could only be through the secondary market and at prevailing market prices.
16. Repo was permitted on CP, CD and NCD of less than one year of original maturity in January 2013.
17. Term repo was introduced in October 2013.
18. Scheduled cooperative banks allowed access to the RBI liquidity adjustment facility (LAF).
19. In February 2015, the Reserve Bank allowed re-repo/re-hypothecation of repoed government securities with the objective of developing the term repo/money market.

In order to improve transparency and efficiency in the money market, reporting of all call/notice money market transactions through negotiated dealing system (NDS) within 15 minutes of conclusion of the transaction was made mandatory. Furthermore, a screen-based negotiated quote-driven system for all dealings in the call/notice and the term money markets (NDS-CALL), developed by the CCIL, was operationalised in September 2006 to ensure better price discovery.

Beginning in June 2000, the Reserve Bank introduced a full-fledged liquidity adjustment facility (LAF). Subsequently it was operated through overnight fixed rate repo and reverse repo from November 2004. This helped to develop interest rate as an important instrument of monetary transmission. It also provided greater flexibility to the Reserve Bank in determining both the quantum of liquidity as well as the rates by responding to the liquidity needs of the system on a daily basis.

2.4 Trends in Money Market

The rates of return on various instruments in the money market have shown greater co-movement, especially since the introduction of LAF. Interest rates in the money market came down significantly in the first half of 2000s (Table 2.2). For example, the average repo rate came down from 11.2 per cent in 2000-01 to 6.0 per cent by 2004-05. This was reflected in the other market interest rates as the weighted average call money rate fell from 9.1 per cent to 4.7 per cent during this period. The commercial paper (CP) rate came down from 10.8 per cent to 5.8 per cent. Similarly, the certificate of deposits (CD) rate fell from 9.4 per cent to 5.0 per cent. Thus, there was a general reduction in money market rates in the first half of the 2000s.

This was followed by a period of gradual increase in money market rate till 2008-09 when the global financial crisis struck. During this period new instruments such as collateralised borrowing and lending obligation (CBLO), which is a tripartite repo offered by the Clearing Corporation of India Limited (CCIL), and market repo became active. As the average policy repo rate rose from 6.2 per cent in 2005-06 to 7.4 per cent in 2007-08, other money market rates also rose in tandem. For example, the weighted average call money rate rose from 5.6 per cent to 7.1 per cent. The CP rate rose from 6.7 per cent to 10.7 per cent. The CD rate rose from 6.1 per cent to 9.2 per cent.

As the spillover impact of global financial crisis became apparent on the Indian economy, the Reserve Bank sharply reduced the repo rate and consequently other money market rates fell concurrently. For instance, the weighted average call money rate fell from 7.1 per cent in 2008-09 to 3.2 per cent in 2009-10. Both the CBLO and market repo rates were even lower at 2.7 per cent and 2.8 per cent respectively. It could be seen from Table 2.2 that 2009-10 recorded the lowest interest rates across the money market.

Table 2.2: Interest Rates in the Money Market								
(Percent per annum: Annual Averages)								
	Repo Rate	Call Rate	CBLO Rate	Market Repo Rate	91 day T-Bills	364-day T Bills	CP Rate	CD Rate
1	2	3	4	5	8	9	6	7
2000-01	11.2	9.1	-	-	9	9.8	10.8	9.6
2001-02	8.5	7.2	-	-	7	7.3	9.2	8
2002-03	7.7	5.9	-	-	5.8	5.9	7.7	6.6
2003-04	7	4.6	-	-	4.6	4.7	6.1	5.3
2004-05	6	4.7	-	-	4.9	5.2	5.8	5
2005-06	6.2	5.6	5.3	5.4	5.7	6	6.7	6.1
2006-07	7	7.2	6.2	6.3	6.6	7	8.5	7.9
2007-08	7.8	6.1	5.2	5.5	7.1	7.5	9.3	9.1
2008-09	7.4	7.1	6.1	6.5	7.1	7.2	10.7	9.2
2009-10	4.8	3.2	2.7	2.8	3.6	4.4	5.3	5.4
2010-11	5.9	5.7	5.4	5.5	6.2	6.6	8.7	7.7
2011-12	8	8.1	7.8	7.9	8.4	8.4	10.1	9.6
2012-13	8.0	8.0	7.9	8.0	8.2	8.0	9.2	9.0
2013-14	7.6	8.1	8	8.3	8.2	8.1	9.3	9
2014-15	7.9	7.6	7.8	8.1	8.4	8.4	8.8	8.7

As domestic inflationary pressures rose the Reserve Bank had to tighten monetary policy by raising the policy interest rate. As the average repo rate rose from 5.9 per cent in 2010-11 to 8.0 per cent in 2011-12 other money market rates rose in tandem. During the 4-year period 2011-12 to 2014-15, the interest rates across the money market remained stable. The average rates in the various segments of the money market remained in the range of 7.6-8.8 per cent in 2014-15.

The data analysis thus suggests that money market rates have been well behaved moving more or less in tandem with one another. Once the policy repo rate changes, the other money market rates also change. This pattern is very much evident across the interest rate cycles and the adjustment seems to be quick. The money market had also widened since the mid-2000s with the development of new instruments such as CBLO and market repo.

2.4.1 Collateralised money market expanded in the mid-2000s

In the development of various constituents of the money market, the most significant aspect was the growth of the collateralised market *vis-à-vis* the uncollateralised market. Since the late 1990s, while the daily turnover in the call money market either stagnated or declined, that of the collateralised segment (market repo plus CBLO) increased manifold (Chart 2.1). This was a significant development as it reduced the risk in the money market.

The global financial crisis demonstrated that the money market could be a major source of risk, which could have a contagion effect on the other segments of the financial market. With the increasing collateralisation of the money market that too backed by government securities as the underlying instrument the incidence of risk in the Indian money market was mitigated to a large extent.

2.4.2 Variety of instruments increased the depth of the money market

Since the mid-2000s, both the CP and CD volumes also increased significantly (Chart 2.2). The CP market provides an important channel of resource mobilisation to corporates. At the same time it gives an opportunity to banks to diversify their asset portfolio as they can, to some extent, substitute loans with CPs. Moreover, CPs enhance liquidity as it could be traded in the secondary market unlike loans. Similarly, CDs give an opportunity to banks to access wholesale lending market. Tradability of CDs give banks the flexibility to meet their short-term liquidity requirements.

Chart 2.1 : Average daily turnover in the money market has moved towards collateralised segment

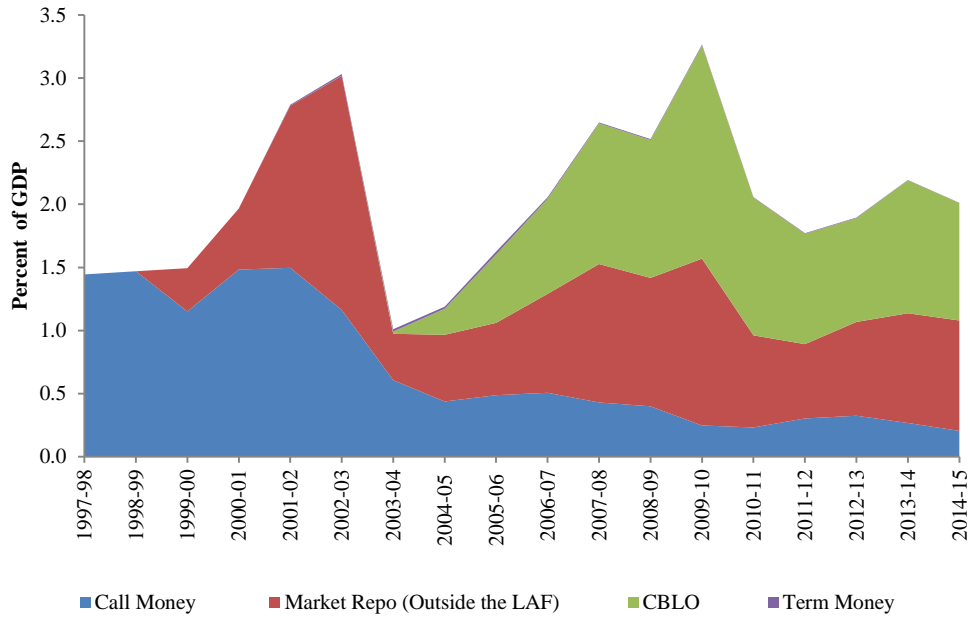
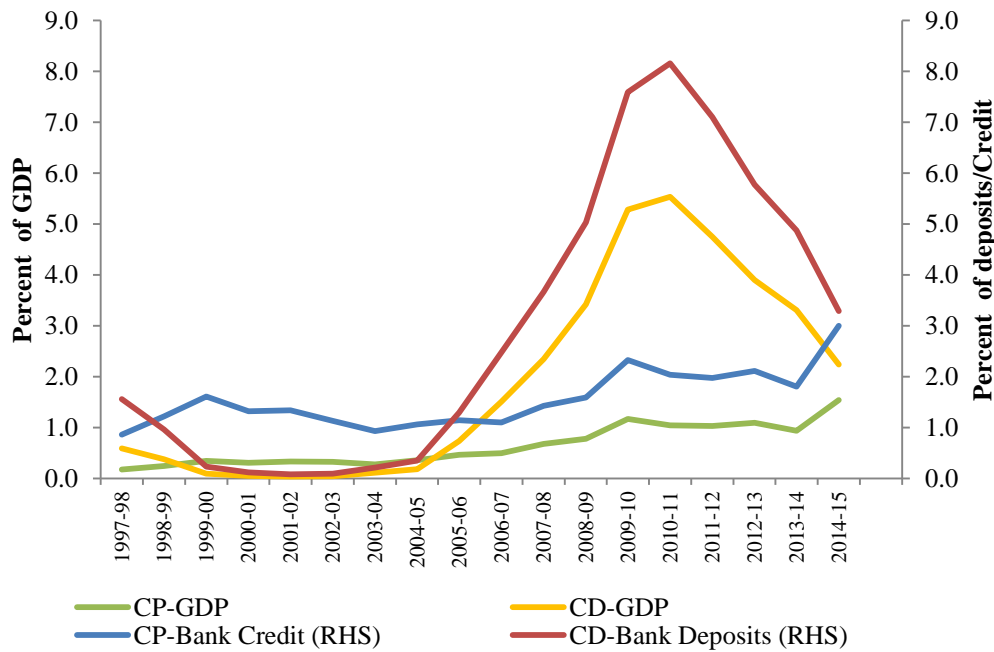


Chart 2.2 : Outstanding CPs and CDs



At the very short-end of government securities market, issuance of 91-day and 364-day treasury bills increased sharply (Chart 2.3). Treasury bills provide greater flexibility to government for its cash management. In addition, it provides opportunity to banks and other investors to improve the liquidity of their portfolio.

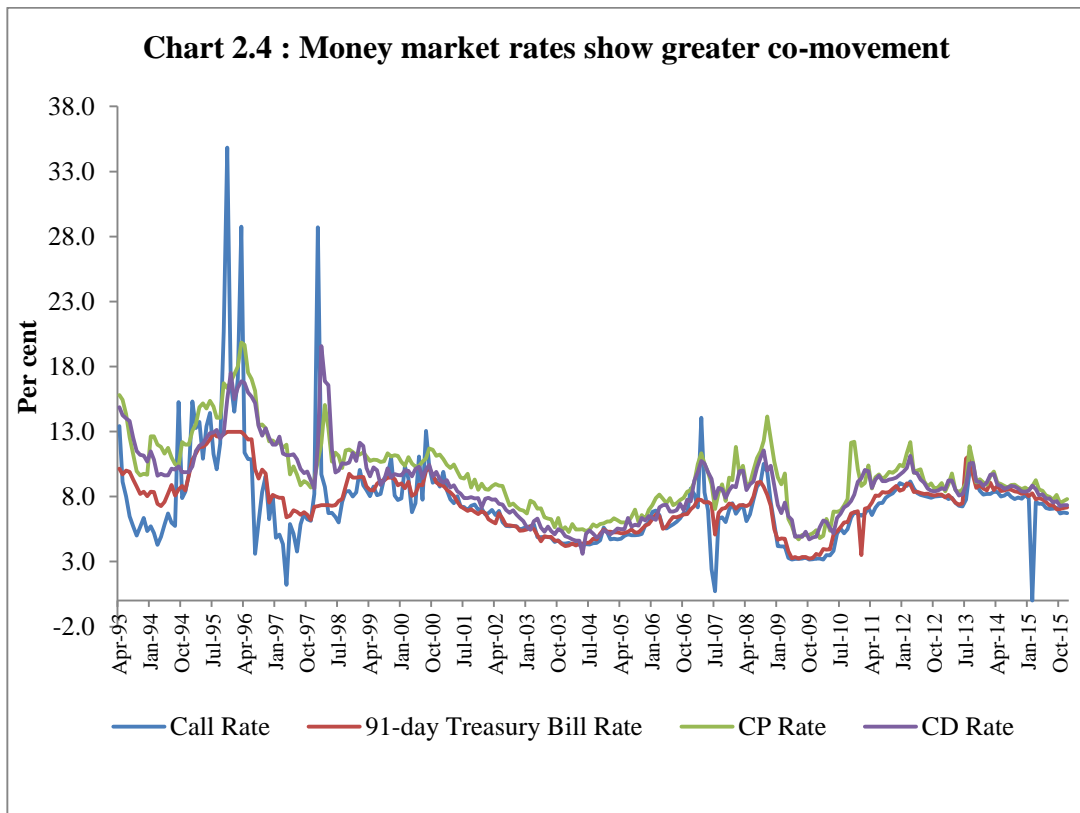
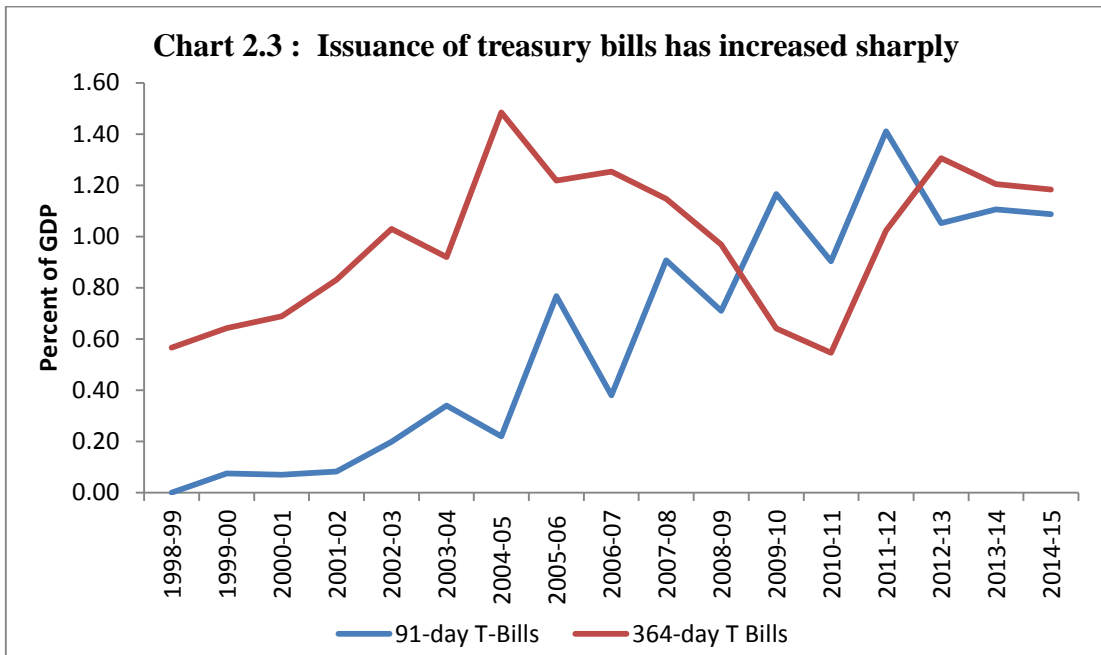
The introduction of a wide range of instruments with the supportive policy and infrastructure helped widen and deepen the money market. The overall money market now is much larger relative to GDP than a decade ago. As the money market developed, the rates in the money market showed greater co-movement (Chart 2.4).

2.5 Foreign Exchange Market

Following a balance of payments (BoP) crisis, the rupee, which was pegged to a basket of currencies since September 1975, was adjusted downwards (depreciated) in two quick steps against the US dollar by 9 per cent on July 1 and then 11 per cent on July 3, 1991. The exchange rate of the rupee thereafter transited to a market determined exchange rate regime from March 1, 1993 via a temporary dual exchange rate system in between following the broad reform framework articulated in the Report of the High Level Committee on Balance of Payments (Chairman: Dr. C. Rangarajan).

2.5.1 Liberalisations in the Indian foreign exchange market

Subsequently, India became fully convertible on its current account for external transactions in August 1994 by accepting the obligations under Article VIII of the Articles of Agreement of the IMF. Moreover, a liberalised Foreign Exchange Management Act (FEMA), 1999 replaced the earlier restrictive Foreign Exchange Management Act (FEMA), 1973. Since then the exchange rate of the rupee has been largely market determined with the RBI intervening to ensure orderly market conditions in the event of excess volatility.



Alongside current account convertibility and market determined exchange rate, the capital account transactions have been progressively liberalised. For non-residents and domestic corporates the capital account is practically free. Moreover, for banks and resident individuals capital account transactions have been significantly liberalised. These reforms have imparted considerable depth and resilience to the Indian foreign exchange market.

2.5.2 Rise in turnover in the Indian foreign exchange market

The daily average turnover in the Indian foreign exchange market rose sharply from under US \$ 5 billion in 1999-2000 to over US \$ 50 billion in 2007-08. Thereafter it has remained at a high level fluctuating around US \$ 55 billion. As capital flows to and from India rose substantially since the mid-2000s, these were reflected in the jump in turnover in the foreign exchange market (Chart 2.5).

2.5.3 Nominal and real exchange rate movements

As regards exchange rate, the Indian Rupee *vis-à-vis* the US dollar is the most widely tracked currency rate both by the market and economic entities. Since the bulk of the overseas trade is invoiced in the US dollar, there is understandable interest in the ₹/US \$ exchange rate. During 2004-05 to 2006-07 as the current account deficit in our balance of payments (BoP) remained small and capital inflows were steady, the nominal ₹/US \$ exchange rate showed remarkable stability. In 2007-08 as capital inflows increased sharply much in excess of the financing requirement of the current account of BoP, the ₹/US \$ exchange rate appreciated. Since then the ₹/US \$ rate has shown a steady depreciation particularly from the year 2012-13 onwards as the current account of BoP widened and capital inflows waned and turned more volatile following the global financial turmoil.

From the standpoint of economic competitiveness, a broad-based real effective exchange rate (REER) is considered to be more appropriate. The 36-currency REER indicator (Base: 2004-05=100) has remained above its base value of 100 during the period 2004-05 to 2014-15, except 2008-09.

While there are several issues in considering REER as a reliable indicator to gauge external competitiveness, it could broadly be surmised that for a number of years it has remained significantly above 100 suggesting loss of competitiveness because of real overvaluation. The overvaluation has occurred during different periods due to different reasons. Particularly, the overvaluation since 2008-09, despite nominal depreciation could be attributed to high domestic inflation. If domestic inflation remains relatively high vis-à-vis our trading partners, the real exchange rate trends get overvalued. The movement in nominal ₹ / US \$ exchange rate and REER since 2004-05 are given in Chart 2.6.

2.6 Debt Market

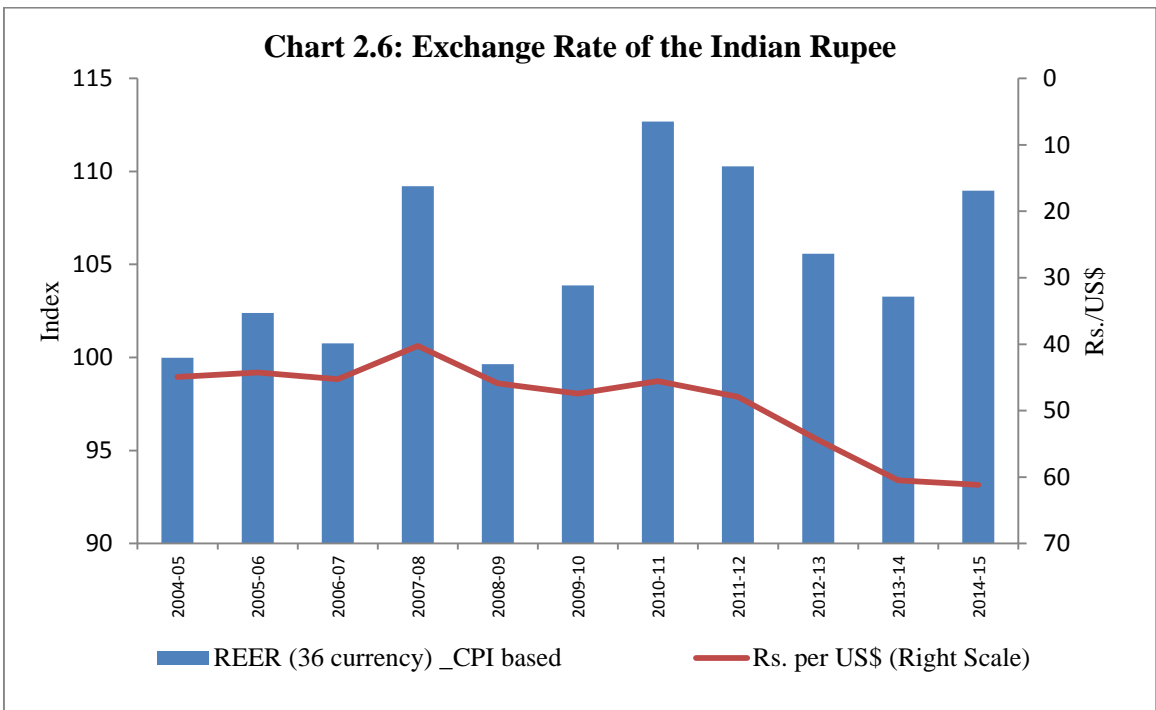
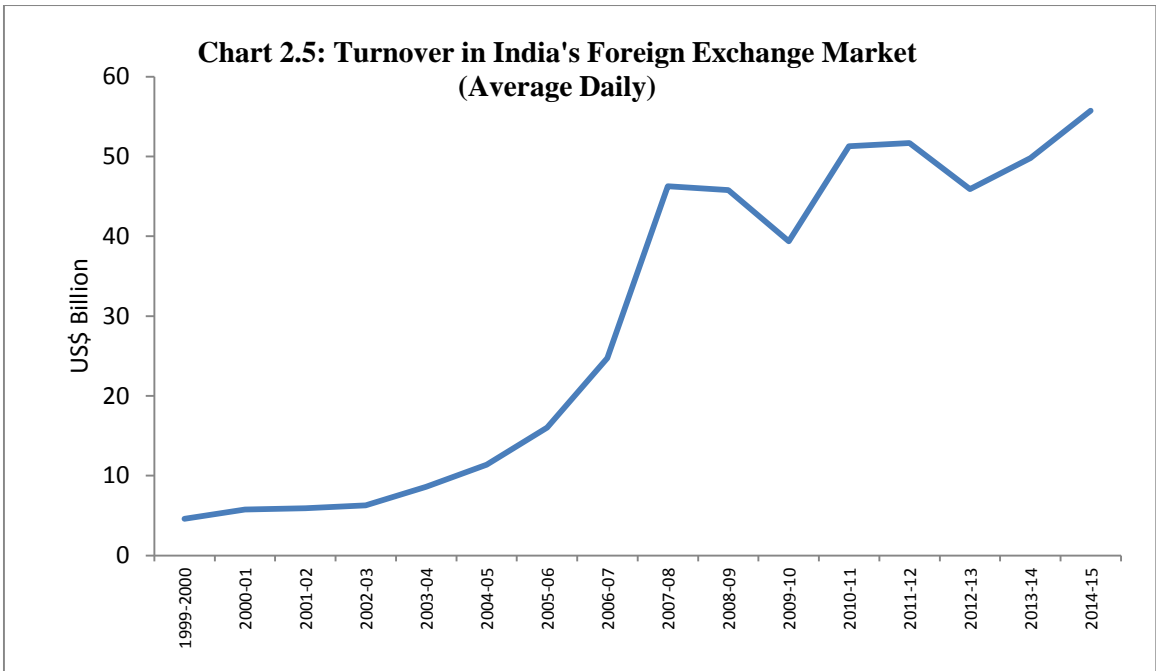
The debt market comprises of (i) government securities market and (ii) corporate bond market.

2.6.1 Government securities market

The government securities market dominates the Indian debt market. As part of reform, a transition was made from an administered interest rate regime to auction based price discovery in central government securities in 1992. Subsequently the Reserve Bank also withdrew from the market for primary auction of government securities in April 2006 further reinforcing the framework for market-determined yields in the government securities market.

2.6.1.1 Reforms in government securities market

There were significant institutional and technological changes to develop the government securities market. A fundamental reform was the Government's enactment of Fiscal Responsibility and Budget Management Act (FRBM), which prohibited the Reserve Bank to participate in the primary auction to eschew automatic monetisation of deficit and impose market discipline to discourage excessive government borrowing. Consequently the institution of Primary Dealers (PDs) was developed to underwrite auctions of government securities in the primary market.



An electronic platform of Negotiated Dealing System (NDS) was developed for ease of auctions and trading in the government securities market. Centralised clearing and settlement system in government securities was facilitated with the establishment of the Clearing Corporation of India Limited (CCIL). The introduction real time gross settlement (RTGS) further mitigated settlement and payments risks. A list of key reforms in the government securities market is given in Table 2.3.

A well-functioning government securities market is important to establish a risk free sovereign rupee yield curve, which also facilitates pricing of other instruments of varying risks in the market. A liquid government securities market is required not only to ensure financing of the government budget but also for smooth conduct of monetary policy.

This is because open market operations (OMO) of buying and selling of government securities to inject or withdraw primary liquidity from the market is the central tool of conduct of monetary policy. Even for daily fine-tuning of liquidity through central bank repo operation, government securities are the underlying instruments. While central banks in market economies signal their policy stance through policy interest rate, liquidity management through OMO is critical to achieve the objective.

2.6.1.2 Trends in government debt

The combined outstanding central and state government market debt has risen from under ₹ 10 trillion in March 2001 to over ₹ 60 trillion by March 2015. During this 15-year period clearly three distinct phases can be seen from Chart 2.7. First, the combined government debt showed a sharp increase from around 40 per cent of GDP in March 2001 to 48 per cent by March 2004. Thereafter following the move towards rule based fiscal policy which was first adopted by the central government followed by state governments, combined government debt to GDP ratio showed a steady decline to around 43 per cent by March 2011.

Table 2.3: Key Reforms in the Government Securities Market

	Year	Reform Initiated
1.	June 1992	: Introduction of auction method for issue of central government securities to make yields on government securities market determined.
2.	March 1995	: Primary Dealer system introduced to strengthen the market intermediation and support primary issue.
3.	July 1995	: Delivery <i>versus</i> Payment (DvP) system in government securities was introduced to reduce settlement risk.
4.	March 1997	: Introduction of WMA system for Centre following discontinuation of automatic monetisation.
5.	April 1997	: FIMMDA was established for self-regulation and development of market practices and ethics.
6.	July 1997	: Foreign Institutional Investors (FIIs) were permitted to invest in government securities to broaden the market.
7.	April 2000	: Sale of securities allotted in primary issues on the same day to improve secondary market.
8.	February 2002	: Clearing Corporation of India Limited (CCIL) was established to act as a clearing agency for transactions in government securities.
9.	January 2003	: Retail trading of government securities permitted on stock exchanges to facilitate easier access and wider participation.
10.	March 2004	: Introduction of DvP III to obtain netting efficiency and to enable rollover of repos.
11.	April 2004	: Introduction of RTGS to provide real time, online, large value inter-bank payment and settlements.
12.	August 2005	: The Negotiated Dealing System-Order Matching (NDS-OM), an anonymous order matching system, which allows straight-through processing (STP) was established to provide the NDS members with a more efficient trading platform.
13.	August 2006	: Government Securities Act, 2006 passed by the Parliament to facilitate wider participation in government securities market and create the enabling provisions for issue of Separately Traded Registered Interest and Principal Securities (STRIPS).

Following the global financial crisis and the consequent domestic fiscal stimulus to boost aggregate demand, combined government debt to GDP ratio has shown a steady increase to about 48 per cent by end-March 2015. The increase in government debt, apart from its other macroeconomic consequences, could potentially crowd out private debt making it challenging for developing a corporate bond market.

2.6.1.3 Turnover in government securities market

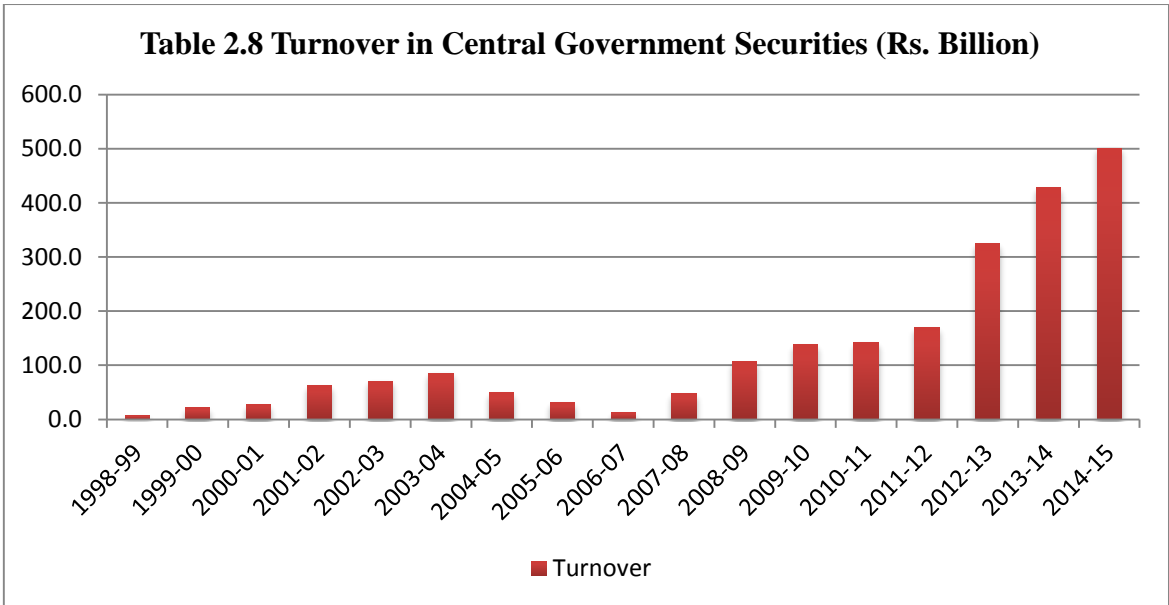
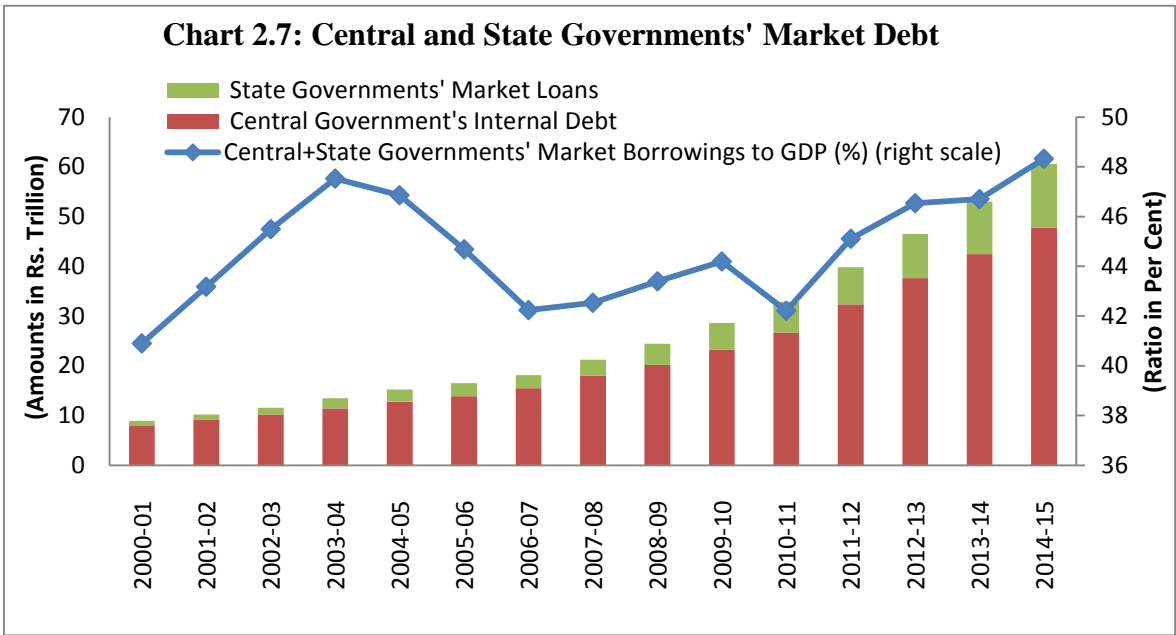
Notwithstanding a substantial volume of outstanding government debt, the turnover of government securities in the secondary market remains relatively low (Chart 2.8). This is partly because banks are the predominant holder of government debt, and as a part of their statutory liquidity ratio (SLR) obligation they hold a substantial part of these securities without marking those to market. Moreover, there is not much demand for government securities from retail investors. The turnover in the government securities, however, is increasing in more recent year with the reduction in SLR ratio and participation of foreign portfolio investors (FPIs).

2.6.2 Corporate bond market

India being a bank dominated financial system, the reliance of corporates on the bond market remains relatively less. Moreover, the corporate bond issuances are largely through private placement with institutions. It is again the public sector undertakings (PSUs) and non-banking financial companies (NBFCs) which are the major issuers in the corporate bond market. The issuance by non-government non-financial corporate sector is relatively less.

2.6.2.1 Reforms in the corporate bond market

Several policy initiatives were taken by the Securities and Exchange Board of India (SEBI) and the RBI to develop the corporate bond market following the recommendations of a number of committees particularly, the High Level Expert Committee on Corporate Debt and Securitisation (Chairman: Dr. R.H. Patil) which gave its report in December 2005.



SEBI has allowed setting of a dedicated debt segment on exchanges for transparent trading of corporate bonds. Settlement of OTC trades in corporate bond on DvP basis was initiated to eliminate settlement risks. Efforts were made to liberalise listing requirements and simplify disclosure norms.

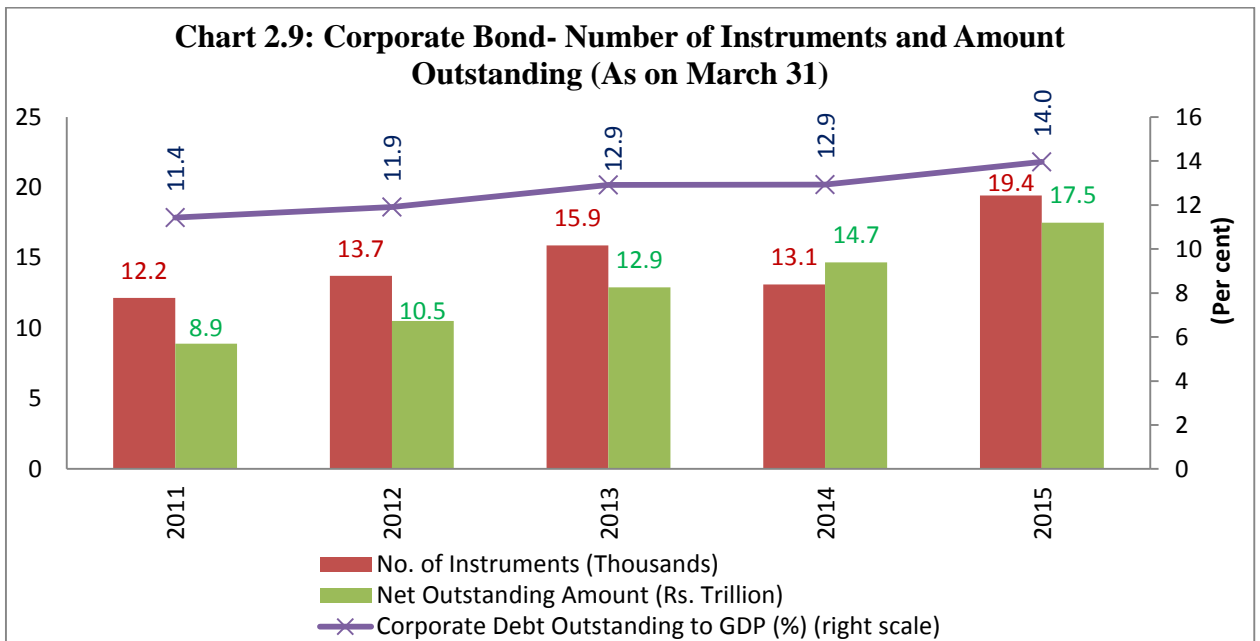
Banks were allowed to issue long-term bonds for infrastructure financing and affordable housing. Furthermore, banks were permitted to provide partial credit enhancement to corporate bonds. In order to enhance liquidity, repo in corporate bonds was allowed. The investment limit for foreign portfolio investors (FPIs) was recently raised to over US \$ 50 billion.

2.6.2.2 Trends in corporate bond market

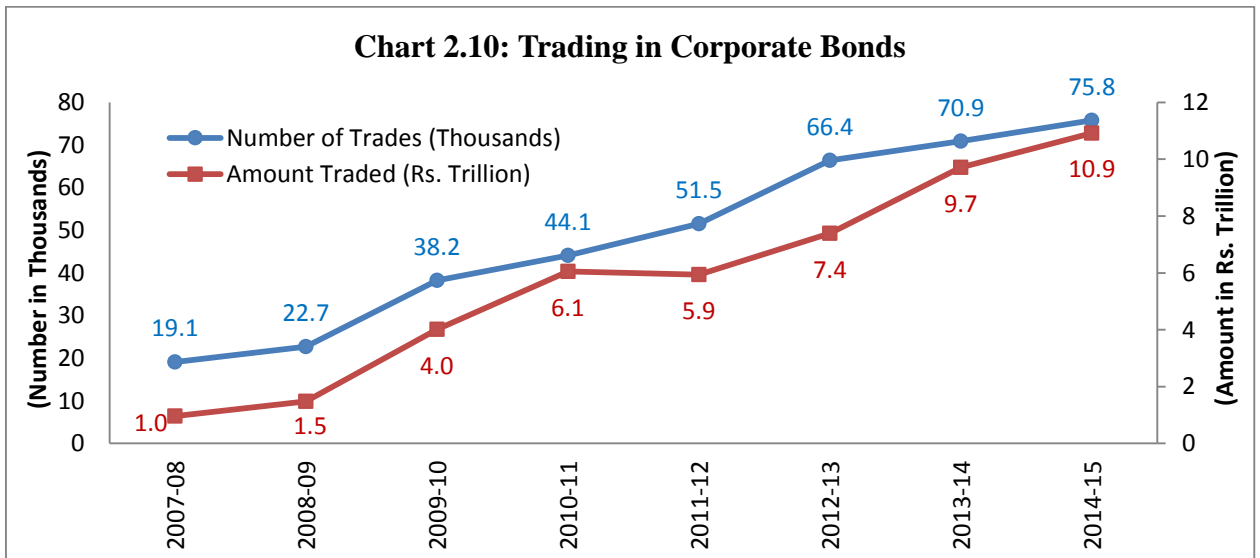
Notwithstanding various policy initiatives from time to time, corporate bond market still remains relatively underdeveloped in India. However, in recent years the activity in the corporate bond market is picking up. For example, total primary market issuance increased from ₹1.2 trillion in 2007-08 to ₹4.2 trillion in 2014-15. The component of public issue, however, remained low as ₹15 billion in 2007-08 and ₹40 billion in 2014-15. The bulk of the issues were at the highest rating. For example, 74 per cent of public issues and 70 per cent of private issues were rated AAA.

The net volume of corporate bond outstanding doubled from ₹8.9 trillion in March 2011 to ₹17.5 trillion by March 2015. As a percentage of GDP, the numbers have also been impressive, rising from 11.4 per cent to 14.0 per cent during the period. The number of outstanding instruments also increased from 12,200 to 19,400 during the same period (Chart 2.9).

The secondary market trading in the corporate bond market is also improving. For example, the number of secondary market trade increased from 19,100 in 2007-08 to 75,800 in 2014-15. The amount traded rose impressively from ₹1 trillion in 2007-08 to nearly ₹11 trillion in 2014-15 (Chart 2.10).



Source: SEBI website.



Source: SEBI website.

Note: Including OTC trades.

2.7 Credit Market

India has a bank dominated financial system. Accordingly, the bulk of the resource requirements of the economy is met from the banks. The banking sector includes commercial banks as well as cooperative banks, both urban and rural.

2.7.1 Trend in bank credit

Bank credit has expanded faster than the growth in nominal GDP. Consequently all scheduled commercial banks' credit to GDP ratio more than doubled from 26.6 per cent in 2000-01 to 54.5 per cent by 2014-15 (Chart 2.11).

All scheduled banks are dominated by the commercial banks and hence the bulk of the credit is accounted for by the commercial banks. Credit by commercial banks to GDP ratio rose steadily from 24.3 per cent in 2000-01 to 52.8 per cent in 2014-15. The dominance of commercial banks in the banking sector can be gauged from the fact that the outstanding credit by the scheduled cooperative banks was only 1.7 per cent of GDP in 2014-15 (Chart 2.12).

2.7.2 Liberalisation of lending rates

With the objective of providing credit to the productive sectors of the economy, bank lending rates as well as the allocation of bank credit were closely regulated by the Reserve Bank till the late 1980s. Furthermore, there were a number of sector-specific, programme-specific and purpose-specific credit stipulations.

With the initiation of financial sector reforms in the early 1990s, various steps were taken to deregulate the lending rates of commercial banks. First, the credit limit size classes of scheduled commercial banks, on which administered rates were prescribed, were compressed into three slabs in April 1993. Second, a system of prime lending rate (PLR), the rate charged for the prime borrowers of the bank, was introduced in October 1994. The PLR system went through several modifications from a single PLR to multiple PLRs and then to a Benchmark PLR (BPLR).

Chart 2.11: Growth in All Scheduled Banks' Credit

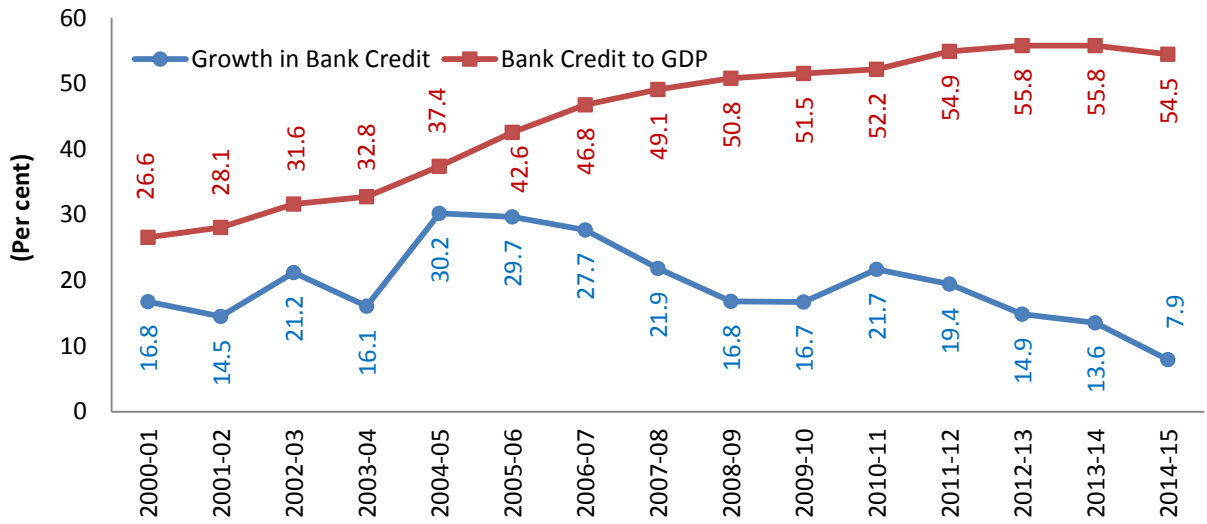
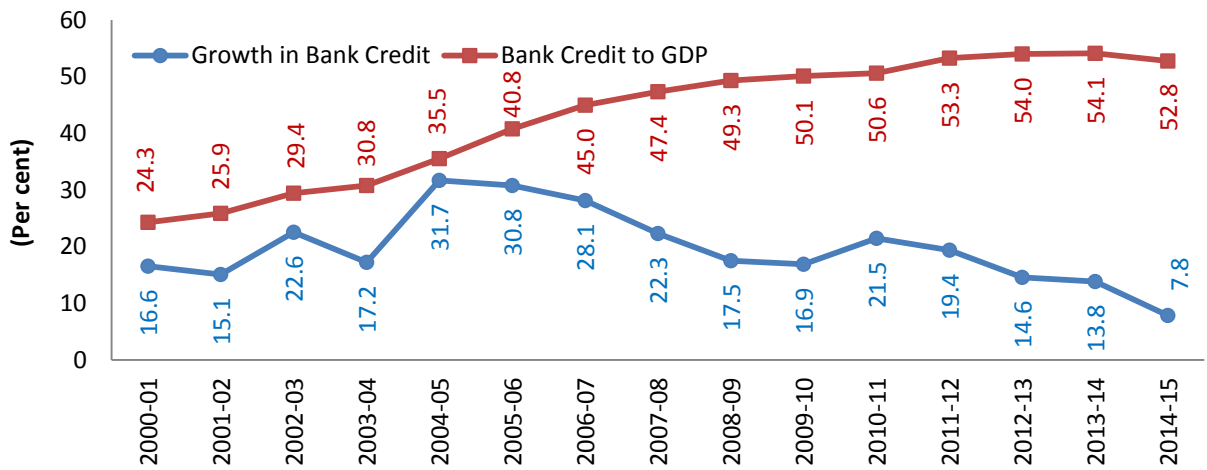


Chart 2.12: Growth in All Scheduled Commercial Banks' Credit and Bank Credit to GDP Ratio



Another important development during this time was the introduction of a 'loan system' of delivery of bank credit in April 1995. The objective was to bring about greater discipline in the utilisation of bank credit. Furthermore, the Reserve Bank relaxed the requirement of PLR being the floor rate for loans above Rs.2,00,000. Thus, in April 2001, commercial banks were allowed to lend at sub-PLR rates for loans above Rs.2,00,000. However, the divergence in PLRs and the widening of spreads for borrowers continued to persist. The PLRs turned out to be rigid and inflexible in relation to the overall direction of interest rates in the economy. In order to address these issues, a BPLR system was introduced in April 2003.

However, the BPLR system evolved in a manner that did not meet its objective. Competition in an environment of excess liquidity had forced the pricing of a significant proportion of loans far out of alignment with BPLRs undermining its role as a reference rate. Furthermore, there was a growing public perception of under-pricing of credit for corporates and over-pricing of credit to agriculture as well as small and medium enterprises.

The lack of transparency in the BPLR system also hindered transmission of monetary policy signals. Following the recommendations of a Working Group (Chairman: Deepak Mohanty), the Base Rate system of loan pricing replaced the BPLR system in July 2010. Base Rate system gave flexibility to banks to determine their lending rate essentially based on their cost of funds and assessment of credit risk in a transparent and non-discriminatory manner.

A snapshot of the evolution of lending rate deregulation in the bank credit market is given in Table 2.4.

Table 2.4 : Evolution of Lending Rate Structure in India

Sep. 1990	The structure of lending rates was rationalized into six size-wise slabs. Of these, banks were free to set interest rates on loans of over ₹ 2 lakh with minimum lending rates prescribed by RBI.
April 1992	Slabs compressed into four.
April 1993	Slabs compressed into three.
Oct. 1994	Lending rates for loans with credit limits of over ₹ 2 lakh deregulated. Banks were required to declare their Prime lending rates (PLRs).
Feb. 1997	Banks allowed to prescribe separate PLRs and spreads over PLRs, both for loan and cash credit components.
Oct. 1997	For term loans of 3 years and above, separate Prime Term Lending Rates (PTLRs) were required to be announced by banks.
April 1998	PLR converted as a ceiling rate on loans up to ₹ 2 lakh.
April 1999	Tenor-linked Prime Lending Rates (TPLRs) introduced.
Oct. 1999	Banks were given flexibility to charge interest rates without reference to the PLR in respect of certain categories of loans/credit.
April 2000	Banks allowed to charge fixed/floating rate on their lending for credit limit of over Rs.2 lakh.
April 2001	The PLR ceased to be the floor rate for loans above ₹ 2 lakh. Banks allowed to lend at sub-PLR rate for loans above ₹ 2 lakh.
April 2002	Dissemination of range of interest rates through the Reserve Bank's website was introduced.
April 2003	Benchmark PLR (BPLR) system introduced and tenor-linked PLRs discontinued.
Feb. 2010	Draft circular on Base Rate placed on RBI web site for obtaining comments/suggestions from public/stakeholders.
April 2010	Base Rate system of loan pricing introduced effective July 1, 2010. Rupee lending rate structure completely deregulated

2.7.3 Trends in lending rate

Wide dispersion persisted in actual lending rates prior to the introduction of the base rate owing to substantial sub-BPLR lending. It was, therefore, not feasible to ascertain the actual lending rate. For empirical purpose various proxies were used. PLR was one such popular indicator. But the problem was, the bulk of the bank lending was at sub-PLR rates. Hence, PLR turned out to be not such a good indicator of actual lending rate. In order to address this issue, following Mohanty et al. (2012) we provide here the weighted average lending rate (WALR) derived from account level data for advances as at end-March each year as reported in Basic Statistical Returns (BSR) submitted by banks to RBI. The methodology for computation for WALR is given in Annex 2.1. WALR can be considered as a close proxy for the actual lending rate. The annual bank lending rates thus computed for the period 1992 to 2015 is given in Chart 2.13. The movements in nominal weighted average lending rate (WALR) for the banking industry as a whole has shown a gradual decline. It came down from a range of 16-17 per cent in most part of the 1990s to about 11 per cent by 2008-09. It since rose to 12 percent and more or less remained flat around that rate. The declining trend in bank lending rate is clearly visible in the 2000s (Chart 2.13).

2.8 Interest Rates across Debt and Credit Markets

How did the bank lending rate behaved *vis-à-vis* other long-term interest rates? Weighted average bank lending rate, yield on AAA rated 10-year corporate bonds and 10-year government securities for the period March 2002 to March 2015 are given in Chart 2.14. As could be expected 10-year government securities being the least risky, have the lowest interest rate. The 10-year AAA rated corporate bond yields, though higher, moved in close correspondence with 10-year government securities. The bank lending rate (WALR) was significantly higher than the AAA bond rates. The divergence in interest rates between the credit market and the bond market was particularly noticeable during 2002-2007. Subsequently there appears to have been greater convergence.

Chart 2.13 : Nominal Weighted Average Lending Rate of SCBs (As on March 31)

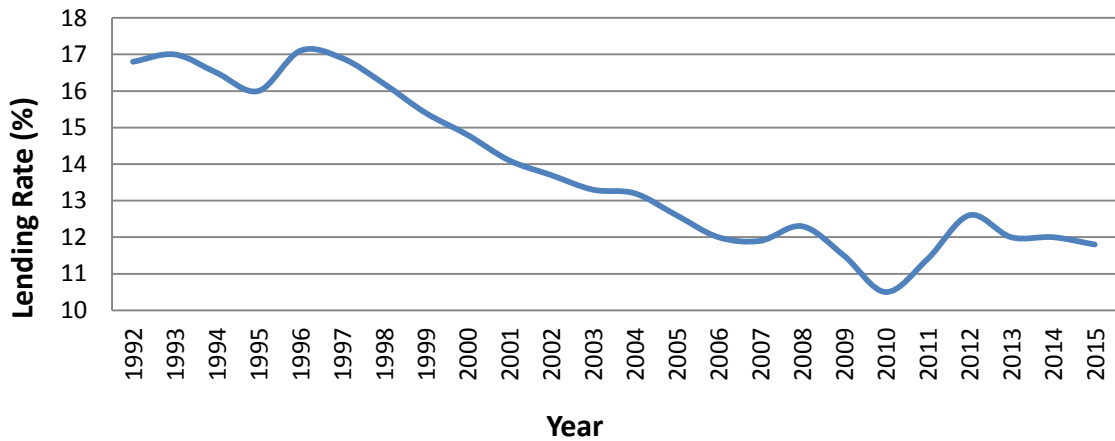
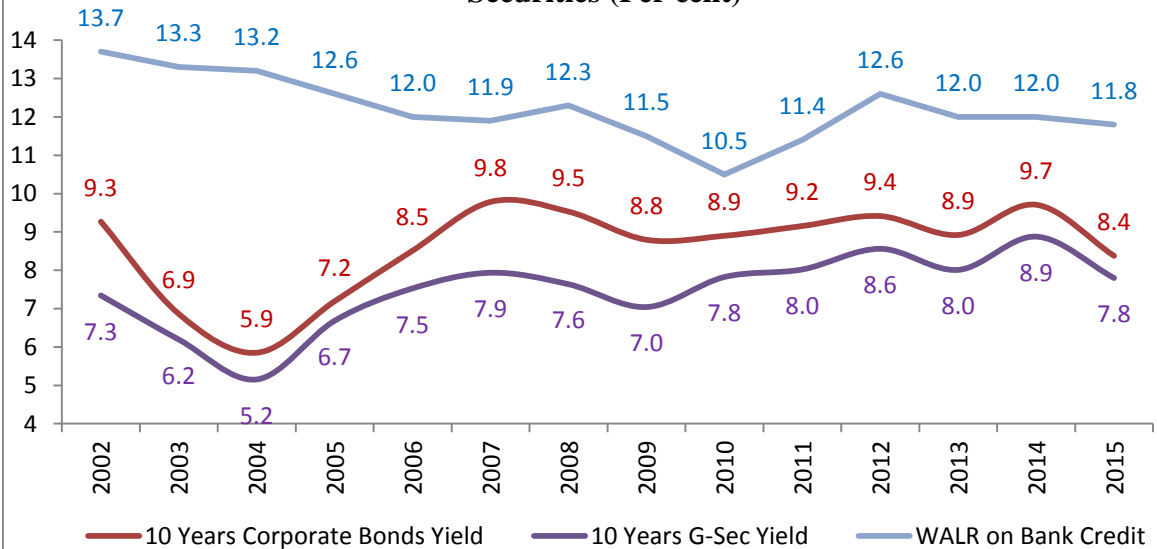


Chart 2.14: Weighted Average Bank Lending Rates and Yields on 10 Years' Maturity AAA Rated Corporate Bonds and Government Securities (Per cent)



2.9 Monetary Operating Procedure

Monetary policy operating procedure is essentially about the nuts and bolts of monetary policy implementation on a day-to-day basis. The primary objective of monetary policy is price stability, meaning a low and stable inflation rate. However, monetary policy cannot directly control inflation. Hence, it has to operate through various intermediate steps by deploying instruments at its control to influence its final objective. What instrument to be used is again dictated by the state of development of the financial market?

The development of money market as well as its growing inter-linkages with other segments of financial markets enabled the Reserve Bank to alter the operating procedures of monetary policy consistent with the objectives of monetary policy. Based on the recommendations of Chakravarty Committee (1985), a monetary targeting framework with feedback was introduced during the mid-1980s, under which reserve money was used as operating target and broad money (M_3) as an intermediate target. By the mid-1990s, this framework was rendered increasingly inadequate due to several developments.

Structural reforms and financial liberalisation led to a paradigm shift in the financing of government and commercial sectors with increasingly market-determined interest rates and exchange rate. Development in the various segments of the financial market led to deepening of the financial sector. This provided the Reserve Bank to effectively transmit policy signals through indirect instruments such as interest rates. On the other hand, increase in liquidity emanating from capital inflows raised the ratio of net foreign assets to reserve money and rendered the control of monetary aggregates more difficult. With financial innovations, the stability in the demand function for money also came under question.

Recognising these challenges and the growing complexities of monetary management, the Reserve Bank switched to a multiple indicators approach in 1998-99. Under this approach, a host of macroeconomic indicators including interest rates in different segments of financial markets, along with other indicators on currency, lending by banks and financial institutions, fiscal position, trade, capital flows, inflation rate, exchange rate, refinancing and transactions in foreign exchange available on high frequency basis were juxtaposed with output data for drawing implications for monetary policy formulation. However, the approach itself continued to evolve and was further

augmented by forward-looking indicators drawn from Reserve Bank's various surveys and a panel of parsimonious time series models (Mohanty, 2011).

2.9.1 Development of liquidity adjustment facility

Along with the multiple indicators approach, operating procedure also underwent a change following the recommendation of Narasimham Committee II (1998). The RBI introduced the Interim Liquidity Adjustment Facility (ILAF) in April 1999, under which liquidity injection was done at the Bank Rate and liquidity absorption was through fixed reverse repo rate. The ILAF gradually transited into a full-fledged liquidity adjustment facility (LAF) with periodic modifications based on experience coupled with development of financial markets and the payment system. The LAF was operated through overnight fixed rate repo and reverse repo from November 2004, which provided an informal corridor for the call money rate.

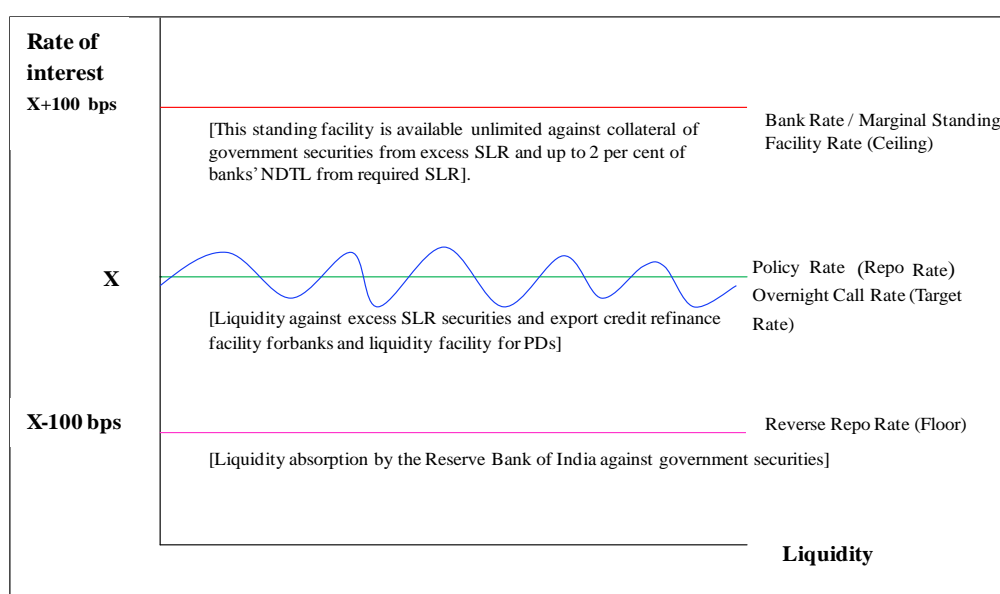
Though the LAF helped to develop interest rate as an instrument of monetary transmission, two major weaknesses came to the fore. First was the lack of a single policy rate, as the operating policy rate alternated between repo during deficit liquidity situation and reverse repo rate during surplus liquidity condition. Second was the lack of a firm corridor, as the effective overnight interest rates dipped (rose) below (above) the reverse repo (repo) rate in extreme surplus (deficit) conditions. Recognising these shortcomings, a new operating procedure was put in place in May 2011.

The key features of the new operating procedure were as follows. First, the weighted average overnight call money rate was explicitly recognised as the operating target of monetary policy.¹ Second, the repo rate was made the only one independently varying policy rate. Third, a new Marginal Standing Facility (MSF) was instituted under which scheduled commercial banks (SCBs) could borrow overnight at 100 basis points above the repo rate up to one per cent of their respective net demand and time liabilities (NDTL). This limit was subsequently raised to 200 basis points and in addition, SCBs

¹ Even though the share of call money market in the overnight money market is lower than that of collateralized segment, the weighted overnight call rate is used as operating target. This is partly on account of high correlation between the overnight call money rate and the collateralized money market rate at 0.9. The issue was examined in detail by the Working Group on Operating Procedure of Monetary Policy (2011) which observed that the transmission of policy rate to the overnight call money rate is stronger than the overnight money market rate. In addition, the call money market is a pure inter-bank market and, hence, better reflects the net liquidity situation.

were allowed to borrow funds under MSF on overnight basis against their excess SLR holdings as well. Moreover, the Bank Rate being the discount rate was aligned to the MSF rate. Fourth, the revised corridor was defined with a fixed width of 200 basis points. The repo rate was placed in the middle of the corridor, with the reverse repo rate 100 basis points below it and the MSF rate as well as the Bank Rate 100 basis points above it (Chart 2.15). Thus, under the new operating procedure, all the three other rates announced by the Reserve Bank, *i.e.*, reverse repo rate, MSF rate and the Bank Rate, were linked to the single policy repo rate.

Chart 2.15: Revised LAF Framework



The new operating procedure was expected to improve the implementation and transmission of monetary policy for the following reasons. First, explicit announcement of an operating target makes market participants clear about the desired policy impact. Second, a single policy rate removes the confusion arising out of policy rate alternating between the repo and the reverse repo rates, and makes signalling of monetary policy stance more accurate. Third, MSF provides a safety valve against unanticipated liquidity shocks. Fourth, a fixed interest rate corridor set by MSF rate and reverse repo rate, reduces uncertainty and communication difficulties and helps keep the overnight average call money rate close to the repo rate.

2.9.2 Introduction of term repo in the liquidity adjustment facility

With a view to ensuring flexibility and transparency in liquidity management operations, the Reserve Bank further revised the liquidity management operations in September 2014. Its features include: (i) assured access to liquidity of 1 per cent of NDTL in the form of overnight fixed rate repos of 0.25 per cent of bank-wise NDTL and the balance through variable rate 14- day term repos; (ii) more frequent auctions of term repos during a fortnight; and (iii) higher frequency of access to Reserve Bank's overnight liquidity, with the introduction of variable rate overnight repo/reverse repo auctions.

The introduction of variable rate term repo under the Liquidity Adjustment Facility (LAF) was one of the major efforts by the RBI to develop the term money market. Initially, term repos of 7-day and 14-day tenors were introduced to inject liquidity through variable rate auctions. Gradually, the scope of term repo was increased both in terms of quantum of liquidity injection as well as tenor (2 days to 56 days).

2.9.3 Experience with the new operating procedure

In the implementation of the new procedure, the RBI prefers to keep the systemic liquidity in deficit mode as monetary transmission is found to be more effective in this situation (RBI, 2011).² The Reserve Bank also announced an indicative liquidity comfort zone of (+) / (-) 1.0 per cent of net demand and time liabilities (NDTL) of banks. This implies that if liquidity deviates significantly from this indicative band there could be a need to deploy other instruments such as OMO to restore liquidity into the comfort zone.

Since its implementation, the systemic liquidity has been in deficit mode, which has helped in better transmission of policy rate to various segments of money markets. First, the overnight interest rate has been more stable since its implementation. Second, the repo rate and weighted call rate are far more closely aligned under the new operating procedure than earlier; implying improved transmission of monetary policy in terms of movement in call money market interest rate. Third, the call money rate in turn is observed to be better aligned with other money market interest rates after the implementation of new operating procedure than before (Charts 16 & 17).

² Reserve Bank of India (2011), Report of the Working Group on Operating Procedure of Monetary Policy (Chairman: Deepak Mohanty), March.

Chart 2.16 : Liquidity Adjustment Facility and Call Rate

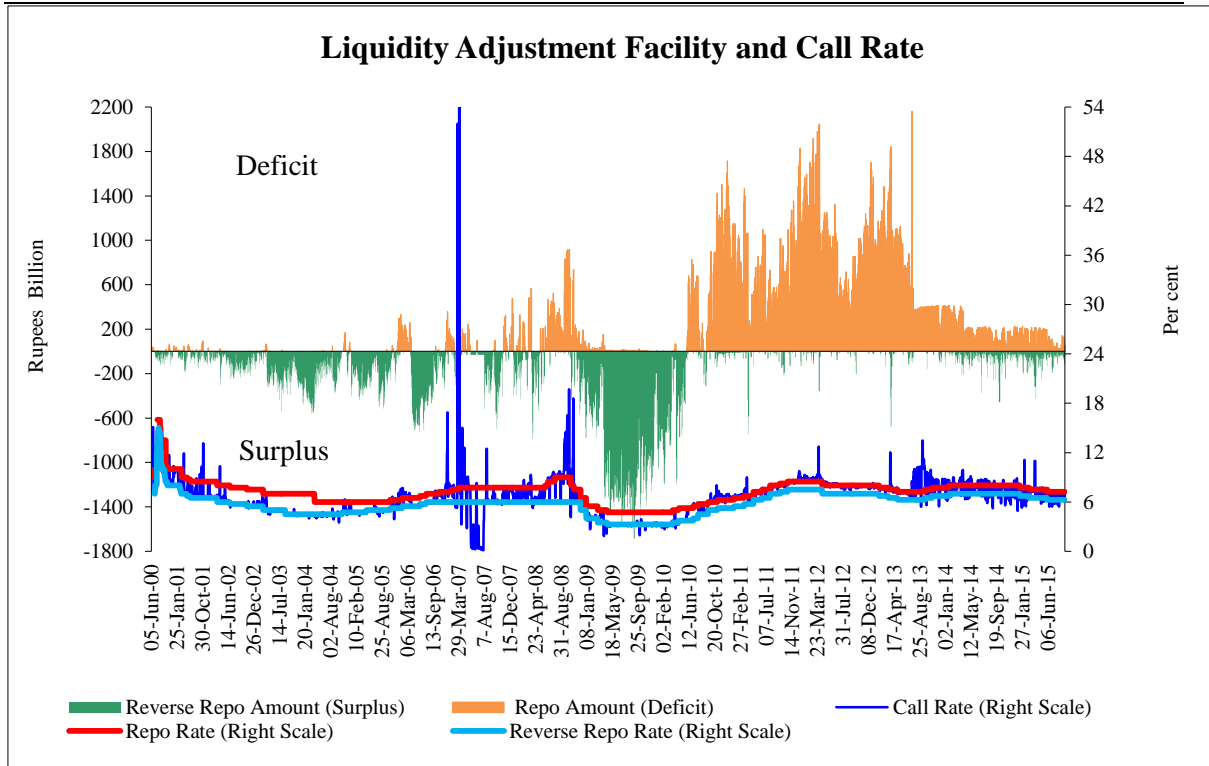
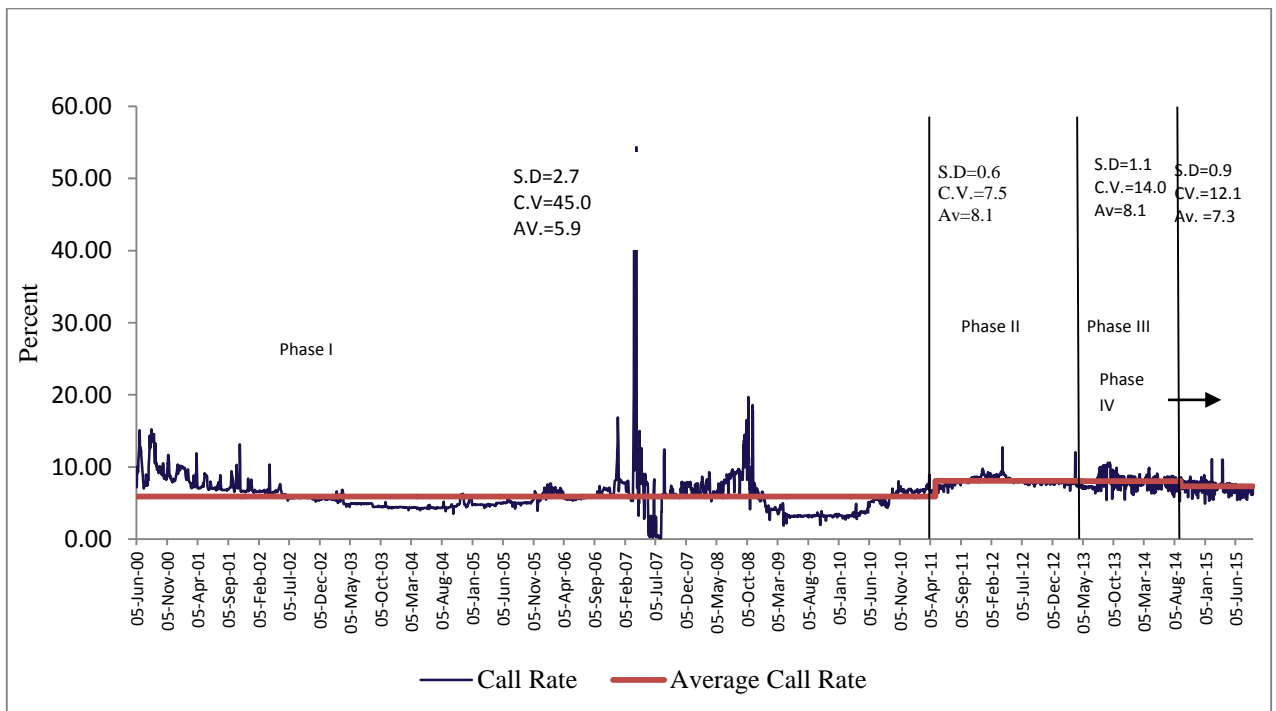


Chart 2.17: Stability of Call Rate under Various Regimes of Liquidity Framework



The coefficient of variation (CV) in the call money rate dropped sharply from 45.0 prior to the adoption of the new procedure to 7.5 during May 2011 to May 2013. It increased to 14.0 during May 2013 to August 2014 as volatility temporarily returned to the money market emanating from global market pressures following the US Fed's announcement of its intention to raise Fed Fund rate known as 'taper tantrum'. The volatility in call money rate, as measured by the CV has since moderated.

2.10. Conclusion

The development of the money market and refinement of operating procedure of monetary policy have moved in tandem. A number of new instruments such as market repo, CBLO, CP and CDs were introduced in the money market. Auction based pricing of government securities added depth to the bond market. More recently the volume of the corporate bond is also expanding. Secondary market transactions have also been increasing. Financial sector reforms along with Reserve Bank's emphasis on development of various segments of financial market enabled shifts in operating procedures based on direct quantity-based instruments to indirect interest rate-based instruments. The Reserve Bank has been able to better transmit monetary policy signals in the money market through a single policy repo rate. Evidence so far suggests a significant improvement in monetary policy transmission under the new operating framework.

There has been a swift transmission of policy rate at the short-end of money market, partly due to the prevalence of market liquidity in deficit mode. However, ensuring market liquidity in a deficit mode of desired level on a sustained basis is contingent on Reserve Bank's ability to smoothly conduct OMOs and the market appetite for such operations. Hence, there is a need to develop the market microstructure and further enhance secondary market transactions in government securities to facilitate smooth conduct of OMOs. Active OMO is important to keep day to day liquidity in the comfort zone so that the LAF can transmit the operating interest rate signal more efficiently.

Methodology for computation of WALR based on BSR 1

The nominal weighted average effective lending rate (WALR) for scheduled commercial banks (SCBs) is computed on the basis of granular data from the Basic Statistical Returns (BSR) of banks, data on which are made available by the Reserve Bank. In the BSR, interest rate applicable as at end-March is captured under Part A for each loan account. The WALR is computed as follows.

$$WALR = \frac{\sum_{j=1}^m i_j c_j}{\sum_{j=1}^m c_j}$$

Where for loan account j , the interest rate charged is i_j and the loan amount outstanding is c_j as at end-March of a particular year; the number of accounts for which WALR is computed is m .

Chapter 3

Integration of Financial Markets

In this Chapter we formally test the relationship between the policy rate, which is a short-term interest rate, and the long-term interest rates. More specifically we examine whether there is a long-term equilibrium relationship for representative interest rates across market segments. One way of testing this is to run a regression. Often time series data are non-stationary, i.e., they contain unit roots. In other words, economic time series are generally seen to be I (1) processes. In such a scenario they could produce spurious relation among relevant variables characterised by high R^2 in regression analysis.

For example, if we regress a time series Y_t on another time series X_t , we may get a high R^2 , which is not necessarily because of strong relationship between these two variables but because of common trend in the variables. “Granger (1981) and Engle and Granger (1987) offered a solution to the spurious regression problem by introducing the concept of cointegration. Cointegration regression retains the terms in levels but only in linear combination that are stationary (Bhaumik, 2015).” However, before testing for cointegration we do the basic data analysis and necessary diagnostic checks.

3.1 Summary Statistics of Monthly Interest Rate Series

We examine monthly time series data for 4 interest rate variables representative of the relevant segments of the market for the 17-year period from March 1998 (1998M03) to March 2015 (2015M03) which gives us a long time series of 205 data points for empirical analysis.

The 4 interest rate series are: One, the overnight average call money rate (CMR_AVG) which is at the shortest end of the uncollateralised money market interest rate. This rate is taken as a proxy for the policy interest rate because of its high correlation with the policy repo and reverse repo rates. As explained in Chapter 2, during the period of surplus liquidity it was the reverse repo rate which served as the effective policy rate by providing a floor to oversight market interest rates. In absence of a floor at reverse repo rate market interest rate would have fallen significantly below the reverse repo rate.

Similarly, during the period of deficit liquidity it was the repo rate, which served as the effective policy rate as oversight market interest rate tends to move around the repo rate.

For the time period under consideration here we had prolonged periods of both surplus and deficit liquidity. Thus, in effect there was no unique policy rate. This makes overnight average call money rate the best possible proxy for the policy rate because of its strong correlation and immediate transmission from the reverse repo/repo rates.

Two, in the term structure of interest rate, we next consider Treasury Bill interest rate of 15-91 day residual maturity (RESID_1591D) to represent a risk free money market interest. Three, in terms of the long term risk free interest rate, we take the yield on government securities with 10-year residual maturity (RESID_10Y). This is the most actively traded segment of the government bond market and hence the price discovery is better reflective of market conditions.

Four, we consider the weighted average lending rate of commercial banks (WALR_BSRLI) representing the credit market. It is important to note that lending rates vary not only across banks but also across activities in the same bank. Hence, there is no unique bank lending rate. WALR is computed and released by the RBI from account-wise information of banks following the methodology suggested by Mohanty *et al* (2012), elaborated in Chapter 2. Thus, with these four interest rates we try to represent the various segments of the financial markets through which monetary policy transmission could be considered to occur.

The summary statistics given in Table 3.1 show that during the 17-year period, CMR_AVG rate averaged 6.81 percent closely followed by RESD_1591D rate at 6.94 percent, giving a spread of only 13 basis points. The average RESID_10Y rate at 8.15 percent yielded an average spread of 121 basis points vis-à-vis average RESD_1591D rate. The average WALR_BSRLI at 12.79 percent yielded an average spread of 464 basis points vis-à-vis RESID_10Y rate.

Table 3.1: Interest Rates (Summary Statistics)

	CMR_AVG	RESD_1591D	RESID_10Y	WALR_BSRLI
Mean	6.810122	6.940027	8.149949	12.78976
Median	6.970000	7.057200	7.945400	12.27000
Maximum	14.07000	11.14067	12.33060	16.20000
Minimum	0.730000	3.115900	4.006500	10.53000
Std. Dev.	1.996353	1.865186	1.987246	1.352805
Skewness	0.041906	-0.202970	0.391270	0.761643
Kurtosis	3.497314	2.152668	2.821040	2.788777
Jarque-Bera	2.172534	7.540234	5.504211	20.20118
Probability	0.337474	0.023049	0.063793	0.000041
Sum	1396.075	1422.705	1670.740	2621.900
Sum Sq. Dev.	813.0271	709.6991	805.6255	373.3364
Observations	205	205	205	205

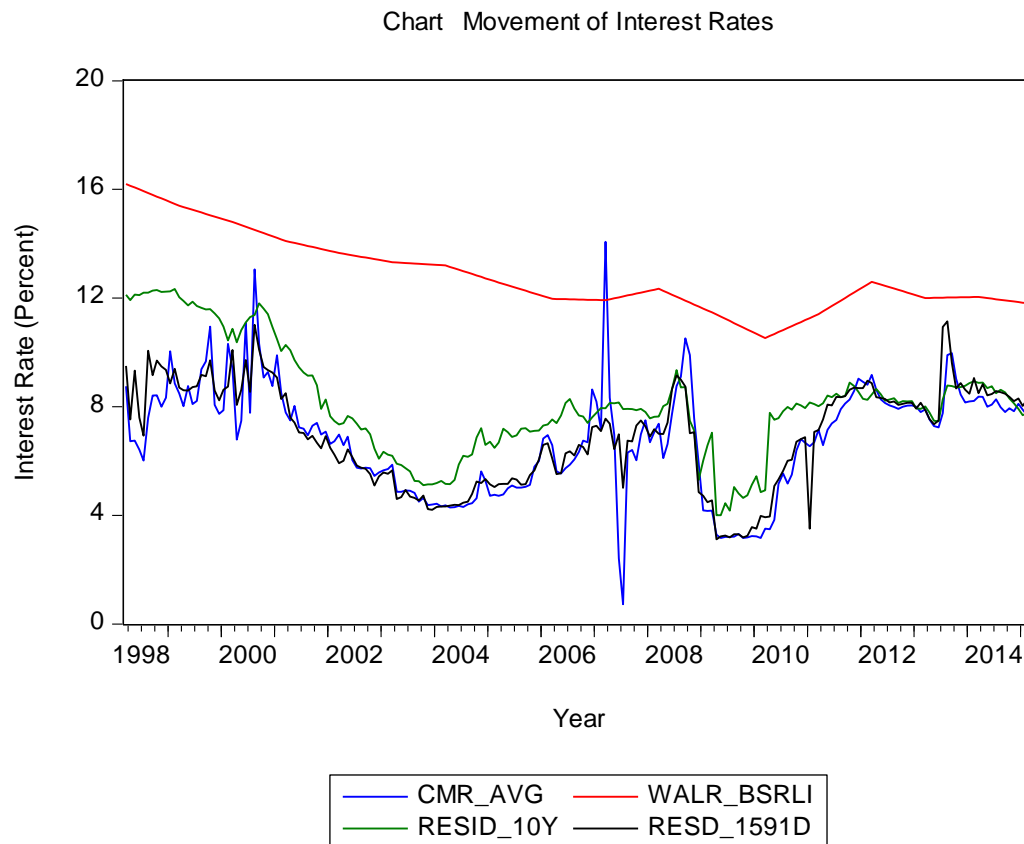
3.1.1 Interest rates across markets show close movement

We plot these 4 interest rate series which suggest a very close movement among CMR_AVG, RESD_1591D and RESID_10Y. While CMR_AVG showed occasional high volatility, it did not influence RESD_1591D and RESID_10Y as such volatilities were very short lived. Generally, CMR_AVG shows March-end seasonal spikes for a few days coinciding with the annual closure of commercial banks' balance sheet. During those few days banks tend to hoard cash and refrain from participating fully in the overnight money market, which artificially jacks up the overnight rate. This is followed by a fall in rates as banks release their excess cash immediately after end-March. But, the fall is cushioned by the reverse repo rate in the RBI's LAF window. Financial markets understand this quirk and hence do not react to such anticipated annual ritual.

The volatility in the call money rate was noticeably significant in 2007 which was policy driven. As rates rose sharply, the RBI removed the reverse repo floor and consequently the rates collapsed. Hence, the RBI had to abandon this policy and continued to provide the reverse repo window regularly as was the earlier practice.

The WALR_BSRLI rate appeared to be stickier, moving slowly. However, its broad direction visually appeared to be in consonance with the other interest rates over the longer horizon. Bank lending rates do not react to changes in the policy rate as quickly as money markets or bond markets do. There are several reasons for this. Banks generally rely on cost plus pricing of their loan products. As money market rates fall, cost of their market borrowing falls but it constitutes only a small portion of banks' liabilities in India. Deposits account for the bulk of banks' liabilities, the cost of which falls very slowly as term deposits in the Indian banking system are generally fixed interest rate contracts. Notwithstanding the short-term distortion, over the medium-term lending rates show flexibility.

Chart 3.1: Movement of Interest Rates



3.2 Correlation among Interest Rates

Now we move from these visual impressions to testing the correlation among these interest rates. As can be seen from the Table 3.2, the correlation among these interest rates was statistically highly significant. The correlation coefficients were also high. Expectedly the correlation coefficient at the shorter end between CMR_AVG and RESD_1591D was the highest at 0.88. The next highest correlation of 0.83 was between RESD_1591D and RESID_10Y. The correlation between CMR_AVG and WALR_BSRLI was the lowest at 0.36, though statistically highly significant at 1% level.

As one moved along the term structure the correlation of WALR_BSRLI improved with the highest correlation of 0.69 observed with RESID_10Y which was statistically significant at 1% level. This suggests a greater interrelation between the bond market and the bank credit market notwithstanding a slow process of adjustment from the policy rate to the bank lending rate. However, strong correlation among interest rates across market does not mean that there is a long-term stable relationship. This is an issue we probe further in this chapter by testing for cointegration. But before doing that we need to ascertain whether the data series stationarity by performing unit root test.

Table 3.2: Cross-Correlation among interest rates

Probability	CMR_AVG	RESD_1591D	RESID_10Y	WALR_BSRLI
CMR_AVG	1.000000			

RESD_1591D	0.883030	1.000000		
	26.80764	-----		
	0.0000	-----		
RESID_10Y	0.707198	0.828600	1.000000	
	14.25147	21.08765	-----	
	0.0000	0.0000	-----	
WALR_BSRLI	0.357798	0.415194	0.689420	1.000000
	5.459252	6.502569	13.56052	-----
	0.0000	0.0000	0.0000	-----

3.3 Unit Root Tests for Monthly Interest Rate Series

For unit root, the standard tests are Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test. Another method for testing for unit root is KPSS test. “The ADF test is based on the assumption that the error term is serially independent and has a constant variance. Phillips and Perron (1988) developed a generalisation of ADF test that allows for a less restrictive assumption concerning the distribution of the error terms (Bhaumik, 2015).”

3.3.1 Concept of stationarity in time series data

We test for unit root using the EView software. As per the characterization of unit root in EView: “A series is said to be stationary if the mean and autocovariances of the series do not depend on time. Any series that is not stationary is said to be nonstationary. A common example of a nonstationary series is the random walk:

$$y_t = y_{t-1} + \epsilon_t$$

Where ϵ is a stationary random disturbance term. The series y has a constant forecast value, conditional on t , and the variance is increasing over time. The random walk is a difference stationary series since the first difference of y is stationary:

$$y_t - y_{t-1} = (1 - L) y_t = \epsilon_t$$

A difference stationary series is said to be integrated and is denoted as $I(d)$ where d is the order of integration. The order of integration is the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary. For the random walk above, there is one unit root, so it is an $I(1)$ series. Similarly, a stationary series is $I(0)$.

Standard inference procedures do not apply to regressions which contain an integrated dependent variable or integrated regressors. Therefore, it is important to check whether a series is stationary or not before using it in a regression. The formal method to test the stationarity of a series is the unit root test.

3.3.2 Features of unit root test

Following EView the basics features of unit root tests is characterised as follows. Consider a simple AR (1) process:

$$y_t = \rho y_{t-1} + x_t' \delta + \epsilon_t$$

Where x_t are optional exogenous regressors which may consist of constant, or a constant and trend, ρ and δ are parameters to be estimated, and the ϵ_t are assumed to be white noise. If $|\rho| \geq 1$, y is a nonstationary series and the variance of y increases with time and approaches infinity. If $|\rho| < 1$, y is a trend-stationary series. Thus, the hypothesis of trend-stationarity can be evaluated by testing whether the absolute value of ρ is strictly less than one.

The unit root tests that EViews provides generally test the null hypothesis $H_0: \rho = 1$ against the one-sided alternative $H_1: \rho < 1$. In some cases, the null is tested against a point alternative. In contrast, the KPSS Lagrange Multiplier test evaluates the null of $H_0: \rho < 1$ against the alternative $H_0: \rho = 1$.

3.3.2.1 ADF test

The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the y series follows an AR (ρ) process and adding ρ lagged difference terms of the dependent variable y to the right-hand side of the test regression:

$$\Delta y_t = \alpha y_{t-1} + x_t' \delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \dots + \beta_p \Delta y_{t-p} + v_t$$

3.3.2.2 PP test

The Phillips-Perron (PP, 1988) gives an alternative nonparametric method of controlling for serial correlation when testing for a unit root. The asymptotic distribution of the PP modified t-ratio is the same as the ADF statistics.

3.3.2.3 KPSS test

The Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test differs from the other unit root tests described here in that the series y_t is assumed to be trend-stationary under the null. The KPSS statistics is based on the residuals from the OLS regression of y_t on the exogenous variables x_t :

$$y_t = x_t' \delta + u_t$$

The LM statistic is defined as:

$$LM = \sum_{t=1}^T S(t)^2 / (T^2 f_0)$$

Where f_0 , is an estimator of the residual spectrum at frequency zero and where $S(t)$ is a cumulative residual function:

$$S_t = \sum_{r=1}^t u_r$$

Based on the residuals $u_t = y_t - x_t' \delta$

We now test for unit root of the different interest rate series that we have chosen here.

3.4 Unit Root Test for Monthly Interest Rate Series

We perform unit root tests on our four chosen variables using EView software. The detailed results are given in Table 3.3.

CMR_AVG: Both the ADF and PP tests reject the Null Hypothesis that CMR_AVG has a unit root at both 1% and 5% levels of significance. Hence we conclude that CMR_AVG is an I(0) variable, i.e., it does not have a unit root.

RESD_1591D: Both the ADF and PP tests cannot reject the Null Hypothesis that RESD_1591D has a unit root at both 1% and 5% levels of significance. Hence we conclude that RESD_1591D is an I(1) variable.

RESID_10Y: Both the ADF and PP tests cannot reject the Null Hypothesis that RESID_10Y has a unit root at both 1% and 5% levels of significance. Hence we conclude that RESID_10Y is an I(1) variable.

WALR_BSRLI: Both the ADF and PP tests cannot reject the Null Hypothesis that WALR_BSRLI has a unit root at 1% level of significance. While ADF test cannot reject the Null Hypothesis that WALR_BSRLI has a unit root even at 5% and 10% levels of significance, PP test rejects it at 5%. Given the very clear evidence from more restrictive ADF test, we conclude that WALR_BSRLI is an I (1) variable.

Thus, out of the four variables we find that one variable, i.e., call money rate is a stationery series; the other three variables – a representative money market rate, long-term government bond market rate and bank lending rate – are nonstationary. We perform another round of unit root tests on the first difference (Δ) of latter three variables and find those to be stationary at 1% level of confidence. We do not report the details of the results here to save space. This suggests that RESD_19D, RESID_10Y and WALR_BSRLI were I (1) variables and their first difference were I (0) variables making them ideal candidates in testing for cointegration.

Table 3.3: Unit Root Tests for Monthly Interest Rate Variables

<p>Null Hypothesis: CMR_AVG has a unit root Exogenous: Constant Lag Length: 1 (Automatic - based on SIC, maxlag=14)</p> <hr/> <table border="1"> <thead> <tr> <th></th> <th>t-Statistic</th> <th>Prob.*</th> </tr> </thead> <tbody> <tr> <td>Augmented Dickey-Fuller test statistic</td> <td>-3.556936</td> <td>0.0075</td> </tr> <tr> <td>Test critical values: 1% level</td> <td>-3.462574</td> <td></td> </tr> <tr> <td>5% level</td> <td>-2.875608</td> <td></td> </tr> <tr> <td>10% level</td> <td>-2.574346</td> <td></td> </tr> </tbody> </table> <hr/> <p>*MacKinnon (1996) one-sided p-values.</p> <p>Augmented Dickey-Fuller Test Equation Dependent Variable: D(CMR_AVG) Method: Least Squares Date: 12/15/15 Time: 15:23 Sample (adjusted): 1998M05 2015M03 Included observations: 203 after adjustments</p> <hr/> <table border="1"> <thead> <tr> <th>Variable</th> <th>Coefficient</th> <th>Std. 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CMR_AVG(-1)	-0.179060	0.039931	-4.484273	0.0000																																																																																																																		
C	1.212888	0.283229	4.282353	0.0000																																																																																																																		
	Mean dependent var																																																																																																																					
R-squared	0.090535	0.005882																																																																																																																				
Adjusted R-squared	0.086033	1.190547																																																																																																																				
S.E. of regression	1.138182	3.106497																																																																																																																				
Sum squared resid	261.6826	3.139028																																																																																																																				
Log likelihood	-314.8627	3.119656																																																																																																																				
F-statistic	20.10871	2.243710																																																																																																																				
Prob(F-statistic)	0.000012																																																																																																																					
<p>Null Hypothesis: RESD_1591D has a unit root Exogenous: Constant Lag Length: 1 (Automatic - based on SIC, maxlag=14)</p> <hr/> <table border="1"> <thead> <tr> <th></th> <th>t-Statistic</th> <th>Prob.*</th> </tr> </thead> <tbody> <tr> <td>Augmented Dickey-Fuller test statistic</td> <td>-2.122488</td> <td>0.2361</td> </tr> <tr> <td>Test critical values: 1% level</td> <td>-3.462574</td> <td></td> </tr> <tr> <td>5% level</td> <td>-2.875608</td> <td></td> </tr> <tr> <td>10% level</td> <td>-2.574346</td> <td></td> </tr> </tbody> </table> <hr/> <p>*MacKinnon (1996) one-sided p-values.</p> <p>Augmented Dickey-Fuller Test Equation</p>		t-Statistic	Prob.*	Augmented Dickey-Fuller test statistic	-2.122488	0.2361	Test critical values: 1% level	-3.462574		5% level	-2.875608		10% level	-2.574346		<p>Null Hypothesis: RESD_1591D has a unit root Exogenous: Constant Bandwidth: 5 (Newey-West automatic) using Bartlett kernel</p> <hr/> <table border="1"> <thead> <tr> <th></th> <th>Adj. t-Stat</th> <th>Prob.*</th> </tr> </thead> <tbody> <tr> <td>Phillips-Perron test statistic</td> <td>-2.711561</td> <td>0.0738</td> </tr> <tr> <td>Test critical values: 1% level</td> <td>-3.462412</td> <td></td> </tr> <tr> <td>5% level</td> <td>-2.875538</td> <td></td> </tr> <tr> <td>10% level</td> <td>-2.574309</td> <td></td> </tr> </tbody> </table> <hr/> <p>*MacKinnon (1996) one-sided p-values.</p> <hr/> <table border="1"> <tbody> <tr> <td>Residual variance (no correction)</td> <td>0.534751</td> </tr> </tbody> </table>		Adj. t-Stat	Prob.*	Phillips-Perron test statistic	-2.711561	0.0738	Test critical values: 1% level	-3.462412		5% level	-2.875538		10% level	-2.574309		Residual variance (no correction)	0.534751																																																																																					
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Residual variance (no correction)	0.534751																																																																																																																					

Dependent Variable: D(RESID_1591D)				HAC corrected variance (Bartlett kernel)		0.392894
Method: Least Squares						
Date: 12/15/15 Time: 15:32						
Sample (adjusted): 1998M05 2015M03						
Included observations: 203 after adjustments						
Variable	Coefficient	Std. Error	t-Statistic	Prob.		
RESID_1591D(-1)	-0.057090	0.026898	-2.122488	0.0350		
D(RESID_1591D(-1))	-0.272549	0.066780	-4.081278	0.0001		
C	0.394827	0.192658	2.049365	0.0417		
R-squared	0.112881	Mean dependent var	0.001242			
Adjusted R-squared	0.104010	S.D. dependent var	0.738958			
S.E. of regression	0.699474	Akaike info criterion	2.137691			
Sum squared resid	97.85269	Schwarz criterion	2.186655			
Log likelihood	-213.9756	Hannan-Quinn criter.	2.157500			
F-statistic	12.72449	Durbin-Watson stat	1.959721			
Prob(F-statistic)	0.000006					
				Phillips-Perron Test Equation		
				Dependent Variable: D(RESID_1591D)		
				Method: Least Squares		
				Date: 12/15/15 Time: 15:32		
				Sample (adjusted): 1998M04 2015M03		
				Included observations: 204 after adjustments		
Variable	Coefficien	t	Std. Error	t-Statistic	Prob.	
RESID_1591D(-1)	-0.084656	0.027599	-3.067356	0.0025		
C	0.578748	0.198219	2.919739	0.0039		
R-squared	0.044505	Mean dependent var	0.008421			
Adjusted R-squared	0.039774	S.D. dependent var	0.749944			
S.E. of regression	0.734878	Akaike info criterion	2.231531			
Sum squared resid	109.0892	Schwarz criterion	2.264061			
Log likelihood	-225.6161	Hannan-Quinn criter.	2.244690			
F-statistic	9.408673	Durbin-Watson stat	2.459828			
Prob(F-statistic)	0.002455					

Null Hypothesis: RESID_10Y has a unit root
 Exogenous: Constant
 Lag Length: 0 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.189665	0.2108
Test critical values: 1% level	-3.462412	
5% level	-2.875538	
10% level	-2.574309	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
 Dependent Variable: D(RESID_10Y)
 Method: Least Squares
 Date: 12/15/15 Time: 15:27
 Sample (adjusted): 1998M04 2015M03
 Included observations: 204 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID_10Y(-1)	-0.032449	0.014819	-2.189665	0.0297
C	0.243342	0.124337	1.957119	0.0517

R-squared	0.023185	Mean dependent var	-0.021169
Adjusted R-squared	0.018350	S.D. dependent var	0.424496
S.E. of regression	0.420583	Akaike info criterion	1.115405
Sum squared resid	35.73176	Schwarz criterion	1.147935
Log likelihood	-111.7713	Hannan-Quinn criter.	1.128564
F-statistic	4.794632	Durbin-Watson stat	2.014894
Prob(F-statistic)	0.029694		

Null Hypothesis: RESID_10Y has a unit root
 Exogenous: Constant
 Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.168896	0.2184
Test critical values: 1% level	-3.462412	
5% level	-2.875538	
10% level	-2.574309	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.175156
HAC corrected variance (Bartlett kernel)	0.166183

Phillips-Perron Test Equation
 Dependent Variable: D(RESID_10Y)
 Method: Least Squares
 Date: 12/15/15 Time: 15:27
 Sample (adjusted): 1998M04 2015M03
 Included observations: 204 after adjustments

Variable	Coefficien	t	Std. Error	t-Statistic	Prob.
RESID_10Y(-1)	-0.032449	0.014819	-2.189665	0.0297	
C	0.243342	0.124337	1.957119	0.0517	

R-squared	0.023185	Mean dependent var	0.021169
Adjusted R-squared	0.018350	S.D. dependent var	0.424496
S.E. of regression	0.420583	Akaike info criterion	1.115405
Sum squared resid	35.73176	Schwarz criterion	1.147935
Log likelihood	-111.7713	Hannan-Quinn criter.	1.128564
F-statistic	4.794632	Durbin-Watson stat	2.014894
Prob(F-statistic)	0.029694		

Null Hypothesis: WALR_BSRLI has a unit root
 Exogenous: Constant
 Lag Length: 1 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
--	-------------	--------

Null Hypothesis: WALR_BSRLI has a unit root
 Exogenous: Constant
 Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
--	-------------	--------

Augmented Dickey-Fuller test statistic	-2.239372	0.1932	Phillips-Perron test statistic	-2.905478	0.0464
Test critical values: 1% level	-3.462574		Test critical values: 1% level	-3.462412	
5% level	-2.875608		5% level	-2.875538	
10% level	-2.574346		10% level	-2.574309	
*MacKinnon (1996) one-sided p-values.			*MacKinnon (1996) one-sided p-values.		
Augmented Dickey-Fuller Test Equation			Residual variance (no correction)		
Dependent Variable: D(WALR_BSRLI)			0.001982		
Method: Least Squares			HAC corrected variance (Bartlett kernel)		
Date: 12/15/15 Time: 15:30			0.015231		
Sample (adjusted): 1998M05 2015M03					
Included observations: 203 after adjustments					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
WALR_BSRLI(-1)	-0.002280	0.001018	-2.239372	0.0262	
D(WALR_BSRLI(-1))	0.904674	0.027666	32.70013	0.0000	
C	0.027306	0.012853	2.124503	0.0349	
R-squared	0.869018	Mean dependent var	-0.021346		
Adjusted R-squared	0.867708	S.D. dependent var	0.049074		
S.E. of regression	0.017849	Akaike info criterion	-5.199058		
Sum squared resid	0.063718	Schwarz criterion	-5.150094		
Log likelihood	530.7044	Hannan-Quinn criter.	-5.179249		
F-statistic	663.4642	Durbin-Watson stat	1.932268		
Prob(F-statistic)	0.000000				
Phillips-Perron Test Equation					
Dependent Variable: D(WALR_BSRLI)					
Method: Least Squares					
Date: 12/15/15 Time: 15:29					
Sample (adjusted): 1998M04 2015M03					
Included observations: 204 after adjustments					
Variable	Coefficien	t	Std. Error	t-Statistic	Prob.
WALR_BSRLI(-1)	-0.015027	0.002319	-6.480572	0.0000	
C	0.170699	0.029833	5.721771	0.0000	
R-squared	0.172124	Mean dependent var	-0.021569		
Adjusted R-squared	0.168025	S.D. dependent var	0.049056		
S.E. of regression	0.044745	Akaike info criterion	-3.65924		
Sum squared resid	0.404425	Schwarz criterion	-3.33393		
Log likelihood	345.3242	Hannan-Quinn criter.	-3.52764		
F-statistic	41.99781	Durbin-Watson stat	0.165359		
Prob(F-statistic)	0.000000				

3.5 Specification of a Cointegration Model to Test Long-Term Equilibrium Relationship

Out of the four interest rate variables, we have three interest rates - RESD_1591D, RESID_10Y and WALR_BSRLI - which are I (1) variables, except for CMR_AVG which is I (0). This gives us the opportunity to test whether there is long-term equilibrium relationship among these three interest rate series which taken together gives us a system that encompasses the money market, debt market and the credit market.

Given the strong correlation between CMR_AVG and RESD_1591D one could even consider the latter as a proxy for the policy rate. We saw from the descriptive statistics that both the mean and median for these two variables are quite close. We examine this proposition more formally by testing for equality.

We could not reject the null hypothesis that the mean of CMR_AVG is equal to the mean of RESD_1591D even at 10 % level of confidence (Table 3.4). Similarly we could not reject the null hypothesis that the median of CMR_AVG is equal to the median of RESD_1591D even at 10 % level of confidence (Table 3.5). Hence, we conclude that RESD_1591D is a good proxy for the policy rate represented by CMR_AVG, the former being I (1), which gives us the flexibility to consider this as a part of cointegrating system.

In a major way, these three rates represent three markets: short-term money market, long-term bond market and credit market. In testing for cointegration among these three rates we could actually see how these markets are integrated. The appropriate glue that bonds the various financial markets is interest rate.

Table 3.4 : Test for Equality of Means Between Series				
Method		df	Value	Probability
t-test		408	-0.680777	0.4964
Satterthwaite-Welch t-test*		406.1299	-0.680777	0.4964
Anova F-test		(1, 408)	0.463458	0.4964
Welch F-test*		(1, 406.13)	0.463458	0.4964
*Test allows for unequal cell variances				
Analysis of Variance				
Source of Variation		df	Sum of Sq.	Mean Sq.
Between		1	1.729704	1.729704
Within		408	1522.726	3.732172
Total		409	1524.456	3.727276
Category Statistics				
				Std. Err.
Variable	Count	Mean	Std. Dev.	of Mean
CMR_AVG	205	6.810122	1.996353	0.139431
RESD_1591D	205	6.940027	1.865186	0.130270
All	410	6.875074	1.930615	0.095346

Table 3.5 : Test for Equality of Medians Between Series					
Method		df	Value	Probability	
Wilcoxon/Mann-Whitney			1.057736	0.2902	
Wilcoxon/Mann-Whitney (tie-adj.)			1.057738	0.2902	
Med. Chi-square		1	0.087805	0.7670	
Adj. Med. Chi-square		1	0.039024	0.8434	
Kruskal-Wallis		1	1.119688	0.2900	
Kruskal-Wallis (tie-adj.)		1	1.119692	0.2900	
van der Waerden		1	1.175414	0.2783	
Category Statistics					
			> Overall		
Variable	Count	Median	Median	Mean Rank	Mean Score
CMR_AVG	205	6.970000	101	199.3073	-0.052890
RESD_1591D	205	7.057200	104	211.6927	0.052960
All	410	7.044500	205	205.5000	3.46E-05

We additionally perform a Granger Causality test between the two variables under consideration, i. e., CMR_AVG and RESID_1591. Granger (1969) causality test between two variables ‘y’ and ‘x’ shows how much of ‘y’ can be explained by its lagged values and whether including the lagged variable of the other variable ‘x’ improves the predictability ‘y’ statistically significantly.

The test results (Table 3.6) show that the null hypothesis that RESD_1951D does not Granger Cause CMR_AVG cannot be rejected at 1% level of significance. Similarly the null hypothesis that CMR_AVG does not Granger Cause RESD_1591D cannot be rejected at 1% level of significance. Thus the results conclusively show a bidirectional causality. On balance of consideration we infer that RESID_1591 can be reasonably considered an appropriate proxy for the policy rate.

Table 3.6 : Granger Causality Tests

Pairwise Granger Causality Tests			
Null Hypothesis:	Obs	F-Statistic	Prob.
RESD_1591D does not Granger Cause CMR_AVG	201	17.8566	2.E-12
CMR_AVG does not Granger Cause RESD_1591D		3.43609	0.0097

3.5.1 Johansen cointegration test

Since we have more than two variables, we use the Johansen procedure to test for cointegration. “Assuming that there are k variables, y_1, y_2, \dots, y_k , collected in a vector Y, are integrated of order one, the following cases are possible: Either there is no cointegration at all or there exist one or two up to k-1 linear independent cointegration vectors. In this case we cannot use single equation procedures which allow at most for one cointegration relation (Kirchgässner, et al.2013).”

EViews supports VAR-based cointegration tests using the methodology developed in Johansen (1991, 1995). Consider a VAR of order p :

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

Where y_t is a k -vector of nonstationary I (1) variables x_t is a d -vector of deterministic variables, and ϵ_t is a vector of innovations. We may rewrite this VAR as,

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \epsilon_t$$

Where:

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

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta'y_i$ is I (0). r is the number cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the VEC model. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π .

We specify the level data y_t and the cointegrating equations with linear trends which has the following formulation:

$$H^*(r): \Pi y_{t-1} + Bx_t = \alpha(\beta'y_{t-1} + p_0 + p_1 t) + \alpha_{\perp} \gamma_0$$

The terms associated with α_{\perp} are the deterministic terms "outside" the cointegrating relations

3.5.2 Results of the cointegration test

Since in our model we have three variables, at the most we could have two cointegration. If, however, there is no long-term equilibrium relationship there may not be any cointegration. Before formally testing for cointegration we examine the plot of the three variables - RESD_1591D, RESID_10Y and WALR_BSRLI – under consideration. The plot clearly suggests the presence of an intercept and possibly a linear trend. The linear trend is apparent from WALR_BSRLI which has shown a declining trend falling from around 16 percent in the earlier part of the sample period in 1999-2000 to around 12 percent by 2014-15. RESD_1591D and RESID_10Y though more volatile, the overall direction has been one of decline. We accordingly test for cointegration in the data with an intercept and a linear trend. The detailed results are presented in Table 3.7.

Both the trace-test and maximum-eigenvalue test suggest presence of one cointegrating equation at 5% level of confidence. The cointegrating equation normalised with respect to RESD_1591D is given below:

$$\text{RESD_1591D} = \quad \quad \quad \mathbf{0.799} \quad \quad \quad \mathbf{+ 0.444} \quad \quad \quad \mathbf{+0.018 \text{ TREND} - 7.016 C}$$

$$\quad \quad \quad \mathbf{RESID_10Y} \quad \quad \quad \mathbf{WALR_BSRLI}$$

$$\quad \quad \quad (0.092) \quad \quad \quad (0.232) \quad \quad \quad (0.004)$$

Figures in parentheses are standard errors.

It could be seen that the relationship among the three interest rate variables is statistically significant and positive which would suggest that the interest rates in the money market, debt market and credit market move in the same direction besides showing a co-movement. The trend variable has also turned out to be statistically significant.

Table 3.7 : Cointegration Test for Monthly Interest Rate Variables

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.130432	44.54682	42.91525	0.0340
At most 1	0.053040	16.31566	25.87211	0.4675
At most 2	0.025930	5.306955	12.51798	0.5529
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.130432	28.23116	25.82321	0.0236
At most 1	0.053040	11.00870	19.38704	0.5124
At most 2	0.025930	5.306955	12.51798	0.5529
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):				
RESD_1591D	RESID_10Y	WALR_BSRLI	@TREND(98M04)	
-1.668057	1.332391	0.741199	0.030213	
-0.199690	-0.414304	2.110508	0.027608	
-0.050669	-0.552020	0.351975	0.006659	
Unrestricted Adjustment Coefficients (alpha):				
D(RESD_1591D)	0.234934	0.028785	0.026039	
D(RESID_10Y)	0.023192	-0.000239	0.066781	
D(WALR_BSRLI)	0.001158	-0.003962	0.000609	
1 Cointegrating Equation(s):		Log likelihood	241.4914	
Normalized cointegrating coefficients (standard error in parentheses)				
RESD_1591D	RESID_10Y	WALR_BSRLI	@TREND(98M04)	
1.000000	-0.798768	-0.444349	-0.018113	
	(0.09222)	(0.23227)	(0.00406)	
Adjustment coefficients (standard error in parentheses)				
D(RESD_1591D)	-0.391884			
	(0.07666)			
D(RESID_10Y)	-0.038685			
	(0.05018)			
D(WALR_BSRLI)	-0.001932			
	(0.00214)			
2 Cointegrating Equation(s):		Log likelihood	246.9958	
Normalized cointegrating coefficients (standard error in parentheses)				
RESD_1591D	RESID_10Y	WALR_BSRLI	@TREND(98M04)	
1.000000	0.000000	-3.258749	-0.051510	
		(0.60993)	(0.01408)	
0.000000	1.000000	-3.523426	-0.041810	
		(0.75217)	(0.01736)	
Adjustment coefficients (standard error in parentheses)				
D(RESD_1591D)	-0.397632	0.301099		
	(0.07713)	(0.06406)		
D(RESID_10Y)	-0.038638	0.030999		
	(0.05054)	(0.04198)		
D(WALR_BSRLI)	-0.001141	0.003185		
	(0.00210)	(0.00175)		

3.5.3 Vector error correction model

We now turn to test the stability of the cointegrating relationship by estimating a vector error correction (VEC) model. The equation for RESD_1591D is given below:

$\Delta \text{RESD}_{1591D} =$	-0.392EC	-0.143 $\Delta \text{RESD}_{1591D}(-1)$	+0.006 $\Delta \text{RESD}_{1591D}(-2)$
	(0.077)	(0.084)	(0.075)
	[-5.112]	[-1.692]	[0.082]
	+0.031 $\Delta \text{RESID}_{10Y}(-1)$	+0.004 $\Delta \text{RESID}_{10Y}(-2)$	+0.148 $\Delta \text{WALR}_{BSRLI}(-1)$
	(0.127)	(0.120)	(2.652)
	[0.246]	[0.033]	[0.050]
	+1.910 $\Delta \text{WALR}_{BSRLI}(-2)$	+0.382C	
	(2.640)	(0.050)	
	[0.724]	[0.751]	

$R^2 = 0.227$; Δ : change; EC: Error correction term; C: Constant

Figures in () are standard errors and figures in [] are t statistics.

The equation shows that the error correction (EC) term has a negative sign which suggests that it brings the system into equilibrium in the event of a deviation. Moreover the EC term is statistically significant at 1% level. Other variables were statistically insignificant, underscoring again the important role of EC term restoring equilibrium. The details of VEC results are given in Table 3.8.

Thus, this exercise establishes a stable long-run equilibrium relationship among interest rates in money, bond and credit market. To the extent that policy rate change has a strong impact on the money market, it can be considered to have an influence on the other segments of the market.

Table 3.8: Vector Error Correction Estimates

Cointegrating Eq:	CointEq1		
RESD_1591D(-1)	1.000000		
RESID_10Y(-1)	-0.798768		
	(0.09222)		
	[-8.66186]		
WALR_BSRLI(-1)	-0.444349		
	(0.23227)		
	[-1.91308]		
@TREND(98M03)	-0.018113		
	(0.00406)		
	[-4.45589]		
C	7.105553		
Error Correction:	D(RESD_1591D)	D(RESID_10Y)	D(WALR_BSRLI)
CointEq1	-0.391884	-0.038685	-0.001932
	(0.07666)	(0.05018)	(0.00214)
	[-5.11203]	[-0.77091]	[-0.90298]
D(RESD_1591D(-1))	-0.143008	0.088416	0.002269
	(0.08450)	(0.05532)	(0.00236)
	[-1.69232]	[1.59838]	[0.96213]
D(RESD_1591D(-2))	0.006103	0.090540	0.002669
	(0.07465)	(0.04886)	(0.00208)
	[0.08176]	[1.85288]	[1.28110]
D(RESID_10Y(-1))	0.031213	-0.084334	-0.001479
	(0.12700)	(0.08314)	(0.00355)
	[0.24576]	[-1.01440]	[-0.41708]
D(RESID_10Y(-2))	0.003998	-0.127561	-0.003507
	(0.11976)	(0.07839)	(0.00334)
	[0.03339]	[-1.62716]	[-1.04901]

D(WALR_BSRLI(-1))	0.148246	-0.024895	0.956446
	(2.65181)	(1.73588)	(0.07402)
	[0.05590]	[-0.01434]	[12.9211]
D(WALR_BSRLI(-2))	1.910706	0.443683	-0.030280
	(2.63988)	(1.72807)	(0.07369)
	[0.72378]	[0.25675]	[-0.41092]
C	0.038155	-0.016572	-0.001450
	(0.05045)	(0.03302)	(0.00141)
	[0.75633]	[-0.50185]	[-1.02982]
R-squared	0.226980	0.028169	0.866865
Adj. R-squared	0.199087	-0.006898	0.862062
Sum sq. resids	82.76762	35.46630	0.064491
S.E. equation	0.653175	0.427570	0.018233
F-statistic	8.137670	0.803298	180.4533
Log likelihood	-196.5103	-110.9174	526.3744
Akaike AIC	2.024854	1.177400	-5.132420
Schwarz SC	2.155875	1.308421	-5.001399
Mean dependent	-0.007638	-0.021446	-0.021122
S.D. dependent	0.729855	0.426103	0.049091
Determinant resid covariance (dof adj.)		2.07E-05	
Determinant resid covariance		1.84E-05	
Log likelihood		241.4914	
Akaike information criterion		-2.113776	
Schwarz criterion		-1.655205	

3.6 Conclusion

In this Chapter, we proceed very systematically to empirically examine the integration among the key segments of the financial market: money, debt and credit markets. We formally test for integration in the financial market across its key segments and along the yield curve. We examine a long monthly time series of interest rate for 17 years from 1998-99 to 2014-15 coinciding with a period of financial sector reforms which widened and deepened financial markets in India.

We first examine the correlation among the representative interest rates in these markets which turn out to be statistically highly significant. Most time series data are seen to contain a significant trend component. In such situations, regression analysis could give spurious results. Hence in time series which contain unit roots, cointegration is considered to be a more appropriate method to examine the underlying long-term relationships. We follow systematically first testing for unit roots in the interest rate series. We, thereafter, examine the question whether there is a long-term equilibrium relationship among interest rates in these markets by testing for cointegration following the Johansen procedure.

We test for unit roots in our data series by applying ADF and PP tests. Having ascertained that the chosen series contained unit root we proceed to estimate cointegration. The cointegration results suggested a single cointegrating equation among a very short term interest rate of Treasury Bills with a residual maturity of 15-91 days, the yield on government security with a residual maturity of 10-years and a measure of weighted average bank lending rate. Once we establish this long-term relationship, we test for the stability of this relationship by estimating a vector error correction (VEC) model which showed that not only was the error correction term statistically significant but also had a negative sign suggesting convergence of the system to equilibrium in the event of temporary deviation.

Since the Treasury Bill rate with a residual maturity of 15-91 days shadows the policy rate one could infer that a long-term relationship exists among policy rate and other key market rates. These findings prompt us to infer that there is a stable long-term relationship among interest rates in the major segments of the financial markets which augurs well for considering interest rate as a key instrument of monetary policy. This finding in an important way establishes the first stage of interest rate channel of monetary transmission from the policy rate to the broader financial markets.

Monthly Interest Rate Series

Month	RESID_1591D	RESID_10Y	WALR_BSRLI
1998M03	9.50	12.12	16.20
1998M04	7.53	11.92	16.13
1998M05	9.32	12.13	16.07
1998M06	7.60	12.11	16.00
1998M07	6.93	12.19	15.93
1998M08	10.05	12.20	15.87
1998M09	9.16	12.27	15.80
1998M10	9.70	12.29	15.73
1998M11	9.48	12.22	15.67
1998M12	9.36	12.23	15.60
1999M01	8.86	12.25	15.53
1999M02	9.40	12.33	15.47
1999M03	8.70	12.03	15.40
1999M04	8.61	11.89	15.35
1999M05	8.59	11.73	15.30
1999M06	8.73	11.86	15.25
1999M07	8.75	11.71	15.20
1999M08	9.17	11.64	15.15
1999M09	9.13	11.58	15.10
1999M10	9.70	11.59	15.05
1999M11	8.59	11.43	15.00
1999M12	8.23	11.25	14.95
2000M01	8.63	10.94	14.90
2000M02	8.74	10.44	14.85
2000M03	10.09	10.87	14.80
2000M04	8.07	10.37	14.74
2000M05	8.62	10.82	14.68
2000M06	9.71	11.10	14.63
2000M07	8.55	11.30	14.57
2000M08	11.02	11.37	14.51

Month	RESD_1591D	RESID_10Y	WALR_BSRLI
2000M09	10.10	11.81	14.45
2000M10	9.46	11.61	14.39
2000M11	9.34	11.40	14.33
2000M12	9.25	10.94	14.28
2001M01	9.08	10.48	14.22
2001M02	8.28	10.04	14.16
2001M03	8.49	10.27	14.10
2001M04	7.60	10.08	14.06
2001M05	7.41	9.71	14.03
2001M06	7.05	9.46	13.99
2001M07	7.03	9.26	13.95
2001M08	6.80	9.14	13.92
2001M09	6.93	9.15	13.88
2001M10	6.67	8.79	13.84
2001M11	6.47	7.92	13.81
2001M12	6.92	8.27	13.77
2002M01	6.48	7.65	13.73
2002M02	6.23	7.47	13.70
2002M03	5.92	7.34	13.66
2002M04	6.01	7.40	13.63
2002M05	6.43	7.65	13.60
2002M06	6.14	7.57	13.58
2002M07	5.83	7.37	13.55
2002M08	5.75	7.16	13.52
2002M09	5.71	7.20	13.49
2002M10	5.52	6.98	13.46
2002M11	5.10	6.46	13.43
2002M12	5.43	6.08	13.41
2003M01	5.57	6.34	13.38
2003M02	5.53	6.23	13.35
2003M03	5.66	6.19	13.32
2003M04	4.60	5.91	13.31
2003M05	4.67	5.85	13.30

Month	RESID_1591D	RESID_10Y	WALR_BSRLI
2003M06	4.93	5.73	13.29
2003M07	4.69	5.62	13.28
2003M08	4.64	5.26	13.27
2003M09	4.54	5.26	13.26
2003M10	4.73	5.11	13.25
2003M11	4.23	5.14	13.24
2003M12	4.21	5.14	13.23
2004M01	4.31	5.19	13.22
2004M02	4.33	5.27	13.21
2004M03	4.33	5.15	13.20
2004M04	4.36	5.15	13.15
2004M05	4.38	5.30	13.09
2004M06	4.37	5.87	13.04
2004M07	4.47	6.19	12.99
2004M08	4.51	6.15	12.94
2004M09	4.79	6.24	12.89
2004M10	5.25	6.87	12.83
2004M11	5.19	7.21	12.78
2004M12	5.33	6.59	12.73
2005M01	5.14	6.71	12.68
2005M02	5.04	6.49	12.62
2005M03	5.15	6.69	12.57
2005M04	5.16	7.19	12.52
2005M05	5.16	7.06	12.47
2005M06	5.36	6.88	12.42
2005M07	5.31	6.95	12.37
2005M08	5.13	7.19	12.32
2005M09	5.15	7.21	12.27
2005M10	5.48	7.08	12.22
2005M11	5.66	7.11	12.17
2005M12	6.06	7.12	12.12
2006M01	6.60	7.31	12.07

Month	RESID_1591D	RESID_10Y	WALR_BSRLI
2006M02	6.65	7.34	12.02
2006M03	6.10	7.53	11.97
2006M04	5.52	7.39	11.97
2006M05	5.54	7.68	11.96
2006M06	6.28	8.13	11.96
2006M07	6.36	8.28	11.95
2006M08	6.20	7.93	11.95
2006M09	6.59	7.68	11.95
2006M10	6.52	7.64	11.94
2006M11	6.25	7.41	11.94
2006M12	7.25	7.61	11.93
2007M01	7.29	7.77	11.93
2007M02	7.10	7.95	11.92
2007M03	7.56	7.94	11.92
2007M04	7.37	8.13	11.95
2007M05	6.44	8.12	11.99
2007M06	6.99	8.16	12.02
2007M07	5.01	7.91	12.06
2007M08	6.75	7.92	12.10
2007M09	6.72	7.92	12.13
2007M10	7.30	7.87	12.17
2007M11	7.49	7.92	12.20
2007M12	7.28	7.81	12.24
2008M01	6.90	7.57	12.27
2008M02	7.17	7.63	12.31
2008M03	7.00	7.64	12.34
2008M04	6.99	8.02	12.27
2008M05	7.42	8.11	12.20
2008M06	8.65	8.65	12.12
2008M07	9.15	9.35	12.05
2008M08	8.99	8.71	11.98
2008M09	8.74	8.72	11.91

Month	RESID_1591D	RESID_10Y	WALR_BSRLI
2008M10	7.03	7.48	11.83
2008M11	7.06	7.12	11.76
2008M12	4.86	5.30	11.69
2009M01	4.72	6.00	11.62
2009M02	4.48	6.57	11.54
2009M03	4.55	7.04	11.47
2009M04	3.12	4.01	11.39
2009M05	3.23	4.01	11.31
2009M06	3.26	4.45	11.24
2009M07	3.19	4.18	11.16
2009M08	3.30	5.04	11.08
2009M09	3.30	4.80	11.00
2009M10	3.18	4.64	10.92
2009M11	3.24	4.74	10.84
2009M12	3.57	5.13	10.76
2010M01	3.51	5.44	10.69
2010M02	3.97	4.85	10.61
2010M03	3.93	4.93	10.53
2010M04	3.95	7.78	10.60
2010M05	5.08	7.52	10.68
2010M06	5.32	7.58	10.75
2010M07	5.63	7.83	10.82
2010M08	6.01	7.99	10.90
2010M09	6.04	7.90	10.97
2010M10	6.71	8.12	11.04
2010M11	6.81	8.05	11.12
2010M12	6.88	7.95	11.19
2011M01	3.51	8.15	11.26
2011M02	7.07	8.10	11.34
2011M03	7.14	8.02	11.41
2011M04	7.53	8.13	11.51
2011M05	8.07	8.41	11.61

Month	RESD_1591D	RESID_10Y WALR_BSRLI	
2011M06	8.05	8.35	11.71
2011M07	8.36	8.48	11.81
2011M08	8.35	8.35	11.91
2011M09	8.38	8.40	12.00
2011M10	8.63	8.88	12.10
2011M11	8.70	8.76	12.20
2011M12	8.68	8.55	12.30
2012M01	8.68	8.29	12.40
2012M02	8.96	8.25	12.50
2012M03	8.87	8.45	12.60
2012M04	8.35	8.65	12.55
2012M05	8.33	8.46	12.50
2012M06	8.29	8.23	12.45
2012M07	8.16	8.26	12.40
2012M08	8.19	8.31	12.35
2012M09	8.07	8.14	12.30
2012M10	8.11	8.20	12.25
2012M11	8.14	8.20	12.20
2012M12	8.15	8.20	12.15
2013M01	7.93	7.94	12.10
2013M02	8.14	7.92	12.05
2013M03	7.87	8.01	12.00
2013M04	7.55	7.79	12.00
2013M05	7.36	7.48	12.01
2013M06	7.49	7.46	12.01
2013M07	10.94	8.27	12.01
2013M08	11.14	8.78	12.02
2013M09	9.61	8.76	12.02
2013M10	8.67	8.71	12.02
2013M11	8.87	8.72	12.03
2013M12	8.63	8.77	12.03
2014M01	8.48	8.87	12.03

Month	RESID_1591D	RESID_10Y	WALR_BSRLI
2014M02	9.06	8.94	12.04
2014M03	8.50	8.88	12.04
2014M04	8.82	8.89	12.02
2014M05	8.42	8.69	12.00
2014M06	8.47	8.75	11.98
2014M07	8.57	8.49	11.96
2014M08	8.53	8.63	11.93
2014M09	8.48	8.53	11.91
2014M10	8.36	8.30	11.89
2014M11	8.21	8.12	11.87
2014M12	8.30	7.92	11.85
2015M01	8.03	7.69	11.83
2015M02	8.26	7.77	11.82
2015M03	7.78	7.80	11.80

RESID_1591D Interest Rate on Treasury Bills with Residual Maturity of 15-91 days

RESID_10Y Interest Rate on Government Securities with Residual Maturity of 10 years

WALR_BSRLI Weighted Average Lending Rate of Commercial Bank

Source: Database on Indian Economy (DBIE), Reserve Bank of India (<http://dbie.rbi.org.in>) and the Author's own computation

Chapter 4

Review of Literature on Monetary Transmission

In this chapter, we review the literature, both theoretical and empirical, on monetary transmission and particularly review country specific studies including that for India. We also briefly capture the stylized facts on monetary policy in India as it evolved during 1997-98 to 2014-15.

Monetary policy transmission mechanisms can be defined as the processes by which changes in monetary policy decisions affect the rate of economic growth and/or the inflation rate (Taylor, 1995). The monetary transmission mechanism describes how policy induced changes in the nominal money stock or the short-term nominal interest rate impact real variables such as aggregate output and employment (Ireland, 2005). Central banks have a variety of tools for implementing monetary policy, but the tool that has received the most attention in the literature has been the overnight interest rate (Tobias and Shin, 2009).

How does monetary policy affect output and inflation is an important question. The monetary policy framework of a central bank aims to attain the desired objectives of policy in terms of inflation and growth. Typically, central banks exercise control over the monetary base and/or short-term interest rates such as the rate at which the central bank supplies or absorbs reserves to/from the banking system in the economy. How these interest rate actions and liquidity operations of the central banks impact the end-objectives depends on the underlying monetary transmission.

Monetary transmission refers to a process through which changes in the policy get translated into the ultimate objectives of inflation and growth. Traditionally, four key channels of monetary policy transmission have been identified in literature such as (i) money or interest rate channel; (ii) credit or balance sheet channel; (iii) asset price channel; and (iv) exchange rate channel. In recent years, a fifth channel, i.e., expectations channel has assumed increased prominence in the conduct of forward-looking monetary policy.

The recent literature also talks about the increasing role of central bank communication in shaping monetary policy outcomes. It is, however, not very clear whether communication can be taken as a distinct channel of transmission or it could be considered to be acting through how economic agents form their expectations. In this scenario monetary policy credibility has an important role to play. Monetary policy credibility is considered to be high for advanced countries as compared to emerging market and developing economies (EMDEs). This partly explains why developed countries are able to keep their inflation rates low despite very accommodative monetary policy in the recent years. This gives them the ability to look through supply side price pressures emanating from crude oil and food. On the other hand, EMDEs are not able to look through supply shocks and yet anchor inflation expectations.

Another way of looking at monetary transmission is through two sets of channels: (i) neoclassical channels and (ii) non-neoclassical channels. The neoclassical channels focus on how interest rate changes operating through investment, consumption and trade impact the ultimate objectives. The non-neoclassical channels operate primarily through change in credit supply and impact on the behaviour of banks and their balance sheets (Boivin et al., 2011). How these channels function in a given economy depends on the stage of development of the economy and the structure of its financial system. Against this backdrop we turn to exploring monetary transmission channels a little more in detail.

4.1 Monetary Transmission Channels

Money or interest rate channel is based on the Keynesian theory that prices are sticky and adjust to a monetary shock with a delay. Theoretically, it can be seen in an IS-LM framework. As short-term nominal policy interest rate changes, it changes the short-term real interest rate with a lag, as prices are sticky. In due course it changes the long-term interest rates once market participants expect a particular sequence of short term interest rate to prevail as the long-term interest rate could be seen as a function of the sequence of short-term future interest rates. Movements in real interest rates results in changes in the cost of capital, which affect the investment decision of firms. Similarly, private consumption is affected by both wealth and substitution effects arising from changes in interest rates.

The interest rate adjustment process is, however, not straight forward. It depends on the extent of financial market developments, integration across markets and liquidity in such markets. For instance, markets could be quiet segmented. Consequently, interest rate adjustment in the money market may be much faster compared to the debt market. If the debt market is not very liquid, markets may demand liquidity premium to hold relatively illiquid securities. This also impedes transmission.

The determination of interest rate in the credit market could be much more complex. Banks normally price their loans on a cost plus basis and hence the changes in deposit rates become important for pricing of loan rates. Banks may be loath to change their deposit rates if they perceive the policy rate changes to be temporary. In addition deposit rate changes also depends on the nature of deposit rate contracts, whether fixed or floating. In advanced markets banks tend to rely more on wholesale market funding than retail deposit funding and to that extent cost of bank liability could be more responsive to policy rate changes. If banks have long-term relationship with their customer, they may want to smooth interest rate changes leading to slower pass-through of policy rate to lending rates (Egert and MacDonald, 2009). Hence, bank lending rates are seen to be sticky responding more slowly to policy rate changes. On balance, therefore, transmission of policy rate to different segments of the market is subject to various frictions. We now turn to a discussion on credit channel.

4.1.1 Credit channel

Credit channel works through its impact on both the demand for loans as well as the supply of loans. The credit channel can also be considered as three different channels: (i) bank lending channel, (ii) balance sheet channel, and (iii) bank equity capital channel.

4.1.1.1 Bank lending channel

If the central bank wants to tighten monetary policy, it could do any of the following two things: (i) it could raise the policy interest rate or (ii) it could raise the reserve requirement for banks. In the latter case commercial banks are left with less reserves and hence their ability to expand credit gets curtailed.

Even when the central bank raises interest rate, for that rate to be effective it drains reserves from the banking system. By conducting open market operations (OMO) to withdraw reserves by selling government securities it drains the reserves. Lower free reserves with commercial banks thus results in curtailment of bank credit. As credit creates deposits, lower credit expansion leads to lower deposit growth. In addition, lower credit growth results in lower economic activity and hence lower deposit growth.

It could be argued that borrowers can substitute bank credit with capital market instruments such as bonds. This substitutability in practice is not easy. Even for large firms accessing capital market takes time. In addition, given various regulatory requirements including ratings, many firms may opt out of the capital market. Moreover, in EMDEs capital markets may not be that well developed to give an easy access to firms. Particularly marginal, small and medium Enterprises (MSMEs) with little access to the capital market remain more vulnerable.

Kashyap and Stein (1994) provide an explanation as to what is meant by the lending view of monetary policy transmission. It means open market operations affect the supply of bank loans, which in turn affect both the magnitude of aggregate output and its composition. “The essential ingredient that underlies this mechanism is the imperfect substitutability of bank loans and publicly issued bonds, both as corporate liabilities and as bank assets. Similarly, the lending view need not imply that the more traditional money channel of policy transmission is inoperative; clearly the two channels can coexist and can complement each other. Nonetheless, the distinction between the two is an important one: the existence of a lending channel can influence both the potency and the distributional consequences of monetary policy, as well as the information content of a variety of indicators that policymakers look to.” Thus Kashyap and Stein make the additional point that it is not only the firms which find substitution between loan and bond difficult, even the banks in their asset side find it difficult to substitute loans with other kinds of investment in the event of a loan retrenchment.

4.1.1.2 Balance sheet channel

Monetary policy also affects the balance sheet of firms and therefore the value of their assets that can serve as collateral. The balance sheet channel operates through changes in the net worth of the borrower as interest payment as a share of total expenditure

rises. As interest rates increase, the cost of servicing debt also rises. Consequently the retained earnings of the firm reduce which lowers its net worth. As the equity of the firm reduces its ability to contract debt also goes down. This results in lower investment spending.

Weaker balance sheets also accentuate moral hazard and adverse selection problems. As interest rate rises more credit worthy firms opt out of the loan market. Less credit worthy firms tend to access banks. In such a scenario banks also find it difficult to make a proper assessment of risk. This ultimately leads to credit rationing and further reduction in credit. Bernanke and Gertler (1995) articulated the balance sheet channel by suggesting that as external financing premium for a firm goes up with a deterioration of its net worth, fluctuations in the quality of borrowers' balance sheet affect the investment and spending decisions. Bernanke, Gertler and Glichrist (1996) show that endogenous procyclical movements in borrower balance sheets can amplify and propagate business cycles which they term as "financial accelerators".

4.1.1.3 Bank equity capital channel

A strand of the recent literature discusses about the role of bank equity capital in credit supply also known as the bank capital channel or the risk-taking channel of monetary transmission. "The different types of bank capital regulations have different impacts. In particular, when the risk-based capital requirement is binding, banks prefer to hold government bonds rather than make new loans. However, when the capital regulation is the requirement of a flat minimum percentage of capital against all assets, banks are indifferent between government bonds and new loans. In other words, different risk weights in the capital regulations affect banks' lending behavior and thus ultimately private investment (Honda, 2004)".

Monetary policy could have an asymmetric impact depending on the health of the banking system. If the banks are not in good health, they may find it more costly to raise capital, which could reduce loan supply. Even if they do not curtail loan supply, the lending rate would increase to compensate for increasing cost of capital. The imposition of risk-based capital standards can change the basic short- and long-run loan-market outcomes.

“In the short-run with fully insured deposits, increasing the risk-based capital ratio leads to a contraction in bank lending and an increase in the market loan rate, but the ultimate long-run effects on equilibrium lending and the loan rate are indeterminate (Kopecky and VanHoose, 2004)”. Borio and Zhu (2012) view the bank lending behavior associated with capital requirement as ‘risk-taking channel’ : “The broad credit (balance-sheet) and bank lending channels, grounded on the economics of imperfect information, subsequently highlighted financing constraints, but tended to relegate risk perceptions and pricing to a rather secondary role. The risk-taking channel highlights the role of the measurement, management and pricing of risk, alongside its nexus with financing constraints and liquidity. To be sure, we are by no means arguing that this is *the* main channel; this would obviously be wrong. Rather, we are arguing that it is a channel that deserves closer exploration, especially since it may be becoming more prominent.”

Following the global financial crisis in 2008, now there is greater emphasis on the quality and quantity of bank capital. This is formalised in the Basel III capital requirement, which many countries including India are adopting. There are conflicting views. Agencies like the Institute of International Finance (IIF) is of the view that stringent capital requirement will slow down credit growth and have a significant adverse impact on GDP growth. The Bank for International Settlements (BIS) is of the view that it could have a minor impact. But the likely stability of the banking system may outweigh the cost of capital. Notwithstanding these arguments, the important point is that bank capital channel will gain in importance in the years to come. We now turn to asset price channel.

4.1.2 Asset price channel

Monetary policy has an impact on asset prices. For example once interest rate is raised, it can put downward pressure on equity prices, bond prices, prices of other financial assets and real estate prices. Falling asset prices translates into lower financial wealth of the households and thereby reduces household consumption. Similarly, lower prices of financial assets reduce the market value of firms relative to the replacement cost of capital (Tobin’s q), adversely affecting investment demand.

Tobin’s q is defined as market value of a firm over the replacement cost of its capital. As equity prices fall, the market value of the firm falls and at some stage it makes Tobin’s q less than unity. In that stage the firm has no incentive to undertake additional

capital expenditure. “ One way to look at q is that it represents the comparison between, on one hand, the marginal efficiency of capital, the internal rate of return on investment at its cost in the commodity markets, and on the other, the financial cost of capital, the rate at which investors discount the future returns from such discounts (Tobin, 1978).”

Tobin’s q can have wider application including the housing market. If the market value of a house turns out to be lower than its replacement cost then it may not make economic sense to undertake additional investment in construction. House is a very important collateral in the portfolio of the households. Once the value of this collateral falls, households’ ability to borrow and spend comes down. Even if the household is not borrowing, the very fact that the collateral value has come down reduces household spending. That is how house prices are considered a key indicator affecting aggregate demand.

Another important asset market is the equity market. As interest rate falls, equity prices rise. This increases the wealth of the households which prompts greater household spending that in turn raises the aggregate GDP. “From a monetarist viewpoint, in the event that an expansionary monetary policy results in increased money supply, the actual level of liquidity held by the public will exceed its desired level. This, in turn, leads market participants to seek to decrease liquidity at their disposal by buying equity, bonds and housing, which result in a rise in the respective prices. An increase in bond prices is automatically translated into a decrease in the interest rate, which is already under pressure through the interest rate channel. Falling interest rates will then increase the attractiveness of equities, fuelling equity purchases and causing equity prices to rise further (Egert and MacDonald, 2009)”. We now turn to the exchange rate channel.

4.1.3 Exchange rate channel

Exchange rate plays an important role in monetary transmission. Changes in interest rate affects exchange rate, which in turn affects both domestic, and import prices. Consequently it affects imports, exports and investment. The impact, however, would depend on the openness of the domestic economy – how big is the share of trade in GDP and how open is the capital account of the balance of payments (BoP)? It will also depend on the very nature of exchange rate regime that the country follows - whether a fixed exchange rate regime or a floating exchange rate regime. Even in the case of a floating

exchange rate regime, the transmission will depend on the extent of flexibility of the exchange rate. In most EMDEs, central banks intervene in their foreign exchange markets to limit volatility of the exchange rate, and hence a freely floating exchange rate is a rarity. Another important aspect is that transmission depends not only on the nominal exchange rate but also the real exchange rate, i.e., nominal exchange rate deflated by relative inflation between the home country and its trading partners.

In the case of a flexible exchange rate regime and an open capital account, the initial impact of an increase in the interest rate is that it makes deposits in domestic currency more attractive than those in foreign currencies, leading to an exchange rate appreciation. The precise impact, however, is uncertain. It depends on expectations about domestic and foreign interest rates and inflation, which may be affected by a policy change. Subsequently, the appreciation of the exchange rate will have a direct impact on the prices of tradable through imported goods and services. Finally, this will affect net exports and thus the overall GDP.

Typically pass-through of exchange rate to domestic prices lie in the range of 0 to 1, i.e., 0 meaning no pass through and 1 indicating full pass-through. Empirical literature suggests that pass-through is higher in the case of developing countries as compared to developed economies. In the case of both the set of countries, however, the pass-through is seen to be declining over time. The difference in pass-through can be attributed to changes in the macroeconomic environment, particularly the level and variability of inflation (Taylor, 2000). Moreover if the consumers have an opportunity to switch away from imported goods to domestic products, firms may be reluctant to pass on the full cost of exchange rate changes, which again limits the pass-through. However, such options may not always be there, for example net crude oil importing countries will find it hard not to pass on the exchange rate changes to domestic prices unless offset by subsidies. Hence pass-through is generally seen to be higher for intermediate goods like energy and raw materials as compared to final goods.

A depreciation of exchange rate should reduce imports by making import prices costly in domestic currency terms. Correspondingly it should increase exports as the price realisation for exporters in domestic currency will be higher. Accordingly exporters will be more willing to cut price to improve their export turnover. But this may not be as straight forward and it would depend on import intensity of exports. If the import

component of exports is very large, the price advantage would be offset to a large extent by higher import costs. The aggregate output of the economy would be impacted on the basis of what happens to net exports.

The overall impact will be determined by the price elasticity of exports and imports. The Marshall-Lerner condition indicates that the price elasticity of imports plus exports should be greater than unity for depreciation to improve net exports, and consequently overall output. There are also additional complications, if because of exchange rate pass-through domestic inflation picks up the real exchange rate becomes overvalued which can adversely impact exports.

It is seen that for developing countries import of capital goods is relatively high. If import prices go up because of exchange rate depreciation, domestic investment gets adversely affected. Thus the impact of exchange rate changes on output is ambiguous. But the essential point is that exchange rate does affect output besides its direct impact on domestic inflation. Now we turn to expectations channel.

4.1.4 Expectations channel

In market economies expectations play a very important role in monetary transmission. It is not always the current monetary policy action but the likely future actions that shape monetary transmission. It is, however, not very clear how economic entities and market participants form their expectations – whether in a forward looking manner or a backward looking manner or a combination of both. Boivin, Kiley, and Mishkin (2010) point out the important shifts in the practice of monetary policy, and hence potentially in its transmission to activity and inflation, is the manner in which the “management of expectations” has become an important tool of monetary authorities throughout the world. Shifts in the behaviour of the monetary authority can affect the transmission mechanism.

These effects have two forms, both of which are likely to be quantitatively important. First, expenditures depend directly on the expected path of policy rates through the influence of this path on asset prices. For example, if a rise in the policy rate is expected to be more persistent, the expectations hypothesis of the term structure indicates that the impact on long-term interest rates will be larger than if it is expected to be temporary. Second, the nature of the policy rule can have important feedback effects

through its influence on expected spending and inflation. For example, policy behaviour that responds strongly to deviations of output from potential and deviations of inflation from desired levels will lead to greater stability in expectations for income and inflation. This will impart greater stability in actual spending and inflation. Indeed, some research has emphasized the potential importance of changes in policy behaviour of this type in shifts in the aggregate impact of monetary policy actions (e.g., Boivin and Giannoni, 2006).

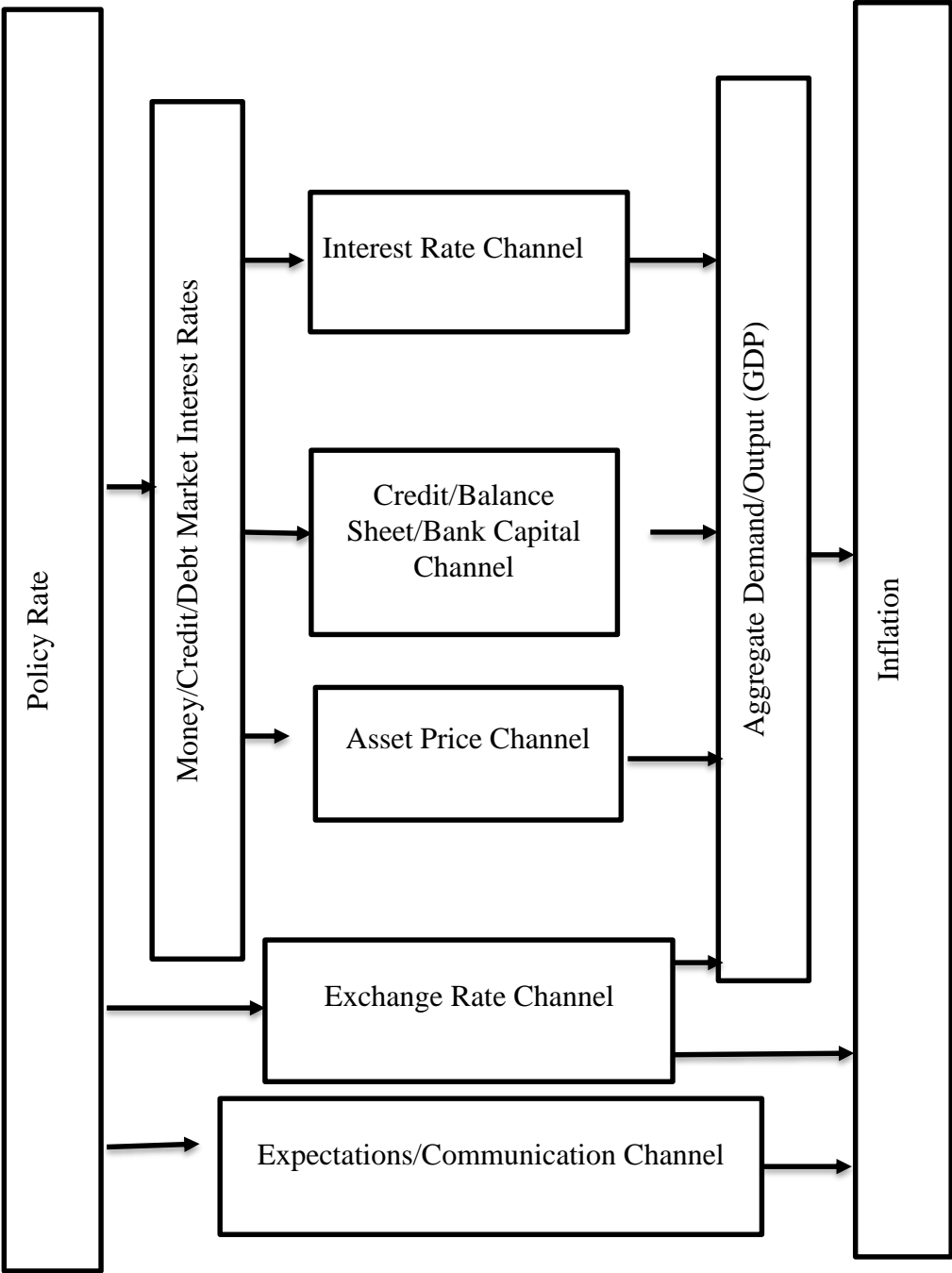
Financial market expectations about the future path of monetary policy are the driving force behind the behaviour of market interest rate and hence understanding how financial markets determine this policy path and what factors cause the policy path to change is central to understanding how monetary policy influences the entire term structure of interest rates (Gordon, 2004). In this context the central bank communication plays a critical role. While most central banks would refrain from giving an explicit guidance on the future path of policy rate, what markets infer from the guidance becomes important in markets' expectations formation.

Reviewing the growing literature on central bank communication Blinder et al. (2008) observe that, “the evidence suggests that communication can be an important and powerful part of the central bank’s toolkit since it has the ability to move financial markets, to enhance the predictability of monetary policy decisions, and potentially to help achieve central banks’ macroeconomic objectives.” As many central banks are adopting inflation targeting as their monetary policy framework, transparency and communication plays even a bigger role in achieving the desired monetary policy objectives.

4.2 Conclusion: Transmission Channels

Against this backdrop, a simple schematic presentation of channels of monetary transmission is illustrated in Chart 4.1. It shows that changes in monetary policy indicated by a change in the policy rate first transmits to the broader financial market and then through various traditional channels affects aggregate demand (output) and inflation. We examined this first round of transmission to the broader financial markets and across the term structure in the Indian context in Chapter 3.

Chart: 4.1 Schematic Presentation of Monetary Transmission



Often it is the output that gets impacted first before inflation gets impacted. Certain channels like exchange rate can simultaneously impact output and inflation. The expectations channel is believed to directly impact inflation for which central bank communication and credibility seem to play a major role. For EMDEs where central bank credibility is considered to be relatively low, it is the traditional channels which appear to dominate monetary transmission.

It is also not the case that a single channel of monetary transmission is operational at any time, various channels of monetary transmission would be operating at different strengths. That is how monetary policy transmission is termed 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. This is because not only different channels of monetary transmission tend to operate at the same time but also they change over time. As Bernanke and Gertler (1995) observed: to a large extent, empirical analysis of the effects of monetary policy has treated monetary transmission mechanism itself as a “black box”.

Changes in interest rate by the monetary authority could also induce movements in asset prices, which 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. At the same time, policy actions and announcements affect expectations about the future course of the economy and the degree of confidence with which these expectations are held.

On the output side, these changes affect the spending, saving and investment behaviour of individuals and firms in the economy. In a simplistic view, other things being equal, higher interest rates tend to encourage saving rather than spending. Similarly, a higher value of currency in the foreign exchange market encourages spending by making foreign goods less expensive relative to goods produced at home. So changes in the interest rate and exchange rate affect the demand for goods and services produced.

On the inflation front, the level of demand relative to domestic supply capacity - in the labour market and elsewhere - is a key influence on domestic inflationary pressure. If demand for labour exceeds the supply, there will be upward pressure on wages, which some firms will be able to pass into higher prices charged to consumers. Otherwise supply constraints could arise because of inadequate capacity or shortage of certain essential

goods. This scenario is more akin to EMDEs. In such a situation even if wages do not rise immediately, inflation could still increase significantly. Also, exchange rate movements have a direct effect on the domestic prices of imported goods and services, and an indirect effect on the prices of those goods and services that compete with imports or use imported inputs, and thus on the component of overall inflation.

In sum, monetary policy transmission is a complex process passing through various stages and at the same time showing time variation. Moreover, simultaneous occurrence of different channels makes it difficult to disentangle the impact of a particular channel of monetary transmission in an economy.

4.3 New Keynesian Synthesis

Among the various channels of monetary transmission, the interest rate channel is considered to be widely operational in market economies. Both theoretical and empirical work have built on the Keynesian interest rate channel culminating in the New Keynesian synthesis which incorporates both sticky prices and rational expectations into the interest rate channel of monetary transmission mechanism. New Keynesian models have emerged as workhorse models of central banks for monetary policy purposes.

Following Ireland (2005), the basic New Keynesian model can be illustrated as a system of three equations in three variables. The three variables are (i) output (y_t), (ii) inflation (π_t), and (iii) interest rate (i_t).

Equation (1) is the IS curve augmented with expectations. It suggests output in period t is equal to its expected value in the next period minus the ex-ante real interest rate which is obtained by subtracting the expected inflation from the nominal interest rate. The coefficient of real interest rate (σ) is taken as positive. Thus output in the current period is determined by its expected value in the next period and it has a negative relationship with the real interest rate. This would suggest that monetary policy could have an impact on output by changing the policy rate.

$$y_t = E_t y_{t+1} - \sigma(i_t - E_t \pi_{t+1}) \quad \dots\dots(1)$$

Equation (2) is the New Keynesian Phillips curve, which suggests that inflation in period t is determined by its expectational value in the next period plus the output in the current period. Here, how inflation expectations are formed is important for actual inflation outcome.

$$\pi_t = \beta E_t \pi_{t+1} + \gamma y_t \dots\dots\dots(2)$$

Equation (3) is a Taylor (1993) type policy reaction function, an interest rate rule, which basically suggests that policy rate, responds to both inflation and output. α is the weightage given by the central bank to inflation and Ψ is the weightage given to growth.

$$i_t = \alpha \pi_t + \psi y_t \dots\dots\dots(3)$$

These three equations taken together essentially represent the New Keynesian interest rate channel of monetary transmission. The central bank changes policy rate taking a view on how inflation and output are evolving. For example, if the central bank raises the policy rate then the real interest rate rises, as prices are sticky. With the rise in real interest rate households and firms cut down their spending as reflected in the IS curve. As aggregate demand falls, it brings down inflation as depicted by the Philips curve. Following the New Keynesian formulation of interest rate channel, we estimate a VAR model of three variables – policy rate, output and inflation – for India to test for the interest rate channel of monetary transmission in Chapter 5.

4.4 Literature Review: Theory and Evidence

In general, transmission mechanism is largely conditioned by the monetary policy framework, structure and depth of the financial system in which the central bank operates and the state of real economy. While there is vast empirical literature on monetary policy transmission for advanced economies, only a limited number of empirical studies have examined the monetary transmission mechanisms in emerging market and developing economies (EMDEs). This is understandable given the underdeveloped nature of financial markets and rapid structural changes in EMDEs. However, since the 2000s, analysis of monetary transmission mechanisms in EMDEs, including India, has gained prominence due to structural and economic reforms and subsequent transition to market oriented policy regimes.

In the literature, there is a general recognition that monetary policy affects real economy at least in the short run. However, there is no general agreement on the channel through which monetary policy influences the behaviour of output and prices. The theoretical explanations on monetary policy transmission have evolved over the years, with major episodes of crises playing an important role in prompting reevaluations of earlier tenets.

Keynes in his general theory of output and employment described the importance of interest rate channel of monetary policy transmission. Monetarist characterisation of transmission mechanism by Friedman and Schwartz (1963) emphasised the role of money supply besides other assets. Life cycle hypothesis by Ando and Modigliani (1963) emphasised the wealth effect, while Tobin (1969) highlighted the importance of the cost of capital and portfolio choice in the transmission of monetary policy. Woodford (2003) emphasized the role of expectations in monetary policy.

4.4.1 Empirical literature for advanced countries

Monetary policy transmission has been an issue of extensive research particularly since Bernanke's seminal article in 1986 which provided alternative explanations of real and nominal sources of prices for explaining money-income relationship. However, the findings on the efficacy of various channels of transmission remain an unresolved issue. Bernanke and Blinder (1988) pointed out the importance of credit channel of monetary policy transmission in the US. However, Romer and Romer (1990) did not find support for credit channel of monetary transmission.

Bernanke and Blinder (1992) studying monetary policy transmission in the US show that the interest rate on Federal funds is extremely informative about future movements of real macroeconomic variables. Further, using innovations to the funds rate as a measure of changes in policy, they present evidence consistent with the view that monetary policy works at least in part through "credit" (i.e., bank loans) as well as through "money" (i.e., bank deposits).

This lack of a consensus on the channels of monetary transmission can be clearly seen from the debate in a Symposium on 'The Monetary Policy Transmission' published in the Journal of Economic Perspectives in 1995. Taylor (1995) using a financial market prices framework reviewed the impact of monetary policy transmission on real GDP and

prices, and found the traditional interest rate channel to be an important channel. Obstfeld and Rogoff (1995) emphasised the importance of exchange rate channel and concluded that the conduct of monetary policy has international implications. Meltzer (1995) re-emphasised transmission through multiple asset prices, extending beyond interest rates, exchange rate and equity prices.

Bernanke and Gertler (1995) contested the efficacy of interest rate channel. They argued that monetary policy affects short-term interest rates but has little impact on long-term interest rates which can only have large effects on purchases of durable assets, implying monetary policy ineffectiveness. They argued that the puzzle could be resolved through the credit channel of transmission. Edwards and Mishkin (1995), however, doubted the effectiveness of the bank lending channel arguing that with financial innovations, banks were becoming increasingly less important in credit markets. Given these contrasting views, Mishkin (1995, 1996 and 2001) provided an overview on the working of various channels for better understanding of monetary policy transmission.

Notwithstanding the various theoretical perspectives and the lack of a consensus, several empirical studies have tried to identify the various channels of monetary policy transmission across a number of countries. Using VECM approach, Ramey (1993) found that the money channel was much more important than credit channel in explaining the direct transmission of monetary policy shock on the US economy. Recognising the importance of financial frictions despite developments in macroeconomics, Bean et al. (2002) highlighted the inadequacy of interest rate channel in explaining the impact of monetary policy shock on demand.

Roldos (2006) studies changes in Canada's monetary policy transmission following changes in financial structure using a VAR model which showed that, monetary policy had become more effective in the 1990s, when measured as the average impact of interest rate changes on the output gap, or alternatively, on aggregate demand.

In the euro area countries, Smets and Wouters (2002) found that monetary policy shock via the interest rate channel affected real output, consumption and investment demand. Angeloni et al. (2003) also found the interest rate channel to be the completely dominant channel of transmission in a few euro area countries, while being an important

channel in almost all of them. Where the interest rate channel was not dominant, either bank lending channel or other financial transmission channel was present.

Surveying the empirical studies on monetary policy transmission then, Loayza and Schmidt-Hebbel (2002) concluded that traditional interest rate channel was still the most relevant channel in influencing output and prices, while exchange rate channel became important in open economies. Recent survey by Boivin et al. (2010) also concluded that the neoclassical channels, i.e., direct interest rate effects on investment spending, wealth and inter-temporal substitution effects on consumption, and the trade effects through the exchange rate, continued to remain the core channels in macroeconomic modelling, while there was little evidence on the efficacy of bank-based non-neoclassical channels of transmission.

Empirical results also show that the experience of monetary policy of the US Federal Reserve (Fed) vis-à-vis the European Central Bank (ECB) during 2001-2007 was different. During this period, the Fed cut interest rates more vigorously than the ECB. By comparison with the Fed, the ECB followed a more measured course of action. Using a DSGE model with financial frictions, Christiano *et al.* (2008) found that the ECB's policy actions had a greater stabilising effect than those of the Fed. As a consequence, a potentially severe recession turned out to be only a slowdown, and inflation never departed from levels consistent with the ECB's quantitative definition of price stability. Other factors that account for the different economic outcomes in the euro area and the US include differences in shocks and differences in the degree of wage and price flexibility.

4.4.2 Empirical literature for EMDEs

A number of studies have also examined the efficacy of various channels in EMDEs with contrasting results. Using VAR framework, Disyatat and Vongsinsirikul (2003), in Thailand, found 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 the Philippines, Bayangos (2010) found the credit channel of monetary transmission to be important.

In Sri Lanka, Amarasekara (2008) found interest rate channel to be important for monetary policy transmission. Ghazanchyan (2014) studies the effectiveness of monetary policy instruments in Sri Lanka through interest rate, bank lending, exchange rate and

asset price channels in VAR models. He finds interest rate channel is the most important monetary policy transmission channel as it directly affects the decision making of economic agents.

In the case of South Africa, Kabundi and Nonhlanhla (2011) using a FAVAR framework concluded 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. Ncube and Ndou (2011) showed that monetary policy tightening in South Africa marginally weaken inflationary pressures through household wealth and the credit channel.

Mohanty and Turner (2008) argued that credible monetary policy frameworks put in place across EMDEs in recent years have strengthened the interest rate channel of monetary policy transmission. Acosta-Ormaechea and Coble (2011) comparing the monetary policy transmission in dollarised and non-dollarised economies found that the traditional interest rate channel was found to be more important in Chile and New Zealand while the exchange rate channel played a more substantial role in controlling inflationary pressures in Peru and Uruguay.

Mukherjee and Bhattacharya (2011) empirically examine the operation of the traditional Keynesian interest rate channel of the monetary policy transmission mechanism in five potential inflation targeting economies in the Middle East and North Africa (MENA) region and compare it with fourteen inflation targeting (IT) emerging markets and developing economies (EMDEs) using pooled ordinary least squares (OLS) with fixed effects, and find that private consumption and investment in both groups of countries are sensitive to movements in real interest rates.

Some studies, on the other hand, have argued that monetary policy transmission is weak in the EMDEs and low income countries. Reviewing monetary policy transmission in low income countries, Mishra et al. (2010) found that weak institutional mechanism impaired the efficacy of traditional monetary transmission channels viz., interest rate, bank lending, and asset price. Similarly, for a group of EMDEs, Bhattacharya et al. (2011) argued that the weakness in domestic financial system and the presence of a large and segmented informal sector led to ineffective monetary policy transmission. Based on VECM model, they suggested that the most effective mechanism of monetary policy

impacting inflation was through the exchange rate channel, while interest rates did not affect aggregate demand.

Bulíř and Jan Vlček (2015) study transmission mechanism in a sample of 16 countries that includes advanced, emerging market, and low-income countries, to test the functioning of the interest rate transmission mechanism along the yield curve. They find a robust link from short-term policy and interbank rates to longer-term bond yields. Furthermore, they find that the strength of the transmission mechanism seems to be affected by the choice of the monetary regime: countries with a credible inflation-targeting regime seem to have “better behaved” yield curves than those with other monetary regimes.

4.4.3 Studies for post global financial crisis period

The recent financial crisis has shown the inadequacy in monetary transmission mechanism through the traditional channels. Thus, during the post-crisis period, a number of studies have attempted to capture the additional dimensions of central bank policy that have been at the centre stage for policy transmission. While research prior to the crisis often cast doubts on the strength of the bank lending channel, evidence during crisis showed that bank specific characteristics, financial innovations, business models can have implications for provision of credit and smooth transmission of monetary policy. Therefore, the recent crisis has clearly highlighted the role of banks as a potential source of frictions in the transmission mechanism of monetary policy.

Cecchetti et al. (2009) emphasised that the disentangling effects of the various channels during the crisis period was difficult. They pointed out that the crisis, in fact, has exposed the inadequacy of models, which could not examine (i) the role that financial factors play in the monetary policy transmission process through various channels and (ii) how financial disturbances can be amplified and spill over to the real economy. Walsh (2009) argued that financial frictions, albeit not a part of consensus model of monetary policy, affect both the monetary policy transmission process and generate distortions in the real economy.

For the euro area, ECB (2010) found that during the recent episode of financial turmoil, nonstandard monetary policy measures undertaken to keep the interest rate pass-through channel operational proved to be effective. Trichet (2011) emphasised that even though non-standard measures helped restoring the monetary policy transmission during crisis, they needed to be pursued independently from standard measures.

Taylor and Williams (2010) viewed that though simple interest rate rules have worked well in transmitting the monetary policy, further research was needed that incorporates a wider set of models and economic environments, especially international linkages of monetary policy. Recognising the large scale use of unconventional monetary policy measures through quantitative easing during the recent crisis, Curdia and Woodford (2010) extended the basic New Keynesian model of monetary transmission mechanism to explicitly include the central bank's balance sheet. Highlighting the role of financial intermediaries in monetary policy transmission, Bean et al. (2010) have emphasised that the role of monetary policy in the run up to crisis was less through conventional monetary policy channels but more from 'risk taking channel'.

Bernanke (2011) and Yellen (2011) argued that the transmission channels through which unconventional and conventional monetary policy affect economic conditions are quite similar. However, Yellen (2011) highlighted the importance of 'portfolio balance channel' and 'expectations' channel during crisis. Analysing the impact of quantitative easing adopted during 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.

In short, crisis has highlighted two important aspects of monetary policy transmission. First, due to information asymmetries and other inefficiencies across financial markets, the conventional channels of monetary policy transmission may not always work effectively. In this context, a number of studies have underscored the importance of financial intermediaries' stability to facilitate a smooth transmission of policy. Second, when the traditional interest rate channel of the monetary policy transmission mechanism broke down after policy rates reached the zero lower bound during crisis, the role of unconventional policy measures became more prominent which worked mainly through asset price and expectations channels.

4.4.4 Empirical studies on India

A number of studies have also examined the importance of different channels of monetary policy transmission in India. The RBI Working Group on Money Supply (Chairman: Y.V. Reddy, 1998) pointed to some evidence of interest rate channel of monetary transmission. Al-Mashat (2003) using a structural VECM model for the period 1980:Q1 to 2002:Q4 found interest rate and exchange rate channels to be important in the transmission of monetary policy shocks on key macroeconomic variables. Bank lending was not an important channel due to the presence of directed lending under priority sector. On the other hand, Aleem (2010) studying credit channel, asset price channel and exchange rate channel of monetary policy transmission using VAR models for the period 1996:Q4 to 2007:Q4 found credit channel to be the only important channel of monetary transmission in India.

RBI (2005) using a VAR framework for the period 1994-95 to 2003-04 found that monetary tightening through a positive shock to the Bank Rate had the expected negative effect on output and prices with the peak effect occurring after around six months. Monetary easing through a positive shock to broad money had a positive effect on output and prices with peak effect occurring after about two years and one year, respectively. Further, exchange rate depreciation led to increase in prices with the peak effect after six months and a positive impact on output.

Mallick (2009) examines monetary transmission in India using a five-variable VAR. He finds that a contractionary monetary policy shock was associated with a weak but statistically significant reduction in real output in the second and third quarters after the shock. However, the effects on the price level were positive. Monetary policy shocks accounted for a small part of the forecast error variance in real output, leading Mallick to conclude that demand shocks have been of “relatively limited importance” in India.

Using cointegrated VAR approach, Singh and Kalirajan (2007) showed the significance of interest rate as the major policy variable for conducting monetary policy in the post-liberalised Indian economy, with CRR playing a complementary role. Patra and Kapur (2010) also found that aggregate demand responds to interest rate changes with a lag of at least three quarters. However, they pointed out that the presence of institutional

impediments in the credit market such as administered interest rates could lead to persistence of the impact of monetary policy up to two years.

Bhaumik et al. (2010) highlighted the importance of bank ownership in monetary policy transmission through the credit channel. Bhattacharya, Patnaik and Shah (2011) estimate a VECM and conclude that the monetary policy transmission mechanism in India is weak. They find evidence of incomplete, but statistically significant, exchange rate pass through. Pandit and Vashisht (2011) found that policy rate channel of transmission mechanism, a hybrid of the traditional interest rate channel and credit channel, works in India, as in other six EMDEs considered by them.

4.5 Stylised Facts on Monetary Policy in India during 1997-98 to 2014-15

Against the backdrop of mixed evidence on interest rate channel of monetary transmission, we briefly examine the stylised facts on how monetary policy was responding to changes in the macro economic outlook. Moreover, we trace how the levers of monetary operations were changing.

4.5.1 Activation of the Bank Rate

In 1997-98, the Indian economy had to contend with the spillover effect of the Southeast Asian crisis. The Bank Rate had to be raised sharply by 200 basis points to 11.0 percent to fend off capital outflows. While stability could be restored in the financial markets, real GDP growth slowed down to around 5.0 per cent. Subsequently the Bank Rate was reduced three times to 9.0 percent by April 1998.

From monetary policy perspective, 1997-98 was a watershed year as it marked the activation of interest rate as a tool of monetary policy. This is evident from the fact that between April 1997 and April 1998 the Bank Rate was changed 7 times. Prior to this the Bank Rate was changed only twice in 1991 in the wake of the Balance of payments (BoP) crisis. It is interesting that since the inception of the RBI in 1935 till March 1997, the Bank Rate had changed only 13 times. In 1997-98, the monetary policy framework of the RBI changed from monetary targeting to a multiple indicator approach.

In 1998-99, despite a variety of domestic and international uncertainties, the economy performed reasonably well with a higher real GDP growth of 6.0 per cent. The headline wholesale price index (WPI) inflation rate was 4.8 per cent by end-March 1999

notwithstanding a high inflation in the first half of the year due to food price pressures. This year also marked the introduction of a liquidity management strategy through an active use of fixed rate repo operations. In order to influence the long-term interest rate, the Bank Rate was revised downward thrice, from 10.5 per cent at end-March 1998 to 8.0 per cent by end-March 1999. The transmission mechanism of monetary policy seemed to be evolving towards greater significance of interest rates aided by financial sector reforms initiated earlier in the decade following the BoP crisis of 1991.

In 1999-2000, despite a number of difficult domestic and international developments, such as the Kargil conflict and the sharp increase in oil prices, the Indian economy registered a higher real GDP growth rate 6.4 per cent. The annual rate of WPI inflation was 6.5 per cent largely reflecting the impact of rise in administered oil prices.

4.5.2 Early evidence of interest rate channel of monetary transmission

“The flexibility to conduct monetary management in India was recognised and strengthened by the analytical work of the Reserve Bank's Working Group on Money Supply (1998). The Group reported that monetary policy exclusively based on monetary targets set by estimates of money demand could lack precision because while the money demand function exhibited parametric stability, predictive stability was less certain. The gradual emergence of rate variables such as interest rates with their growing sensitivity to financial developments and economic activity has contributed to the information content of quantity variables. Rate variables together with quantity variables would thus need to be used in the framework of multiple indicators to optimise management goals. In other words, the rate variables cannot be regarded as substituting for monetary targeting so long as the rate channel of transmission of policy has not evolved into a robust and reliable one. Such an outcome requires that certain conditions are satisfied, viz., the elimination of fiscal dominance in macroeconomic processes and of the connect between monetary and internal debt management, and the full integration of financial markets (RBI Annual Report 1999-2000).”

Against this background, the unveiling of the liquidity adjustment facility (LAF) with repo auctions in June 2000, as an operating aid to manage liquidity and influence the rate variables, gains importance. From most indications, it was already apparent that the

introduction of LAF helped the market participants to assess liquidity conditions better and facilitated the gradual adjustment in the interest rates to the realities of the market.

During the year 2000-01, the GDP growth at 5.2 per cent reflected the impact of two consecutive years of below-average monsoons, a downturn in industrial growth and the unprecedented severity of the Gujarat earthquake. The lower growth performance of 2000-01 was associated with signs of stability as inflation turned relatively benign towards the close of the year.

The operating procedures of monetary policy had undergone significant changes. The gradual switchover to indirect market-based instruments in the conduct of monetary policy was made possible because of simultaneous efforts at developing various segments of the financial market, particularly money, foreign exchange and government securities market.

The increasing responsibility of the Reserve Bank in undertaking reform in the financial markets ought to be seen essentially in the context of improving the effectiveness of the transmission channels of monetary policy. Development of financial markets encompassed regulatory and legal changes, building up of institutional infrastructure, constant fine-tuning in market microstructure and massive upgradation of technological infrastructure. An important development in the evolution of monetary policy in India was the activation of the Bank Rate as instrument of monetary policy in 1997. This was followed up with a more active recourse to repo operations, leading to an orderly progress to a full-fledged LAF.

Monetary and financial conditions also continued to remain stable in 2001-02. The monetary and credit policy for 2002-03 was reinforced by favourable developments in the form of low inflation, ample liquidity in financial markets, continuing capital inflows and a substantial build-up of foreign exchange reserves. The return to high growth in 2003-04 brought with it renewed business optimism and consumer confidence in the near-term outlook for the economy and a wider appreciation regarding India's potential for growth. Inflation hardened in 2004-05 mainly on account of the influence of international price movements in respect of crude oil and metals.

4.5.3 Recognition of the influence of globalisation on monetary policy

In its Annual Report for 2004-05, the RBI talked about consolidating the gains obtained in recent years from reining in inflationary expectations given the volatility in the inflation rate during 2003-04 and subsequent spikes in headline inflation during 2004-05: “It is important to appreciate that sustained efforts over time have helped to build up confidence in price stability. Inflationary expectations can turn adverse in a relatively short time if noticeable upward movements in prices continue to take place.”

Interestingly the RBI also recognised the impact of global developments on domestic monetary policy: “With the growing financial integration across borders, the conduct of monetary policy is becoming increasingly complex. It is not a coincidence that most of the uncertainties facing monetary policy at the present juncture are essentially international in character. The path of inflation is governed not only by domestic economic activity, but also by the extent of liquidity emanating from capital flows and the movements in international commodity prices. Although the policy objectives remain rooted in the domestic macroeconomic circumstances, the process of monetary policy formulation has to factor in global macroeconomic developments, particularly, trends in world economic growth and trade, international price trends and movements in international interest rates and exchange rates.”

With a view to managing liquidity pressures emanating from large and persistent capital flows, sterilisation operations were undertaken through the liquidity adjustment facility (LAF) and open market operations, supported by the Market Stabilisation Scheme (MSS). With increasing globalisation of the Indian economy and greater integration of the financial markets it was becoming apparent that the frequency of monetary policy making twice a year was becoming inadequate. While the RBI had the flexibility to announce monetary policy actions any time during the year it was not the same as more frequent structured communication practiced by major central banks. The RBI, therefore, announced major changes in its monetary policy formulation process.

4.5.4 Monetary policy formulation becomes more frequent and broad-based

With a view to further strengthening the consultative process in monetary policy, the Reserve Bank, in July 2005, set up a Technical Advisory Committee on Monetary Policy with external experts in the areas of monetary economics, central banking, financial

markets and public finance. The Committee was expected to meet at least once in a quarter to review macroeconomic and monetary developments and advise the Reserve Bank on the stance of monetary policy. The views of the Advisory Committee were discussed in the following meeting of the Committee of the Central Board (CCB) of the Reserve Bank. Concomitantly, the Reserve Bank switched to a quarterly announcement of monetary policy while retaining the flexibility to take specific measures as the evolving circumstances warrant. The First Quarter Review, the first in the series, was released on July 26, 2005.

The Indian economy recorded strong growth during this period, which averaged 8.6 per cent per annum during the four-year period ended 2006-07. Underlying inflationary pressures were also rising in parts because of faster growth and occasional supply shocks emanating from food and crude oil prices. This prompted the RBI not only to reiterate its self-imposed medium-term ceiling on WPI headline inflation at 5.0 per cent but also to set a more ambitious target on inflation: "In recognition of India's evolving integration with the global economy and societal preferences in this regard, the resolve, going forward, would be to condition policy and expectations for inflation in the range of 4.0-4.5 per cent. This would help in maintaining self-accelerating growth over the medium-term, keeping in view the desirability of inflation at around 3 per cent to ensure India's smooth global integration."

The RBI also recognised the challenges of conducting monetary policy in absence of a representative consumer price index: "In the context of inflation, it may be noted that, globally, consumer price inflation is the preferred indicator of central banks for assessing inflationary conditions. On the other hand, in India, wholesale price inflation has emerged as the key measure of assessing inflationary pressures, partly due to its availability on a higher frequency (weekly basis) and partly due to the absence of a comprehensive measure of consumer price inflation in the country."

There were four measures of consumer price inflation in India; these measures, compiled on the basis of occupational classification and residence, cater to the specific needs of the user groups. The multiple consumer price indices, in view of differences in weighting diagrams of the commodity baskets, can lead to divergences in inflation numbers, especially in the short-run, and this constrains the assessment of inflationary pressures in the economy. At the same time, the limitations of the wholesale price index

were well recognised; in particular, its coverage was restricted to prices of goods while the growing services sector was excluded. In recognition of these limitations, the Reserve Bank attempts to extract information available from all the price indices (Reserve Bank of India Annual Report, 2006-07).

4.5.5 Impact of global financial crisis on monetary policy

Global financial markets witnessed turbulent conditions during the most part of 2007-08 as losses on US sub-prime mortgage loans escalated into widespread financial stress, raising fears about stability of banks and other financial institutions. The crisis in the sub-prime mortgage market gradually deepened and spilled over to markets for other assets.

The Indian economy continued to perform well during 2007-08, with a GDP growth rate of 9 per cent but an upsurge in inflation in India occurred at a time when global commodity prices were volatile and at historically elevated levels. Net capital flows to India increased sharply to US \$ 108.0 billion (or 9.2 per cent of GDP) during 2007-08, which were 2.4 times higher than the level in 2006-07. Large net capital flows, which were significantly higher than the current account deficit, led to an accretion of foreign exchange reserves, placing continued pressure on monetary management.

In view of the progressive build-up of underlying inflationary pressures, monetary policy recognised the need to smoothen and enable the adjustment of demand on an economy-wide basis so that inflation expectations were contained. Accordingly, the Reserve Bank continued taking monetary tightening measures. The cash reserve ratio (CRR) was increased by 300 basis points in phases from 6.0 per cent in March 2007 to 9.0 per cent by August 2008. The repo rate under the liquidity adjustment facility (LAF) was increased in phases by 150 basis points from 7.5 per cent in March 2007 to 9 per cent by July 2008.

The Indian economy exhibited five successive years of high growth with moderate inflation and macroeconomic stability during 2003-08, before encountering the contagion from the global economic crisis in 2008-09. The average GDP growth of 8.8 per cent achieved during this phase was not only the highest ever-recorded in India's post-independence economic history, but also one of the highest in the world in the recent period. More importantly, inflation in India averaged at about 5.3 per cent during this period.

As the global economy veered towards recession, commodity prices fell sharply. This was reflected in a decline in headline inflation in India, as measured by year-on-year variations in the WPI to under 1.0 per cent by end March 2009 from the peak of about 13 per cent in August 2008. However, this was cold comfort as consumer price inflation remained high. The divergent trends in inflation as measured by the WPI and CPIs once again brought out the measurement issues as well as the choice of an appropriate price index for monitoring changes in price levels at the national level that could be used as the reference indicator for conduct of policies.

While inflationary pressures remained, the Reserve Bank had lowered the repo rate by 425 basis points, the reverse repo rate by 275 basis points and the CRR by 400 basis points over a period of about seven months between October 2008 and April 2009 as a response to the global crisis. The overall provision of potential liquidity through conventional as well as several non-conventional liquidity windows was close to ₹ 5.6 trillion, or equivalent of about 9.0 per cent of GDP.

4.5.6 Inflation becomes generalised post global financial crisis

In 2009-10, the focus of macroeconomic policy shifted from containing the contagion of the global crisis to management of recovery. Nevertheless the reform process continued to make the financial system more responsive. With a view to imparting transparency to the loan pricing process, and improving the assessment of monetary policy transmission and promoting competition in the credit market, the Reserve Bank introduced a new system of “base rate” in July 2010, which replaced the earlier BPLR system.

Even as growth reverted to its trend, new challenges emerged. First, the headline inflation accelerated from the negative levels in mid-2009 to double digits during March-July of 2010. The whole of 2010-11 was marked by inflation persistence, with headline inflation averaging 9.6 per cent. The Reserve Bank responded to the inflation challenge through calibrated monetary policy normalisation. It raised repo rate seven times during the year by 25 basis points (bps) each. Despite these actions, inflation remained elevated due to both newer supply-side shocks and demand factors. As input costs rose and were passed on substantially amidst strong consumption demand, inflation became generalised.

Growth had averaged 8.8 per cent during 2005-06 to 2010-11, despite a low of 6.7 per cent in 2008-09 due to the external shock. Structural bottlenecks and governance issues primarily exacerbated the subsequent slowdown, although high inflation, monetary tightening and global factors also played a role.

The year 2012-13 was marked by slowing growth, lingering inflation, large fiscal and current account gaps and deteriorating asset quality. Thus, monetary policy was faced with a Hobson's choice. With growth decelerating further and staying below trend for the second consecutive year, ordinarily the policy response would have been an accommodative monetary policy. The Reserve Bank did ease monetary policy, but in a calibrated manner. There was clearly a demand from industry and financial markets for a more aggressive easing. At the same time, there were worries that consumer price inflation was hurting people and that the Reserve Bank was not able to subdue inflation. Persisting inflation was eroding the competitive efficiency of the economy and lowering the financial savings of households with its adverse consequences for the current account deficit (CAD), investment and long-term growth. The Reserve Bank further calibrated monetary tightening in line with the evolving macroeconomic dynamics.

4.5.7 Fed taper tantrum increases monetary policy challenges

The year 2013-14 began with tumultuous changes. The indication by the US Federal Reserve (Fed) that it would unwind part of the monetary stimulus earlier than anticipated led to severe tightening in financial conditions. Currencies of the Emerging Market and Developing Economies (EMDEs) depreciated speedily. This, in turn, led to a decline in equity prices as portfolio shifts occurred from EMDEs to US markets. Political unrest in parts of the Middle East also put upward pressure on global oil prices.

The economy had to face serious challenges to stability in 2013-14 emanating from exchange rate pressures amid capital outflows, persistence of near double digit inflation, fiscal imbalances and a decline in investment. This prompted the Reserve Bank and the government to take several measures to stabilise the economy. Monetary and fiscal policies, therefore, needed to maintain caution during 2014-15 so that the gains in macro-stability are preserved and the disinflationary momentum gathers traction.

4.5.8 Move to a flexible inflation targeting framework

In the backdrop of inflationary pressures and persistent divergence between WPI and CPI inflation, the RBI moved to review its monetary policy framework. With the annual average consumer price inflation touching double digits for six years, establishing a credible nominal anchor to rein in inflation and anchor inflation expectations assume importance. Against this backdrop, the Reserve Bank constituted an Expert Committee to Revise and Strengthen the Monetary Policy Framework (Chairman: Dr. Urjit Patel). Following the Expert Committee's recommendation, the Reserve Bank in January 2014 adopted a glide path for disinflation based on a CPI inflation. A combination of favourable factors such as the collapse of international commodity prices, particularly of crude, and loss of pricing power among corporates due to weakening demand as well as pro-active supply management and deregulation of key fuel prices worked in alignment with a disinflationary monetary policy stance to moderate inflation significantly in 2014-15.

A chronology of monetary policy actions in India for the years 2001-02 to 2014-15 is given in Annex 4.1.

4.6 Conclusion: Stylised Facts on Monetary Policy in India

During the period 1997-98 to 2014-15, monetary policy had to contend with several external and internal shocks. The monetary policy framework for this period could be characterised as one of multiple indicators approach which was implemented following the breakdown of the monetary targeting framework. At the same times towards the mid-2010s, the multiple indicators approach was under strain as inflation expectations rose and consumer price inflation diverged significantly from the wholesale price inflation. At the same time, this was a period monetary reforms and liberalisation in the financial markets continued to give greater importance to market-based price discovery. This period saw India recording its highest growth and surge in external capital inflows. This created additional challenge for monetary policy. There were periods of price stability interspersed with years of inflationary pressures.

At the beginning of the period monetary policy framework transited from monetary targeting to a multiple indicator approach, which continued to be followed till the end of the period when the Reserve Bank signalled its intention to move to a flexible inflation targeting.

With the evidence that interest rate was gaining in importance in monetary transmission, progressive changes were made to transit from a quantity-based monetary operating framework to an interest rate based framework with the institutionalisation of the Liquidity Adjustment Facility (LAF). The various interest rates from the Reserve Bank were aligned to the policy repo rate, which emerged as the key rate for signalling the change of monetary policy stance.

The frequency of structured policy announcements was increased, and policymaking became more consultative with the institution of an external Technical Advisory Committee (TAC) on Monetary Policy. The influence of the global economy in domestic monetary policy making was clearly recognised in the mid-2000s with increasing openness of the economy. This had strong implications in terms of the inflation target that India should aim at. It could not be very different from a globally acceptable norm, which is around 2 per cent for advanced countries and 3-4 per cent for EMDEs. Policy statements talked about containing inflation expectations in the range of 3-4 per cent. But this was more of a self-imposed aspiration rather than a formal one built into the policy. During this period, while the economy was undergoing rapid structural transformation the foundations of a market-based monetary policy was reinforced.

Annex 4.1: Monetary Policy Actions in India: 2001 to 2015

Date	CRR	Bank Rate	SLR	Repo Rate	Reverse Repo Rate	Marginal Standing Facility	Monetary Policy Stance
27-Apr-01	8.00	7.00	25.0	9.00	6.75		Provision of adequate liquidity, vigil on price level and greater flexibility to the interest rate regime in the medium term
30-Apr-01				8.75			
19-May-01	7.50						
28-May-01					6.50		
7-Jun-01				8.50			
23-Oct-01		6.50					
3-Nov-01	5.75						
29-Dec-01	5.50						
5-Mar-02					6.00		
28-Mar-02				8.00			
1-Jun-02	5.00						
27-Jun-02					5.75		
30-Oct-02		6.25			5.50		
12-Nov-02				7.50			
16-Nov-02	4.75						
3-Mar-03					5.00		
7-Mar-03				7.10			
19-Mar-03				7.00			
30-Apr-03		6.00					
14-Jun-03	4.50						
25-Aug-03					4.50		Price stability and maintaining monetary and interest rate environment conducive to growth and financial stability
31-Mar-04				6.00			
18-Sep-04	4.75						
2-Oct-04	5.00						
27-Oct-04					4.75		
29-Apr-05					5.00		
26-Oct-05				6.25	5.25		
24-Jan-06				6.50	5.50		
8-Jun-06				6.75	5.75		
25-Jul-06				7.00	6.00		
31-Oct-06				7.25			

Date	CRR	Bank Rate	SLR	Repo Rate	Reverse Repo Rate	Marginal Standing Facility	Monetary Policy Stance
23-Dec-06	5.25						Price stability, anchoring inflation expectations, maintaining growth momentum and financial stability, credit quality and credit delivery
6-Jan-07	5.50						
31-Jan-07				7.50			
17-Feb-07	5.75						
3-Mar-07	6.00						
31-Mar-07				7.75			
14-Apr-07	6.25						
28-Apr-07	6.50						
4-Aug-07	7.00						
10-Nov-07	7.50						
26-Apr-08	7.75						
10-May-08	8.00						
24-May-08	8.25						
12-Jun-08				8.00			
25-Jun-08				8.50			
5-Jul-08	8.50						
19-Jul-08	8.75						
30-Jul-08				9.00			
30-Aug-08	9.00						
11-Oct-08	6.50						
20-Oct-08				8.00			Price stability, anchoring inflation expectations, financial stability and financial inclusion
25-Oct-08	6.00						
3-Nov-08				7.50			
8-Nov-08	5.50		24.0				
8-Dec-08				6.50	5.00		
5-Jan-09				5.50	4.00		
17-Jan-09	5.00						
5-Mar-09				5.00	3.50		
21-Apr-09				4.75	3.25		Contain inflation, anchor inflation
7-Nov-09			25.0				

Date	CRR	Bank Rate	SLR	Repo Rate	Reverse Repo Rate	Marginal Standing Facility	Monetary Policy Stance
13-Feb-10	5.50						expectations and maintain an interest rate regime consistent with price, output and financial stability
27-Feb-10	5.75						
19-Mar-10				5.00	3.50		
20-Apr-10				5.25	3.75		
24-Apr-10	6.00						
2-Jul-10				5.50	4.00		
27-Jul-10				5.75	4.50		
16-Sep-10				6.00	5.00		
2-Nov-10				6.25	5.25		
18-Dec-10			24.0				
25-Jan-11				6.50	5.50		
17-Mar-11				6.75	5.75		
3-May-11				7.25	6.25	8.25	
16-Jun-11				7.50	6.50	8.50	
26-Jul-11				8.00	7.00	9.00	
16-Sep-11				8.25	7.25	9.25	
25-Oct-11				8.50	7.50	9.50	
28-Jan-12	5.5						Provision of comfortable liquidity to meet required credit growth, price stability, well anchored inflation expectations and orderly conditions in financial markets
13-Feb-12		9.50 Technical Adjustment					
10-Mar-12	4.75						
17-Apr-12		9.00		8.00	7.00	9.00	Contain inflation and anchor inflation expectations, support a sustainable growth path over the medium-term and provide liquidity to facilitate credit availability to productive sectors
11-Aug-12			23.00				
22-Sep-12	4.50						
03-Nov-12	4.25						
29-Jan-13		8.75		7.75	6.75	8.75	
09-Feb-13	4.00						
19-Mar-13		8.50		7.50	6.50	8.50	
03-May-13		8.25		7.25	6.25	8.25	

Date	CRR	Bank Rate	SLR	Repo Rate	Reverse Repo Rate	Marginal Standing Facility	Monetary Policy Stance
15-July-13		10.25				10.25	Address the risks to macroeconomic stability from external shocks, continue to address the heightened risks to growth, guard against re-emergence of inflation pressures, manage liquidity conditions to ensure adequate credit flow to the productive sectors of the economy
20-Sep-13		9.50		7.50	6.50	9.50	
07-Oct-13		9.00				9.00	
29-Oct-13		8.75		7.75	6.75	8.75	
28-Jan-14		9.00		8.00	7.00	9.00	To achieve the glide path for inflation recommended by the Expert Committee to Revise and Strengthen the Monetary Policy Framework (January 2014); as also in line with the Agreement on Monetary Policy Framework (February 2015). SLR was sequentially reduced to create room for banks to increase their lending to productive sectors.
14-Jun-14			22.50				
09-Aug-14			22.00				
15-Jan-15		8.75		7.75	6.75	8.75	
07-Feb-15			21.50				
04-Mar-15		8.50		7.50	6.50	8.50	

Source: Updated from Report of the Working Group on Operating Procedure of Monetary Policy, RBI, March 2011.

Chapter 5

Empirical Model on Interest Rate Channel

The key question in monetary policy is how the change in the principal policy instrument impacts the ultimate objectives of growth and inflation? It is not an easy question to examine given the long and variable lags with which monetary policy impacts the ultimate objectives. Moreover, the process through which monetary policy transmits to the ultimate objectives is not very clear and hence it is termed as a ‘black box’. There is also the additional challenge of examining monetary policy transmission for emerging market and developing economies like ours, which are undergoing rapid structural changes.

There are also issues of underdeveloped nature of the financial market and availability of consistent data series for a reasonable length of time. Notwithstanding these challenges, in this Chapter we set up and estimate our empirical models to examine two key questions: One, how does the policy interest rate of the Reserve Bank of India impact economic growth and inflation in India? Two, what role does liquidity plays in monetary transmission in India? While there are studies on the first issue, there is perhaps no empirical work on the second issue to the best of our knowledge.

5.1 Unrestricted VAR Model

We set up a Vector Auto Regressive (VAR) model of three variables – policy interest rate, output growth and inflation – based on quarterly data for a period of 16 years beginning from the financial year 1999-2000 ending with 2014-15. This yields us 64 data points, which can be considered adequate for a three variable VAR model.

The choice of the time period was dictated primarily by four considerations: First, interest rate as a primary policy tool came to be used actively only starting from the 2000s once the liquidity adjustment facility (LAF) was put in place (Chapter 2). Second, this period was characterised by a single monetary framework known as a “multiple indicators approach”. Prior to this period monetary policy followed a monetary targeting approach and subsequent to this period, the Reserve Bank moved to a flexible inflation-targeting

regime. Third, during this period the wholesale price index (WPI) was the headline inflation, i.e., the Reserve Bank was responding to WPI inflation in its monetary policy action. Fourth, a consistent quarterly Gross Domestic Product (GDP) series is available only towards the latter part of the 1990s. This provides us the opportunity to assess the impact of monetary policy on the entire economy.

We represent the policy rate by the overnight weighted average call money rate (CMR_AVG), as there was no unique policy rate for the period under consideration. This was because, as discussed in detail in Chapter 2, during the period of excess liquidity it was the reverse repo rate, which served as a policy rate by providing a floor to the overnight call money rate. Similarly, during the period of deficit liquidity it was the repo rate that served as a policy rate by providing a ceiling to the overnight call money rate. It was not until May 2011 that the Reserve Bank of India (RBI) formally articulated a single policy rate. Moreover, given the high correlation of overnight call money rate with both the reverse repo rate and the repo rate, depending on the liquidity situation, we take CMR_AVG as a proxy for the policy rate.

We take the year-on-year quarterly real GDP growth rate at factor cost at 2004-05 prices as an indicator of changes in real output. We take the year-on-year quarterly variation in the Wholesale Price Index (WPI) with the base 2004-05=100 as an indicator of inflation. It is worth clarifying that during the period of our study, it was the WPI inflation, which was the formal indicator of inflation articulated by the RBI for policy purposes. It is only in 2014-15 that the RBI signalled its intention to switch to Consumer Price Index (CPI) based inflation for policy purposes.

In a simultaneous equation framework VAR is considered to be an appropriate technique. It obviates the necessity to *a priori* identification of certain variables as endogenous and others as exogenous. According to Sims (1980) who developed VAR model, “if there is simultaneity among a set of variables, then all these variables may be treated in the same way. In VAR modelling, the value of a variable is expressed as a linear function of its lagged values and all other variables included in the model” (Bhaumik, 2015).

Moreover, VAR also allows for placing restrictions on variables on *a priori* theoretical grounds besides inclusion of exogenous variables, which we will return to a

little later when we estimate a Structural VAR (SVAR). Thus the VAR model provides considerable flexibility, which perhaps explains its wider usage in monetary policy analysis.

5.2 Relationship among Growth, Inflation and Policy Rate

We now turn to look at the summary statistics of the three variables under consideration (Table 5.1). The WPI inflation rate averaged 5.7 percent with the median rate following closely at 5.8 percent during the period under consideration. It varied in a wider range of -1.8 to 11.0 percent during the period. The GDP growth rate averaged 6.9 percent with the median rate being a little lower at 6.6 percent. It varied in the range of 1.7 to 11.4 percent during the period. The call money rate averaged 6.7 percent with the median rate a little higher at 6.9 percent. It varied in the relatively narrower range of 3.2 to 10.4 percent during the period.

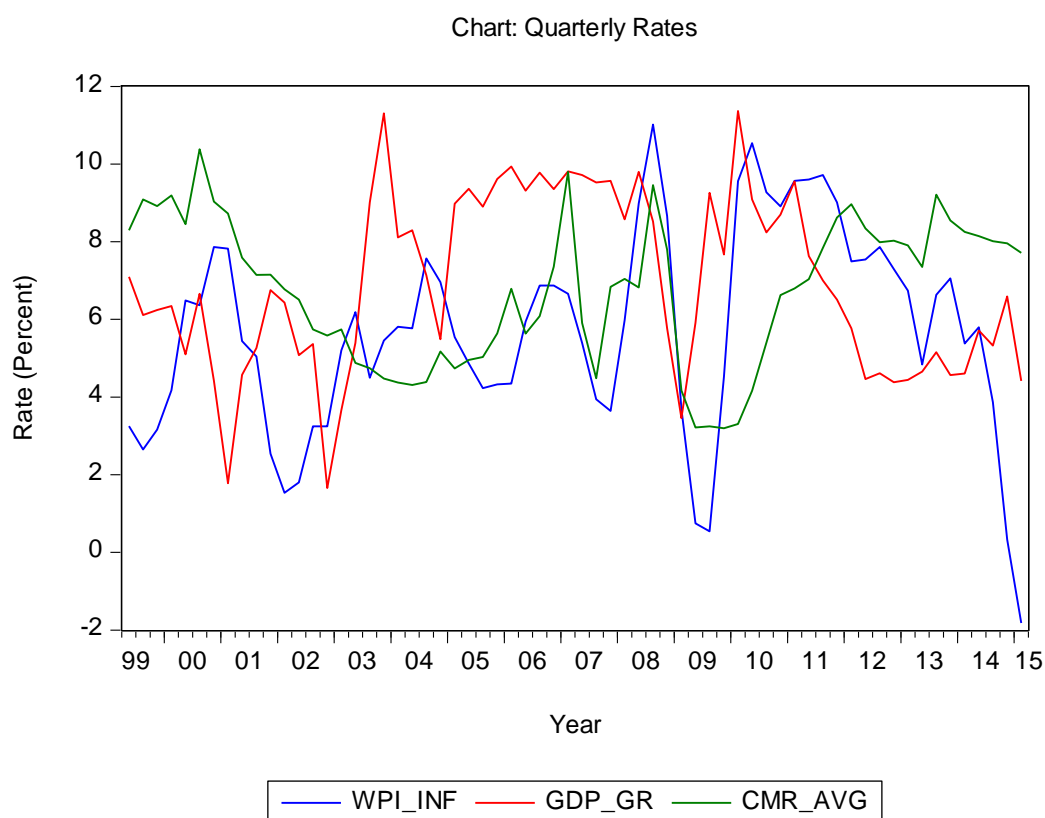
Table 5.1: Summary Statistics of Quarterly Model

	WPI_INF	GDP_GR	CMR_AVG
Mean	5.688695	6.920394	6.735758
Median	5.781900	6.624900	6.936700
Maximum	11.01520	11.36850	10.38330
Minimum	-1.818900	1.656100	3.200000
Std. Dev.	2.656186	2.280960	1.854934
Skewness	-0.321819	-0.082869	-0.214071
Kurtosis	2.995730	2.193487	2.038183
Jarque-Bera	1.104766	1.807820	2.955726
Probability	0.575576	0.404983	0.228125
Sum	364.0765	442.9052	431.0885
Sum Sq. Dev.	444.4856	327.7751	216.7693
Observations	64	64	64

5.2.1 Real policy rate shows phases of both positive and negative values

The quarterly data are plotted in Chart 5.1. It shows that the call money rate remained above the inflation rate at the beginning of the period. The call money rate, however, dipped below the inflation rate following the global financial crisis in 2008 as the RBI lowered the policy rate to respond to the crisis. It has since moved over the inflation rate, and the gap is quite noticeable in 2014-15, as the WPI inflation rate has turned negative. Thus the period shows a phase of positive real policy rate, followed by a phase of negative real policy rate after the global financial crisis as policy rate was lowered and inflation rose and now there is a phase of positive real policy rate.

Chart 5.1: Quarterly Growth, Inflation and Policy Rate



One could see a phase of high GDP growth rate during 2003-04 to 2007-08. During this period the inflation rate generally remained moderate. The policy rate was broadly above the inflation rate, which would mean that the real policy rate was positive. Thus, during this high growth phase of 2003-04 to 2007-08 inflation remained contained despite high growth. Subsequently, as the RBI reduced policy interest rate sharply responding to the global financial crisis (Chapter 4), inflation rose and real policy rate

turned significantly negative. Following normalisation of monetary policy, in the more recent period, policy rate has turned positive. Of course, supply shocks with two consecutive years of below normal monsoon rains and high global commodity prices played a major role in inflation up tick. Apart from normalisation of policy rate, lower commodity prices, particularly crude oil prices have played a role in the sharp down turn in WPI inflation during 2014-15. While supply shocks come and go, it is again the aggregate demand that shapes inflation outcome over the medium-term.

5.3 Variable Unit Root Tests

We now turn to estimating the VAR model of our chosen three variables. The first step is to ensure that the variables are $I(0)$, i. e., they are stationary. We have earlier discussed the unit root test procedure in detail in Chapter 3. VAR models are generally estimated for stationary variables. We first use both ADF and PP to test for the presence of unit root.

For the inflation rate (WPI_INF), ADF test rejects the presence of unit root at 1% level of confidence while the PP test fails to do so. Since it is a rate of change and not in a level form we accept the more restrictive ADF results and conclude that WPI_INF is a stationary series. In the case of GDP growth rate (GDP_GR) both ADF and PP tests reject the presence of unit root at 5% level of confidence. Hence, we accept that GDP_GR is a stationary variable.

As regards interest rate (CMR_AVG), it turns out to be a borderline case with both ADF and PP tests not able to reject the presence of unit root at 10% level of confidence but indicating the series to be stationary at 11.5% level of confidence. However, considering that the monthly series of CMR_AVG was stationary as we examined in Chapter 3, we are inclined to accept that it is a stationary series but not without doing further tests. We conduct Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, which confirms that CMR_AVG is a stationary series at 1% level of confidence. Overall, therefore, we infer that all the three variables are stationary. The details of unit root tests are given in Table 5.2.

Table 5.2: Unit Root Tests for the Quarterly Model

Null Hypothesis: WPI_INF has a unit root Exogenous: Constant Lag Length: 1 (Automatic - based on SIC, maxlag=10)				Null Hypothesis: WPI_INF has a unit root Exogenous: Constant Bandwidth: 4 (Newey-West automatic) using Bartlett kernel					
t-Statistic Prob.*				Adj. t- Stat Prob.*					
Augmented statistic	Dickey-Fuller	test-	4.629857	0.0004	Phillips-Perron test statistic	-2.354761	0.1586		
Test critical values:	1% level	-	3.540198	-	Test critical values:	1% level	-3.538362		
	5% level	-	2.909206	-		5% level	-2.908420		
	10% level	-	2.592215	-		10% level	-2.591799		
*MacKinnon (1996) one-sided p-values.				*MacKinnon (1996) one-sided p-values.					
Augmented Dickey-Fuller Test Equation Dependent Variable: D(WPI_INF) Method: Least Squares Date: 12/18/15 Time: 15:01 Sample (adjusted): 12/01/1999 3/01/2015 Included observations: 62 after adjustments				Residual variance (no correction) 2.725160 HAC corrected variance (Bartlett kernel) 3.369141					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Phillips-Perron Test Equation Dependent Variable: D(WPI_INF) Method: Least Squares Date: 12/18/15 Time: 15:02 Sample (adjusted): 9/01/1999 3/01/2015 Included observations: 63 after adjustments				
WPI_INF(-1)	-0.347914	0.075146	4.629857	0.0000	Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(WPI_INF(-1))	0.644830	0.109723	5.876913	0.0000	WPI_INF(-1)	-0.169980	0.085255	1.993785	0.0507
C	1.993249	0.473731	4.207554	0.0001	C	0.906712	0.538374	1.684169	0.0973
R-squared	0.410195	Mean dependent var	0.072103		R-squared	0.061180	Mean dependent var	-0.080506	
Adjusted R-squared	0.390202	S.D. dependent var	1.730145		Adjusted R-squared	0.045789	S.D. dependent var	1.717431	
S.E. of regression	1.351063	Akaike criterion	3.486837		S.E. of regression	1.677650	Akaike criterion	3.903896	
Sum squared resid	107.6968	Schwarz criterion	3.589763		Sum squared resid	171.6851	Schwarz criterion	3.971932	
Log likelihood	-105.0919	Hannan-Quinn criter.	3.527248		Log likelihood	-120.9727	Hannan-Quinn criter.	3.930655	
F-statistic	20.51656	Durbin-Watson stat	1.828813		F-statistic	3.975178	Durbin-Watson stat	1.007618	
Prob(F-statistic)	0.000000				Prob(F-statistic)	0.050652			

Null Hypothesis: GDP_GR has a unit root					Null Hypothesis: GDP_GR has a unit root				
Exogenous: Constant					Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=10)					Bandwidth: 0 (Newey-West automatic) using Bartlett kernel				
<hr/>					<hr/>				
			t-Statistic	Prob.*				Adj. t-Stat	Prob.*
<hr/>					<hr/>				
Augmented Dickey-Fuller test statistic			-2.913179	0.0494	Phillips-Perron test statistic			-2.913179	0.0494
Test critical values:	1% level		-3.538362		Test critical values:	1% level		-3.538362	
	5% level		-2.908420			5% level		-2.908420	
	10% level		-2.591799			10% level		-2.591799	
<hr/>					<hr/>				
*MacKinnon (1996) one-sided p-values.					*MacKinnon (1996) one-sided p-values.				
<hr/>					<hr/>				
Augmented Dickey-Fuller Test Equation					Phillips-Perron Test Equation				
Dependent Variable: D(GDP_GR)					Dependent Variable: D(GDP_GR)				
Method: Least Squares					Method: Least Squares				
Date: 12/18/15 Time: 15:00					Date: 12/18/15 Time: 15:01				
Sample (adjusted): 9/01/1999 3/01/2015					Sample (adjusted): 9/01/1999 3/01/2015				
Included observations: 63 after adjustments					Included observations: 63 after adjustments				
<hr/>					<hr/>				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.
<hr/>					<hr/>				
GDP_GR(-1)	-0.253755	0.087106	-2.913179	0.0050	GDP_GR(-1)	-0.253755	0.087106	-2.913179	0.0050
C	1.723614	0.637394	2.704160	0.0089	C	1.723614	0.637394	2.704160	0.0089
<hr/>					<hr/>				
R-squared	0.122133	Mean dependent var	-0.042556		R-squared	0.122133	Mean dependent var	-0.042556	
Adjusted R-squared	0.107742	S.D. dependent var	1.653216		Adjusted R-squared	0.107742	S.D. dependent var	1.653216	
S.E. of regression	1.561619	Akaike info criterion	3.760554		S.E. of regression	1.561619	Akaike info criterion	3.760554	
Sum squared resid	148.7578	Schwarz criterion	3.828590		Sum squared resid	148.7578	Schwarz criterion	3.828590	
Log likelihood	-116.4575	Hannan-Quinn criter.	3.787313		Log likelihood	-116.4575	Hannan-Quinn criter.	3.787313	
F-statistic	8.486612	Durbin-Watson stat	1.929403		F-statistic	8.486612	Durbin-Watson stat	1.929403	
Prob(F-statistic)	0.004994				Prob(F-statistic)	0.004994			
<hr/>					<hr/>				

Null Hypothesis: CMR_AVG has a unit root				Null Hypothesis: CMR_AVG has a unit root							
Exogenous: Constant				Exogenous: Constant							
Lag Length: 0 (Automatic - based on SIC, maxlag=10)				Lag Length: 0 (Automatic - based on SIC, maxlag=10)							
<hr/>				<hr/>							
			t-Statistic	Prob.*				t-Statistic	Prob.*		
<hr/>				<hr/>				<hr/>			
Augmented	Dickey-Fuller	test-	2.523811	0.1148	Augmented	Dickey-Fuller	test-	2.523811	0.1148		
statistic					statistic						
Test critical		-			Test critical		-				
values:	1% level	3.538362			values:	1% level	3.538362				
		-					-				
	5% level	2.908420				5% level	2.908420				
		-					-				
	10% level	2.591799				10% level	2.591799				
<hr/>				<hr/>				<hr/>			
*MacKinnon (1996) one-sided p-values.				*MacKinnon (1996) one-sided p-values.							
Augmented Dickey-Fuller Test Equation				Augmented Dickey-Fuller Test Equation							
Dependent Variable: D(CMR_AVG)				Dependent Variable: D(CMR_AVG)							
Method: Least Squares				Method: Least Squares							
Date: 12/20/15 Time: 22:31				Date: 12/20/15 Time: 22:33							
Sample (adjusted): 9/01/1999 3/01/2015				Sample (adjusted): 9/01/1999 3/01/2015							
Included observations: 63 after adjustments				Included observations: 63 after adjustments							
<hr/>				<hr/>				<hr/>			
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.		
<hr/>				<hr/>				<hr/>			
CMR_AVG(-			-		CMR_AVG(-			-			
1)	-0.185552	0.073521	2.523811	0.0142	1)	-0.185552	0.073521	2.523811	0.0142		
C	1.237708	0.512476	2.415153	0.0187	C	1.237708	0.512476	2.415153	0.0187		
<hr/>				<hr/>				<hr/>			
R-squared	0.094547	Mean dependent-			R-squared	0.094547	var				
Adjusted R-squared	0.079704	S.D. dependent			Adjusted R-squared	0.079704	var				
S.E. of regression	1.080042	Akaike info			S.E. of regression	1.080042	var				
Sum squared resid	71.15598	Schwarz criterion			Sum squared resid	71.15598	var				
Log likelihood	-93.22793	Hannan-Quinn criter.			Log likelihood	-93.22793	var				
F-statistic	6.369620	Durbin-Watson stat			F-statistic	6.369620	var				
Prob(F-statistic)	0.014229				Prob(F-statistic)	0.014229	var				
<hr/>				<hr/>				<hr/>			

Null Hypothesis: CMR_AVG is stationary				
Exogenous: Constant				
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel				
<hr/>				
LM-Stat.				
<hr/>				
Kwiatkowski-Phillips-Schmidt-Shin test				
statistic			0.177232	
<hr/>				
Asymptotic	critical			
values*:	1% level		0.739000	
	5% level		0.463000	
	10% level		0.347000	
<hr/>				
*Kwiatkowski-Phillips-Schmidt-Shin		(1992, Table 1)		
<hr/>				
Residual variance (no correction)		3.387020		
HAC corrected variance (Bartlett kernel)		13.73470		
<hr/>				
KPSS Test Equation				
Dependent Variable: CMR_AVG				
Method: Least Squares				
Date: 12/20/15 Time: 22:35				
Sample: 6/01/1999 3/01/2015				
Included observations: 64				
<hr/>				
Variable	Coefficient	Std. Error	t-Statistic Prob.	
<hr/>				
C	6.735758	0.231867	29.050120	0.0000
<hr/>				
Mean				
R-squared	0.000000	dependent var	6.735758	
Adjusted		S.D. dependent		
R-squared	0.000000	var	1.854934	
S.E. of		Akaike	info	
regression	1.854934	criterion	4.089077	
Sum				
squared		Schwarz		
resid	216.7693	criterion	4.122810	
Log		Hannan-Quinn		
likelihood	-129.8505	critier.	4.102366	
Durbin-Watson				
stat	0.362558			

5.4 VAR Lag Length Selection

We now estimate a three variable unrestricted quarterly VAR model of inflation rate (WPI_INF), GDP growth rate (GDP_GR) and policy rate represented by call money rate (CMR_AVG). As a first step we examine the lag structure of the variables. We use three alternative selection criteria - Akaike information criterion, Schwarz criterion, Hannan-Quinn criterion. All three methods point to optimal lag length of two which we use in the VAR estimation.

The estimated unrestricted VAR model is given in Table 5.3 (left panel). Each individual equation seem to have good explanatory power with the first lags turning out to be statistically significant at 1% level. However, in a VAR interpretation of individual equations are not very meaningful, they are better studied as a system and the best way to do that is to study the impulse response functions.

**Table 5.3: Unrestricted VAR Estimates (left panel)
and SVAR Estimates (right panel)**

Vector Autoregression Estimates				Vector Autoregression Estimates			
Date: 12/25/15 Time: 14:25				Date: 12/18/15 Time: 15:46			
Sample (adjusted): 12/01/1999 3/01/2015				Sample (adjusted): 9/01/2000 3/01/2015			
Included observations: 62 after adjustments				Included observations: 59 after adjustments			
Standard errors in () & t-statistics in []				Standard errors in () & t-statistics in []			
	WPI_INF	GDP_GR	CMR_AVG		WPI_INF	GDP_GR	CMR_AVG
WPI_INF(-1)	1.209756 (0.11452) [10.5633]	-0.111386 (0.12638) [-0.88132]	0.134529 (0.09485) [1.41834]	WPI_INF(-1)	1.206875 (0.11703) [10.3123]	-0.101533 (0.13100) [-0.77504]	0.143607 (0.09306) [1.54315]
WPI_INF(-2)	-0.554900 (0.11363) [-4.88340]	0.101734 (0.12540) [0.81129]	-0.105036 (0.09411) [-1.11612]	WPI_INF(-2)	-0.577156 (0.12500) [-4.61708]	0.152723 (0.13993) [1.09146]	-0.179122 (0.09940) [-1.80203]
GDP_GR(-1)	0.069849 (0.12313) [0.56729]	0.588310 (0.13588) [4.32974]	0.037979 (0.10197) [0.37244]	GDP_GR(-1)	0.074198 (0.12523) [0.59249]	0.580309 (0.14018) [4.13974]	0.058361 (0.09958) [0.58606]
GDP_GR(-2)	-0.008864 (0.11648) [-0.07610]	0.023589 (0.12854) [0.18352]	-0.011892 (0.09647) [-0.12328]	GDP_GR(-2)	0.006119 (0.11968) [0.05113]	0.000228 (0.13396) [0.00170]	0.009364 (0.09516) [0.09840]
CMR_AVG(-1)	0.189560 (0.16606) [1.14154]	-0.235826 (0.18325) [-1.28689]	0.818876 (0.13753) [5.95427]	CMR_AVG(-1)	0.114643 (0.17789) [0.64447]	-0.215562 (0.19912) [-1.08257]	0.712172 (0.14145) [5.03477]
CMR_AVG(-2)	-0.311213 (0.18019) [-1.72718]	-0.198320 (0.19884) [-0.99736]	-0.002060 (0.14923) [-0.01381]	CMR_AVG(-2)	-0.292984 (0.18609) [-1.57443]	-0.232744 (0.20830) [-1.11735]	0.054776 (0.14797) [0.37017]
C	2.364686 (1.20679) [1.95948]	5.632167 (1.33176) [4.22911]	0.855236 (0.99946) [0.85569]	C	2.547714 (1.23161) [2.06860]	5.699875 (1.37863) [4.13446]	0.966118 (0.97934) [0.98649]
R-squared	0.774422	0.639811	0.681863	LIQD	0.556184 (0.46082) [1.20696]	-0.438328 (0.51582) [-0.84977]	0.939760 (0.36643) [2.56465]
Adj. R-squared	0.749814	0.600518	0.647157	R-squared	0.781290	0.644464	0.700424
Sum sq. resids	96.73794	117.8105	66.35380	Adj. R-squared	0.751271	0.595665	0.659306
S.E. equation	1.326225	1.463561	1.098377	Sum sq. resids	91.58275	114.7515	57.90774
F-statistic	31.46974	16.28296	19.64693	S.E. equation	1.340052	1.500010	1.065573
Log likelihood	-101.7652	-107.8744	-90.07806	F-statistic	26.02646	13.20648	17.03437
Akaike AIC	3.508555	3.705627	3.131550	Log likelihood	-96.68869	-103.3417	-83.16612
Schwarz SC	3.748715	3.945787	3.371711	Akaike AIC	3.548769	3.774295	3.090377
Mean dependent	5.776968	6.930611	6.672718	Schwarz SC	3.830469	4.055995	3.372077
S.D. dependent	2.651462	2.315592	1.849103	Mean dependent	5.836364	6.983200	6.561839
				S.D. dependent	2.686942	2.358975	1.825579
Determinant resid covariance (dof adj.)	4.250845			Determinant resid covariance (dof adj.)	4.312637		
Determinant resid covariance	2.967483			Determinant resid covariance	2.785463		
Log likelihood	-297.6417			Log likelihood	-281.3723		
Akaike information criterion	10.27876			Akaike information criterion	10.35160		
Schwarz criterion	10.99925			Schwarz criterion	11.19670		

5.5 Impulse Response Function of Unrestricted VAR

We now examine the impulse response functions of the unrestricted VAR given in Chart 5.2. Here the solid lines show response of various endogenous variables to shocks. The dotted lines provide +/- two standard error bands around impulse responses. We summarise below the impulse responses for key variables. Since the variables are set out as annual percentage changes, these are subject to easy interpretation.

First, an increase in the policy rate, here proxied by the call money rate, results in a decline in the GDP growth rate after 1 quarter. The negative impact persists for over 12 quarters. However, the statistically significant impact sets in after 2 quarters which persists for another 5 quarters. It could therefore be inferred that an increase in the policy rate has a statistically significant negative impact on the GDP growth rate with a lag of 6 months which lasts for over another year. Thus, the negative impact of policy rate change persists for nearly 2 years. Since the numbers are in percentages, it could be seen that a 1.0 percentage point increase in the policy rate, reduces the GDP growth rate by around 0.5 percentage points at the peak of its impact around the 4th quarter.

Second, an increase in the policy rate, here proxied by the call money rate, results in a decline in the inflation rate after 3 quarters. The negative impact persists for over 10 quarters. However, the statistically significant impact sets in after 4 quarters which persists for another 4 quarters. It could therefore be inferred that an increase in the policy rate has a statistically significant negative impact on the inflation rate with a lag of a year which lasts for another year. Since the numbers are in percentages, it could be seen that a 1.0 percentage point increase in the policy rate, reduces the inflation rate by around 0.5 percentage points at the peak of its impact around the 6th quarter.

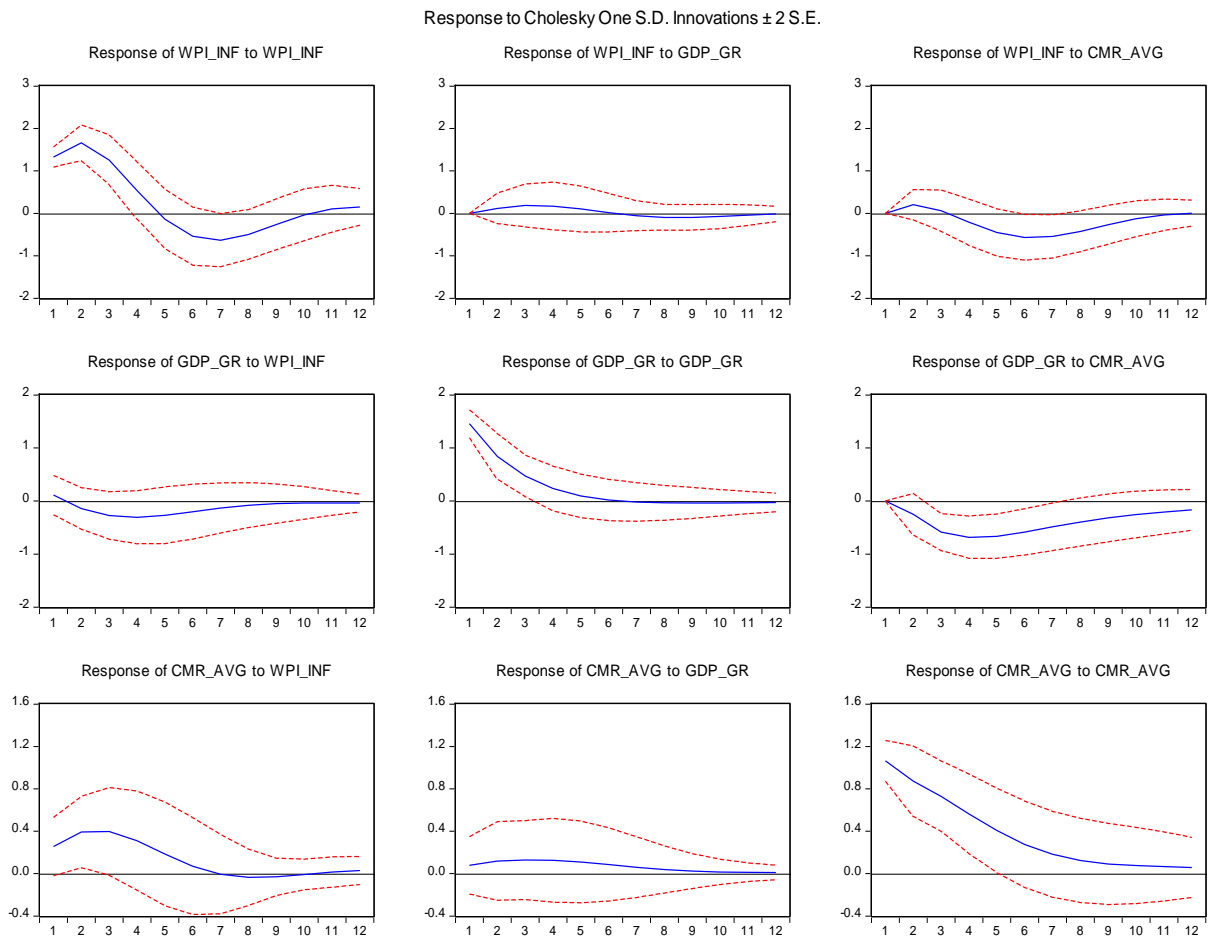
Thus, policy rate changes first impact growth before impacting inflation. For example, if policy rate is raised it first brings down growth and then inflation. This finding seems to be consistent with the New Keynesian formulation of monetary policy transmission which postulates that monetary policy can reduce inflation only by reducing growth.

Third, an increase in the inflation rate, results in a decline in the GDP growth rate after 1 quarter. The negative impact persists for over 10 quarters. A 1.0 percentage point increase in the inflation rate, reduces the GDP growth rate by 0.2 percentage points at the peak of its impact around the 4th quarter. While the general direction of the negative relationship between inflation and GDP growth rate is clear, it is not found to be statistically significant. We cross check this finding from the impulse response function of GDP to inflation. A change in the GDP growth rate is positively associated with the change in inflation rate in the initial 4 quarters which turns negative subsequently. However, it is not found to be statistically significant. From the broad direction of these relationships, it could be surmised that while there may be trade-offs between inflation and growth in the short run, there does not seem to be such a trade-offs in the long run.

Fourth, the policy rate seems to be responding positively to the inflation rate which is clearly statistically significant in the first two quarters. The overall positive response of policy rate persists for a year and half. Policy rate also appear to be responding to positively to GDP growth rate, though it turns out to be statistically not significant. Thus policy rate seems to be responding to inflation. Since high growth tends to coexist with high inflation in the short-run, by implication policy rate appears to be responding to high growth when considered inflationary.

With the above learning from the unrestricted VAR, we next turn to setting up a SVAR model.

Chart 5.2: Impulse Response Functions of Unrestricted VAR



5.6 SVAR Model

Sim's Vector Auto Regressive (VAR) methodology has been extensively used in examining the efficacy of monetary policy transmission across several countries. Following Bernanke and Blinder (1992), we use a standard SVAR approach to examine how monetary policy shocks affect the real economy. SVAR models, unlike in the unstructured VAR models, provide explicit behavioural interpretations for all 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.

5.6.1 SVAR model specification

Consider a K -dimensional time series, $y_t, t = 1, 2, \dots, T$. y_t can be approximated by a vector autoregression of finite order ' p '. Our objective is to learn about the parameters of the SVAR model

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

where, ε_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

$$B(L)y_t = \varepsilon_t$$

where, $B(L) = B_0 - B_1 L - B_2 L^2 - \dots - B_p L^p$ is the autoregressive lag order polynomial. The variance-covariance matrix of the structural error term is typically normalised such that:

$$E(\varepsilon_t \varepsilon_t') \equiv \Sigma_\varepsilon = I_K.$$

First, this means, that there are as many structural shocks as variables in the model. Second, structural shocks by definition are mutually uncorrelated, which implies that Σ_ε is diagonal. Third, the variances of all structural shocks are normalized to unity.

In order to allow estimation of the structural model one requires to derive its reduced-form representation. This involves expressing y_t as a function of lagged y_t only. For deriving the reduced form representation, both sides of the SVAR representation is multiplied by B_0^{-1} :

$$B_0^{-1} B_0 y_t = B_0^{-1} B_1 y_{t-1} + \dots + B_0^{-1} B_p y_{t-p} + B_0^{-1} \varepsilon_t$$

Thus, the model can be represented as:

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + e_t$$

with, $A_i = B_0^{-1} B_i, i = 1, 2, \dots, p$, and $e_t = B_0^{-1} \varepsilon_t$. Equivalently the model can be written more compactly as:

$$A(L)y_t = e_t,$$

with, $A(L) = A_0 - A_1 L - A_2 L^2 - \dots - A_p L^p$ denotes the autoregressive lag order polynomial. Standard estimation methods allow us to obtain consistent estimates of the reduced-form parameters $A_i, i = 1, 2, \dots, p$, the reduced-form errors e_t and their covariance matrix $E(e_t e_t') \equiv \Sigma_e$.

Thus, the reduced-form innovations e_t are, in general, a weighted average of the structural shocks ε_t . As a result, studying the response of the vector y_t to reduced-form shocks e_t will not tell us anything about the response of y_t to the structural shocks ε_t . It is the latter responses that are of interest if we want to learn about the structure of the economy. These structural responses depend on $B_i, i = 0, 1, 2, \dots, p$.

By construction, $e_t = B_0^{-1} \varepsilon_t$ and hence, $\Sigma_e = B_0^{-1} B_0^{-1'}$, given that, $\Sigma_\varepsilon = I_K$. Identification can be achieved by imposing identifying restrictions on B_0^{-1} in $e_t = B_0^{-1} \varepsilon_t$. By construction a unit innovation in the structural shocks in this representation is an innovation of size one standard deviation, so structural impulse responses based on B_0^{-1} are responses to one-standard deviation shock.

Equivalently, one could have left the diagonal elements of Σ_ε unconstrained and set the diagonal elements of B_0 to unity in $e_t = B_0^{-1} \varepsilon_t$. A useful result in this context is that, B_0 being lower-triangular implies that B_0^{-1} is lower-triangular as well.

The vector y_t is split into two components, viz., $[Z_t', R_t']'$, where, R_t represents the instrument of monetary policy, and Z_t is a vector containing all other (non-policy) endogenous variables. Accordingly, the matrices B_i are decomposed as follows:

$$B_i = \begin{bmatrix} B_i^{ZZ} & B_i^{ZR} \\ B_i^{RZ} & B_i^{RR} \end{bmatrix}, \text{ for } i = 0, 1, 2, \dots, k.$$

Noting that the scalar $B_0^{RR} = 1$, it follows that,

$$Z_t = (B_0^{ZZ})^{-1} [b^Z + \sum_{i=1}^k B_i^{ZZ} Z_{t-i} - B_0^{ZR} R_t + \sum_{i=1}^k B_i^{ZR} R_{t-i} + \varepsilon_t^Z] \quad (1)$$

$$R_t = b^R - B_0^{RZ} Z_t + \sum_{i=1}^k B_i^{RZ} Z_{t-i} + \sum_{i=1}^k B_i^{RR} R_{t-i} + \varepsilon_t^R \quad (2)$$

where, ε_t^Z is a vector of orthogonal disturbances and ε_t^R is a disturbance that is assumed to be orthogonal to ε_t^Z . The first equation describes the evolution of the non-policy variables of the model in response to changes in all contemporary and past endogenous variables as well as unforecastable shocks. The second equation characterizes the behaviour of the monetary policy instrument in response to other endogenous variables, lagged values of the policy variable and unforecastable shocks.

The identifying assumption is that the policy variable, R_t affects non-policy variables only with a lag of one period (assumed here to be one quarter). Formally, it is assumed that, $B_0^{ZR} = 0$. The policy variable, however, is allowed to respond to all contemporaneous variables. As Z_t and ε_t^R are uncorrelated in this case, estimates of the coefficients appearing in equations (1) and (2) are obtained by applying OLS on each equation of that system separately. An estimate of $var(\varepsilon_t^R)$ is given further by the sample variance of the residuals of equation (1).

Let us define, $G = B_0^{-1}$, so that $e_t = G\varepsilon_t$. Consider the vector y_t contains four variables, viz., y_1, y_2 and y_3 . The nature of the system is such that the pure innovations are serially uncorrelated and orthogonal to each other.

We define the G matrix as,

$$G = \begin{pmatrix} 1 & 0 & 0 \\ g_{21} & 1 & 0 \\ g_{31} & g_{32} & 1 \end{pmatrix}$$

Thus, the system can be defined as,

$$\begin{pmatrix} e_t^{y1} \\ e_t^{y2} \\ e_t^{y3} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ g_{21} & 1 & 0 \\ g_{31} & g_{32} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_t^{y1} \\ \varepsilon_t^{y2} \\ \varepsilon_t^{y3} \end{pmatrix}$$

Under this framework, it is assumed that y_1 shocks are most exogenous and are not contemporaneously affected by the other variables considered in the model. Accordingly all the coefficient of the remaining variables in the first row of the matrix G are kept as zero. y_2 is assumed to have been impacted by y_1 shocks contemporaneously but not by other shocks. y_3 is assumed to have been impacted contemporaneously by both y_1 and y_2 shocks.

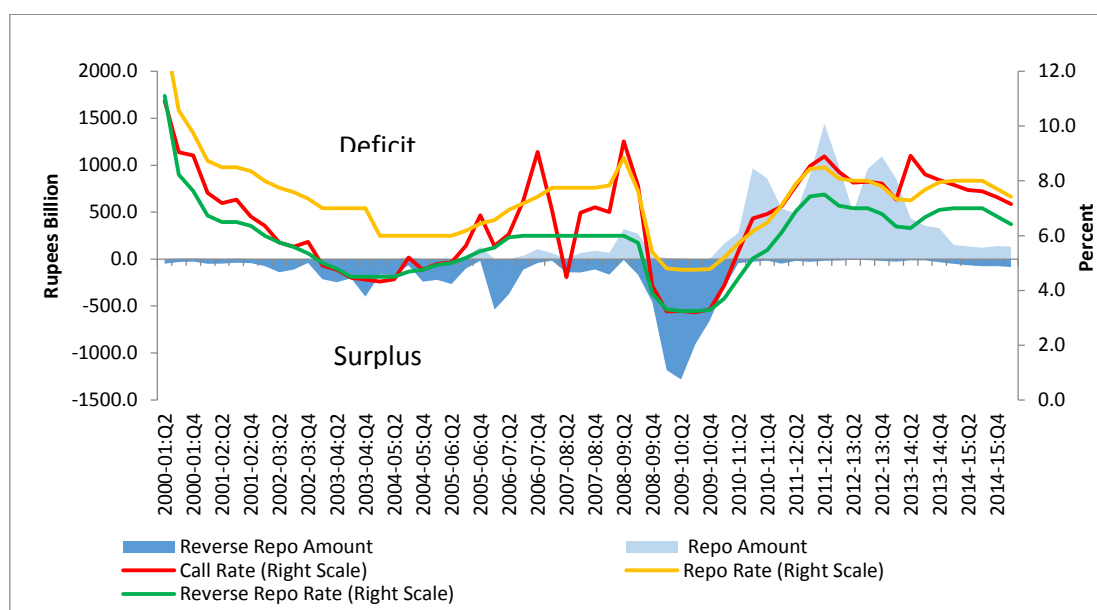
5.6.2 SVAR variable ordering

Now we turn to imposing certain restrictions on the unrestricted VAR based on certain assumed priors in the spirit of a New Keynesian Model derived from stylised policy response and the broad indications from the unrestricted VAR. We order the variables in the Structural VAR (SVAR) model with the following assumption. First, the policy rate responds to growth inflation balance which would mean that the policy rate not only responds to the contemporaneous values of inflation and growth but also it's lagged values. Second, GDP growth rate is impacted not only by the lagged value of inflation but also the contemporaneous value of the policy rate. Third, inflation is impacted by the contemporaneous values of both GDP growth rate and policy rate besides their lagged values.

5.6.3 Modelling liquidity effect

In addition, we test for the impact of liquidity on transmission. Since the time the liquidity adjustment facility (LAF) became operational one could discern two distinct phases: (i) During the initial 10 year period from 2000-01:Q2 to 2010-11:Q1 the liquidity in the system was in surplus which meant that RBI absorbed liquidity from the system on a regular basis from the banks at the reverse repo rate. (ii) During the subsequent more recent nearly 5 year period from 2010-11:Q2 to 2014-15:Q4 the liquidity in the system was in deficit which meant that RBI injected liquidity to the system on a regular basis for the banks at the repo rate (Chart 5.3).

Chart 5.3: Liquidity Adjustment Facility and Call Rate



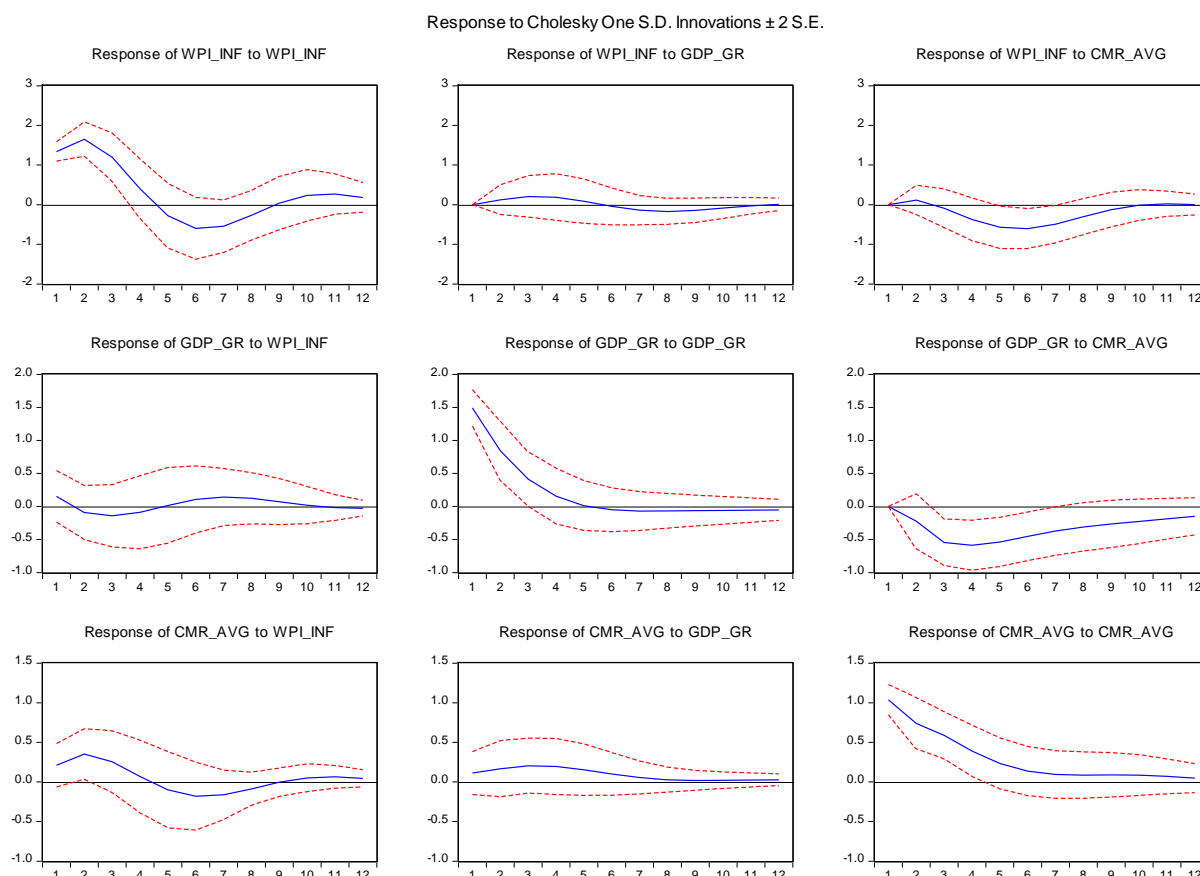
In order to test whether and how liquidity made a difference to transmission, we introduce liquidity as an exogenous variable into our SVAR model. We specify liquidity through a Dummy variable (0: denoting surplus liquidity and 1: denoting deficit liquidity).

The estimated SVAR model is given in the right hand panel of Table 5.5. The estimated individual equations show similar parameter values as in the unrestricted VAR with variables largely explained by their lagged values. However, the liquidity Dummy turned out to be positive and statistically significant at 1% level in the policy rate (CMR_AVG) equation. This suggests that liquidity deficit had a positive impact on the policy rate, and to the extent the policy rate is seen to impact GDP growth and inflation in the overall SVAR model, it could be surmised that liquidity deficit improves monetary transmission.

5.6.4 Impulse response functions of SVAR

We examine the impulse response functions of the SVAR model with liquidity which turns out to be broadly similar to the unrestricted VAR (Chart 5.4). An increase in policy rate generally reduces GDP growth rate which is statistically significant between 2nd and 7th quarters. The increase in policy rate generally results in a decline in inflation rate which is statistically significant between 4th and 8th quarters of the policy action. This combined with the observation that liquidity deficit has a positive impact on the policy rate would imply that liquidity deficit conditions improve monetary transmission.

Chart 5.4: Impulse Response Functions of SVAR Model



5.6.5 Variance decomposition

We turn to examining the variance decomposition, “which reflects the proportion of forecast error variance of a variable which is explained by an unanticipated change (shock) in itself as opposed to that proportion attributed to change in other interrelated variables (Bhaumik, 2015).” We examine the variance decomposition both in the unrestricted VAR and SVAR, results of which are given in Table 5.4.

First, in the unrestricted VAR for inflation even in the 10th quarter 85.1 percent of forecast error variance is explained by its own shock while policy rate explained 13.5 percent and the remainder 1.4 percent is explained by GDP growth. In the SVAR model the contribution of policy rate improved to 14.4 percent.

Second, in the unrestricted VAR for GDP growth even in the 10th quarter 55 percent of forecast error variance is explained by its own shock while policy rate explained 39 percent and the remainder 6 percent is explained by inflation. In the SVAR model the contribution of policy rate to GDP growth rate reduced to 32 percent.

Third, in the unrestricted VAR for policy rate even in the 10th quarter 83.7 percent of forecast error variance is explained by its own shock while inflation explained 14.2 percent and the remainder 2.1 percent is explained by GDP growth. In the SVAR model the contribution of inflation rate reduced to 11.7 percent and that of GDP growth increased to 5.9 percent.

Overall these findings suggest that the bulk of the error variance of a variable is explained by its own shock, policy rate change has a substantial influence on inflation and GDP growth. Policy rate seems to be responding more to inflation than to GDP growth. However, the adverse impact of an increase in policy rate on GDP growth is much stronger than that on inflation.

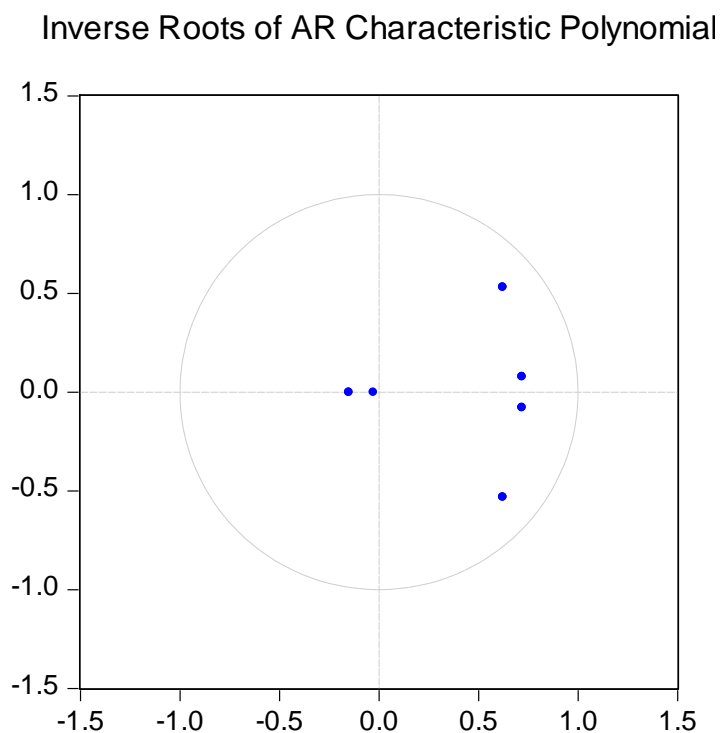
Table 5.4: Comparison of Variance Decomposition of Unrestricted VAR (Left Panel) and SVAR (Right Panel)

Variance Decomposition of WPI_INF:					Variance Decomposition of WPI_INF:				
Period	S.E.	WPI_INF	GDP_GR	CMR_AVG	Period	S.E.	WPI_INF	GDP_GR	CMR_AVG
1	1.326225	100.0000	0.000000	0.000000	1	1.340052	100.0000	0.000000	0.000000
2	2.138069	98.81012	0.297706	0.892172	2	2.134681	99.35425	0.334677	0.311071
3	2.487854	98.50739	0.774382	0.718227	3	2.456318	98.66006	0.963494	0.376448
4	2.559158	97.45939	1.183804	1.356810	4	2.523646	96.00385	1.475714	2.520433
5	2.604121	94.39024	1.295304	4.314457	5	2.603301	91.36152	1.494032	7.144447
6	2.718965	90.49159	1.190722	8.317686	6	2.738875	87.31532	1.375695	11.30899
7	2.844730	87.59623	1.128185	11.27559	7	2.838614	84.97178	1.522219	13.50600
8	2.920315	86.00764	1.173053	12.81931	8	2.872268	83.85692	1.842921	14.30016
9	2.945584	85.31332	1.257081	13.42960	9	2.878918	83.48919	2.087530	14.42328
10	2.949494	85.10208	1.314976	13.58295	10	2.889738	83.51982	2.162668	14.31751
11	2.951920	85.09176	1.333309	13.57493					
12	2.955857	85.12849	1.332387	13.53913					
Variance Decomposition of GDP_GR:					Variance Decomposition of GDP_GR:				
Period	S.E.	WPI_INF	GDP_GR	CMR_AVG	Period	S.E.	WPI_INF	GDP_GR	CMR_AVG
1	1.463561	0.591866	99.40813	0.000000	1	1.500010	1.035414	98.96459	0.000000
2	1.712040	1.118372	96.72809	2.153538	2	1.737135	1.058390	97.28085	1.660763
3	1.890521	3.017646	85.56494	11.41742	3	1.872073	1.486269	88.66634	9.847394
4	2.046931	4.826435	74.30790	20.86567	4	1.969920	1.542055	80.70065	17.75729
5	2.170855	5.850956	66.25544	27.89361	5	2.042136	1.441418	75.09792	23.46066
6	2.257527	6.216897	61.27123	32.51187	6	2.094951	1.621954	71.41762	26.96043
7	2.313623	6.248670	58.34418	35.40715	7	2.133598	2.003748	68.95909	29.03716
8	2.348821	6.178440	56.63121	37.19035	8	2.160653	2.278793	67.34227	30.37894
9	2.370989	6.107145	55.60261	38.29024	9	2.178899	2.351225	66.30128	31.34749
10	2.385266	6.059884	54.96115	38.97897	10	2.191477	2.331460	65.61344	32.05510
11	2.394706	6.036953	54.54639	39.41666					
12	2.401052	6.032917	54.27232	39.69476					
Variance Decomposition of CMR_AVG:					Variance Decomposition of CMR_AVG:				
Period	S.E.	WPI_INF	GDP_GR	CMR_AVG	Period	S.E.	WPI_INF	GDP_GR	CMR_AVG
1	1.098377	5.419824	0.500756	94.07942	1	1.065573	3.919414	1.093399	94.98719
2	1.461310	10.26104	0.946809	88.79215	2	1.354171	9.167740	2.187663	88.64460
3	1.686031	13.27857	1.283908	85.43752	3	1.512114	10.20245	3.601106	86.19645
4	1.809002	14.49021	1.591584	83.91821	4	1.575338	9.582410	4.852434	85.56516
5	1.866479	14.59753	1.835946	83.56652	5	1.603191	9.646630	5.599593	84.75378
6	1.889985	14.37471	1.994526	83.63077	6	1.622095	10.65243	5.852927	83.49464
7	1.899670	14.22936	2.075210	83.69543	7	1.633931	11.49874	5.883640	82.61762
8	1.904381	14.19441	2.107181	83.69841	8	1.638799	11.71903	5.878651	82.40232
9	1.906971	14.18263	2.117644	83.69973	9	1.641329	11.68349	5.873905	82.44260
10	1.908557	14.16137	2.120983	83.71765	10	1.644510	11.73591	5.867026	82.39707
11	1.909814	14.14819	2.122242	83.72957					
12	1.910954	14.15380	2.123094	83.72310					
Cholesky Ordering: WPI_INF GDP_GR CMR_AVG					Cholesky Ordering: WPI_INF GDP_GR CMR_AVG				

5.6.6 Stability test for SVAR model

We examine the stability of our SVAR model by examining whether all the inverse roots of AR characteristic polynomial lie within the unit root circle. As we have three variables with a maximum of two lags we should expect 6 such inverse roots. As can be seen from Chart 5.5, all 6 inverse roots lie within the inverse root circle which prompts us to conclude that the model is stable.

Chart 5.5: Inverse Roots Test



5.6.7 Residual autocorrelation test

We test for the possibility of autocorrelation in our SVAR model by conducting residual serial correlation LM test which rules out residual auto correlation up to 5 lags at a significance level of 5.0 % (Table 5.5).

Lags	LM-Stat	Prob
1	14.14170	0.1174
2	15.38526	0.0809
3	4.764082	0.8544
4	14.96275	0.0920
5	2.224023	0.9874

Probs from chi-square with 9 df.

5.6.8 SVAR residual normality test

We test for the normality of the residual from the estimated SVAR model. We cannot reject the null hypothesis that the residuals are multivariate normal even at 10% level of significance for the joint Jarque-Bera statistics (Table 5.6). This would suggest that our SVAR model is well specified and robust.

Table 5.6: Jarque-Bera Residual Normality Test

VAR Residual Normality Tests
 Orthogonalization: Cholesky (Lutkepohl)
 Null Hypothesis: residuals are multivariate normal
 Date: 01/31/16 Time: 10:02
 Sample: 6/01/1999 3/01/2015
 Included observations: 59

Component	Skewness	Chi-sq	df	Prob.
1	-0.056157	0.031011	1	0.8602
2	-0.360731	1.279579	1	0.2580
3	0.249040	0.609874	1	0.4348
Joint		1.920463	3	0.5891

Component	Kurtosis	Chi-sq	df	Prob.
1	2.389970	0.914836	1	0.3388
2	3.211516	0.109983	1	0.7402
3	4.612138	6.389178	1	0.0115
Joint		7.413997	3	0.0598

Component	Jarque-Bera	df	Prob.
1	0.945847	2	0.6232
2	1.389562	2	0.4992
3	6.999051	2	0.0302
Joint	9.334460	6	0.1556

5.7 Block Exogeneity Wald Test

Since we have three endogenous variables in our SVAR specification we conduct block exogeneity test to examine the influence of these variables individually and jointly (Table 5.7).

As could be recalled that the SVAR model is specified with two period lag. The results with two period lag show that inflation is explained jointly by output and policy rate only at a significance level of 11%. However, output is explained jointly by inflation and policy rate at a significance level of 2%. In fact the influence of policy rate by itself on output is very strong at 1% level of significance.

These results are consistent with the impulse response functions that we examined earlier. In the short-run the influence of policy rate on output is very clearly significant but on inflation its influence is weak.

Table 5.7: Block Exogeneity Wald Test

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 01/31/16 Time: 09:53
Sample: 6/01/1999 3/01/2015
Included observations: 59

Dependent variable: WPI_INF			
Excluded	Chi-sq	df	Prob.
GDP_GR	0.699339	2	0.7049
CMR_AVG	3.216048	2	0.2003
All	7.485171	4	0.1124
Dependent variable: GDP_GR			
Excluded	Chi-sq	df	Prob.
WPI_INF	1.193479	2	0.5506
CMR_AVG	10.18028	2	0.0062
All	11.18372	4	0.0246
Dependent variable: CMR_AVG			
Excluded	Chi-sq	df	Prob.
WPI_INF	3.437541	2	0.1793
GDP_GR	0.762733	2	0.6829
All	4.385123	4	0.3564

5.8 Lags in Monetary Policy

It is well known that monetary policy impacts output and inflation with uncertain and variable lags. We also know from the New Keynesian formulation that monetary policy first impacts output and then inflation. If inflation is a manifestation of excess demand in the economy it may not be feasible for policy to reduce inflation without first reducing output.

In other words, if output is expanding at a rate higher than its potential it would be difficult to bring inflation down to its desired level without moderating output. In this context the lags in monetary policy assume particular significance. This was observed from the estimated impulse response functions in our SVAR model: lags are shorter for growth but longer for inflation. We, therefore, explore this issue in a bivariate granger causality framework in our SVAR specification.

With a shorter two period lag, the findings are broadly similar to the results of the block exogeneity tests: policy rate change has a stronger influence on growth than on inflation. For instance, the premise that policy rate change impacts output cannot be rejected at 1% level of significance. On the other hand the premise that policy rate change impacts inflation can be rejected at 5% level of significance but cannot be rejected at 10% level of significance (Table 5.8).

Table 5.8: Granger Causality Test with 2-Period Lag

Pairwise Granger Causality Tests
Date: 01/31/16 Time: 09:56
Sample: 6/01/1999 3/01/2015
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP_GR does not Granger Cause WPI_INF	62	1.53376	0.2245
WPI_INF does not Granger Cause GDP_GR		0.78288	0.4619
CMR_AVG does not Granger Cause WPI_INF	62	2.94321	0.0608
WPI_INF does not Granger Cause CMR_AVG		1.17138	0.3173
CMR_AVG does not Granger Cause GDP_GR	62	6.73683	0.0024
GDP_GR does not Granger Cause CMR_AVG		0.20984	0.8113

With the insight from the impulse response functions from the SVAR model that the statistically significant impact of policy on output and inflation persists up to 8 quarters, we extend the lag length in our Granger Causality test to 8 quarters to ascertain the impact of policy rate change on growth and inflation. The results suggest that at longer lags policy rate has a more significant impact on inflation than on output.

For instance at 8-period lag, impact of policy rate on inflation cannot be rejected at 5% level of significance. Impact of policy rate on growth can be rejected at 5% level but it cannot be rejected at 10% level (Table 5.9). Thus the impact of policy rate change is weaker in the short run but stronger in the long run.

Table 5.9: Granger Causality Test with 8-Period Lag

Pairwise Granger Causality Tests
Date: 01/31/16 Time: 09:58
Sample: 6/01/1999 3/01/2015
Lags: 8

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP_GR does not Granger Cause WPI_INF	56	0.42455	0.8992
WPI_INF does not Granger Cause GDP_GR		1.18149	0.3348
CMR_AVG does not Granger Cause WPI_INF	56	2.44916	0.0298
WPI_INF does not Granger Cause CMR_AVG		0.92431	0.5074
CMR_AVG does not Granger Cause GDP_GR	56	2.08498	0.0611
GDP_GR does not Granger Cause CMR_AVG		0.30608	0.9592

5.9 Conclusion

We examine the interest rate channel of monetary transmission in India by estimating a quarterly SVAR model for the 15-year period 1999-2000 to 2014-15 coinciding with a period in which interest rate came to the fore as the principal operating instrument of monetary policy. Building on the initiation of the process of financial market liberalisation following the balance of payments (BoP) crisis of 1991, both the monetary policy framework and the operating procedure of monetary policy changed towards the end of the 1990s to give greater importance to interest rate as a tool of monetary policy.

However, it is in the early 2010s that interest rate assumed its primary role as the principal monetary instrument.

This was supported by another round of reform to the operating procedure which besides clearly spelling out the relationship among the various interest rates of the central bank, articulated the overnight interest rate as the operating target and endeavoured to keep the liquidity in the system in a deficit model so as to enhance the efficacy of interest rate channel of monetary transmission.

We set up a SVAR model of three variables of policy rate, growth and inflation. We proceed systematically in our technical analysis. We first test an unrestricted VAR before moving on to imposing restrictions in the SVAR model. In the SVAR model we additionally test for the impact of liquidity as an exogenous variable. All the diagnostics of the SVAR model suggest that the model is statistically stable.

The model shows that monetary policy impacts growth and inflation with lags. Changes in policy rate has a negative relationship with growth and inflation. It first impacts growth with a shorter lag of two quarters, which persists till the 7th quarter. Once growth is impacted inflation gets impacted from the 3rd quarter, which persists till the 8th quarter. Thus, the full impact of monetary policy action on growth and inflation persists for two years.

At its peak a one-percentage point change in policy rate shaves off ½ percentage point each from growth and inflation. The reduction in inflation follows a fall in output growth validating the simple New Keynesian formulation of interest rate channel of monetary transmission. Liquidity has a statistically significant impact on monetary transmission with liquidity deficit strengthening monetary transmission.

Granger Causality test show that policy rate has an influence on both output and inflation. At a shorter lag length policy rate has a relatively stronger impact on output than on inflation. On the other hand, at the longer lags policy rate has a stronger impact on inflation. Thus, monetary policy acts on its end objectives of inflation and sustainable growth with variable lags. While a trade-off between growth and inflation is seen in the short-run, in the long-run lower inflation appears to have a positive impact on growth.

Quarterly Inflation, Output and Policy Rate

Quarter	WPI_INF	GDP_GR	CMR_AVG
6/01/1999	3.25	7.10	8.29
9/01/1999	2.65	6.11	9.09
12/01/1999	3.17	6.24	8.92
3/01/2000	4.17	6.35	9.19
6/01/2000	6.49	5.10	8.45
9/01/2000	6.37	6.66	10.38
12/01/2000	7.86	4.42	9.04
3/01/2001	7.82	1.78	8.73
6/01/2001	5.44	4.57	7.59
9/01/2001	5.05	5.26	7.14
12/01/2001	2.54	6.75	7.15
3/01/2002	1.54	6.43	6.78
6/01/2002	1.80	5.08	6.51
9/01/2002	3.24	5.37	5.74
12/01/2002	3.25	1.66	5.59
3/01/2003	5.20	3.66	5.74
6/01/2003	6.19	5.40	4.88
9/01/2003	4.50	9.02	4.74
12/01/2003	5.45	11.31	4.47
3/01/2004	5.81	8.11	4.38
6/01/2004	5.77	8.30	4.31
9/01/2004	7.57	7.14	4.39
12/01/2004	6.96	5.49	5.18
3/01/2005	5.55	8.98	4.73
6/01/2005	4.87	9.36	4.95
9/01/2005	4.23	8.90	5.03
12/01/2005	4.33	9.61	5.64
3/01/2006	4.35	9.94	6.79
6/01/2006	5.94	9.31	5.63
9/01/2006	6.87	9.78	6.08
12/01/2006	6.87	9.36	7.36
3/01/2007	6.66	9.82	9.80
6/01/2007	5.39	9.72	5.90
9/01/2007	3.95	9.53	4.48
12/01/2007	3.64	9.57	6.84
3/01/2008	5.98	8.57	7.04
6/01/2008	8.98	9.80	6.83
9/01/2008	11.02	8.52	9.46
12/01/2008	8.66	5.77	7.80
3/01/2009	3.69	3.46	4.17
6/01/2009	0.75	5.91	3.22
9/01/2009	0.54	9.26	3.25
12/01/2009	4.53	7.67	3.20
3/01/2010	9.56	11.37	3.30
6/01/2010	10.54	9.09	4.16
9/01/2010	9.28	8.24	5.40
12/01/2010	8.91	8.70	6.62
3/01/2011	9.56	9.56	6.79
6/01/2011	9.60	7.63	7.04

Quarter	WPI_INF	GDP_GR	CMR_AVG
9/01/2011	9.71	7.00	7.84
12/01/2011	9.01	6.51	8.63
3/01/2012	7.50	5.77	8.97
6/01/2012	7.54	4.46	8.34
9/01/2012	7.87	4.62	7.98
12/01/2012	7.29	4.38	8.03
3/01/2013	6.74	4.44	7.90
6/01/2013	4.84	4.66	7.35
9/01/2013	6.63	5.15	9.21
12/01/2013	7.05	4.56	8.55
3/01/2014	5.38	4.61	8.26
6/01/2014	5.80	5.71	8.15
9/01/2014	3.87	5.33	8.02
12/01/2014	0.33	6.59	7.96
3/01/2015	-1.82	4.42	7.71

CMR_AV: Average Call Money Rate

GDP_GR: Real (2004-05=100) Gross Domestic Product (GDP) Growth Rate at Factor Cost

WPI_INF: Wholesale Price Index Inflation Rate

Source: Database on Indian Economy (DBIE), Reserve Bank of India (<http://dbie.rbi.org.in>) and the Author's own computation

Chapter 6

Conclusions

How does monetary policy affect output and inflation is an important question? The monetary policy framework of a central bank aims to attain the desired objectives of policy in terms of inflation and growth. Typically, central banks exercise control over the monetary base and/or short term interest rates such as the rate at which the central bank supplies or absorbs reserves to/from the banking system in the economy. How these interest rate actions and liquidity operations of the central banks impact the end-objectives of monetary policy – i.e., price stability and sustainable growth - depends on the underlying monetary transmission, which in turn depends on structure of the economy and the state of development in financial markets.

6.1 Transmission Channels

Monetary transmission refers to a process through which changes in the policy get translated into the ultimate objectives of inflation and growth passing through some intermediate process. Traditionally, four key channels of monetary policy transmission have been identified in literature such as (i) money or interest rate channel; (ii) credit or balance sheet channel; (iii) exchange rate channel; and (iv) asset price channel. In recent years, a fifth channel, i.e., expectations channel has assumed increased prominence in the conduct of forward-looking monetary policy.

Interestingly, the channels of monetary transmission are often referred to 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. This is because not only different channels of monetary transmission tend to operate at the same time but also they change over time.

In general, transmission mechanism is largely conditioned by the monetary policy framework, structure and depth of the financial system in which the central bank operates and the state of real economy. While there is vast empirical literature on monetary policy transmission for advanced economies, only a limited number of empirical studies have examined the monetary transmission mechanisms in emerging markets and developing

economies (EMDEs). This is understandable given the underdeveloped nature of financial markets and rapid structural changes in EMDEs. However, since the 2000s, analysis of monetary transmission mechanisms in EMDEs, including India, has gained prominence due to structural and economic reforms and subsequent transitions to market oriented policy regimes. Literature on monetary transmission in India is still in a nascent stage, which makes our research relevant.

6.2 Empirical Evidence on Interest Rate Channel in India

The RBI Working Group on Money Supply (Chairman: Y.V. Reddy, 1998) pointed to some evidence of interest rate channel of monetary transmission. RBI (2005) using a VAR framework for the period 1994-95 to 2003-04 found that monetary tightening through a positive shock to the Bank Rate had the expected negative effect on output and prices. Using cointegrated VAR approach, Singh and Kalirajan (2007) showed the significance of interest rate as the major policy variable for conducting monetary policy in the post-liberalised Indian economy. Patra and Kapur (2010) also found that aggregate demand responds to interest rate changes. Pandit and Vashisht (2011) found that policy rate channel of transmission mechanism works in India. Mohanty (2014) found evidence that policy rate increases have a negative effect on output growth and a moderating impact on inflation.

6.3 Issues that the Thesis Examined

In this thesis we examined three issues: (i) development and extent of integration in the domestic financial market in India, (ii) evidence of interest rate channel of monetary transmission, and (iii) the impact of liquidity on the interest rate channel of monetary transmission.

We set the context by briefly tracing the evolution of the monetary policy framework since the mid-1980s and how interest rate has formally evolved as the operating target of monetary policy since the 2000s. We review the developments in relevant segments of the financial market. We then empirically test for the integration across segments of the financial market encompassing money, government securities and credit markets. We provide analysis on the basis of monthly data on interest rate/yield in these segments of the market for a period of 17 years from March 1998 to March 2015 broadly coinciding with the period of gradual interest rate liberalisation and market developments.

Apart from correlation, we perform cointegration analysis to formally test for long-term equilibrium relationship among key interest rate. We additionally test for the stability in the cointegrating relationship by estimating a short-term vector error correction model (VECM).

After ascertaining integration in the financial markets, we review both theoretical and empirical literature on monetary transmission with an emphasis on the interest rate channel. We particularly focus on EMDEs including India. We estimate a quarterly model for the 16 year period from 1999-2000:Q₁ to 2014-15:Q₄ coinciding with the period of gradual adoption of interest rate as the key operating instrument of monetary policy in India. Another consideration for the time period was that quarterly gross domestic product (GDP) data are available only towards the latter part of the 1990s.

We first set out an empirical model in an unstructured Vector Auto Regression (VAR) framework. With the insight from the unstructured VAR coupled with theoretical underpinnings, we proceed to develop a structural VAR (SVAR) to examine the interest rate channel of monetary policy. Our representative economy-wide model is specified in three variables: (i) policy rate, (ii) GDP growth rate and (iii) headline inflation rate broadly in a New Keynesian framework. In the model, we additionally try to control for liquidity as an exogenous dummy variable to show the efficacy of transmission under varying liquidity conditions.

6.4 Key Findings of the Thesis

First, the development of the money market and refinement of operating procedure of monetary policy have moved in tandem. A number of new instruments such as market repo, CBLO, CP and CDs were introduced in the money market. Auction based pricing of government securities added depth to the bond market. More recently the volume of the corporate bond is also expanding. Secondary market transactions have also been increasing. Financial sector reforms along with Reserve Bank's emphasis on development of various segments of financial market enabled shifts in operating procedures based on direct quantity-based instruments to indirect interest rate-based instruments. The Reserve Bank has been able to better transmit monetary policy signals in the money market through a single policy repo rate.

Second, we formally test for integration in the financial market across its key segments and along the yield curve. The cointegration results suggested a single cointegrating equation among a very short-term interest rate of Treasury Bills with a residual maturity of 15-91 days, the yield on government security with a residual maturity of 10-years and a measure of weighted average bank lending rate. Once we establish this long-term relationship, we test for the stability of this relationship by estimating a vector error correction (VEC) model, which showed that not only was the error correction term statistically significant but also had a negative sign suggesting convergence of the system to equilibrium in the event of temporary deviation.

Third, since the Treasury Bill rate with a residual maturity of 15-91 days shadows the policy rate one could surmise that a long-term relationship exists among policy rate and other key market rates. These findings prompt us to infer that there is a stable long-term relationship among interest rates in the major segments of the financial markets which augurs well for considering interest rate as a key instrument of monetary policy. This finding in an important way establishes the first stage of interest rate channel of monetary transmission from the policy rate to the broader financial markets.

Fourth, our SVAR model shows that monetary policy impacts growth and inflation with lags. A change in policy rate has a negative relationship with growth and inflation. It first impacts growth with a shorter lag of two quarters, which persists till the 7th quarter. Once growth is impacted inflation gets impacted from the 3rd quarter, which persists till the 8th quarter. Thus, the full impact of monetary policy action on growth and inflation persists for two years.

Fifth, at its peak a one-percentage point change in policy rate shaves off ½ percentage points each from growth and inflation. The reduction in inflation follows a fall in output growth validating the simple New Keynesian formulation of interest rate channel of monetary transmission. Liquidity has a statistically significant impact on monetary transmission with liquidity deficit strengthening monetary transmission.

Sixth, Granger Causality test show that policy rate has an influence on both output and inflation. At a shorter lag length policy rate has a relatively stronger impact on output than on inflation. On the other hand, at the longer lags policy rate has a stronger impact on inflation. Thus, monetary policy acts on the end objectives of inflation and growth with

variable lags. While there is a trade-off between growth and inflation in the short-run, in the long run lower inflation has a positive impact on growth.

6.5 Policy Relevance of the Findings

The findings of this research have significant policy relevance. It suggests that financial sector reform has resulted in integration across market segments underscoring the need for continuation of reform in the financial market. It provides robust evidence that interest rate channel of monetary transmission is effective. Thus it lends support to the current framework of monetary policy, which relies on interest rate (repo rate) as the principal instrument of monetary policy of the Reserve Bank of India. Our findings also suggest caution in using interest rate to contain inflation given its short-term significant negative impact on growth.

6.6 Suggestion for Further Research

Our finding validates interest rate channel of monetary transmission to wholesale price index (WPI) inflation, which was considered headline inflation during the period of our study till 2014-15. Now that the Reserve Bank of India has switched to a flexible inflation-targeting regime with the consumer price index (CPI) inflation as the headline inflation, future research should test the efficacy of interest rate channel of transmission to CPI inflation.

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