

Development Research Group

Study  
No. 44

**Role of Financial Frictions  
in Monetary Policy Transmission in India**



Shesadri Banerjee  
Harendra Behera  
Sanjib Bordoloi  
Rakesh Kumar



Department of Economic and  
Policy Research  
Reserve Bank of India



**DRG Studies Series**

Development Research Group (DRG) has been constituted in Reserve Bank of India in its Department of Economic and Policy Research. Its objective is to undertake quick and effective policy-oriented research backed by strong analytical and empirical basis, on subjects of current interest. The DRG Studies are the outcome of collaborative efforts between experts from outside Reserve Bank of India and the pool of research talent within the Bank. These studies are released for wider circulation with a view to generating constructive discussion among the professional economists and policy makers.

Responsibility for the views expressed and for the accuracy of statements contained in the contributions rests with the author(s).

There is no objection to the material published herein being reproduced, provided an acknowledgement for the source is made.

DRG Studies are published in RBI web site only and no printed copies will be made available.

Director  
Development Research Group

# DRG Study

## Role of Financial Frictions in Monetary Policy Transmission in India\*

by

Shesadri Banerjee\*

Harendra Behera<sup>¤</sup>

Sanjib Bordoloi<sup>†</sup>

Rakesh Kumar<sup>#</sup>

---

\* The views expressed in this study are of the authors alone, and not of the institutions to which they belong. The usual disclaimer applies.

\* Madras Institute of Development Studies, 79 Second Main Road, Gandhinagar, Adyar, Chennai 600020, India. Tel: 91-44-24412589/24411574 (Ext: 340). E-mail: [shesadri.banerjee@mids.ac.in](mailto:shesadri.banerjee@mids.ac.in)

<sup>¤</sup> Reserve Bank of India, Central Office Building, Shahid Bhagat Singh Marg, Mumbai 400001, India. E-mail: [hbehera@rbi.org.in](mailto:hbehera@rbi.org.in)

<sup>†</sup> Reserve Bank of India, Central Office Building, Shahid Bhagat Singh Marg, Mumbai 400001, India. E-mail: [sanjibb@rbi.org.in](mailto:sanjibb@rbi.org.in)

<sup>#</sup> Reserve Bank of India, Central Office Building, Shahid Bhagat Singh Marg, Mumbai 400001, India. E-mail: [rarya@rbi.org.in](mailto:rarya@rbi.org.in)

## **Acknowledgements**

We are deeply grateful to Dr. Michael Debabrata Patra, Executive Director, Reserve Bank of India (RBI), for his encouragement to pursue this Development Research Group (DRG) study. We are thankful to Mr. Sitikantha Pattnaik for shaping the scope of this research. We would like to thank Dr. Satyananda Sahoo, the former Director of DRG in RBI, and his team members for their continuous support at different stages of the study. The work has also been benefitted from valuable comments and suggestions of Professor Chetan Ghate and Dr. Rudrani Bhattacharya who were the discussants of the study presented at Annual Conference of Department of Economic and Policy Research at Kochi (June 2017) and the comments of other participants at the conference.

## Executive Summary

In macroeconomics literature, the mechanism of monetary policy transmission (MPT) has been a subject of extensive research in many countries over the last couple of decades. In the course of such investigations, researchers have found financial market frictions as one of the major determinants of propagation mechanism of the monetary policy shocks. The credit channel based explanation of MPT attributes weak transmission of monetary policy in emerging market and developing economies (EMDEs) is due to the predominance of financial market frictions. Presence of information asymmetries, limited enforceability of contracts and heterogeneity among the economic agents give rise to frictions in the financial market transactions, which play a crucial role in determining the degree of pass-through and speed of adjustments in the MPT mechanism. In this study, we examine the critical role of different financial frictions and the associated structural rigidities in the MPT in India.

At the outset, we document the stylised facts from the cyclical properties of the real and financial variables, investigate the MPT mechanism using the Structural Vector Autoregression (SVAR) methodology and explore the potential sources of financial frictions that can deter the transmission process. First, the empirical regularities show that: (i) the operational target (weighted average call money rate) and the policy instrument (repo rate) are closely related; (ii) relatively strong co-movement exists between the business cycle and the credit growth cycle; and (iii) counter-cyclical movement of interest rate spread indicates linkage between the real and financial sectors of the economy. Second, the SVAR analysis, based on seasonally adjusted quarterly data of real output, consumer price inflation, non-food credit growth, deposit interest rate, lending interest rate and weighted average call money rate (WACR) over the sample period of 1999:Q4 to 2015:Q3, reveals slow and weak transmission of monetary policy shocks through a combination of interest rate and bank lending channels. The peak effects of a monetary policy shock, on an average, are observed with a lag of three to four quarters. Moreover, the effects persist for nearly eight to twelve quarters. Third, we find evidence from the literature on different types of frictions prevailing in the bank dominated credit market in India. Broadly, these include financially excluded segment of the population, credit-constrained households, interest rate rigidity, policy-driven market distortions related to administered interest rate on small savings, high statutory liquidity ratio (SLR) and capital adequacy ratio for banks. In view of the empirical findings and evidence from the literature, we take this study forward to understand the role of different frictions related to the credit market structure and the banking sector of the economy.

We propose a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) model with an imperfectly competitive banking sector at the core. Following Gerali et al. (2010) and Anand et al. (2014), we develop a modelling framework using Indian economy specific features of liquidity-constrained households, competitive labour market and reserve requirements for the commercial banks. We incorporate a variety of real, nominal and financial shocks to the prototype economy in order to pin down the business cycle features and quantify the variance decomposition of shocks. Combining the methods of calibration and Bayesian estimation for the sample period 1999:Q4 through 2015:Q3, the baseline parameterisation is configured and validated with second order moments of the data.

Simulation of the baseline model replicates co-movement of the credit market interest rates with incomplete pass-through and produces contractionary effects on the real and financial variables as a consequence of a positive interest rate shock. Following a positive interest rate shock, the spectrum of interest rates shifts up and squeezes the demand for credit. This leads to contractionary effects emanating from the demand side of the economy *via* reduction of consumption and investment demand, and from the supply side *via* cost of physical capital. This two-pronged contraction leads to a sharp decline in the demand for factors of production, in particular the labour, which drives down the aggregate output and inflation subsequently. The variance decomposition results show that the transmission of an interest rate shock to aggregate demand and inflation is low and sensitive to the degree of financial market frictions and structural composition of the credit market.

Focusing on the credit market friction parameters, we undertake counterfactual experiments and evaluate the responsiveness of MPT using the accumulated effects over a time horizon of eight quarters. In general, it is observed that MPT improves as friction in the financial system diminishes. More specifically, based on the elasticity measure, our results suggest that: (i) presence of liquidity-constrained and collateral-constrained households poses major obstacles for the transmission; (ii) easing of the collateral constraint and greater financial inclusion can enhance the degree of transmission more than proportionately; (iii) interest rate rigidity on the lending side and composition of savers and borrowers in the credit market have important implications for the transmission mechanism; and (iv) rigidity in the deposit interest rate does not appear to be a significant determinant of the weak MPT though its role becomes prominent as the depositor base expands in the economy.

We undertake simulation experiments further on the central bank loss function with respect to a set of alternative policy rules, which include the conventional form of Taylor rule, asset price augmented Taylor rule and credit cycle augmented Taylor rule. The results show that except the case of housing price augmented Taylor rule, the

standard form of Taylor rule with forecast-based inflation and contemporaneous output turns out as the optimal one for all the policy frameworks under study. In fact, adjusting the policy interest rate to smooth out the credit cycle exacerbates volatility of inflation and output. In addition, comparing three different policy frameworks for stabilising inflation and output, we find that inflation stabilisation is the most desirable policy option for the central bank as it minimises the welfare loss irrespective of the policy rules. Overall, it appears that targeting financial stability through monetary policy rule may not be appropriate for the purpose of economic stabilisation.

# Contents

<b>1</b>	<b>Introduction</b>	<b>4</b>
<b>2</b>	<b>Background of Study</b>	<b>9</b>
2.1	Nexus between Monetary Transmission and Financial Market Frictions . . . . .	9
2.1.1	Sources of Frictions in Financial Market Transactions . . . . .	10
2.1.2	Financial Friction: A Determinant of Transmission Mechanism . . . . .	11
2.2	Indian Experience of Monetary Policy Transmission . . . . .	12
2.2.1	Operating Procedure of Monetary Policy . . . . .	12
2.2.2	Role of Bank Lending Channel . . . . .	14
2.2.3	Impediments in Pass-through of Monetary Policy . . . . .	15
2.3	Stylised Facts on Indian Macroeconomic and Financial Variables . . . . .	16
2.3.1	Cyclical Behaviour of Interest rates, Credit and Output . . . . .	16
2.3.2	Evidence on Monetary Transmission from SVAR Analysis . . . . .	19
<b>3</b>	<b>The Model</b>	<b>21</b>
3.1	Description of the Economy . . . . .	22
3.2	Household Sector . . . . .	23
3.2.1	Liquidity-constrained Household . . . . .	23
3.2.2	Patient Household . . . . .	24
3.2.3	Impatient Household . . . . .	25
3.2.4	Entrepreneur . . . . .	26
3.2.5	Competitive Labour Market . . . . .	28
3.3	Producers . . . . .	29
3.3.1	Monopolistically Competitive Retailer . . . . .	29
3.3.2	Capital Goods Producing Sector . . . . .	29
3.3.3	Housing Goods Producing Sector . . . . .	30
3.4	Banking Sector . . . . .	31
3.4.1	Retail Branch . . . . .	31
3.4.2	Wholesale Branch . . . . .	34
3.5	Fiscal Authority . . . . .	35
3.6	Central Bank . . . . .	36
3.7	Resource Constraint and Aggregation . . . . .	36
3.8	Forcing Processes . . . . .	36



<b>4</b>	<b>Quantitative Analysis</b>	<b>37</b>
4.1	Baseline Model . . . . .	38
4.1.1	Calibrated Parameters . . . . .	38
4.1.2	Estimated Parameters . . . . .	39
4.1.3	Model Validation . . . . .	43
4.1.4	Variance Decomposition Results . . . . .	45
4.2	Transmission Mechanism of Monetary Policy Shock . . . . .	46
4.2.1	Transmission to Banking Sector . . . . .	48
4.2.2	Transmission to Real Sector . . . . .	49
4.2.3	Transmission to Inflation . . . . .	50
4.3	Financial Frictions and Monetary Transmission: Evidence from Counterfactual Experiments . . . . .	51
4.4	Policy Implications . . . . .	54
<b>5</b>	<b>Conclusion</b>	<b>57</b>
<b>6</b>	<b>Bibliography</b>	<b>60</b>
<b>7</b>	<b>Appendix A: Alternative Channels of Monetary Transmission</b>	<b>68</b>
<b>8</b>	<b>Appendix B: Econometric Specification of SVAR Analysis</b>	<b>70</b>
<b>9</b>	<b>Appendix C: Data Sources and Computations</b>	<b>71</b>
<b>10</b>	<b>Appendix D: Log-linearised Model and Description of Steady-state</b>	<b>72</b>
10.1	Liquidity-constrained Household . . . . .	72
10.2	Patient Household . . . . .	72
10.3	Impatient Household . . . . .	72
10.4	Wholesale Goods Producing Entrepreneur . . . . .	73
10.5	Final Goods Producing Retailer . . . . .	74
10.6	Capital Goods and Housing Goods Producing Sectors . . . . .	74
10.7	Retail Banking Sector Operations . . . . .	75
10.8	Wholesale Banking Sector Operations . . . . .	75
10.9	Fiscal Policy Block . . . . .	75
10.10	Monetary Policy Block . . . . .	76
10.11	Aggregation & Market Clearing Conditions . . . . .	76
10.12	List of Shock Variables . . . . .	76
10.13	Description of Steady-state . . . . .	76



# 1 Introduction

In the literature on macroeconomics, transmission mechanism of monetary policy remains one of the fiercely debated areas. Monetary policy transmission (MPT) implies the process through which policy action of the monetary authority is transmitted to the policy objectives. Given the welfare consequences and distributional implications of the business cycle fluctuations, the central bank needs to intervene from time to time with appropriate policy design. The success of such policy intervention depends on smooth functioning of the transmission mechanism. Researchers have investigated the channels of MPT to explore the effects of monetary policy shocks. Consequently, a host of studies have emerged following different approaches explaining the pass-through mechanism of MPT to the real, nominal and financial variables and describing the intensity and efficiency of various channels.<sup>1</sup>

Although there is a consensus on the main conduits of MPT, determinants of the relative strengths of different transmission channels are still not well established. Ambiguity arises from the empirical evidence on the diverse nature of the transmission channels as well as the temporal variations of MPT across countries over different sample periods.<sup>2</sup> While examining the role of a variety of structural and policy-driven factors, researchers have found financial market frictions to be one of the major determinants of the impact and propagation mechanism of monetary policy shocks in the economy. After the global financial crisis, different economies have experienced sizeable decline in potential output and low inflation expectations coexisting with weak household and corporate balance sheets. This kind of experience emphasises the relevance and need for understanding the role of financial frictions in the MPT mechanism.

Theoretically, it is argued that due to presence of information asymmetries, limited enforceability of contracts and heterogeneity among the economic agents, the financial market is characterised by certain types of wedges, which can be viewed either in terms of price of liquidity or the availability of liquid financial resources. In terms of price of liquidity, the wedge can arise from the difference between the return received by providers of financial resources and the cost of capital paid by capital users. In terms of the availability of liquidity, the wedge can crop up from the difference between actual and desired liquidity of financial resources accessed by the financially constrained market participants. Such wedges in the financial market transactions are termed as financial frictions, which can influence the MPT mechanism. Using a cross-country analysis, Cecchetti and Krause (2001) showed that the transmission of a monetary policy action to the interest rate movements, domestic output

---

<sup>1</sup>A number of surveys on the theories of the monetary transmission mechanism are given in Bernanke (1993), Gertler and Gilchrist (1993), Kashyap and Stein (1993, 2000), Hubbard (1995), and Cecchetti (1995).

<sup>2</sup>See the cross-country analysis on MPT in Mishra and Montiel (2013), and Mishra et al. (2016).

and prices depend significantly on the structure of the country's banking system and financial markets. This lending view based on credit channel of MPT attributes the weaker transmission mechanism of monetary policy in the emerging market and developing economies (EMDEs) to their underdeveloped financial sector compared to the advanced countries.

Indian economy, similar to other EMDEs, features weak transmission mechanism of monetary policy and incomplete pass-through due to its less deepened and fragmented financial market, costly intermediation and policy-driven market distortions. The transmission process primarily works through the interest rate channel (RBI, 2005; Singh and Kalirajan, 2007; Patra and Kapur, 2010) and broad credit channel (Khundrakpam, 2011; Jain and Khundrakpam, 2012). Aleem (2010) studied the credit channel, asset price channel and exchange rate channel of MPT using VAR models for the period of 1996:Q4 to 2007:Q4 and found the credit channel to be the only important channel of monetary transmission in India.

In our study, the cyclical properties of the real and financial variables reveal that: (i) the operational target (weighted average call money rate) and the policy instrument (repo rate) are closely related; (ii) strong co-movement exists between the business cycle and credit growth cycle; and (iii) counter-cyclical movement of interest rate spread indicates some degree of real and financial sector linkage in the economy. Using the seasonally adjusted quarterly data on real output, consumer price inflation, non-food credit growth, deposit interest rate, lending interest rate and weighted average call money rate for the sample period of 1999:Q4 to 2015:Q3, we take a preview of the MPT in India based on a Structural Vector Autoregression (SVAR) framework. Our empirical analysis suggests a slow and weak transmission process through a combination of interest rate and bank lending channels.<sup>3</sup> The expected peak effect of a monetary policy shock, on an average, takes place with a lag of three to four quarters. Overall, the effect persists for eight to twelve quarters.

The incomplete pass-through and long and uncertain time lag involved in MPT mechanism makes it difficult to predict the precise effects of monetary policy actions on the economy. In order to improve MPT in the economy, the Reserve Bank of India (RBI) has taken up different measures, which include changes in the operating framework, deregulation of the interest rates, adoption of a more market-driven approach for evaluating the cost of funds for the commercial banks like marginal cost based lending rate (MCLR) system and others. Despite all the efforts of RBI on various occasions, the process of MPT does not work seamlessly due to institutional bottlenecks and the structural arrangements of the bank-led credit market (Patra and Kapur, 2010; Mohanty, 2016).

---

<sup>3</sup>This result is in line with Pandit and Vashisht (2011). They 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 EMDEs.

In India, the financial sector is largely dominated by the public sector commercial banks, which formalise the credit market activities. These scheduled commercial banks play a pivotal role in transmitting the policy-induced monetary impulses across different sectors of the economy. Broadly speaking, the effects of MPT occurs in two steps: first, the change in the policy rate affects the commercial bank interest rates, and second, the retail interest rates of the banks impact the consumption/savings and investment decision-making of the households and firms. Nevertheless, the expected outcome of policy intervention gets choked off in these two steps due to several factors associated with the traits of bank-based formal credit market and fiscal profligacy. Some of them are pointed out by Acharya (2017). First, there exists a large segment of financially excluded population that can potentially deter the transmission mechanism. Second, borrowers are often credit-constrained and can get the credit subject to the value of their collaterals. Third, presence of the administered interest rate structure on small savings constrains the adjustment of interest rate for the deposits. Fourth, about 90 per cent of total liabilities of the commercial banks are in the form of deposits, which are set at fixed interest rates. This discourages banks to reduce their lending rates in line with the policy rate and imparts rigidity in the transmission process. Fifth, persistence of the large market borrowing programme of the government hardens the interest rate expectations. Besides, high statutory liquidity ratio, which provides a captive market for government securities and suppresses the cost of borrowing for the government artificially, partly strangles the MPT mechanism. Finally, the deterioration in banking sector health due to low quality of assets and the unexpected loan losses in credit portfolios have led to significant distortions in the pricing of assets. All these factors, in sum, lead to frictions in the form of rigidities in the interest rate determination and cause impediments in the pass-through of MPT to aggregate demand and inflation.

In view of the empirical observations and evidence from the existing literature on MPT in India, we undertake this study to understand the role of frictions emanating from the credit market composition and the banking sector. We propose a New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) model with an imperfectly competitive banking sector at the core. Following Gerali et al. (2010) and Anand et al. (2014), we develop a modelling framework and augment the same by Indian economy-specific features like liquidity-constrained household, competitive labour market and reserve requirements for the commercial bank.

Our model consists of five building blocks: (i) household sector, (ii) production sector, (iii) banking sector, (iv) fiscal authority, and (v) central bank. Household sector comprises of heterogeneous agents. Primarily, there are two types of households: one is the liquidity-constrained households excluded from the access to formal financial services, and other is

the financially included households. Again, the financially included group is characterised by three different sub-groups, namely patient household (saver), impatient household (borrower) and entrepreneur (borrower). These three types of households are different from each other in terms of their time preferences (alternatively, the degree of impatience). Production sector is operated by the perfectly competitive firms producing intermediate goods, capital goods, housing goods and monopolistically competitive retail sector producing final goods. Banking sector offers a one-period financial instrument like deposit contract (for the saver) and loan contracts (for the borrowing household and firm). It operates with two branches, namely, wholesale branch and retail branch. Wholesale branch operates competitively while retail branch operates under a monopolistically competitive environment. Bank collects deposits from the patient household and issues collateralised loans to the borrowing household and the wholesale firm after meeting the statutory requirements in the forms of cash reserve ratio, liquidity ratio and capital adequacy ratio. It accumulates capital from its profit. The fiscal authority spends on final consumption goods and finances its spending by lump-sum taxes and issuing government securities which are held by the commercial banks. The central bank follows a Taylor-type interest rate rule by targeting the forecast-based inflation and current state of business cycle.

The model features real frictions in the forms of external habit formation in consumption, investment adjustment costs in the production of capital goods and housing goods. Nominal friction is considered following Rotemberg (1982) in the price-setting behaviour of retail goods sector. In the spirit of interest rate rigidity, credit-constrained borrowers and regulatory norms as observed in India, financial frictions are modelled by the financially excluded population, collateral constraints, quadratic adjustment costs for interest rate setting and maintaining the capital adequacy and reserve requirements of the bank. On one hand, the collateral constraints for the borrowing household and firm, and on the other hand, the balance sheet constraint and the law of motion for capital accumulation of the bank together construct a built-in feedback mechanism between the real and financial sectors of the model. Following the business cycle literature, we incorporate eight exogenous shocks in the model namely total factor productivity, marginal efficiency of investment, monetary policy, fiscal spending, mark-up, preference for housing goods, loan to value (LTV) ratio for the borrowing household and entrepreneur.

Baseline parameterisation of the model is configured by combining the methods of calibration and estimation. The well known deep parameters and steady-state shares are calibrated while the economy-specific friction parameters and shock structure are estimated with quarterly data (1999:Q1 to 2015:Q3) using Bayesian methodology. The baseline model is validated with the second order moments of the data based on volatility and cross-correlations

of the key macroeconomic and financial variables. Simulation results of the baseline model replicate the co-movement of the credit market interest rates with incomplete pass-through. In response to a positive interest rate shock, the spectrum of interest rates shifts up and squeezes the demand for credit. As a consequence, the contractionary effects set in from the demand side via reduction of consumption and investment demand, and supply side via cost of capital in the economy. This leads to a sharp decline in the demand for factors of production, in particular for the labour market, which drives down the aggregate output and inflation subsequently. The variance decomposition results show that the transmission of an interest rate shock to aggregate demand and inflation is paltry and subject to the structural attributes and degree of financial market frictions.

Focusing on the credit market friction parameters, we undertake the counterfactual experiments and evaluate the responsiveness of MPT using the accumulated effects over a time horizon of eight quarters. In general, it is observed that MPT improves as the friction in the financial system diminishes. More specifically, based on the elasticity measure, our results suggest that: (i) presence of liquidity-constrained and collateral-constrained households poses major obstacles for the transmission, (ii) easing of the collateral constraint and greater financial inclusion can enhance the degree of transmission more than proportionately, (iii) interest rate rigidity on the lending side and composition of saver and borrower in the credit market have important implications for the transmission mechanism, and (iv) rigidity in the deposit interest rate does not appear to be a significant one for the weak MPT, though its role becomes prominent as the depositors' base (i.e., proportion of savers) expands in the economy.

Further, our policy experiments using central bank loss function with respect to a set of alternative policy rules show that except for the case of housing price augmented Taylor rule, the standard form of the Taylor rule with forecast-based inflation and contemporaneous output stands out as the optimal one for all policy frameworks under consideration. Housing price augmented Taylor rule performs marginally better than the standard form of the Taylor rule. In contrast, adjusting policy interest rate to smooth out the credit cycle does not seem to be useful. Moreover, based on central bank loss function, we compare three different policy frameworks for stabilising output and inflation such as, (i) higher weightage for inflation stabilisation relative to output stabilisation, (ii) higher weightage for output stabilisation relative to inflation stabilisation, and (iii) equal weightage for inflation and output stabilisation. It is found that higher weightage for inflation stabilisation relative to output stabilisation is the most desirable policy option for the central bank as it minimises welfare loss irrespective of the policy rules. Overall, it appears that targeting financial variables in the monetary policy rule may not be appropriate for the purpose of economic stabilisation.

The rest of the paper is organised as follows. Section 2 provides the background of study. Section 3 lays out the model. Section 4 reports the quantitative analysis with results from the baseline model, discussion based on counterfactual experiments, and policy implications. Section 5 concludes the study.

## 2 Background of Study

### 2.1 Nexus between Monetary Transmission and Financial Market Frictions

MPT describes the sequence of actions through which policy-induced changes in the nominal money stock or the short-term nominal interest rate impact aggregate demand and inflation (Taylor, 1995; Woodford, 2003, and Ireland, 2008). The qualitative feature and quantitative significance of transmission mechanism vary across countries and over time periods. Different competing views are found in the literature on MPT according to the channels of transmission.<sup>4</sup> These include the money channel, interest rate channel, credit channel comprising bank lending and balance sheet channels, exchange rate channel, asset price channel and expectation channel.<sup>5</sup> Although the literature provides some unanimous views on these channels, their relative importance for an effective monetary transmission is still contentious. The effectiveness of different transmission channels varies depending upon the economic structure and financial conditions. Empirical evidence, for example, has shown that interest rate channel is the most relevant one for advanced economies due to their well-developed financial markets. In contrast, credit channel is the major conduit of transmission in the EMDEs. In case of small open economies with flexible exchange rates, where the interest rate channel is relatively weak, the exchange rate channel appears to be more crucial for the transmission mechanism (Mohanty and Turner, 2008; Kletzer, 2012). Researchers have examined various structural factors that can potentially determine the relative importance of different channels of monetary transmission. On the whole, it is observed that the financial market frictions play a major role in determining the nature and degree of pass-through of a monetary policy shock to the macroeconomic and financial variables. In the following subsections, first, we unfold the sources of frictions in the financial architecture, and then explore their role for different channels of MPT.

---

<sup>4</sup>We have provided a brief discussion on these channels of transmission in Appendix A.

<sup>5</sup>Even though such transmission channels have their distinguishing effects on the real economy, there are possibilities for interlinkages between the channels through which they may magnify or countervail the influence of each other in the transmission process.



### 2.1.1 Sources of Frictions in Financial Market Transactions

In an economy, if all agents are homogenous, financial resources remain liquid and flow to the most profitable project or individual who values it most. However, in reality, it does not happen due to market incompleteness and heterogeneity among the economic agents in multiple dimensions. There is a limit to the feasible range of intertemporal and/or intratemporal trades of claims. It means that the agents are unable to postpone their spending or insure themselves to smoothen their consumption and/or investment. In such a situation, distribution of funds becomes important to determine the flow of funds and their allocation. This typical feature of financial market has received considerable empirical support from different economic regions based on the cyclical properties of financial markets over different time periods.

The nature of market incompleteness and/or heterogeneity among the agents plays a critical role to determine the degree of financial frictions and their implications for the economy. Incompleteness of the financial market can be exogenous or endogenous (Quadrini, 2011). In case of exogenously induced market incompleteness, certain assets may not be traded in the market. For endogenous market incompleteness, markets can remain incomplete as the participants may not be willing to involve in certain trades due to problems of information asymmetry and limited enforcement (Brunnermeier et al., 2012).

Information asymmetries limit the ability of the sellers (say, lenders) to force the buyers (say, borrowers) to fulfil their financial obligations. In this case, the limit emerges from the inability of the seller to observe the buyer's action. For example, if the repayment depends on the performance of the business and the performance depends on the unobservable work effort, the borrower may have an incentive to choose the low level of work effort. Again, let us consider a situation where seller of a financial contract (say, lender) can observe whether the buyer (say, borrower) is obeying the contractual obligations. But, there is no instrument available using which the seller can enforce the contractual obligations. This gives rise to limited enforceability problem and leads to market incompleteness.

Along with information asymmetry and limited enforcement problems, heterogeneities among the economic agents with respect to different dimensions, such as endowments, time preference, risk aversion, productivity and belief, lead to presence of at least two groups of agents. One group of agents is financially constrained (borrowers) and seeks external funds, while the other group (lenders) provides at least some of the financial resources to the first group. In consequence of such market incompleteness and interaction between the heterogeneous agents, one can observe a wedge to exist in the financial market, either in terms of price of liquidity (i.e., difference between the return received by providers of financial capital and the cost of capital paid by capital users) or the availability of liquid

financial resources (i.e., difference between the actual and desired liquid financial resources availed by the financially constrained market participants). This wedge, precisely, defines the friction of financial market.

Since late 1970s, a body of literature started to evolve providing the theoretical justifications for financial frictions at the micro-level (Townsend, 1979; Stiglitz and Weiss, 1981; Hart and Moore, 1994; Kiyotaki, 2011) and their macroeconomic implications (Bernanke and Gertler, 1989; Carlstrom and Fuerst, 1997; Kiyotaki and Moore, 1997; Cooley et al., 2004; Kiyotaki and Moore, 2008; Gertler and Kiyotaki, 2010; Mendoza, 2010; Jermann and Quadrini, 2012). Researchers have also investigated empirical validations using the time-series data (Bernanke et al., 1999; Heathcote et al., 2009; Curdia and Woodford, 2010; Brzoza-Brzezina and Kolasa, 2013; Merola, 2015; Copaciu et al., 2015; Galvao et al., 2016; Guerrieri and Iacoviello, 2017), cross-sectional data (Aysun et al., 2013; Mateju, 2013; Guerrieri and Iacoviello, 2017; Mian et al., 2017) and panel data (Bhaumik et al., 2011). In this entire gamut of work, we are focusing on a particular segment of literature that has recognised the pivotal role of financial market frictions in determining the strength of different transmission channels of monetary policy.

### **2.1.2 Financial Friction: A Determinant of Transmission Mechanism**

The role of financial friction was primarily identified for the (broad) credit channel of transmission. The literature on external finance premium (Bernanke et al., 1999) as well as collateralised debt (Kiyotaki and Moore, 1997) has recognised the role of friction in credit channel of monetary transmission. Altering the external finance premium on borrowing (i.e., price of credit) or the valuation of collateral (i.e., credit limit), instruments of monetary policy can affect the wedge to move countercyclically, and create an additional impact on the real variables beyond its standard effect through the cost of capital. In case of the balance sheet channel of transmission, the effect of monetary policy on aggregate demand, which works through the policy rate to retail interest rates, largely depends on the magnitude of external finance premium, valuation of collateral and borrower's access to credit (Aysun et al., 2013; Gertler and Kiyotaki, 2010; Iacoviello, 2015; Guerrieri and Iacoviello, 2017). In case of the bank lending channel, changes in bank's loan supply induced by monetary policy actions affect the real economy subject to the imperfect substitutability between deposits and other sources of finance for the bank. Such a structure tends to amplify the propagation mechanism of the monetary policy shock (Gambacorta, 2008; Dib, 2010; Gambacorta and Signoretti, 2014). For both of these channels, friction in the credit market creates an enhancement mechanism for the effects of monetary policy shocks by changing the cost and availability of credit in response to changes in interest rates and other policy instruments.

Some studies, which are aligned with the broad credit channel, argue for the role of frictions with reference to bank capital and risk-taking channels of transmission mechanism. Under the bank capital channel, the strength of bank's balance sheet (instead of the borrower's balance sheet) is the main focus. Due to the presence of capital adequacy requirement, which places a constraint on issuing new equities and ownership, bank's balance sheet position provides an additional leverage on the effects of monetary policy shock (Blum and Hellwig, 1995; Van den Heuvel, 2002). Under the risk-taking channel, banks search for a higher yield in response to an increase in its risk appetite (Rajan, 2005; Borio and Zhu, 2012). For both the channels, a higher degree of financial friction on bank's capital entails higher borrowing premium for the bank, which forces them to reduce their credit supply. Using the bank-level data, several studies find evidence for the significance of financial constraints commonly proxied by bank size, liquidity and capitalisation (Kashyap and Stein, 1995 and 2000; Kishan and Opiela, 2000; Khwaja and Mian, 2008).

Apart from the credit channel, the role of financial frictions can be found for other transmission channels too depending on the structural attributes and policy environment of the underlying economy. Effectiveness of the interest rate channel critically depends on the state of financial development, segmentation of the financial market, access for the market participants and level of market distortions due to policy interventions. As an example, administered interest rate regime by policy intervention, lack of financial deepening and a large group of small borrowers weaken the interest rate channel in the emerging market economies. On the front of policy environment, Altunbas et al. (2009) found that the dramatic increase in securitisation activity in Europe had feebled the efficacy of interest rate channel, as it allowed greater access to liquidity without any expansion of the bank's balance sheet, and hence the ability to continue lending in the face of a tightening of the monetary policy. For the exchange rate channel, the transaction cost for cross-border financial transactions and the country's risk premium act as the key sources of frictions and take a prominent role in the context of small open emerging market economies. Finally, for the asset price channel, the strength of transmission conspicuously revolves around the information-related frictions of the asset markets (Iacoviello and Neri, 2010; Aysun et al., 2013; Gambacorta and Signoretti, 2014).

## **2.2 Indian Experience of Monetary Policy Transmission**

### **2.2.1 Operating Procedure of Monetary Policy**

In the pre-reform period (before 1990-91), monetary policy regime in India was subject to widespread financial repressions, high fiscal deficit and administered interest rate regime.

It was operated under a framework of automatic monetisation where the RBI facilitated financing of fiscal deficit as the debt manager of the government. The then banking sector was characterised by a high share of government ownership without any competition from private banks and heavily regulated from exposure to the financial markets. The banks used to invest mostly in risk-free assets such as government securities. However, the scenario started to change with implementation of reforms in the operating framework of monetary policy during the late 1990s. These reform measures were aimed at the development of new institutions and instruments in the financial market to bring in efficiency in the financial system and implement market-determined interest rate regime.

The phasing out of automatic monetisation through ad-hoc Treasury bills since 1997 provided space for MPT to work towards output and inflation stabilisation, as well as better environment for fiscal-monetary coordination. This was an important step towards independent monetary policy. With progressive dismantling of the administered interest rate regime, the RBI reduced both Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR) substantially from the level prevailing in the early 1990s. This led to a significant reduction in lending rates of the commercial banks. The creation of Securities and Exchange Board of India (SEBI) was an important institutional development to regulate the financial market.

In the money market segment, Liquidity Adjustment Facility (LAF) was introduced for repo operation in order to provide short-term liquidity to the banks in exchange of government securities. This reduced the short-term volatility in the call money rate and helped in smoothening the interest rate channel of MPT mechanism. A pure inter-bank call money market and framework for auction-based repo/reverse repo were set up subsequently for short-term liquidity management as well as to improve the policy transmission. In order to strengthen the interest rate channel of transmission further, the RBI commenced a new operating procedure in May 2011 that recognised the weighted average overnight call money rate as the operating target for monetary policy.

All the reform measures of operating procedures, in sum, encouraged the role of market forces in determining the interest rates. In the backdrop of these developments, the RBI sets its policy rate, which is repo rate, and thereby provides a signal to the economy at the short-end level with an overall objective of influencing deposit and lending rates to impact the output and prices.

The RBI uses its policy rate as an important counter-cyclical tool to achieve the policy objectives of growth with price and financial stability. However, the effectiveness of monetary policy critically depends on the strength of the transmission mechanism, which further rests on the structural features of the real and financial sectors in the economy. The lit-

erature, which has evolved on the MPT mechanism in India, provides evidence for all the channels of transmission mechanism mentioned in Section 2.1, but their relative strengths vary significantly with different magnitudes and lags. Evidence can be found in Joshi, Sagar and Ray (1998), Al-Mashat (2003), RBI (2005), Mohan (2008), Mohanty and Turner (2008), Aleem (2010), Patra and Kapur (2010), Bhattacharya, Patnaik, and Shah (2010), Mohanty (2012), Kapur and Behera (2012), and Singh (2012). These studies have examined the monetary transmission mechanisms in India using different econometric methodologies and sample periods.

### **2.2.2 Role of Bank Lending Channel**

Out of the bulk of literature, a broad consensus has emerged that the bank lending channel is the most impactful channel through which monetary policy can affect the macroeconomic variables with a lag of two to three quarters. The bank lending channel works with an overlap of the interest rate channel and credit channel. After a policy shock, deposit and lending interest rates are adjusted by the commercial banks, which affect the borrower's and lender's balance sheet, availability of credit, spending and investment decisions of households and entrepreneurs and finally impact the output and inflation. Change in the policy interest rate is an important determinant of household's and firm's demand for bank credit. Although it is slow, but significant and robust. It entails incomplete pass-through of policy rate changes to bank interest rates, and transmits to aggregate demand. Das (2015) has pointed out some of the features of this particular channel in the following way. First, the extent of pass-through to the deposit rate is larger and the adjustment is relatively faster than that to the lending rate. Second, empirical evidence suggests an asymmetric adjustment to the monetary policy shock. The lending rate adjusts more quickly to monetary tightening than to its loosening. Third, the deposit rates do not adjust upwards in response to monetary tightening, but do adjust downwards to its loosening.

In the Indian context, there are empirical studies showing the existence and significance of the bank lending channel of the monetary policy. Using a VAR framework on quarterly panel data of banks for the period 1997 to 2002, Pandit et al. (2006) found that the changes in CRR and the bank rate get transmitted to the bank lending with the impact being much stronger on small banks than large banks. Using the annual panel data of banks from 2000 to 2007, Bhaumik et al. (2010) examined the implications of bank ownership on the transmission of monetary policy to the supply of bank credit. They observe that the bank lending channel of MPT is more effective under the deficit than the surplus in liquidity condition. Pandit and Vashisht (2011) examined the transmission of repo rate from the perspective of demand for bank credit in India. Using monthly data from January 2001 to

August 2010 in a panel framework of seven emerging market economies including India, they found that change in policy interest rate is an important determinant of firm's demand for bank credit. Considering a sample from the post LAF period (2001:Q3 to 2011:Q3) and deploying an approach similar to Hendry's general-to-specific method, Khundrakpam (2011) found that policy rate induced expansion/contraction in deposit forces banks to adjust their credit portfolio. The transmission of policy rate to real bank credit growth takes about seven months over the full sample period as well as across various sub-sample periods. Over the full sample period, a 100 basis points increase in policy rate was found to reduce the annualised growth in real bank credit by 2.17 per cent. However, the magnitude of the impact of policy interest rate on bank credit has been observed to decline during the post Global Financial Crisis period. While pointing out such asymmetric adjustment behaviour of deposit and lending interest rates, Sen Gupta and Sengupta (2014) and Das (2015) argued for the predominance of the bank lending channel of monetary transmission in India.

### **2.2.3 Impediments in Pass-through of Monetary Policy**

In India, MPT remains weak as a consequence of number of frictions originating from the institutional framework, policy-driven market distortions and under-developed financial market. A few of them are discussed below.

It is widely recognised that fiscal profligacy continued to remain intertwined with the banking sector through reserve requirements of banks in the form of government securities, which is known as statutory liquidity ratio or SLR. Lahiri and Patel (2016) showed that policy-induced binding constraint on banks due to the SLR component can result in higher lending rate spread in response to a reduction in policy rate. The rising spread leads to a contraction in the economy instead of an expansionary traction.

Agricultural credit has a significant share of bank credit in India. Given the large share of population depending on the agricultural sector, the government announced a "Comprehensive Credit Policy" in June 2004 with special focus on agricultural credit. Agricultural credit increased from 13 per cent in 2001-02 to around 39 per cent in 2012-13. During the last two-and-half decades, priority sector lending, Interest Subvention Scheme for crop loans and loan waiver schemes in response to agrarian discourse have been implemented by the government. However, these are credit market distortions faced by banks having an important bearing on the MPT mechanism. The credit market distortion in the form of priority sector lending, which is deployed under policy rules, does not respond to either market signals or subsequent monetary policy impulses. This restricts the impact of transmission of monetary policy (Prasad & Ghosh, 2005).

Interest rates in India are largely determined by the market except in the case of small

savings instruments. The interest rates, which are offered on small savings on a medium-term basis and changed quarterly, have been considered as one of the impediments for the MPT mechanism. The small savings instruments such as National Savings Certificates, Provident Funds and other postal savings are linked to interest rates of the government securities and are generally higher than the deposit rates offered by banks. These instruments also pegged with tax incentives to stimulate household savings. As a result, the administered nature of small savings rates provides a competitive interest rates floor to the commercial bank. This puts a binding constraint on the commercial banks to align their deposit rates close to small savings rates and leads to higher adjustment cost for commercial banks. Accordingly, this results in incomplete pass-through of changes in policy rate to deposit rate, with even lesser degree on lending rates.

Further, the prevalence of oligopolistic market structure in the Indian banking sector poses a bottleneck for the pass-through mechanism of MPT. Although the banking sector has been opening up gradually over the last decade for the private and foreign banks, the degree of market imperfection is quite prominent. The data of net interest margin (NIM), which is used as an indicator of market competitiveness for the banking sector (Mandelmann, 2010), shows that during the period 1992 to 2010, Indian banking sector became more competitive but at a decreasing pace. The NIM declined by 18 percentage points between the period 1992-96 and 1997-2001. During 2002-07, it went down by 6 percentage points and after 2007, by 4.4 percentage points further. This indicates that the distortion due to market imperfection is sizeable in the banking sector.<sup>6</sup> Similar evidence can be found from the interest rate spread adjustment behaviour of the commercial banks. Even after introducing the marginal cost based lending rate system, commercial banks adjust the spread over the marginal cost quite arbitrarily, which partly reflects the degree of credit market imperfection. At times, these spreads are too large to be explained by the bank-level business strategy and/or borrower-level credit risk premium (Acharya, 2017).

## **2.3 Stylised Facts on Indian Macroeconomic and Financial Variables**

### **2.3.1 Cyclical Behaviour of Interest rates, Credit and Output**

In view of the increasing role of interest rates as the policy instrument of monetary authority in India, we have looked into the patterns in the movements of repo rate and call money rate over the period of one-and-half decades using the quarterly data from 1999:Q4 to 2015:Q3.

---

<sup>6</sup>Claessens et al. (2001) find that an increased presence of foreign banks is associated with a reduction in profitability and margins for domestic banks.

It is presented in Figure 1.

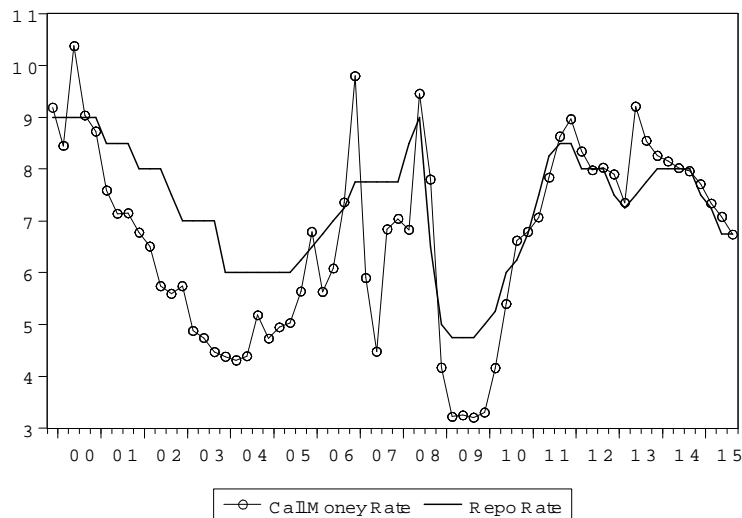


Figure 1: Patterns in Movements of Policy Instrument and Operational Target

Along with the co-movements of policy instrument (repo rate) and operational target (call money rate), one can recognise two major policy-easing cycles that have been pursued by the RBI during the period of study. The first one took place during the pre-crisis period (1999:Q4 to 2008:Q2) and the second one followed during the post-crisis period (2008:Q3 to 2015:Q3). The sharp spikes during 2007-08 and upward movements of the interest rates from 2011-12 onwards are noticeable. These were the periods that witnessed supply-side driven double-digit inflation, and necessitated policy tightening. Overall, a strong association between the repo rate and call money rate is observed for the entire sample period with correlation coefficient of 0.82, which is statistically significant at the level of 1 per cent. This association becomes much stronger during the post-crisis period (0.95) compared to the pre-crisis period (0.79).



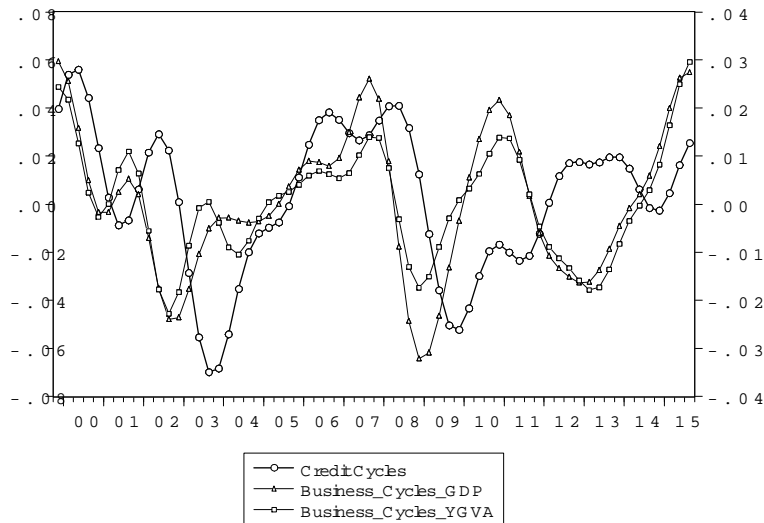


Figure 2: Procyclical Movements in Credit Growth & Economic Activities

Table 1: Correlations between Cyclical Movements of Commercial Bank Credit and Output

Business Cycle	Credit Cycle		
	Pre-crisis	Post-crisis	Full Sample
GDP	0.53**	0.62**	0.55**
GVA	0.43**	0.47**	0.44**

While drawing up the patterns in the movements of policy instrument and its operational target, it is imperative to examine the interaction between cyclical movements of the credit expansion/contraction and the economic activities during the sample period. In Figure 2, business cycle components of Gross Value Added (GVA), Gross Domestic Product (GDP) and growth of aggregate credit provided by the scheduled commercial banks are plotted. In Table 1, the cross-correlations between output and credit growth are reported. It is found that growth of bank credit is procyclical and statistically significant, irrespective of the measures of economic activities. Such procyclical behaviour of credit has intensified in the post-crisis period than the pre-crisis period. Comparing Figures 1 and 2, further, it can be noticed that the policy-easing cycles opted by the RBI were moderately followed by the expansionary movements in the credit side and real activities in the economy.

In this context, we have explored the interaction between the synchronisation of credit and real activities and the degree of financial friction over cyclical fluctuations. Following Hall (2011), different measures of financial friction like interest rate spread between retail lending and deposit rates, and term spread between the short-term and long-term government bond yields are computed and their correlations with credit-to-GDP ratio and credit-to-GVA

ratio are examined. In Figure 3, we have presented the cyclical patterns of the spread and credit-to-output ratio. In Table 2, the cross-correlation results are reported.

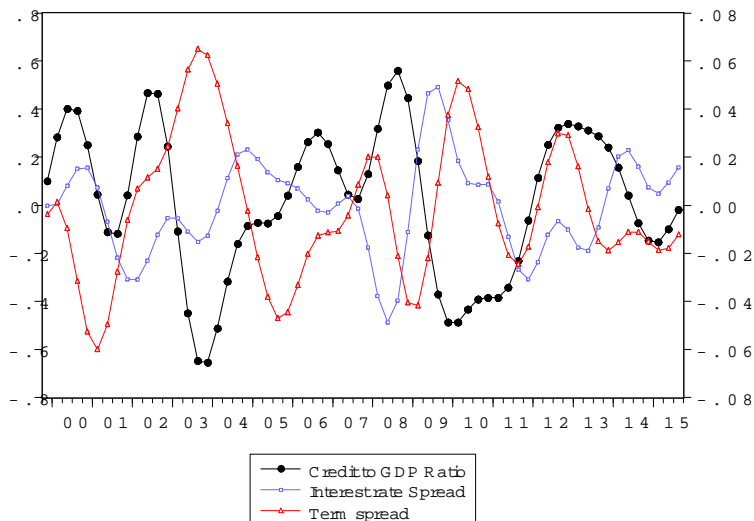


Figure 3: Countercyclical Movements of Spreads and Credit-to-GDP Ratio

Table 2: Correlations between Spreads and Credit-to-Output Ratio during Full Sample Period

Spread	Credit-to-GDP Ratio	Credit-to-GVA Ratio
Lending/Deposit Interest Rate	-0.40**	-0.42**
Short/Long term Govt. Bond Yield	-0.35**	-0.34**

For all cases, it is observed that the measures of spread exhibit a counter-cyclical pattern with the movements of credit-to-output ratio. This observation goes in line with the prediction of the literature on macro-financial linkages. In the literature, it is argued that if financial accelerator mechanism is in place, frictions will be low in the financial market during the good times of business cycle and vice versa (Vlcek and Roger, 2012). The counter-cyclical behaviour of different measures of spread confirms the same for Indian economy.

### 2.3.2 Evidence on Monetary Transmission from SVAR Analysis

In this sub-section, we take a preview of the MPT in India using Structural Vector Autoregression (SVAR) framework. SVAR has become a standard approach for evaluating the effects of monetary policy shocks as it allows the modelling of recursive and non-recursive structures of the economy with a parsimonious set of variables and facilitates the interpretation of the contemporaneous correlation among the disturbances (Sousa and Zaghini,

2007). The econometric specification of SVAR representation and structural restrictions are provided in Appendix B.

We use a six-variable SVAR specification, which includes real GDP growth ( $y$ ), CPI inflation ( $\pi$ ), real non-food credit growth ( $b$ ), interest rate on deposit ( $i^d$ ), interest rate on lending ( $i^b$ ) and call money rate ( $i$ ) producing the monetary policy shock. The definitions and sources of data are provided in Appendix C. The non-food credit is included to consider the credit view of the policy transmission and is assumed to depend contemporaneously on real income, inflation and the lending interest rate. Structural restrictions are imposed for the identification of impact of monetary policy on output and prices. It is assumed that the monetary policy variable does not respond to output and prices contemporaneously because of lags in data release. It is also assumed that output and prices are not affected contemporaneously by financial variables due to adjustment costs. Policy shocks do not have an immediate impact on output and prices due to transmission lags. Deposit rates and lending rates are assumed to depend on growth, inflation and credit demand of the economy. Further, deposit rate is expected to impact the lending rate. The deposit rate responds to economic activity, inflation and credit demand in the economy along with the lending rate.<sup>7</sup> The SVAR model is estimated using seasonally adjusted quarterly data for the period 1999:Q1 through 2015:Q3. The lag length of two is chosen based on the final prediction error method to estimate SVAR. The impulse response of different variables to monetary policy shock from the SVAR model is plotted in Figure 4.

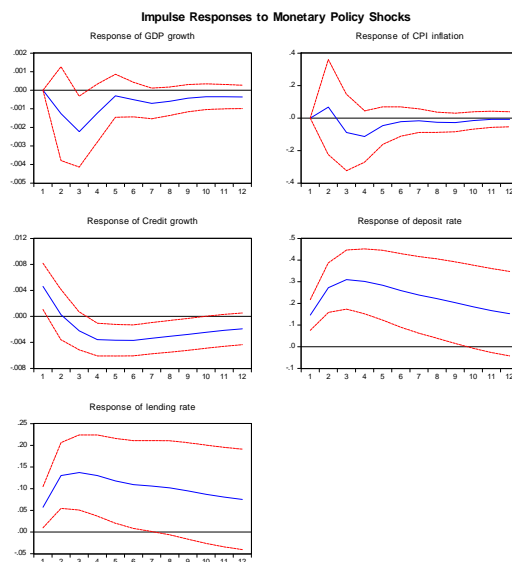


Figure 4: IRF Plots of a Monetary Policy Shock from SVAR

---

<sup>7</sup>According to our restrictions, the elements in the matrix representing impact of shocks on output and prices are assumed to be zero.

The impulse response plots of Figure 4 reveal the following observations. The deposit and lending rates increase in response to increase in policy rate and the effect increases up to the third quarter before tapering-off. Credit starts falling after two periods of lag and the effects remain for a prolonged period. GDP growth declines in response to the policy rate shock with a lag of two quarters and the effect dissipates slowly after peaking at the third quarter. The negative impact on inflation follows after a decline in GDP growth and the peak impact is observed with a lag of one quarter from the corresponding peak impact on the GDP growth. However, a mild presence of price puzzle is observed as the inflation rate increases up to second quarter in response to monetary policy shock.<sup>8</sup> In sum, the result provides evidence for both the interest rate and credit channels of monetary transmission to macroeconomic and financial variables in the economy.

### 3 The Model

There has been a long-standing interest to incorporate financial friction in the mainstream macroeconomic model, which has gained momentum in the post Global Financial Crisis scenario. The associated literature offers two alternative approaches. The first strand of research originated from the influential work of Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), and Bernanke et al. (1999), where financial friction is modelled by an external finance premium that affects the price of credit in the economy via the financial accelerator mechanism. The other seminal contribution came from Kiyotaki and Moore (1997) and Iacoviello (2005), who introduced financial friction via collateralised debt, which affects the quantity of credit availability. Both of these approaches are merged in the New Keynesian Dynamic Stochastic General Equilibrium (NK-DSGE) models to examine the effects of different structural and policy shocks emerging from the real and financial sectors in a prototype economy.

The literature has been advanced by an explicit modelling of the role of financial intermediaries into the analytical framework to provide a better understanding of the complex interactions among the policy rate to the short-term market interest rates and the government bond rates. Goodfriend and McCullam (2007) did pioneering work by introducing banking sector in a DSGE model. They addressed interactions and differences between various types of interest rates based on the credit channel of their banking sector. Later, this stream of research was enriched by the contributions from Curdia and Woodford (2016),

---

<sup>8</sup>Statistically significant response of the macroeconomic and financial variables are broadly observed around the third quarter after a monetary policy shock except for inflation (as the confidence band of its IRF includes both positive and negative quadrants).

Gertler and Kiyotaki (2009), Gertler and Karadi (2011), Andres and Arce (2012), Agenor et al. (2013), Canzoneri et al. (2016) and Bhattarai et al. (2015).

In our study, we develop a medium-scale NK-DSGE model using the collateralised debt approach. The model features imperfect credit market and financial intermediaries for an emerging economy like India. This approach installs the broad credit channel of MPT and highlights the role of borrowing and lending constraints as the key drivers of macro-financial linkage in the economy. It is evident from the literature that credit channel via bank lending is the principal route for MPT in India. Heavily regulated and imperfectly competitive large bank dominated formal credit market with credit-constrained borrowers are the typical features of the Indian financial sector. Such features motivate us to adopt a modelling framework with the bank lending and balance sheet channels for the MPT mechanism.

### 3.1 Description of the Economy

We closely follow Gerali et al. (2010) and Anand et al. (2014) to build up our medium scale DSGE model. The model is essentially an extension of the standard New Keynesian framework with financially excluded population, savers, credit-constrained borrowers and imperfectly competitive banking sector. A variety of frictions are modelled in the forms of collateral constraints and symmetric adjustment costs except external habit formation in consumption and inflation indexation in price-setting. Exogenous shocks are incorporated as appropriate for the business cycle features of a developing economy. The environment of our model is explained below.

The household sector consists of the representatives from the financially excluded, patient, impatient and entrepreneur groups. Financially excluded households are liquidity-constrained and cannot participate in the financial market. In contrast, the representative households from the patient, impatient, and entrepreneur groups are financially included but heterogenous due to the difference in their time preference. Production side of the economy comprises four sectors: (i) intermediate goods producing wholesale firms run by the entrepreneurs, (ii) retailers who convert the intermediate goods into the final goods, (iii) capital goods producing sector which produces new capital using old capital and investment and (iv) housing goods producing sector that operates analogous to capital goods sector.

Operation of the representative commercial bank is managed by its two branches: wholesale branch and retail branch. The bank offers two types of one-period financial instruments: one is deposit contract (for patient households) and the other is loan contract (for impatient households and entrepreneurs). They collect financial resources via selling of deposit contracts to the patient households; issue collateralised loans to the borrowing households and

the wholesale firms; meet the reserve requirements in the form of cash reserve ratio and statutory liquidity ratio and macroprudential norm of the central bank in the form of capital adequacy ratio; and accumulate capital from its profit. The balance sheet constraint of the bank establishes the link between the business cycle and credit cycle in the economy through bank capital. The degree of pass-through of the change in policy rate to retail deposit and lending rates critically depends on the credit market imperfections, interest rate stickiness and adjustment cost of bank's capital-to-asset ratio.

There is a government that spends on final consumption goods. This fiscal expenditure is financed by the lump-sum taxes and issuing of government securities that are held by the commercial banks. The central bank follows a Taylor-type interest rate rule by targeting the forecast-based inflation and current business cycle conditions.

## 3.2 Household Sector

The economy is populated by households and entrepreneurs, each one with a unit mass. Households are segmented into two groups according to their access to the financial market transactions. The first group is the liquidity-constrained households ( $R$ ) that cannot participate in the financial market. The other group of households actively participates in the financial market operations and features heterogeneity with respect to their degree of time preference. This financially included group consists of patient households ( $P$ ), impatient households ( $I$ ), and entrepreneurs ( $E$ ). Patient households have a discount factor ( $\beta_P$ ) which is higher than impatient households ( $\beta_I$ ) and entrepreneurs ( $\beta_E$ ). Such a difference in the time preference allows the patient households to be lenders and impatient households and entrepreneurs to be borrowers in the model environment.

### 3.2.1 Liquidity-constrained Household

A representative  $i^{th}$  household of the financially excluded segment of population consumes the final goods  $C_{R,t}(i)$  and supplies labour  $L_{R,t}(i)$  to the packer in the competitive labour market at real wage rate of  $w_{R,t}$ . They maximise the following utility function:

$$U_{R,t} = \left[ \ln C_{R,t}(i) - \frac{L_{R,t}^{1+\sigma_l}(i)}{1 + \sigma_l} \right] \quad (1)$$

subject to their budget constraint:

$$C_{R,t}(i) \leq w_{R,t} L_{R,t}(i) \quad (2)$$

Hence, their optimal choice of consumption and labour supply yields:

$$\frac{1}{C_{R,t}(i)} = \lambda_{R,t} \quad (3)$$

$$L_{R,t}^{\sigma_l}(i) = w_{R,t} \lambda_{R,t} \quad (4)$$

where,  $\lambda_{R,t}$  is the Lagrangian multiplier implying the shadow price of consumption.

### 3.2.2 Patient Household

A representative patient household  $i$  chooses final consumption goods  $C_{P,t}(i)$  subject to habit formation on aggregate consumption, housing goods  $H_{P,t}(i)$ , labour supply  $L_{P,t}(i)$ , and deposits  $D_t(i)$  in order to maximise the present value of life-time expected utility given the periodical budget constraint. The expected utility function of a patient household is:

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \left[ (1 - \sigma_h) \ln (C_{P,t}(i) - \sigma_h C_{P,t-1}) + \varepsilon_{H,t} \ln H_{P,t}(i) - \frac{L_{P,t}^{1+\sigma_l}(i)}{1 + \sigma_l} \right] \quad (5)$$

where,  $\sigma_h$  denotes the degree of habit persistence in consumption,  $\sigma_l$  is the inverse of Frisch elasticity of labour supply, and  $\varepsilon_{H,t}$  is an exogenous shock to preference for housing services. The flow of funds of the patient households is as follows:

$$\begin{aligned} & C_{P,t}(i) + Q_t^h \{H_{P,t}(i) - (1 - \delta_h) H_{P,t-1}(i)\} + D_t(i) + TX_{P,t}(i) \\ & \leq w_{P,t} L_{P,t}(i) + \left\{ \frac{(1 + i_{t-1}^d)}{\pi_t} \right\} D_{t-1}(i) + \Pi_{P,t}^r \end{aligned} \quad (6)$$

where,  $Q_t^h$  is real price of housing,  $\delta_h$  is depreciation rate of housing goods,  $w_{P,t}$  is real wage,  $i_t^d$  is nominal interest rate on deposits, and  $\pi_t$  is consumer price inflation at date  $t$ . On the outflow of funds, expenditures are incurred for current consumption, accumulation of housing goods, purchase of new deposit contracts, and lump-sum tax paid to the government ( $TX_{P,t}$ ). On the inflow of fund, household receives labour income from the entrepreneurs, interest income from the deposit holding of the previous period, and the profit received from the ownership of retail goods producing firms ( $\Pi_{P,t}^r$ ).

Patient household makes an optimal choice for  $\{C_{P,t}(i), H_{P,t}(i), L_{P,t}(i), D_t(i)\}_{t=0}^{\infty}$  which yields the following optimisation conditions:

$$\frac{(1 - \sigma_h)}{(C_{P,t}(i) - \sigma_h C_{P,t-1})} = \lambda_{P,t} \quad (7)$$

$$\left[ \frac{\varepsilon_{H,t}}{H_{P,t}(i)} \right] = \lambda_{P,t} Q_t^h - \beta_P (1 - \delta_h) \lambda_{P,t+1} Q_{t+1}^h \quad (8)$$

$$L_{P,t}^{\sigma_l}(i) = w_{P,t} \lambda_{P,t} \quad (9)$$

$$\lambda_{P,t} = \beta_P \left( \frac{1 + i_t^d}{\pi_{t+1}} \right) \lambda_{P,t+1} \quad (10)$$

where,  $\lambda_{P,t}$  is Lagrangian multiplier for the budget constraint in real terms.

### 3.2.3 Impatient Household

The representative  $i^{th}$  household from the impatient group derives utility from the consumption of final goods  $C_{I,t}(i)$  subject to habit formation on aggregate consumption, and housing goods  $H_{I,t}(i)$ , and disutility from labour supply  $L_{I,t}(i)$ . It maximises the present value of life-time expected utility:

$$E_0 \sum_{t=0}^{\infty} \beta_I^t \left[ (1 - \sigma_h) \ln (C_{I,t}(i) - \sigma_h C_{I,t-1}(i)) + \varepsilon_{H,t} \ln H_{I,t}(i) - \frac{L_{I,t}^{1+\sigma_l}(i)}{1 + \sigma_l} \right] \quad (11)$$

subject to the sequence of budget constraint which is specified as:

$$\begin{aligned} C_{I,t}(i) + Q_t^h \{ H_{I,t}(i) - (1 - \delta_h) H_{I,t-1}(i) \} + \left\{ \frac{(1 + i_t^{bH})}{\pi_t} \right\} B_{H,t-1}(i) + TX_{I,t}(i) \\ \leq w_{I,t} L_{I,t}(i) + B_{H,t}(i) \end{aligned} \quad (12)$$

where,  $w_{I,t}$  is real wage and  $i_t^{bH}$  is interest rate on borrowing at date  $t$ . Expenditures are incurred for consumption, accumulation of housing goods, repayment of previous period loans  $B_{H,t-1}(i)$  with interest, and lump-sum tax payment to the government  $TX_{I,t}(i)$ . Inflow of funds comes in the forms of labour income and current period borrowing.

In addition to the budget constraint, representative impatient household faces a borrowing constraint that needs to be honoured to get loans from the bank. The household can get credit upto the limit of expected nominal value of their collateral. Household uses its accumulated physical assets of housing as the collateral. The borrowing constraint takes the following form:

$$(1 + i_t^{bH}) B_{H,t}(i) \leq \varepsilon_{LV,t}^H (1 - \delta_h) E_t \{ Q_{t+1}^h \pi_{t+1} \} H_{I,t}(i) \quad (13)$$



where,  $\varepsilon_{LV,t}^H$  is exogenously time varying LTV ratio for the borrowing households.

Impatient household optimally chooses  $\{C_{I,t}(i), H_{I,t}(i), L_{I,t}(i), B_{H,t}(i)\}_{t=0}^{\infty}$  which results into the following optimal conditions:

$$\frac{(1 - \sigma_h)}{(C_{I,t}(i) - \sigma_h C_{I,t-1})} = \lambda_{I,t} \quad (14)$$

$$\left[ \frac{\varepsilon_{H,t}}{H_{I,t}(i)} \right] = \lambda_{I,t} Q_t^h - \beta_I (1 - \delta_h) \lambda_{I,t+1} Q_{t+1}^h - \varepsilon_{LV,t}^H (1 - \delta_h) \mu_{I,t} Q_{t+1}^h \quad (15)$$

$$L_{I,t}^{\sigma_l}(i) = w_{I,t} \lambda_{I,t} \quad (16)$$

$$\lambda_{I,t} = \beta_I \left( \frac{1 + i_t^{bH}}{\pi_{t+1}} \right) \lambda_{I,t+1} + (1 + i_t^{bH}) \mu_{I,t} \quad (17)$$

where,  $\lambda_{I,t}$  and  $\mu_{I,t}$  are the Lagrangian multipliers on the budget and borrowing constraints, respectively.

### 3.2.4 Entrepreneur

There exists infinitely large number of entrepreneurs within a unit interval. The representative entrepreneur  $i$  derives utility from its final consumption ( $C_{E,t}$ ) subject to habit formation on their aggregate consumption. The intertemporal discount factor of the entrepreneur is denoted by  $\beta_E$ . The present value of life-time expected utility function of the entrepreneur is as follows:

$$E_0 \sum_{t=0}^{\infty} \beta_E^t [(1 - \sigma_h) \ln (C_{E,t}(i) - \sigma_h C_{E,t-1})] \quad (18)$$

The entrepreneur faces a budget constraint as well as a borrowing constraint which are given below.

$$\begin{aligned} & C_{E,t}(i) + w_{R,t} L_{R,t}(i) + w_{P,t} L_{P,t}(i) + w_{I,t} L_{I,t}(i) \\ & + \left\{ \frac{(1 + i_{t-1}^{bE})}{\pi_t} \right\} B_{E,t-1}(i) + Q_t^k K_t(i) + \psi_t(u_t) K_{t-1}(i) \\ & \leq \frac{Y_{E,t}(i)}{X_t} + B_{E,t}(i) + Q_t^k (1 - \delta_k) K_{t-1}(i) \end{aligned} \quad (19)$$

$$(1 + i_t^{bE}) B_{E,t}(i) = \varepsilon_{LV,t}^E (1 - \delta_k) E_t \{ Q_{t+1}^k \pi_{t+1} \} K_t(i) \quad (20)$$

where,

$$Y_{E,t} = \varepsilon_{A,t} \{u_t(i) K_{t-1}(i)\}^\alpha L_t^{1-\alpha}(i) \quad (21)$$

$$L_t(i) = L_{R,t}^{\gamma_R}(i) \{L_{P,t}^\gamma(i) L_{I,t}^{1-\gamma}(i)\}^{1-\gamma_R} \quad (22)$$

$$\psi_t(u_t) = \psi_a(u_t - 1) + \frac{\psi_b}{2}(u_t - 1)^2 \quad (23)$$

$$X_t = \frac{P_t}{P_{E,t}} \quad (24)$$

In the above budget and borrowing constraints,  $i_t^{bE}$  is interest rate on borrowing from bank for entrepreneurs,  $B_{E,t}$  is amount of entrepreneurial borrowing,  $Q_t^k$  is real price of physical capital,  $\varepsilon_{A,t}$  is the shock to total factor productivity,  $L_t$  is aggregate labour (after combining the labour inputs from liquidity-constrained, patient and impatient households) and  $K_t$  is physical capital used in wholesale goods production,  $\psi_t(u_t)$  is cost of utilisation of capital,  $Y_{E,t}$  is intermediate wholesale goods produced by the entrepreneur, and  $\left(\frac{1}{X_t}\right)$  is real marginal cost of wholesale goods production at date  $t$ . The share of capital in the production function is  $\alpha$ , the shares of labour of liquidity constrained, patient and impatient households in the production are  $\gamma_R$ ,  $\{\gamma(1 - \gamma_R)\}$ , and  $\{(1 - \gamma)(1 - \gamma_R)\}$ , respectively and the curvature parameters of the utilisation cost function are  $\psi_a$  and  $\psi_b$ .

In the entrepreneurial budget constraint of (19), expenditures are incurred for current consumption, payment of wage bills to liquidity-constrained, patient, and impatient households for their labour supply, repayments of previous period's debt, and utilisation cost of capital. Entrepreneur receives inflow of resources in the form of output produced, borrowing from the bank at current period, and selling of the undepreciated stock of physical capital of the previous period.

The credit availability from the bank is determined by the stock of physical capital, which is offered as collateral by the entrepreneurs. The loan restriction for entrepreneur is given by equation (20). In the borrowing constraint, we have  $\varepsilon_{LV,t}^E$  which is exogenously time-varying LTV ratio for the entrepreneur.

The sequences of  $\{C_{E,t}(i), K_t(i), u_t, L_{R,t}(i), L_{P,t}(i), L_{I,t}(i), B_{E,t}(i)\}_{t=0}^\infty$  are optimally chosen by the entrepreneur, and this results into the following optimal conditions:

$$\frac{(1 - \sigma_h)}{(C_{E,t}(i) - \sigma_h C_{E,t-1})} = \lambda_{E,t} \quad (25)$$

$$\begin{aligned}\lambda_{E,t}Q_t^k &= \varepsilon_{LV,t}^E (1 - \delta_k) \mu_{E,t}Q_{t+1}^k \pi_{t+1} + \\ &\quad \beta_E \lambda_{E,t+1} [r_{t+1}^k u_{t+1} + (1 - \delta_k) Q_{t+1}^k - \psi_{t+1}(u_{t+1})]\end{aligned}\quad (26)$$

$$r_t^k = \psi_a + \psi_b (u_t - 1) \quad (27)$$

$$w_{R,t} = \gamma_R \gamma (1 - \alpha) \left\{ \frac{Y_{E,t}(i)}{X_t} \right\} \left\{ \frac{1}{L_{R,t}(i)} \right\} \quad (28)$$

$$w_{P,t} = (1 - \gamma_R) \gamma (1 - \alpha) \left\{ \frac{Y_{E,t}(i)}{X_t} \right\} \left\{ \frac{1}{L_{P,t}(i)} \right\} \quad (29)$$

$$w_{I,t} = (1 - \gamma_R) (1 - \gamma) (1 - \alpha) \left\{ \frac{Y_{E,t}(i)}{X_t} \right\} \left\{ \frac{1}{L_{I,t}(i)} \right\} \quad (30)$$

$$\lambda_{E,t} = \beta_E \left( \frac{1 + i_t^{bE}}{\pi_{t+1}} \right) \lambda_{E,t+1} + (1 + i_t^{bE}) \mu_{E,t} \quad (31)$$

where, marginal product of capital is:  $r_t^k = \alpha \left\{ \frac{Y_{E,t}(i)}{X_t} \right\} \left\{ \frac{1}{u_t(i)K_{t-1}(i)} \right\}$ ;  $\lambda_{E,t}$  and  $\mu_{E,t}$  are Lagrangian multipliers on the budget and borrowing constraints of the entrepreneurs, respectively.

### 3.2.5 Competitive Labour Market

Labour market is perfectly competitive where liquidity-constrained household, patient household and impatient household sell their labour to entrepreneur. All types of labour inputs are bundled up via an aggregation technology by the entrepreneur in a costless way to produce homogenous labour input for the wholesale goods production. From the entrepreneur's choice of labour input, given the labour aggregator is in place, one can obtain the following aggregate real wage weighted by share of different types of household's labour in the labour market.

$$w_t = \tilde{\gamma} w_{R,t}^{\gamma_R} w_{P,t}^{\gamma(1-\gamma_R)} w_{I,t}^{(1-\gamma)(1-\gamma_R)} \quad (32)$$

where,  $\tilde{\gamma} = \left[ \gamma_R^{\gamma_R} \{\gamma(1-\gamma_R)\}^{\gamma(1-\gamma_R)} \{(1-\gamma)(1-\gamma_R)\}^{(1-\gamma)(1-\gamma_R)} \right]^{-1}$

Since there is no intra-group heterogeneity within the respective household group with respect to their endowments, all individuals within a particular group face the same budget constraint and objective function. Thus, they choose identical time paths for optimisation.

For this reason of symmetry within the group, hereafter we drop the household sector relevant script  $i$ .

### 3.3 Producers

#### 3.3.1 Monopolistically Competitive Retailer

The representative retailer buys homogenous intermediate goods at price  $P_{E,t}$  from the entrepreneur, does the packaging with different brands at zero cost and turns them into differentiated final goods. These differentiated final goods are sold at price  $P_t(j)$  in the imperfect market that features monopolistic competition and nominal price rigidity. This price is indexed by a weighted combination of last period inflation and steady-state level of inflation. If the retailer adjusts the price of his goods beyond the indexation rule suggests, he will face a quadratic adjustment cost parameterised by  $\vartheta_p$ . Further, price of final goods is subject to the mark-up shock due to the presence of exogenously time-varying price elasticity of demand ( $\varepsilon_{Y,t}$ ). The retail sector firm maximises:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ P_t(j) Y_t(j) - P_{E,t} Y_t(j) - \frac{\vartheta_p}{2} \left( \frac{P_t(j)}{P_{t-1}(j)} - \pi_{t-1}^{\theta_p} \pi^{1-\theta_p} \right)^2 P_t Y_t \right] \quad (33)$$

subject to the sequence of demand constraints:

$$Y_t(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\varepsilon_{Y,t}} Y_t \quad (34)$$

and finds the following optimal pricing condition for their goods:

$$1 - \varepsilon_{Y,t} + \left( \frac{\varepsilon_{Y,t}}{X_t} \right) - \vartheta_p \left[ \pi_t - \pi_{t-1}^{\theta_p} \pi^{1-\theta_p} \right] \pi_t + \beta_P \left[ \frac{\left( \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) \vartheta_p}{\left( \pi_{t+1} - \pi_t^{\theta_p} \pi^{1-\theta_p} \right) \pi_{t+1} \left( \frac{Y_{t+1}}{Y_t} \right)} \right] = 0 \quad (35)$$

#### 3.3.2 Capital Goods Producing Sector

The capital goods producing sector is incorporated in order to derive the equation of the market price of capital. This helps in determining the value of collateral of entrepreneurs as they demand loans from the bank. In a perfectly competitive environment at the beginning of each period  $t$ , these producers buy undepreciated last period's capital stock of the entrepreneurs  $(1 - \delta_k) K_{t-1}$  at a price  $P_t^k$ . In addition, they purchase an amount of  $I_t^k$  units of the final goods from retailers at a price of  $P_t$ . The undepreciated capital of the previous period is converted into the new capital at the rate of one-to-one. However, the final good

purchased from the retailers have this conversion subject to a quadratic adjustment costs. Thus, the effective capital stock  $K_t$ , which is finally sold to entrepreneurs at a price  $P_t^k$ , has its law of motion as given below:

$$K_t = (1 - \delta_k) K_{t-1} + \left[ 1 - \frac{\vartheta_k}{2} \left\{ \varepsilon_{i^k,t} \left( \frac{I_t^k}{I_{t-1}^k} \right) - 1 \right\}^2 \right] I_t^k \quad (36)$$

where,  $\vartheta_k$  represents the adjustment cost of investment,  $\varepsilon_{i,t}$  is a shock to the productivity of the investment and  $Q_t^k = \left( \frac{P_t^k}{P_t} \right)$  is the price in real terms of the capital. As a result, the capital producer maximises:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} [Q_t^k \{K_t - (1 - \delta_k) K_{t-1}\} - I_t^k] \quad (37)$$

subject to (36). Hence, the first order condition of optimisation of the capital goods producing firm turns out as:

$$Q_t \left[ \begin{aligned} & 1 - \frac{\vartheta_k}{2} \left\{ \left( \frac{\varepsilon_{i^k,t} I_t^k}{I_{t-1}^k} \right) - 1 \right\}^2 - \vartheta_k \left\{ \left( \frac{\varepsilon_{i^k,t} I_t^k}{I_{t-1}^k} \right) - 1 \right\} \left( \frac{\varepsilon_{i^k,t} I_t^k}{I_{t-1}^k} \right) \\ & + \beta_P \vartheta_k \left\{ \left( \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) \varepsilon_{i^k,t+1} Q_{t+1} \left\{ \left( \frac{\varepsilon_{i^k,t+1} I_{t+1}^k}{I_t^k} \right) - 1 \right\} \left( \frac{I_{t+1}^k}{I_t^k} \right)^2 \right\} \end{aligned} \right] = 1 \quad (38)$$

### 3.3.3 Housing Goods Producing Sector

Similar to capital goods producing sector, we add an explicit sector, which provides the basis for market price of housing goods and subsequently, the valuation of collateral of impatient household for taking loans from the bank. In this sector, firms operate in a competitive environment and produces new housing goods using the previous period undepreciated housing goods from borrowing households  $(1 - \delta_h) H_{t-1}$  and  $I_t^h$  amount of final goods from the retailers. Firms purchase undepreciated housing goods from borrowing households at price of  $P_t^h$  and final goods from the retailers at  $P_t$ . While the old undepreciated housing goods can be converted to new housing goods one-to-one, the new investment in house producing is subject to quadratic adjustment cost. The law of motion of housing goods accumulation is as follows:

$$H_t = (1 - \delta_h) H_{t-1} + \left[ 1 - \frac{\vartheta_h}{2} \left\{ \left( \frac{I_t^h}{I_{t-1}^h} \right) - 1 \right\}^2 \right] I_t^h \quad (39)$$

where,  $\vartheta_h$  denotes the adjustment cost of investment in housing. The housing goods producing firms, therefore, maximise the following objective function:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} [Q_t^h \{H_t - (1 - \delta_h) H_{t-1}\} - I_t^h] \quad (40)$$

subject to (39). This optimisation exercise yields the following first order condition with real price of housing goods  $Q_t^h \left( = \frac{P_t^h}{P_t} \right)$  as:

$$Q_t^h \left[ 1 - \frac{\vartheta_h}{2} \left\{ \left( \frac{I_t^h}{I_{t-1}^h} \right) - 1 \right\}^2 - \vartheta_h \left\{ \left( \frac{I_t^h}{I_{t-1}^h} \right) - 1 \right\} \left( \frac{I_t^h}{I_{t-1}^h} \right) \right. \\ \left. + \beta_P \vartheta_h \left\{ \left( \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \right) Q_{t+1}^h \left\{ \left( \frac{I_{t+1}^h}{I_t^h} \right) - 1 \right\} \left( \frac{I_{t+1}^h}{I_t^h} \right)^2 \right\} \right] = 1 \quad (41)$$

### 3.4 Banking Sector

The representative bank  $j \in [0, 1]$  intermediates all financial transactions among the economic agents in the model and works using two branches: one is the retail branch and the other is the wholesale branch. The retail branch operates in a monopolistically competitive environment through two departments. One department raises differentiated deposits from the patient household, and the other department provides differentiated loans to the impatient household and wholesale goods producing entrepreneurs. The retail level branches hold some market power in conducting their financial intermediation activity, which allows them to set deposit interest rate and lending rates for the borrowing household and entrepreneur. This type of banking structure enables us to examine different degrees of interest rate pass-through from the change of policy rate, which can affect the real and nominal variables through the transmission mechanism. In contrast to the retail branch, the wholesale unit - operating in a competitive market environment - provides wholesale loans and raises wholesale deposits from the retail branches, and takes care of the position of bank capital.

#### 3.4.1 Retail Branch

As in Gerali et al. (2010), we assume that units of deposit and loan contracts are differentiated financial products bought by the households and entrepreneur, and are composed by an aggregator with constant elasticities of substitution (CES). For a representative bank  $j$ , the deposit contract to patient household, loan contract to impatient household and loan contract to entrepreneur, elasticities of substitutions are  $\varepsilon^d$ ,  $\varepsilon^{bH}$ , and  $\varepsilon^{bE}$ , respectively.

We assume that each patient household purchases a deposit contract from each single bank in order to save one unit of her resource. On the other hand, each borrowing household and entrepreneur purchases the loan contract from each single bank in order to meet their ends. Such assumption goes with the standard Dixit-Stiglitz framework for imperfect market structure which shows that the demand for an individual bank's financial contract, either

deposit / loan, depends on the interest rate provided / charged by the bank relative to average rates in the economy. Therefore, the demand functions for deposit and loan contracts for the households and entrepreneur are given by:

$$D_t(j) = \left( \frac{i_t^d(j)}{i_t^d} \right)^{\varepsilon^d} D_t \quad (42)$$

$$B_{H,t}(j) = \left( \frac{i_t^{bH}(j)}{i_t^{bH}} \right)^{-\varepsilon^{bH}} B_{H,t} \quad (43)$$

$$B_{E,t}(j) = \left( \frac{i_t^{bE}(j)}{i_t^{bE}} \right)^{-\varepsilon^{bE}} B_{E,t} \quad (44)$$

where, the average interest rates on deposit ( $i_t^d$ ), lending for household ( $i_t^{bH}$ ), and lending for entrepreneur ( $i_t^{bE}$ ) are defined as follows:

$$i_t^d = \left[ \int_0^1 i_t^d(j)^{\varepsilon^d+1} dj \right]^{\frac{1}{\varepsilon^d+1}} \quad (45)$$

$$i_t^{bH} = \left[ \int_0^1 i_t^{bH}(j)^{1-\varepsilon^{bH}} dj \right]^{\frac{1}{1-\varepsilon^{bH}}} \quad (46)$$

$$i_t^{bE} = \left[ \int_0^1 i_t^{bE}(j)^{1-\varepsilon^{bE}} dj \right]^{\frac{1}{1-\varepsilon^{bE}}} \quad (47)$$

Note that the aforementioned set of demand functions and the average interest rates for the economy are derived from the expenditure minimisation exercise of the retail branches of the representative bank.<sup>9</sup>

**Retail Deposit Department:** The retail deposit department of bank  $j$  collects patient household's deposits,  $D_t(j)$ , and passes them to the wholesale unit, where deposits are remunerated at rate of  $i_t^s$ . The problem of the deposit unit is to maximise its expected present value of profit after taking into account the quadratic adjustment cost parameterised by  $\phi_d$ . The optimisation problem can be written as:

---

<sup>9</sup>See the appendix of Gerali et al. (2010) for further details.

$$Max_{i_t^d} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ i_t^s D_t(j) - i_t^d D_t(j) - \frac{\phi_d}{2} \left( \frac{i_t^d(j)}{i_{t-1}^d(j)} - 1 \right)^2 D_t \right] \quad s.t. \quad D_t(j) = \left( \frac{i_t^d(j)}{i_t^d} \right)^{\varepsilon^d} D_t \quad (48)$$

The first order condition of the above problem produces the following expression for optimal deposit interest rate after imposing the symmetric equilibrium condition:

$$i_t^d = \left( \frac{\varepsilon^d}{\varepsilon^d + 1} \right) i_t^s - \left( \frac{\phi_d}{\varepsilon^d + 1} \right) \left[ \left( \frac{i_t^d}{i_{t-1}^d} \right) - 1 \right] \left( \frac{i_t^d}{i_{t-1}^d} \right) + \beta_P \left( \frac{\phi_d}{\varepsilon^d + 1} \right) \left[ \left( \frac{i_{t+1}^d}{i_t^d} \right) - 1 \right] \left( \frac{i_{t+1}^d}{i_t^d} \right) \left( \frac{D_{t+1}}{D_t} \right) \quad (49)$$

**Retail Loan Department:** Retail loan department of the bank optimally set the lending rates for impatient household's and entrepreneur's borrowing in order to maximise its expected present value of profit and passes them to the wholesale branch at a uniform competitive loan rate of  $i_t^b$ . Similar to the deposit department, loan department also faces quadratic adjustment costs while changing the loan interest rates for household (parameterised by  $\phi_{bH}$ ) and entrepreneur (parameterised by  $\phi_{bE}$ ). So, the retail loan unit maximises:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ i_t^{bH}(j) B_{H,t}(j) + i_t^{bE}(j) B_{E,t}(j) - i_t^b B_t(j) - \frac{\phi_{bH}}{2} \left( \frac{i_t^{bH}(j)}{i_{t-1}^{bH}(j)} - 1 \right)^2 B_{H,t} - \frac{\phi_{bE}}{2} \left( \frac{i_t^{bE}(j)}{i_{t-1}^{bE}(j)} - 1 \right)^2 B_{E,t} \right] \quad (50)$$

subject to (43) and (44), where

$$B_t(j) = B_{H,t}(j) + B_{E,t}(j) \quad (51)$$

After imposing the condition of symmetric equilibrium, the optimal retail loan rates for the household and entrepreneur become as follows:

$$i_t^{bH} = \left( \frac{\varepsilon^{bH}}{\varepsilon^{bH} - 1} \right) i_t^b - \left( \frac{\phi_{bH}}{\varepsilon^{bH} - 1} \right) \left[ \left( \frac{i_t^{bH}}{i_{t-1}^{bH}} \right) - 1 \right] \left( \frac{i_t^{bH}}{i_{t-1}^{bH}} \right) + \beta_P \left( \frac{\phi_{bH}}{\varepsilon^{bH} - 1} \right) \left[ \left( \frac{i_{t+1}^{bH}}{i_t^{bH}} \right) - 1 \right] \left( \frac{i_{t+1}^{bH}}{i_t^{bH}} \right) \left( \frac{B_{H,t+1}}{B_{H,t}} \right) \quad (52)$$



$$\begin{aligned}
i_t^{bE} &= \left( \frac{\varepsilon^{bE}}{\varepsilon^{bE} - 1} \right) i_t^b - \left( \frac{\phi_{bE}}{\varepsilon^{bE} - 1} \right) \left[ \left( \frac{i_t^{bE}}{i_{t-1}^{bE}} \right) - 1 \right] \left( \frac{i_t^{bE}}{i_{t-1}^{bE}} \right) + \\
&\beta_P \left( \frac{\phi_{bE}}{\varepsilon^{bE} - 1} \right) \left[ \left( \frac{i_{t+1}^{bE}}{i_t^{bE}} \right) - 1 \right] \left( \frac{i_{t+1}^{bE}}{i_t^{bE}} \right) \left( \frac{B_{E,t+1}}{B_{E,t}} \right)
\end{aligned} \tag{53}$$

### 3.4.2 Wholesale Branch

Wholesale branch collects deposits from the retail deposit department, generates loans from the deposits and passes them to retail loan department. However, before converting the financial resources from deposits into loans, the branch has to meet the reserve requirements as stipulated by the RBI. Two types of reserve requirements are mandated, one is CRR (parameterised by  $\alpha_c$ ) and the other is SLR (parameterised by  $\alpha_s$ ). CRR is the portion of deposit that the bank is required to keep with the RBI in the form of cash. SLR is the portion of bank's deposit to be held in the form of liquid government securities. The RBI varies these requirements to control credit supply by changing the availability of resources available with the bank to make loans (Anand et al. 2014). The wholesale branch has access to the interbank market to raise loan  $B_t^{IB}$ . Combining net worth of the bank  $Z_t$  with the interbank loan and deposit, the wholesale branch generates wholesale loan of  $B_t$ . Hence, the balance sheet identity that the wholesale branch has to obey is as follows:

$$B_t(j) = (1 - \alpha_c - \alpha_s) D_t(j) + B_t^{IB}(j) + Z_t(j) \tag{54}$$

We assume that capital stock of bank  $j$  is accumulated each period by adding up its periodical earnings according to:

$$\pi_t Z_t(j) = (1 - \delta_b) Z_{t-1}(j) + \Pi_{t-1}^b(j) \tag{55}$$

where, overall bank profit ( $\Pi_{t-1}^b$ ) in the previous period made by the two branches of bank  $j$ , and  $\delta_b$  measures the resources used in managing bank capital and conducting overall banking intermediation activity. Since we assume that bank capital is accumulated out of its periodical earnings, the model has an in-built feedback mechanism between the real and the financial side of the economy on the face of exogenous shocks.<sup>10</sup>

Further, we assume that there is a capital adequacy norm imposed by the central bank, which sets a requirement for the representative commercial bank to maintain their capital

---

<sup>10</sup>If there is any adverse shock which deteriorates the macroeconomic conditions, banks profits will reduce which will further weaken their ability to create new capital. Depending on the nature and size of the shock, it may result in the reduction of amount of loans supplied by the bank and exacerbate the original contraction.

to asset ratio  $\left[ \frac{Z_t(j)}{B_t(j)} \right]$  at level of  $\kappa_b$ . The bank is subject to a quadratic adjustment cost for any deviation of its capital to asset ratio from the stipulated level. This modelling strategy helps addressing the role of macroprudential norm in the bank capital channel of monetary transmission.

The problem for wholesale branch is to choose loan  $B_t(j)$ , deposit  $D_t(j)$ , and interbank borrowing  $B_t^{IB}(j)$ , so as to maximise the expected present value of profits subject to the balance sheet constraint given by equation (54) and the law of motion for bank's net worth equation (55). Hence the wholesale branch will maximise:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ \begin{array}{c} i_t^b B_t(j) + i_t^g \{ \alpha_s D_t(j) \} - i_t^s D_t(j) - i_t B_t^{IB}(j) \\ - Z_t(j) - \frac{\phi_z}{2} \left( \frac{Z_t(j)}{B_t(j)} - \kappa_b \right)^2 Z_t(j) \end{array} \right] \quad (56)$$

where,  $i_t^b$ ,  $i_t^g$ ,  $i_t^s$ , and  $i_t$  are wholesale interest rate on loan, interest rate received from holding of government bonds as SLR, wholesale deposit rate and interest rate for interbank loan, respectively. The adjustment cost of bank capital is parameterised by  $\phi_z$ . In a symmetric equilibrium, the first order condition gives the following results:

$$i_t^s = (1 - \alpha_c - \alpha_s) i_t + \alpha_s i_t^g \quad (57)$$

$$i_t^b = i_t - \phi_z \left( \frac{Z_t}{B_t} - \kappa_b \right) \left( \frac{Z_t}{B_t} \right)^2 \quad (58)$$

The above optimal conditions link the wholesale deposit and lending rates to the policy rate  $i_t$ , interest rate on government bond, reserve requirements, and the leverage of the banking sector. Finally, the profit of bank  $j$ , comes as the sum of earnings from the wholesale and the retail branches and can be written by:

$$\begin{aligned} \Pi_t^b(j) = & i_t^{bH}(j) B_{H,t}(j) + i_t^{bE}(j) B_{E,t}(j) - i_t^d D_t(j) - i_t B_t^{IB}(j) - \frac{\phi_d}{2} \left( \frac{i_t^d(j)}{i_{t-1}^d(j)} - 1 \right)^2 D_t - \\ & \frac{\phi_{bH}}{2} \left( \frac{i_t^{bH}(j)}{i_{t-1}^{bH}(j)} - 1 \right)^2 B_{H,t} - \frac{\phi_{bE}}{2} \left( \frac{i_t^{bE}(j)}{i_{t-1}^{bE}(j)} - 1 \right)^2 B_{E,t} - \frac{\phi_z}{2} \left( \frac{Z_t(j)}{B_t(j)} - \kappa_b \right)^2 Z_t(j) \end{aligned} \quad (59)$$

### 3.5 Fiscal Authority

The government consumes an exogenously specified stream of spending  $G_t$  of final consumption goods and finances this by lump-sum taxes of  $(TX_{P,t} + TX_{I,t})$  and issuing bonds to the bank through SLR. The government budget constraint is given by:

$$G_t + \left( \frac{1 + i_{t-1}^g}{\pi_t} \right) \{ \alpha_s D_{t-1}(j) \} = (TX_{P,t} + TX_{I,t}) + \{ \alpha_s D_t(j) \} \quad (60)$$

### 3.6 Central Bank

The central bank sets an interest rate rule ( $i_t$ ) that follows a standard Taylor rule in the short-run and is specified as given below:

$$\left( \frac{i_t}{i} \right) = \left( \frac{i_{t-1}}{i} \right)^{\phi_i} \left\{ \left( \frac{\pi_{t+1}}{\pi} \right)^{\phi_\pi} \left( \frac{Y_t}{Y} \right)^{\phi_y} \right\}^{(1-\phi_i)} \exp \{ \varepsilon_{m,t} \} \quad (61)$$

where,  $\phi_i$  is the interest rate smoothing parameter,  $\phi_\pi$  and  $\phi_y$  are the policy responses to deviation of expected inflation  $\pi_{t+1}$  and output from their respective steady-state level.  $\varepsilon_{m,t}$  is the monetary policy shock.

### 3.7 Resource Constraint and Aggregation

The following resource constraint represents the final goods market equilibrium condition:

$$Y_t = C_t + I_t^k + I_t^h + G_t + \psi_t(u_t) K_{t-1} + \delta_b \left( \frac{Z_{t-1}}{\pi_t} \right) + Adj_t \quad (62)$$

where, the aggregate consumption is:

$$C_t = C_{R,t} + C_{P,t} + C_{I,t} + C_{E,t} \quad (63)$$

and,  $Adj_t$  includes all types of adjustment costs incorporated in the model.

Physical asset in the form of housing good is aggregated as:

$$H_t = H_{P,t} + H_{I,t} \quad (64)$$

Finally, credit ( $B_t$ ) provided by the bank to the borrowing household and firm is aggregated as:

$$B_t = B_{H,t} + B_{E,t} \quad (65)$$

### 3.8 Forcing Processes

We have eight exogenous variables in our model and they follow AR(1) process as given below:

$$\left(\frac{\varepsilon_{A,t}}{\varepsilon_A}\right) = \left(\frac{\varepsilon_{A,t-1}}{\varepsilon_A}\right)^{\rho_A} \exp\{\xi_{A,t}\} \quad (66)$$

$$\left(\frac{\varepsilon_{i^k,t}}{\varepsilon_{i^k}}\right) = \left(\frac{\varepsilon_{i^k,t-1}}{\varepsilon_{i^k}}\right)^{\rho_{i^k}} \exp\{\xi_{i^k,t}\} \quad (67)$$

$$\left(\frac{G_t}{G}\right) = \left(\frac{G_{t-1}}{G}\right)^{\rho_g} \exp\{\xi_{g,t}\} \quad (68)$$

$$\left(\frac{\varepsilon_{m,t}}{\varepsilon_m}\right) = \left(\frac{\varepsilon_{m,t-1}}{\varepsilon_m}\right)^{\rho_m} \exp\{\xi_{m,t}\} \quad (69)$$

$$\left(\frac{\varepsilon_{y,t}}{\varepsilon_y}\right) = \left(\frac{\varepsilon_{y,t-1}}{\varepsilon_y}\right)^{\rho_y} \exp\{\xi_{y,t}\} \quad (70)$$

$$\left(\frac{\varepsilon_{H,t}}{\varepsilon_H}\right) = \left(\frac{\varepsilon_{H,t-1}}{\varepsilon_H}\right)^{\rho_h} \exp\{\xi_{h,t}\} \quad (71)$$

$$\left(\frac{\varepsilon_{LV,t}^H}{\varepsilon_{LV}^H}\right) = \left(\frac{\varepsilon_{LV,t-1}^H}{\varepsilon_{LV}^H}\right)^{\rho_{LV}^H} \exp\{\xi_{LV,t}^H\} \quad (72)$$

$$\left(\frac{\varepsilon_{LV,t}^E}{\varepsilon_{LV}^E}\right) = \left(\frac{\varepsilon_{LV,t-1}^E}{\varepsilon_{LV}^E}\right)^{\rho_{LV}^E} \exp\{\xi_{LV,t}^E\} \quad (73)$$

The above shock variables drive the aggregate dynamics of our model.

## 4 Quantitative Analysis

We log-linearise the non-linear structure of decision rules, market clearing conditions and resource constraints around the steady-state and obtain a short-run equation system. Our quantitative analysis is premised on this log-linearised system of equations.<sup>11</sup> In this section, first, we set up the baseline parameterisation that works as a benchmark for rest of the analysis, illustrations and discussions. Second, we explain the transmission mechanism of monetary policy shock based on the properties of impulse response functions (IRF). Third, we conduct the sensitivity experiments with respect to different financial friction parameters and examine their role in the MPT mechanism. Finally, we discuss the policy implications of our results for the betterment of transmission process and economic stabilisation.

---

<sup>11</sup>The system of equations and the steady-state specifications are laid out in Appendix D.

## 4.1 Baseline Model

We construct the baseline parameterisation of the model by synthesising the methods of calibration and estimation. We calibrate some of the model parameters which are available from the existing studies and macroeconomic time series data. In contrast, the parameters that are more country-specific in nature like the heterogeneity in household sector composition, frictions in the banking sector and persistence coefficients and standard errors of the exogenous shocks, are estimated using the quarterly data of Indian macroeconomic and financial variables over the sample period of 1999:Q4 to 2015:Q3.<sup>12</sup> We deploy the methodology of Bayesian rule as it allows the prior information to identify the parameters and impact of shocks using the cross-equation restrictions given the general equilibrium set-up. We blend the posterior means of the estimated parameters along with the well known calibrated parameters to create a baseline model for the Indian economy. Using this baseline model, we study the impulse response properties of the monetary policy shock, which is the central focus of this study.

### 4.1.1 Calibrated Parameters

We fall back on the existing DSGE literature to calibrate some of the structural parameters and time-series data of relevant macroeconomic variables to pin down the steady-state shares. In Table 3, the numerical values for calibration are provided. The proportion of liquidity-constrained households ( $\gamma_R$ ) is taken as 40 per cent according to the estimate of Gabriel et al. (2011) for India. The heterogenous discount rates for patient household ( $\beta_P$ ), impatient household ( $\beta_I$ ) and entrepreneur ( $\beta_E$ ) are fixed at 0.96, 0.95 and 0.92, respectively based on the average interest rates on deposits (8 per cent), households' borrowing (9.5 per cent) and firms' borrowing (13 per cent) during the sample period of our study.

Table 3: Calibrated Parameters of Baseline Model

														$\alpha$	$\beta_P$	$\beta_I$	$\beta_E$	$\delta_h$	$\delta_k$	$\sigma_l$	$\varepsilon^y$	$\varepsilon_{LV}^H$	$\varepsilon_{LV}^E$	$\gamma_R$			
														0.25	0.96	0.95	0.92	1.25%	2.5%	0.25	7	0.55	0.25	0.4			
$\pi$	$\vartheta_p$	$\theta_p$	$\varepsilon^d$	$\varepsilon^{bH}$	$\varepsilon^{bE}$	$\alpha_c$	$\alpha_s$	$\kappa_b$	$C/Y$	$G/Y$	$I^k/Y$	$D/Y$	$B_E/B$														
4%	118	0.55	13	2.5	5.4	5.5%	21.5%	0.1	0.54	0.1	0.21	0.52	0.65														

The degree of external habit formation ( $\sigma_h$ ) is set to 0.66 similar to Banerjee and Basu (2017). The Frisch elasticity of labour supply ( $\sigma_l$ ) is taken as 0.25 in line with the elastic

<sup>12</sup>Sources of all the time series data are discussed in Appendix C.

nature of labour supply in India. The share of capital in production is set at 0.25 following Gerali et al. (2010). The quarterly depreciation rates of physical capital ( $\delta_k$ ) and housing goods ( $\delta_h$ ) are set to 2.5 and 1.25 per cent, respectively. The curvature parameters ( $\psi_a, \psi_b$ ) of the utilisation cost of capital are set following Silva et al. (2012).

Nominal friction in the form of price adjustment cost ( $\vartheta_p$ ) is chosen to be 118 following Anand et al. (2010). The degree of inflation indexation is set to 0.55 (Sahu, 2013). Following the Indian experience, capital adequacy requirement ( $\kappa_b$ ), statutory liquidity ratio ( $\alpha_s$ ) and cash reserve ratio ( $\alpha_c$ ) are set at 10, 21.5 and 5.5 per cent, respectively. The depreciation rate of bank capital ( $\delta_b$ ) is chosen as 3.7 per cent (Anand et al., 2014). The elasticities of demand for borrowing by the impatient household ( $\varepsilon^{bH}$ ) and firm ( $\varepsilon^{bE}$ ), and for deposit contract by the patient household ( $\varepsilon^d$ ) are chosen in line with Silva et al. (2012).

The steady-state shares for consumption to GDP ( $\frac{C}{Y}$ ), gross capital formation to GDP ( $\frac{I^k}{Y}$ ), government spending to GDP ( $\frac{G}{Y}$ ), deposit to GDP ( $\frac{D}{Y}$ ), entrepreneurial borrowing to total borrowing ( $\frac{B^E}{B}$ ) ratio - are chosen based on their average value from quarterly data for the sample period of study. Given the level of inflation target, the steady-state value of inflation is chosen as 4 per cent. The long-run value of policy rate is taken as 7 per cent based on the data of repo rate.

Steady-state values of technology and policy shocks are normalised to one. The steady-state value of preference shock to housing is chosen to be 0.2 as proposed by Silva et al. (2012). Following Gerali et al. (2010), we choose the steady-state values of LTV ratio as 0.55 and 0.25 for the impatient household ( $\varepsilon_{LV}^H$ ) and wholesale entrepreneur ( $\varepsilon_{LV}^E$ ), respectively.

#### 4.1.2 Estimated Parameters

There are two constituents for implementing the Bayesian estimation for the unknown set of parameters: one is the historical data for a set of observables and the other is prior distributions. We consider the historical data series of real output ( $y$ ), real gross capital formation ( $ik$ ), real fiscal consumption ( $g$ ), CPI inflation ( $pi$ ), retail deposit rate ( $id$ ), retail loan rate ( $il$ ) and call money rate ( $i$ ). Except the series for interest rates and inflation, all other series are made stationary by taking the first differences. The series of all observables are plotted in Figure 5.

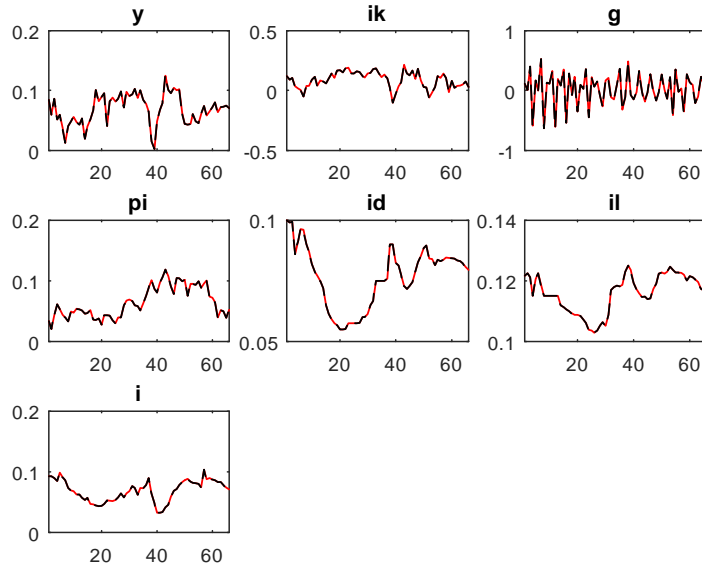


Figure 5: Plots of Historical Data Series

Next, the prior distributions for the relevant parameters are specified. Following the literature, we propose the priors that would fit with the Indian data. In course of specifying the priors for the estimable parameters, we declare their respective probability density functions. Selection of the probability density functions for the priors are based on the theoretical implications of the relevant parameters in the model and the evidence from extant studies. As example, the beta distribution is used for the fraction parameters, while the inverse gamma distribution is specified for the parameters with non-negativity constraints. Due to lack of the estimated DSGE models with financial market frictions for the EMDEs, and for India in particular, we have less information regarding the standard deviations of the prior distributions. Thus, we select higher standard deviations and allow the data to determine the location of the relevant parameters. The choice of such higher standard deviation for the prior's distribution is in line with Gabriel et al. (2012).

We obtain the joint posterior distribution of the estimated parameters by following the Markov Chain Monte Carlo-Metropolis-Hastings (MCMC-MH) algorithm. This algorithm simulates the smoothed histogram that approximates to the posterior distributions from the prior distributions for the parameters of our interest. Two parallel chains are used in the MCMC-MH algorithm. The univariate and multivariate diagnostic statistics show convergence by comparing the 'between' and 'within' moments of multiple chains (Brooks and Gelman, 1998).

In Table 4, the symbols and corresponding description of the estimated parameters (of Figures 6 to 8) are listed. In Table 5, the prior and posterior means of the estimated

parameters are presented. The posterior means of estimated parameters are reported with 90 per cent confidence intervals subject to the posterior standard deviation. Figures 6 to 8 plot the prior versus posterior distributions. Figure 9 plots the diagnostic statistics of multivariate convergence.<sup>13</sup> Our estimation results suggest that all the parameters are well identified and the posteriors are generated based on the information extracted from the observables.<sup>14</sup> The modes of the posterior distributions are significantly different from the prior distributions which suggest that the information is extracted reasonably well from the data to compute the posterior means. Combining the calibrated and estimated parameters of Tables 3 and 5, we constitute the baseline parameterisation of our model for the sample period under study.

Table 4: Description of Estimated Parameters

Parameters	Description	Parameters	Description
$\gamma$	gamma	$\rho_g$	rho_g
$\vartheta_h$	rho_var_h	$\rho_y$	rho_epsy
$\vartheta_k$	rho_var_k	$\rho_h$	rho_epsh
$\phi_d$	phi_id	$\rho_{LV}^H$	rho_epslv_h
$\phi_{bH}$	phi_ibh	$\rho_{LV}^E$	rho_epslv_e
$\phi_{bE}$	phi_ibe	$\sigma_a$	SE_zeta_epsa
$\phi_z$	phi_z	$\sigma_{ik}$	SE_zeta_epsik
$\varphi_i$	phi_i	$\sigma_m$	SE_zeta_epsi
$\varphi_\pi$	phi_pi	$\sigma_g$	SE_zeta_g
$\varphi_y$	phi_y	$\sigma_y$	SE_zeta_epsy
$\rho_a$	rho_epsa	$\sigma_h$	SE_zeta_epsh
$\rho_{ik}$	rho_epsik	$\sigma_{LV}^H$	SE_zeta_epslv_h
$\rho_m$	rho_epsi	$\sigma_{LV}^E$	SE_zeta_epslv_e

<sup>13</sup>All the quantitative simulation and estimation of the model are done by using Dynare version 4.5.1. For details of the computation procedure, see Dynare User Guide, 2013, Ch. 8.

<sup>14</sup>Following the criteria of asymptotic information matrix and collinearity patterns of the parameters, as suggested by Iskrev (2010a, b) and Iskrev and Rotto (2010a, b), identification of the shocks and the structural parameters are examined. The strength of identification is verified by visual inspection of the plots of asymptotic information matrix.



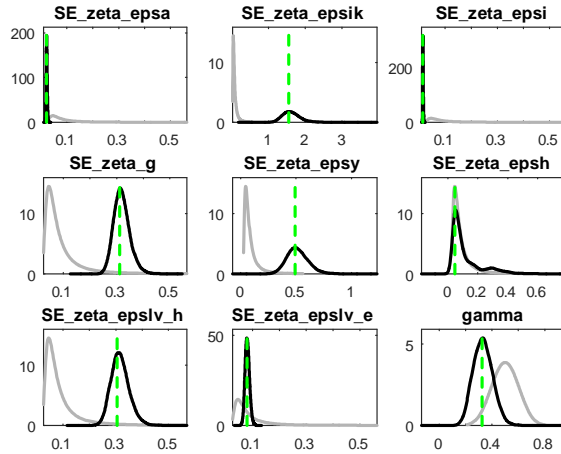


Figure 6: Priors and Posteriors

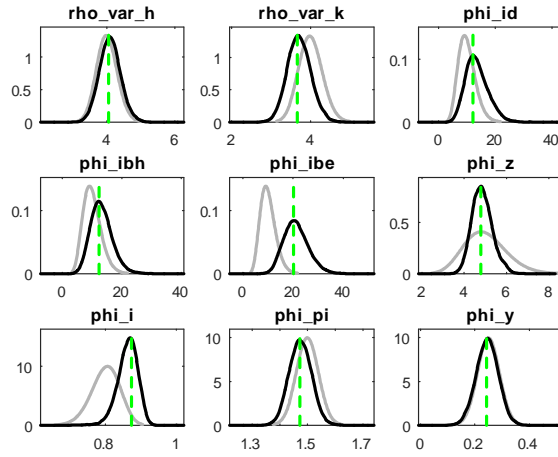


Figure 7: Priors and Posteriors

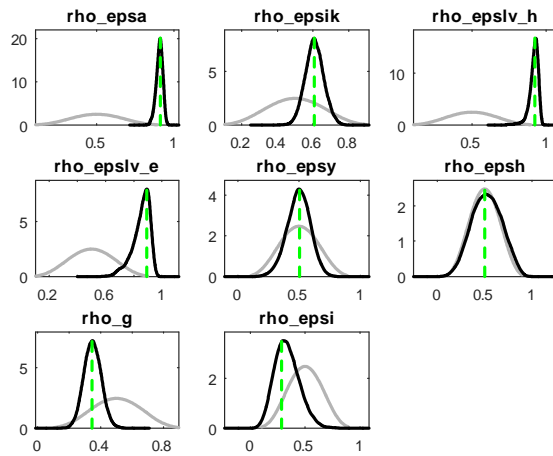


Figure 8: Priors and Posteriors

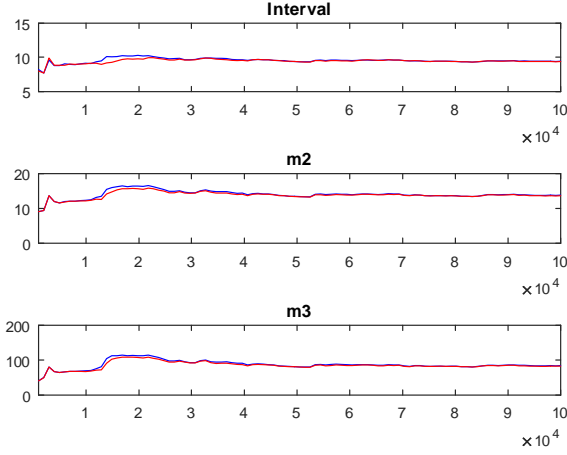


Figure 9: Plots of Multivariate Convergence

Table 5: Prior Densities and Posterior Estimates of Baseline Model

Estimated Parameters	Priors		Posteriors		Estimated Parameters	Priors		Posteriors	
	Mean	Distribution	Mean	90% C.I.		Mean	Distribution	Mean	90% C.I.
$\gamma$	0.50	Beta	0.33	[0.21, 0.45]	$\rho_g$	0.50	Beta	0.35	[0.26, 0.43]
$\vartheta_h$	4	Gamma	4.09	[3.57, 4.57]	$\rho_y$	0.50	Beta	0.49	[0.34, 0.65]
$\vartheta_k$	4	Gamma	3.70	[3.23, 4.19]	$\rho_h$	0.50	Beta	0.52	[0.27, 0.78]
$\phi_d$	10	Gamma	13.45	[6.88, 19.53]	$\rho_{LV}^H$	0.50	Beta	0.92	[0.88, 0.96]
$\phi_{bH}$	10	Gamma	13.06	[6.98, 18.49]	$\rho_{LV}^E$	0.50	Beta	0.85	[0.76, 0.94]
$\phi_{bE}$	10	Gamma	21.12	[13.04, 28.58]	$\sigma_a$	0.10	Inv. Gamma	0.022	[0.019, 0.026]
$\phi_z$	5	Gamma	4.85	[4.07, 5.62]	$\sigma_{ik}$	0.10	Inv. Gamma	1.616	[1.238, 1.960]
$\varphi_i$	0.80	Beta	0.86	[0.82, 0.91]	$\sigma_m$	0.10	Inv. Gamma	0.014	[0.012, 0.016]
$\varphi_\pi$	1.50	Normal	1.47	[1.41, 1.52]	$\sigma_g$	0.10	Inv. Gamma	0.319	[0.269, 0.366]
$\varphi_y$	0.25	Normal	0.24	[0.18, 0.31]	$\sigma_y$	0.10	Inv. Gamma	0.512	[0.359, 0.666]
$\rho_a$	0.50	Beta	0.91	[0.87, 0.94]	$\sigma_h$	0.10	Inv. Gamma	0.113	[0.023, 0.278]
$\rho_{ik}$	0.50	Beta	0.61	[0.52, 0.69]	$\sigma_{LV}^H$	0.10	Inv. Gamma	0.316	[0.261, 0.371]
$\rho_m$	0.50	Beta	0.33	[0.15, 0.51]	$\sigma_{LV}^E$	0.10	Inv. Gamma	0.081	[0.068, 0.094]

### 4.1.3 Model Validation

In order to examine the reliability of baseline model, we compare the model generated second order moments with their data counterpart for the major macroeconomic and financial variables.<sup>15</sup> In Table 6, descriptions of these key variables are provided.

<sup>15</sup>Given the property of stationarity of the model, the data series of output growth, consumption growth, investment growth and credit-to-output ratio are stationarised using Christiano-Fitzgerald asymmetric business cycle filter. The market interest rates, policy interest rate and CPI inflation rate are kept unchanged. Due to unavailability of long time series data related to the housing sector, we find a balanced sample starting from 2009: Q4 to 2015: Q3. Our model validation is, therefore, restricted within that time period.

Table 6: Description of Key Variables

Variable	Description	Variable	Description	Variable	Description
$y$	Output	$qh$	Real price of housing	$u$	Capital utilization
$c$	Consumption	$mc$	Real marginal cost	$lp$	Labour Suply of Patient HH
$ik$	Capital investment	$pi$	CPI inflation	$lip$	Labour Suply of Impatient HH
$ih$	Housing investment	$i$	Policy interest rate	$bh$	Household's borrowing
$b$	Borrowing	$is$	Wholesale deposit rate	$be$	Entrepreneur's borrowing
$h$	Housing	$ib$	Wholesale lending rate	$bib$	Interbank borrowing
$k$	Capital	$id$	Retail deposit rate	$rw$	Aggregate real wage
$l$	Labour	$il$	Aggregate Retail lending rate	$ibh$	Retail lending rate for $bh$
$qk$	Real price of capital	$pi\_b$	Bank's profit	$ibe$	Retail lending rate for $be$

The data and model comparison is done in two steps. First, we check the model generated volatility with empirically observed volatility for a set of real and financial variables. Next, we do the same for key cross-correlations among the macroeconomic and financial variables.<sup>16</sup> In Table 7, relative volatilities of four core variables – consumption to output, capital investment to output, housing investment to output and bank credit to output – along with the volatility of interest rate spread are presented based on the data and model. Although the model slightly overpredicts, it comes close to the volatility indicators moderately.

Table 7: Comparing Volatilities between Data and Model

Target	Data	Model
$\left(\frac{\sigma_c}{\sigma_y}\right)$	1.27	1.15
$\left(\frac{\sigma_{ik}}{\sigma_y}\right)$	3.03	3.26
$\left(\frac{\sigma_{ih}}{\sigma_y}\right)$	1.55	2.46
$\left(\frac{\sigma_b}{\sigma_y}\right)$	1.64	1.99
$\sigma(i^l/i^d)$	0.21	0.24

Further, we examine the model predictions for interrelationship among the major macroeconomic and financial variables in Table 8. It is noticeable that the model is predicting signs

<sup>16</sup>Note that, for the convenience of illustration and analysis, we have defined a new variable  $i^l$  as the weighted sum of retail lending rates to household ( $i^{bH}$ ) and firm ( $i^{bE}$ ). The weights are assigned based on the steady-state shares of credit to household ( $\frac{B_H}{B}$ ) and credit to firm ( $\frac{B_E}{B}$ ).  $i^l$  represents the economy-wide average retail lending rate of the bank.

Table 8: Comparing Cross-correlations between Data and Model

Correlations	Data	Model	Correlations	Data	Model
$(y, c)$	0.30	0.43	$(i^k, \pi)$	0.28	0.19
$(y, b)$	0.20	0.12	$(i^k, i)$	-0.56	-0.14
$(y, i^h)$	0.46	0.50	$(i^h, i)$	-0.37	-0.59
$(y, \pi)$	-0.29	-0.34	$(i^h, i^d)$	-0.31	-0.70
$(y, i)$	-0.64	-0.25	$(i^h, i^l)$	-0.52	-0.61
$(b/y, i^l/i^d)$	-0.52	-0.54	$(i, i^d)$	0.90	0.60
$(b/y, \pi)$	-0.27	-0.38	$(i, i^l)$	0.80	0.93
$(c, i^k)$	-0.39	-0.60	$(i^d, i^l)$	0.84	0.74
$(i^k, b)$	0.20	0.12	$(i^l/i^d, \pi)$	0.40	0.30

of cross-correlations correctly. Quantitatively, though there are some variations, most of the key business cycle relevant correlations like consumption and output, credit and output, consumption and investment, output and inflation, and the financial cycle relevant correlations like credit-to-output ratio and interest rate spread, credit-to-output ratio and inflation, inflation and interest rate spread, co-movements of policy rate, deposit and lending interest rates, and countercyclical movements of real variables to interest rates are explained by the baseline parametric configuration of model.

#### 4.1.4 Variance Decomposition Results

In Table 9, the results of the forecast error variance decomposition (FEVD) of the baseline model are reported. Similar to the vast empirical literature on monetary transmission in India, we find that monetary policy shock can account for only a small portion of output fluctuations (8.72 per cent). In contrast, the shock to fiscal spending explains the variations of aggregate output in a greater magnitude (12.27 per cent). More than 50 per cent of the output fluctuations are explained by the technology shocks. Similar to aggregate output, 75 per cent of the variations of CPI inflation is explained by the supply side disturbances. Monetary policy shock explains little variation of the same (5.32 per cent). Mark-up shock and preference shock for housing appear to be negligible for the movements of real and financial variables.

While the above set of FEVD results align with the findings of existing literature, we obtain an interesting observation from the contribution of the shock to LTV ratio as one of the drivers of business cycle variations. Except the policy rate, shock to LTV ratio for household explains considerable variations across the real, nominal and financial variables of the model. It is also modestly complemented by the similar kind of shock for the entrepreneur. This result provides evidence for the significance of financial shocks in the Indian economy.

Table 9: Baseline Result of Variance Decomposition of Key Aggregates (in per cent)

Variables	$\xi_A$	$\xi_{i^k}$	$\xi_m$	$G$	$\xi_y$	$\xi_{LV}^H$	$\xi_{LV}^E$	$\xi_h$
$y$	48.95	5.58	8.72	12.27	0.25	21.59	2.64	0.00
$\pi$	37.32	38.13	5.32	0.25	3.00	14.21	1.77	0.00
$b$	21.49	24.20	20.09	0.53	0.66	29.95	3.09	0.00
$c$	37.00	34.11	4.59	2.19	0.23	20.09	1.78	0.00
$l$	7.62	8.59	20.26	24.32	0.58	33.16	5.46	0.00
$i^k$	22.59	57.97	3.32	0.95	0.37	10.23	4.57	0.00
$i^h$	19.07	16.26	30.16	5.83	1.03	22.07	5.58	0.00
$i$	24.68	30.64	32.61	0.06	0.66	9.91	1.44	0.00
$i^d$	28.36	32.57	4.95	12.69	1.88	12.17	7.36	0.02
$i^l$	33.81	37.70	11.40	0.21	0.82	14.03	2.03	0.00

As a whole, the bulk of aggregate fluctuations is explained by the technology shocks in the forms of total factor productivity and investment specific technology. The policy shocks remain to be secondary drivers of the cyclical fluctuations in India. Transmission of monetary shock is found to be substantially weak.

## 4.2 Transmission Mechanism of Monetary Policy Shock

In our baseline NK-DSGE model with financial frictions, monetary policy shock affects the economy from the demand side as well as the supply side. While the demand side effect of the policy shock works directly through the credit channel, it exerts the supply side effect indirectly via the cost of capital and the labour market adjustments. In our model, a positive interest rate shock by the monetary authority leads to co-movements in the credit market interest rates, and sets in the contractionary effects on the key macroeconomic and financial variables like credit to household and firm, consumption, investment in physical capital and housing, labour employment, output and inflation. Although the interest rate, asset price and expectation channels of transmission do exist in the model, the dynamics of MPPT is predominantly led by the broad credit channel. Such predominance of credit channel of MPPT is a consequence of the bank lending and the balance sheet channels. The in-built feedback mechanism between real and financial sectors of the model pins down the transmission process of these channels. The bank lending channel comes into action as soon as the set of interest rates starts responding to change in the policy rate and affects the demand for credit in the economy. Besides, the balance sheet channels become operational primarily from the borrower's side (household and firm) and then from the lender's side (bank) too. Given the borrower's balance sheet constraint, contraction of credit demand

impacts the demand for consumption and investment goods, and factors of production in the real side. By a cascading effect, contraction of credit demand also impacts the bank's profitability and net worth position due to presence of its balance sheet constraint. We spell out the details of transmission process and sectoral adjustments using the IRF plots of Figures 10 to 12 based on a positive monetary policy shock in our model.

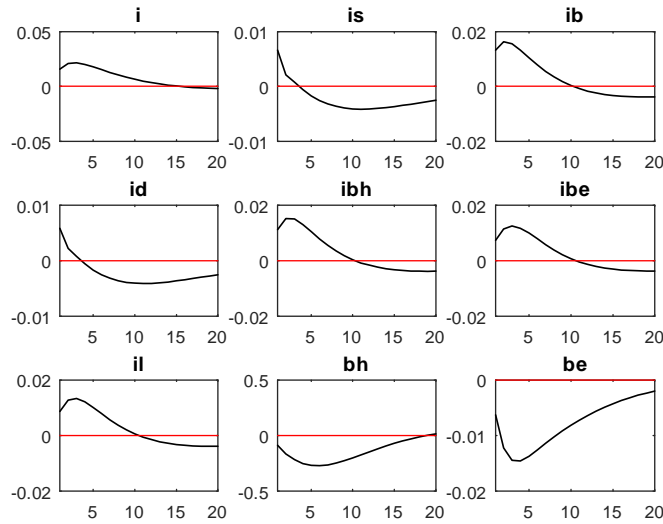


Figure 10: Effects of Monetary Policy Shock

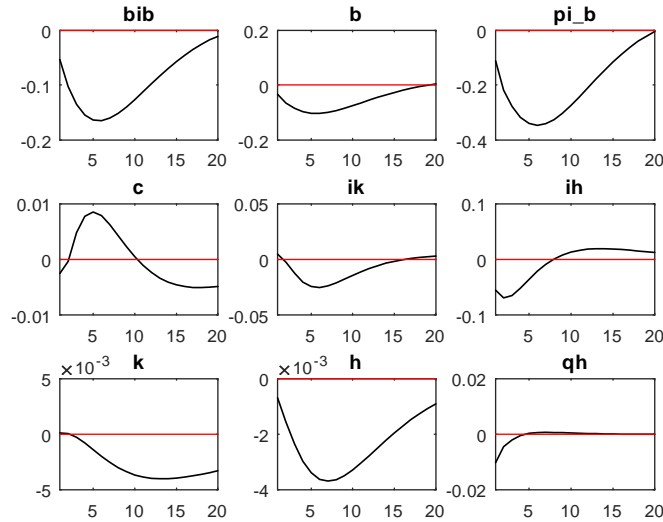


Figure 11: Effects of Monetary Policy Shock

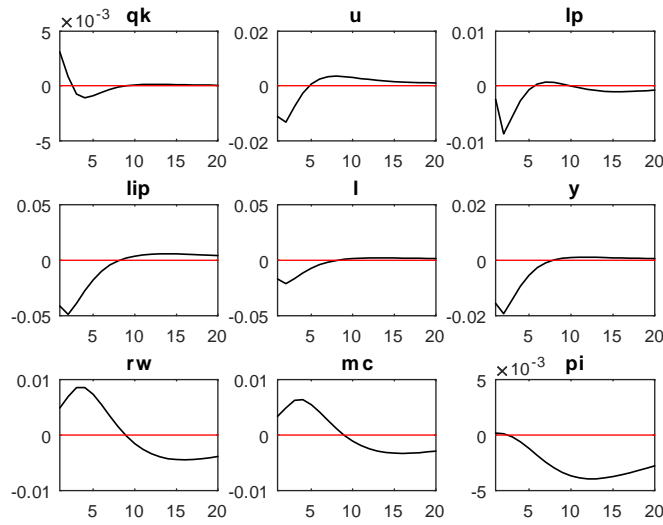


Figure 12: Effects of Monetary Policy Shock

#### 4.2.1 Transmission to Banking Sector

Policy interest rate rises and gears up the entire spectrum of interest rates of the banking sector as an immediate effect of a monetary policy shock. At the outset, it raises the lending and deposit rates of the wholesale branch of the bank subject to SLR, CRR and bank capital adequacy norms. Then, it gradually passes through the deposit and lending rates of the retail branch. The pass-through of the shock remains incomplete at the retail level interest rates as the wholesale and retail branches face different types and degrees of financial frictions in the form of quadratic adjustment costs. Since the interest rate adjustment cost is higher for retail lending to the entrepreneur compared to the household, impact response of the lending rate on firm's borrowing is relatively lower than the household's borrowing interest rate subject to the respective elasticities of credit demand. Subsequently, the demand for credit by the impatient household declines sharply as compared to the credit demanded by the firm. Parallel to this, interest rate on deposits rises but in a modest way due to presence of statutory norms, reserve requirements and interest rate adjustment cost.

On the whole, frictions in the bank-based credit market leads to sluggish upward movements of the market interest rates and shifts the demand schedules for deposit and loan contracts. Due to elastic nature of market demand, rising loan interest rate reduces the bank's earning from credit, affects its profit adversely and thus, drives down the net worth. As apparent from the impulse response plots, interest rates on deposits show faster mean reversion compared to the interest rates on loan contracts. Credit to household and firm shrinks substantially, interbank borrowing by the bank decreases and banks' profitability

goes through a deep negative swing. Following these banking sector adjustments, real segment of our model economy starts responding to the monetary policy shock.

#### 4.2.2 Transmission to Real Sector

**Response from Demand Side:** Demand side channel operates via the standard consumption Euler relations, optimal conditions for the capital investment and the investment in housing goods. As the retail deposit rate and borrowing rates rise, the opportunity cost of current consumption and housing accumulation increase. Further, with the rising retail borrowing rate, the borrowing constraint becomes tighter for the impatient household and reduces their access to loanable fund. So, both the savers and borrowing households will cut down their demand for final goods consumption and investment in housing. Entrepreneurial consumption also follows the similar pattern. Hence, we observe a negative impact effect on aggregate consumption. However, it is reversed in the subsequent periods and dies down later as the impatient household enjoys a positive wealth effect for a while due to their rising real wage from the labour market adjustments.<sup>17</sup>

In contrast to the declining demand for consumption and investment in housing, demand for capital investment from the wholesale firms does not fall at the impact of the shock as it is fixed by the last period's choice of capital. For this reason, there is no change in the stock of physical capital at the period of impact. Nevertheless, in the forthcoming quarters, investment in capital goods starts decelerating due to increased lending rate for firm's borrowing and tightening of their collateral constraint. Therefore, impulse of the interest rate shock goes through the contraction of credit demand from the borrowing household and firm to contraction of the aggregate demand in the economy.

The real price of investment in housing drops following the decline in the demand for housing accumulation as an impact effect. However, the same for physical capital remains positive and exhibits a sharp rise at the impact due to positive investment demand. It is pacified in the later periods with the downturn in capital investment.

**Response from Supply Side:** With rising loan interest rate for firms, the wholesale entrepreneur curtails the purchase of new capital from the capital goods producer as their demand for capital is fully backed by the borrowing from the bank subject to the periodical LTV ratio. Since, the demand for capital is optimally set one period ahead, at the impact of policy shock physical capital does not show any movement and stay close to zero. But in the subsequent periods, the entrepreneur reduces the demand for borrowing subject to

---

<sup>17</sup>Markovic (2006) documented similar type of IRF pattern for consumption while investigating on the bank capital channel of transmission for the UK economy.



the collateral constraint, and we observe a steady decline in the capital goods production. Similar to capital goods production, housing goods producing sector also faces significant contraction with a large swing. As the cost of capital rises, demand for capital and its utilisation descend in the intermediate goods production. Parallel to this, employment level falls as a general equilibrium response to the contraction of derived demand for labour in production and it drives down the aggregate output. It can be observed from the IRF plots that impulse response of aggregate output reflects similar pattern of the impulse response of labour employment.

### 4.2.3 Transmission to Inflation

In order to understand the MPT to inflation, we have to consider the internal adjustment process in the competitive labour market as it influences the responsiveness of real wage and real marginal cost. The role of expectation formation also comes in, which together with the real marginal cost determines the response of inflation.

In the set-up of competitive labour market, slack in employment affects the impatient household more adversely than the patient ones due to higher share of the first group in the production process.<sup>18</sup> Since the labour market is heavily populated by the borrowing households, cut down in their employment pushes up their real wage significantly high which raises the average real wage of the economy. Consequently, the real marginal cost of production rises. So, we observe the IRF plot of real marginal cost to mimic the pattern of average economy-wide real wage.<sup>19</sup>

However, this acceleration in real marginal cost does not translate into inflation as the standard new Keynesian forward-looking expectation channel comes into action. Given the calibrated parameters, forward-looking component occupies dominant share (nearly 65 per cent) in expectation formation in the price-setting behaviour of the final goods producing firm. Therefore, the price-setting retail firm adjusts its inflation expectation downward, which takes over the momentum of real marginal cost and brings down inflation. This adjustment in inflation dynamics takes a couple of quarters and generates a feeble positive response at the impact level. Nevertheless, the positive effect dies down quickly and inflation starts to decline sharply.

---

<sup>18</sup>National Accounts Statistics (NAS) of Ministry of Statistics and Programme Implementation (MOSPI) on household savings suggests that the proportion of households with financial saving is 23 per cent on an average over the period of 2011-12 to 2015-16. This estimate lies in the confidence interval of our model estimated result of saver's proportion (i.e., 21 to 45 per cent). This observation closely supports the fact that proportion of saver is much lesser than the proportion of borrower in the economy.

<sup>19</sup>In a cross-country study, Normandin (2006) observed positive response of real wage with respect to a positive interest rate shock. He found this result to be consistent with the models of nominal and financial frictions.

To summarise the MPT results of our model, a positive interest rate shock leads to output contraction and restrains inflation by raising the market interest rates, squeezing the supply of credit, and shrinking the derived demand for factors of production.

### 4.3 Financial Frictions and Monetary Transmission: Evidence from Counterfactual Experiments

Our baseline model is characterised by the real, nominal and financial frictions which can potentially determine the pass-through of a monetary policy shock. Given the objective of this study, we focus on the role of frictions that are directly or indirectly related to the financial sector. Since the commercial banking led credit market depicts the financial sector in our model, we examine different forms of frictions associated with the credit market activities. These frictions are pertaining to either the price of financial resources or availability of the same. Nevertheless, they have distinguishing implications for the transmission mechanism of a monetary policy shock. As these frictions are captured by a set of parameters, we conduct few counterfactual experiments with respect to baseline values of those parameters and investigate their resultant effects on the transmission mechanism.

We examine the change of accumulated effects of a positive monetary policy shock for different counterfactual experiments and draw our inference accordingly. The accumulated effects of monetary policy shock are taken over the period of eight quarters. In the sensitivity experiment, we reduce the friction parameters one at a time and document the corresponding accumulated effects of monetary policy shock on output, inflation and credit. By comparing these new accumulated effects with the baseline ones, as presented in Table 10, we identify the changes in the magnitude of monetary transmission. In order to understand the policy relevance of these financial market frictions more comprehensively, we evaluate the elasticity of monetary transmission in terms of accumulated effects on output and inflation with respect to each parameter and reported in Table 11. This exercise provides a quantitative assessment for the respective role of different friction components for the transmission mechanism in India.

We start with the set of friction parameters that are related to price-setting actions of the financial products like deposit and loan contracts. In our model, there are three adjustment cost parameters associated with the optimal choice of interest rates on the deposits of patient household ( $\phi_d$ ) and loans for the borrowing household ( $\phi_{bh}$ ) and firm ( $\phi_{be}$ ). In case of interest rate adjustment cost for deposits, the result suggests that the frictionless state ( $\phi_d = 0$ ) has

Table 10: Sensitivity Experiments on Accumulated Effects of Monetary Policy Shock (in per cent)

Variables	$y$	$\pi$	$b$
<i>Baseline</i>	-6.78	-0.88	-67.91
$\phi_d = 0$	-6.80	-0.87	-67.88
$\phi_{bh} = 0$	-6.73	-0.91	-68.89
$\phi_{be} = 0$	-6.47	-1.06	-68.66
$\phi_z = 0$	-11.37	0.49	-107.07
$\xi_{LV}^h = 0.65$	-4.28	-1.22	-64.21
$\gamma_R = 0.10$	-8.44	-0.92	-74.06
$\gamma = 0.83$	-1.20	-1.13	-44.78

negligible impact on the pass-through of policy shock. This may be attributed to the low base of depositors, which is found to be 19.8 per cent of the labour market population.<sup>20</sup> However, in case of the lending rates for household and firm, reductions in interest rate adjustment cost improve the transmission process except for credit. From Table 10, it is apparent that contractionary effect of a positive interest rate shock becomes moderated for output and turns out to be more intensive for inflation in absence of the adjustment costs. In absence of the adjustment costs, flexible retail lending rates lead to faster mobilisation of financial resources and better allocation of the factors of production, and generates stronger effect on inflation reduction with weaker effect for output contraction.

Next, we examine the frictions related to availability of credit. There are two items in the checklist: one is adjustment cost parameter related to maintaining of bank capital adequacy norm and the other is steady-state LTV ratio for collateral constraints. We do the sensitivity experiments for (i) zero adjustment cost for maintaining the bank capital adequacy requirement ( $\phi_z = 0$ ) and (ii) relaxing the collateral constraint for borrowing household by raising the steady-state LTV ( $\xi_{LV}^h = 0.65$ ).

From the change of accumulated effects, it can be noticed that the transmission of monetary policy shock becomes more pronounced for both cases though in different directions and different magnitudes. In absence of adjustment cost for maintaining bank capital adequacy requirement, contractionary effect on output and credit deepen substantially compared to the other types of friction components. Besides, it creates inflationary pressure to some extent. This counter-intuitive result appears due to presence of the large segment of credit-constrained borrowers. In absence of the adjustment cost for restoring capital adequacy

<sup>20</sup>To cross-examine this counterfactual result, we look at the accumulated effects of a monetary policy shock for  $\phi_d = 0$  with  $\gamma = 0.83$ . We find that credit (-44.78 per cent) and output (-1.2 per cent) fall substantially lesser while the inflation declines in a large extent (-1.12 per cent) as compared to the baseline results.

requirement, net worth of the bank improves, which subsequently strengthens the bank capital channel of monetary transmission. However, such improvement of transmission process is nullified due to presence of the large section of borrowing households in the labour market. The predominance of borrowing households augments the contraction of aggregate demand via demand for credit and leads to pervasive response of real wage in the labour market. In combination of these two actions simultaneously, the improvement of transmission under frictionless state for bank capital adequacy does not show up in the counterfactual results.<sup>21</sup>

The easing of collateral constraint for borrowing household clearly produces a favourable impact for the monetary transmission to output and credit with a significant fall in inflation. The reason is relatively straight forward. Higher long-run LTV provides borrowing household greater access to credit and strengthens the credit channel of transmission. This improves the transmission process of policy shock in the economy.

Looking into the household structure of the underlying economy, it is notable that presence of liquidity-constrained household and large proportion of borrowing household in the labour market create serious bottleneck for the pass-through of monetary policy shock. Typically, the proportions of liquidity-constrained household ( $\gamma_R = 0.40$ ) and impatient / borrowing household ( $\gamma(1 - \gamma_R) = 0.402$ ) are inversely related to the MPT mechanism.<sup>22</sup> With declining share of liquidity-constrained household, the transmission of monetary policy improves in the economy. This result supports the fact that greater financial inclusion leads to better transmission process of the policy shock. Along with the proportion of liquidity-constrained household, the share of patient household or saver (19.8 per cent) vis-à-vis impatient household plays an important role for the monetary transmission. As it is evident from our estimation results, the proportion of borrowers is higher than savers in the Indian economy compared to the other economies. This has two implications. First, it limits the scope of the bank to mobilise deposits for loanable fund. Second, there exists relatively larger proportion of credit-constrained borrowers in the competitive labour market, who play a critical role for determining the response of the overall employment, real wage (thereby, real marginal cost and inflation) and finally, aggregate output with respect to a monetary policy shock. Given that a positive policy shock is in place, the contractionary impact on aggregate demand subsequently leads to reduction in the derived demand for labour employment in the labour market. Since, the credit-constrained borrowers occupy the greater share

---

<sup>21</sup>For the validation of our argument regarding this counterfactual result, we look at the accumulated effects of a monetary policy shock for  $\phi_z = 0$  with  $\gamma = 0.83$ . Although the inflationary response in transmission does not revert to be negative (0.22 per cent), we find that transmission to credit (-58.32 per cent) and output (-2.79 per cent) improves.

<sup>22</sup>Note that low value of  $\gamma$  indicates greater proportion of borrowers compared to savers in the population and vice versa.

in the production process, they face the fierce hit of the employment cut, which is pivotal for output contraction. Hence, in our counterfactual experiment with  $\gamma = 0.83$ , we observe little contraction of credit and output and significant reduction of inflation.

Table 11: Financial Frictions and Responsiveness of Monetary Policy Transmission

Friction Parameters	Elasticity of Output Effect	Elasticity of Inflationary Effect
$\phi_d$	0	0.01
$\phi_{bh}$	0.01	-0.03
$\phi_{be}$	0.05	-0.21
$\phi_z$	-0.68	1.56
$\xi_{LV}^h$	-2.03	2.09
$\gamma_R$	1.15	-0.05
$\gamma$	-0.54	0.18

To summarise our observations on the role of different frictions related to financial activities, we compute the elasticity of monetary transmission to output and inflation based on the accumulated effect of the shock.<sup>23</sup> The tabulated numbers in Table 11 reveal how the degree of contractionary effect of a monetary policy shock alters with respect to one unit change in the value of respective friction parameter. The value of elasticity also suggests the quantitative importance of the corresponding friction. It is noticeable that except the frictions for deposit rate adjustment and bank capital adjustment, elimination of the financial frictions from the economy reduces the contractionary effects of monetary policy shock on the real output and stabilises inflation to a larger extent. Given the size of the elasticities, it appears that collateral constraint, financially excluded population and low base of depositors play a major role in hindering the transmission process and need more attention from the policymakers. Frictions related to price of financial resources, albeit quantitatively less significant, play a moderate role to improve the pass-through of the transmission mechanism.

#### 4.4 Policy Implications

In the preceding subsections, we have illustrated the mechanism of MPT and examined the role of different forms of financial frictions. In light of our findings, one would be curious

---

<sup>23</sup>In Appendix E, the IRF plots of our counterfactual experiments are reported. Blue lines denote low level of friction and red lines denote the high degree of friction. In Figures 13 to 16, we have presented the changes of propagation mechanism of monetary policy shock with respect to changes of four major friction parameters of our analysis:  $\xi_{LV}^h$ ,  $\gamma_R$ ,  $\gamma$  and  $\phi_z$ . In Figure 17, we have presented a case of bank capital channel of MPT due to change in the macroprudential policy-driven financial friction of capital adequacy norm ( $\kappa_b$ ). The IRF plots reveal that the presence of CAR works as a friction in the MPT mechanism.

to envisage the policy implications of the same. To this end, we provide a brief discussion on the policy relevance of our study. First, policy intervention is required to bring financially excluded households into the coverage of the banking system. In this regard, the Jan Dhan Yojana of the government and other policy initiatives of the RBI in recent years are likely to improve the policy transmission mechanism in the coming years. Second, the results suggest that a reduction in adjustment costs related to bank lending activities along with an increase in the depositors' base can lead to a better transmission of monetary policy. This can be achieved by improving the levels of operational and managerial efficiency in mobilisation and allocation of the financial resources as well as by protecting the depositors' interest. Typically, the adjustment cost related to lending is high partly due to operational/menu costs, processing fees, documentation charges, stamp duty and so on. The use of data analytics may help in automation, which can successively reduce the adjustment costs and hence, the degree of frictions. Third, our results also suggest that collateral constraint is one of the major sources of financial frictions that lead to incomplete pass-through of policy actions. The removal of collateral constraints by increasing the LTV for households and firms substantially improves the MPT. However, an increase in LTV may have some adverse implications for the financial stability. Hence, there is a trade-off between monetary policy and macro-prudential policy measures. The trade-off can partly be taken care through designing the policies to improve transparency and disclosures, enforcement of laws, market discipline and strong corporate governance by using the credit registries, social and/or venture networks with better enforcement and information tools and social norms so that the rise in LTV does not increase risks to the financial system. Besides, the use of big data may help in getting information about the borrowers related to their income, spending, business operations and other behavioural details. This would enable the lenders to predict the repayment behaviour of borrower, take more informed and profitable credit decisions in real time, and set the collateral requirement for the prospective borrowers more objectively.

Apart from the above mentioned policy implications, our model can be instrumental to examine a variety of policy rules in order to ensure the best possible outcome for macroeconomic stabilisation. With reference to the baseline model, we explore the alternative forms of monetary policy rules by augmenting the Taylor rule specification with financial variables. In Table 12, we list the different forms of asset price and credit augmented monetary policy rules, which are experimented with the baseline model one at a time. The motivation is to check whether the financial variable augmented policy rule can produce a better outcome in terms of economic stabilisation given the choice of policy frameworks. For this purpose, we consider the central bank loss function ( $\mathcal{L}_C$ ) based on variances of inflation and output as given below:

$$\mathcal{L}_C = \sigma_\pi^2 + \alpha_w \sigma_y^2 \quad (74)$$

where,  $\alpha_w > 0$  determines the choice of policy framework according to the relative weightage attached with the policy objectives. When  $0 < \alpha_w < 1$ ; it implies that the policy authority is inclined to minimise its welfare loss incurred due to variability of inflation more rather than the variability of output and hence, attaching higher weightage to inflation stabilisation relative to output stabilisation (IT framework). The situation will be reversed when  $\alpha_w > 1$ , which implies that output stabilisation is relatively more desirable to the policy authority instead of stabilising inflation (YT framework). Finally, for  $\alpha_w = 1$ , the policy authority remains indifferent or in a neutral position with respect to stabilising its policy objectives (Neutral framework).

Table 12: Monetary Policy Rules Augmented by Financial Variables

Policies	Taylor Rule Specifications		Parameters
Rule 1	$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i) \left[ \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} + \varphi_y \hat{Y}_t \right] + \varepsilon_{m,t}$		<i>Baseline Values</i>
Rule 2	$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i)$	$\left[ \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} + \varphi_y \hat{Y}_t + \varphi_f \hat{Q}_t^h \right] + \varepsilon_{m,t}$	$\varphi_f = 1.15$
Rule 3	$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i)$	$\left[ \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} + \varphi_y \hat{Y}_t + \varphi_f \hat{Q}_t^k \right] + \varepsilon_{m,t}$	$\varphi_f = 1.15$
Rule 4	$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i)$	$\left[ \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} + \varphi_y \hat{Y}_t + \varphi_f \hat{B}_t \right] + \varepsilon_{m,t}$	$\varphi_f = 1.15$
Rule 5	$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i)$	$\left[ \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} + \varphi_y (\hat{B}_t - \hat{Y}_t) \right] + \varepsilon_{m,t}$	$\varphi_y = 0.25$
Rule 6	$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i)$	$\left[ \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} + \varphi_y \hat{Y}_t + \varphi_f (\hat{B}_t - \hat{Y}_t) \right] + \varepsilon_{m,t}$	$\varphi_y = 0.25; \varphi_f = 0.1$

For the policy experiment, first, we set up three cases:  $\alpha_w = 0.5$ ,  $\alpha_w = 1$  and  $\alpha_w = 1.5$  denoting three different frameworks in terms of policy objectives. Then, we simulate the baseline model with policy rules 1 to 6 one at a time, record the model generated volatilities of inflation and output, and compute the hypothetical welfare loss of the central bank subject to the choice of  $\alpha_w$ . Rule 1 is the baseline policy rule of standard form with interest rate smoothing, inflation and output. Following Table 4, we use the estimates of policy coefficients (i.e.,  $\varphi_i$ ,  $\varphi_\pi$ , and  $\varphi_y$ ). In Rules 2 and 3, we extend the baseline policy rule by adding the asset prices, i.e., real prices of housing ( $\hat{Q}_t^h$ ) and physical capital ( $\hat{Q}_t^k$ ), respectively. In Rule 4, we consider the case when policy rate responds to the movements of credit cycle ( $\hat{B}_t$ ). Rule 5 depicts the scenario when the central bank responds to the deviation of credit-to-output ratio from its steady-state level instead of output only. Modifying Rule 5 with output targeting component along with the credit-to-output ratio, we present Rule 6 as suggested

by Badarau and Popescu (2012). Following Castelnuovo (2013), we calibrate the value of  $\varphi_f$  as 1.15 except for Rule 6. In case of Rule 6, we set  $\varphi_f$  at 0.1 as suggested in Badarau and Popescu (2014).

The results of model simulation with alternative monetary policy rules are presented in Table 13. Except the case of housing price augmented Taylor rule, it is found that the standard form of Taylor rule with forecast-based inflation and contemporaneous output stands out as the optimal one across all the policy frameworks. Housing price augmented Taylor rule (i.e., Rule 2) performs marginally better than the conventional Taylor rule as it reduces the volatility of output mildly. In contrast, adjusting policy interest rate to smoothen the credit cycle (Rules 4 to 6) does not seem to be useful. In fact, it exacerbates the volatilities of inflation and output. Moreover, comparing three different policy frameworks we find that inflation stabilisation is the most desirable policy option for the central bank as it leads to minimum welfare loss irrespective of the policy rules. Overall, it appears that targeting financial variables in the monetary policy rule may not be appropriate for the purpose of economic stabilisation.

Table 13: Alternative Policy Rules and Central Bank Welfare Loss

Different Policy Rules	$\sigma_\pi^2$ (in %)	$\sigma_y^2$ (in %)	CB Loss (in %)		
			IT ( $\alpha_w = 0.5$ )	Neutral ( $\alpha_w = 1$ )	YT ( $\alpha_w = 1.5$ )
1	0.39	1.10	0.94	1.49	2.04
2	0.39	1.08	0.93	1.47	2.01
3	0.60	1.17	1.19	1.77	2.36
4	1.87	1.39	2.57	3.26	3.96
5	0.53	1.24	1.15	1.77	2.39
6	0.56	1.12	1.12	1.68	2.24

## 5 Conclusion

Recently, the conduct of monetary policy in India has undergone a fundamental institutional reform. The flexible inflation targeting (FIT) has been formally adopted by the RBI. Subsequently, a monetary policy committee (MPC) has been constituted to determine the policy rate in order to achieve the inflation target. Under FIT framework, the RBI is assigned to achieve an inflation target of 4 per cent with a band of +/- 2 per cent. Any failure to achieve the same for three consecutive quarters needs to be explained in the Parliament with the reasons for the failure. In addition, the remedial measures and the expected time line to



return to the targeted inflation rate have to be proposed. Such institutional mandate clearly reflects the need for faster and efficient transmission mechanism in the economy. In this regard, understanding the frictions embedded at the different layers of bank-led credit market in the financial sector can contribute towards better decision making for the monetary authority. With this motivation, we studied the role of different structural bottlenecks and institutional impediments of the credit market arrangements in the transmission channels of the monetary policy.

Examining the friction of financial sector is important as this type of friction debilitates the pass-through of monetary policy both from the policy instrument to intermediate targets and intermediate targets to the policy objectives. In this study, we have addressed this issue using an NK-DSGE model with the banking sector. The model is augmented with the Indian economy-specific features, estimated with the quarterly data (1999:Q4 to 2015:Q3) and validated with the business cycle facts of the key macroeconomic and financial variables. The baseline model replicates a set of stylised facts like: (i) co-movements of the interest rates with incomplete pass-through, (ii) countercyclical movement of interest rate spread, (iii) presence of the broad credit channel in combination with interest rate channel, and (iv) weak pass-through of MPT to output and inflation. In addition, it identifies a pervasive response of real wage in the labour market adjustment and underscores the role of forward-looking expectation for stabilising inflation. Considering the degree of MPT in terms of accumulated effects obtained from the ‘baseline model’ as the *benchmark*, we undertake the counterfactual experiments on the elements of financial frictions. Our experiment provides a comparative analysis on the different credit market frictions which helps evaluating their respective role and quantitative significance. It is found that the collateral constraints and financially excluded segment of the economy cause major obstacles in the MPT while interest rate rigidity on the lending rates is of secondary importance.

There are a few caveats to be mentioned regarding our study. In the modelling framework, structure and implications of the interbank market and sovereign bond market are not addressed explicitly. Oligopolistic competition of the banking sector and increasing role of the non-bank financial corporations are missing, which would provide more appropriate depiction of the Indian financial sector instead of the monopolistically competitive commercial banking sector. Also, the model does not take into account any labour market frictions. In the side of quantitative analysis, the baseline parameterisation of the model is done using Bayesian methodology, which is sensitive to the choice of prior distributions and the historical data series of the observables. Hence, results of the study critically depend on the microfoundation and parametric configuration of the model.

The study can be enriched if the asymmetric pass-through of the monetary policy shock

to the retail interest rates of the commercial bank, subject to the market liquidity, is explained. Besides, the role of informal credit market can be examined as it is quite relevant for India. One can also extend the baseline model to the open economy set-up. All these potential extensions may improve the fitness of the model and provide useful insights for the transmission mechanism of monetary policy in the economy.

## 6 Bibliography

Acharya, V., (2017) Monetary transmission in India: Why is it important and why hasn't it worked well? *Inaugural Aveek Guha Memorial Lecture*, Homi Bhabha Auditorium, Tata Institute of Fundamental Research, Mumbai, November.

Agénor, P. R. & Pereira da Silva, L. A. (2014) Macroprudential regulation and the monetary transmission mechanism. *Journal of Financial Stability*, 13 (C), pp. 44-63.

Al-Mashat, R. (2003) Monetary policy transmission in India: Selected issues and statistical appendix. Country report no. 03/261, International Monetary Fund.

Aleem, A. (2010) Transmission mechanism of monetary policy in India. *Journal of Asian Economics*, 21(2), pp. 186-197.

Altunbas, Y., Gambacorta, L., & Marques-Ibanez, D., (2009) Securitisation and the bank lending channel. *European Economic Review*, 53(8), pp. 996-1009.

Anand, R., Delloro, V., & Peiris, S. J., (2014) A credit and banking model for emerging markets and an application to the Philippines, in *The Evolving Role and Limits of Monetary Policy: New Perspectives for Emerging Market Economies, 2014 BSP International Research Conference Proceedings*, Bangko Sentral ng Pilipinas International Research Conference, Manila, Philippines, published in Issue No. 2, September 2015, pp. 191-230. Available at: <http://www.bsp.gov.ph/downloads/Publications/2014/IRC2014.pdf>

Anand, R., Peiris, S., & Saxegaard, M., (2010) An estimated model with macrofinancial linkages for India. *IMF Working Paper No. WP/10/21*, International Monetary Fund.

Andrés, J., & Arce, O. (2012). Banking competition, housing prices and macroeconomic stability. *The Economic Journal*, 122 (565), pp. 1346-1372.

Aysun, U., Brady, R., & Honigc, A., (2013) Financial frictions and the strength of monetary transmission. *Journal of International Money and Finance*, 32 (February), pp. 1097-1119.

Badarau, C., & Popescu, A., (2014) Monetary policy and credit cycles: A DSGE analysis. *Economic Modelling*, 42, pp. 301-312, October.

Banerjee, S. and Basu, P., (2017) Technology shocks and Business cycles in India. *Macroeconomic Dynamics*, pp. 1-36. doi:10.1017/S1365100517000438

Bernanke, B. S., (1993) How important is the credit channel in the transmission of monetary policy? : A comment. *Carnegie-Rochester Conference Series on Public Policy*, 39 (1), pp. 47-52, December.

Bernanke, B., & Blinder, A. S., (1992) The federal funds rate and the channels of monetary transmission. *American Economic Review*, 82(4), pp. 901-921.

Bernanke, B., & Gertler, M., (1995) Inside the black box: The credit channel of monetary

policy transmission. *Journal of Economic Perspectives*, 9 (4), pp. 27-48.

Bernanke, B., & Gertler, M., (1989) Agency costs, net worth, and business fluctuations. *American Economic Review*, 79(1), pp. 14-31.

Bernanke, B. S., Gertler, M., & Gilchrist, S., (1999) The financial accelerator in a quantitative business cycle framework. In *Handbook of Macroeconomics*, (Eds.) John Taylor and Michael Woodford, pp. 1341-93, Amsterdam: North Holland.

Bhattacharya, R., Patnaik, I., & Shah, A., (2010) Monetary policy transmission in an emerging market setting. *IMF Working Paper, No: WP/11/5*.

Bhattacharya, R., & Patnaik, I., (2015) Financial inclusion, productivity shocks, and consumption volatility in emerging economies. *World Bank Economic Review*, 30 (1), pp. 171-201.

Bhattarai, S., Lee, J. W., & Park, W. Y. (2015) Optimal monetary policy in a currency union with interest rate spreads. *Journal of International Economics*, 96(2), pp. 375-397.

Bhaumik, S. K., Dang, V., & Kutan, A. M., (2011) Implications of bank ownership for the credit channel of monetary policy transmission: evidence from India. *Journal of Banking and Finance*, 35 (9), pp. 2418-28.

Blinder, A. S., (2000) Central-bank credibility: Why do we care? how do we build it?. *American Economic Review*, 90 (5), pp. 1421-1431, December.

Blum, J., & Hellwig, M., (1995) The macroeconomic implications of capital adequacy requirements for banks. *European Economic Review*, 39 (3-4), pp. 739-749.

Borio, C., & Zhu, H., (2012) Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?. *Journal of Financial Stability*, 8 (4), pp. 236-251.

Brooks, S. P., & Gelman, A., (1998) General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics*, 7 (4), pp. 434-455.

Brunnermeier, M. K., Eisenbach, T. M., & Sannikov, Y., (2012) Macroeconomics with financial frictions: A survey. *NBER Working Papers 18102*, National Bureau of Economic Research, Inc.

Brzoza-Brzezina, M., & Kolasa, M. (2013) Bayesian evaluation of DSGE models with financial frictions. *Journal of Money, Credit and Banking*, 45(8), pp. 1451-1476.

Canzoneri, M., Collard, F., Dellas, H., & Diba, B. (2016) Fiscal multipliers in recessions. *The Economic Journal*, 126 (590), pp. 75-108.

Carlstrom, C. T., & Fuerst, T. S., (1997) Agency costs, net worth, and business fluctuations: A computable general equilibrium analysis. *American Economic Review*, 87 (5), pp. 893-910.

Cecchetti, S. G., (1995) Distinguishing theories of the monetary transmission mechanism.

*Federal Reserve Bank of St. Louis Economic Review*, pp. 83-100.

Cecchetti, S. G., & Krause, S., (2001) Financial structure, macroeconomic stability, and monetary policy. *NBER Working Paper No. 8354*.

Christiano, L. J., Eichenbaum, M., & Evans, C. L., (1999) Monetary policy shocks: What have we learned and to what end? In *Handbook of Macroeconomics*, 1 (A), (Eds.) John B. Taylor and Michael Woodford, Amsterdam.

Chui, M., Kuruc, E., & Turner, P., (2016) A new dimension to currency mismatches in the emerging markets - non-financial companies. *BIS Working Papers 550*, Bank for International Settlements.

Claessens, S., Demirgüç-Kunt, A., & Huizinga, H. (2001) How does foreign entry affect domestic banking markets? *Journal of Banking & Finance*, 25 (5), pp. 891-911.

Cooley, T., Marimon, R., & Quadrini, V., (2004) Aggregate consequences of limited contract enforceability. *Journal of Political Economy*, 112 (4), pp. 817-847.

Copaciu, M., Nalban, V., & Bulete, C., (2015) An estimated DSGE model for Romania. *Dynare Working Papers Series No. 48*, November.

Cúrdia, V., & Woodford, M. (2016). Credit frictions and optimal monetary policy. *Journal of Monetary Economics*, 84, pp. 30-65.

Cúrdia, V., & Woodford, M., (2010) Credit spreads and monetary policy. *Journal of Money, Credit and Banking*, 42 (1), pp. 3-35.

Das, S., (2015) Monetary policy in India: Transmission to bank interest rates. *IMF Working Papers 15/129*, International Monetary Fund.

Das, A., Mishra, P., & Prabhala, N., (2015) The bank lending channel of monetary transmission: New evidence from India, mimeo.

Dib, A. (2010). Capital requirement and financial frictions in banking: macroeconomic implications. *Bank of Canada Working Paper*, No. 2010, 26.

Dynare User Guide: An introduction to the solution and estimation of DSGE models, copyright by Thomas Mancini Grioli, January 2003 version.

Fazzari, S. M., Hubbard, R. G., & Bruce, C. P., (1988) Financing constraints and corporate investment. *Brookings Papers on Economic Activity*, Economic Studies Program, The Brookings Institution, 19 (1), pp. 141-206.

Gabriel, V., Levine, P., Pearlman, J., & Yang, B., (2012) An estimated DSGE model of the Indian economy. In *The Oxford Handbook of the Indian Economy*, (Ed.) Chetan Ghatge, pp. 835-890, Oxford University Press: New York.

Gambacorta, L., (2008) How do banks set interest rates?. *European Economic Review*, 52 (5), pp. 792-819.

Gambacorta, L., & Signoretti, F. M., (2014) Should monetary policy lean against the

wind?. *Journal of Economic Dynamics and Control*, 43, pp. 146-174.

Gerali, A., Neri, S., Sessa, L., & Signoretti, F., (2010) Credit and banking in a DSGE model of the Euro area. *Journal of Money, Credit and Banking*, 42 (6), pp. 107-141.

Gertler, M., & Gilchrist, S., (1993) Monetary policy, business cycles and the behavior of small manufacturing firms. *Finance and Economics Discussion Series 93-4*, Board of Governors of the Federal Reserve System (U.S.).

Gertler, M., & Kiyotaki, N., (2010) Financial intermediation and credit policy in business cycle analysis, Chapter 11. *Handbook of Monetary Economics*, 3, pp. 547-599.

Gertler, M., & Karadi, P., (2011) A model of unconventional monetary policy. *Journal of Monetary Economics*, 58 (1), pp. 17-34.

Goodfriend, M & McCallum, B. T., (2007) Banking and interest rates in monetary policy analysis: A quantitative exploration. *Journal of Monetary Economics*, 54 (5), pp. 1480-1507.

Guerrieri, L., & Iacoviello, M., (2017) Collateral constraints and macroeconomic asymmetries. *Journal of Monetary Economics*, 90, October, pp.28-49.

Hall, R. E., (2011) The high sensitivity of economic activity to financial frictions. *The Economic Journal*, 121 (552), pp. 351-378.

Hart, O., & Moore, J., (1994) A theory of debt based on the inalienability of human capital. *Quarterly Journal of Economics*, 109 (4), pp. 841-79.

Heathcote, J., Storesletten, K., & Violante, G. L., (2009) Quantitative macroeconomics with heterogeneous households. *Annual Review of Economics*, 1 (1), pp. 319-354.

Hubbard, R. G., (1995) Is there a 'Credit Channel' for monetary policy? *Federal Reserve Bank of St. Louis Review* 77 (May/June), pp. 63-77.

Iacoviello, M., (2015) Financial business cycles. *Review of Economic Dynamics*, 18 (1), pp.140-163.

Iacoviello, M., & Neri, S., (2010) Housing market spillovers: Evidence from an estimated DSGE Model. *American Economic Journal: Macroeconomics*, 2 (April): pp. 125-164.

Ireland, P., (2008) The monetary transmission mechanism. In *The New Palgrave Dictionary of Economics*, Second Edition, (Eds.) Lawrence Blume and Steven Durlauf, Hampshire: Palgrave Macmillan Ltd.

Iskrev, N., (2010a) Evaluating the strength of identification in DSGE models. An a priori approach. *Working Papers w201032*, Banco de Portugal, Economics and Research Department.

Iskrev, N., (2010b) Local identification in DSGE models. *Journal of Monetary Economics* 57, pp. 189-202.

Iskrev, N., & Ratto, M., (2010a) Computational advances in analyzing identification of DSGE models. 6th DYNARE Conference, June 3-4, Gustavelund, Tuusula, Finland. Bank

of Finland, DSGE-net and Dynare Project at CEPREMAP.

Iskrev, N., and Ratto, M., (2010b) Identification toolbox for DYNARE. 1st MONFISPOL Conference, London, 4-5 November. The London Metropolitan University and the European Research project (FP7-SSH) MONFISPOL.

Jain, R., & Khundrakpam, J. K., (2012) Monetary policy transmission in India: A peep inside the black box. *MPRA Paper No. 50903*, June. Available at: <http://mpra.ub.uni-muenchen.de/50903/>

Jermann, U., & Quadrini, V., (2012) Macroeconomic effects of financial shocks. *American Economic Review*, American Economic Association, 102 (1), pp. 238-271, February.

Joshi, H., Saggarr, M., & Ray, P., (1998) New monetary transmission channels: Role of interest rates and exchange rate in conduct of Indian monetary policy. *Economic and Political Weekly*, 33 (44), pp. 2787-2794.

Kapur, M., & Behera, H., (2012) Monetary transmission mechanism in India: A quarterly model. *RBI Working Paper Series, W.P.S (DEPR) : 09/ 2012*, Mumbai.

Khundrakpam, J. K., (2011) Credit channel of monetary transmission in India - How effective and long is the lag?. *Working Paper (DEPR) 20/2011*, Reserve Bank of India, Mumbai.

Kashyap, A. K., & Stein, J. C., (2000) What do a million observations on banks say about the transmission of monetary policy?. *American Economic Review*, 90 (3), pp. 407-428.

Kashyap, A. K., & Stein, J. C., (1995) The impact of monetary policy on bank balance sheets. *Carnegie-Rochester Conference Series on Public Policy*, 42 (1), pp. 151-195.

Kashyap, A. K., & Stein, J. C., (1993) Monetary policy and bank lending. *NBER Working Paper No. 4317*, April.

Kashyap, A. K., & Stein, J. C., & Wilcox, D. W., (1993) Monetary policy and credit conditions: Evidence from the composition of external finance. *American Economic Review*, 83 (1), pp. 78-98.

Kletzer, K., (2012) Financial frictions and monetary policy transmission in India. *The Oxford Handbook of the Indian Economy*, (ed) Chetan Ghate.

DOI: 10.1093/oxfordhb/9780199734580.013.0022

Khwaja, A. I., & Mian, A., (2008) Tracing the impact of bank liquidity shocks: Evidence from an emerging market. *American Economic Review*, 98 (4), pp. 1413-1442.

Kishan, R. P., & Opiela, T. P., (2000) Bank size, bank capital, and the bank lending channel. *Journal of Money, Credit and Banking*, 32 (1), pp. 121-141.

Kiyotaki, N., & Moore, J. H., (2012) Liquidity, business cycles and monetary policy. *NBER Working Paper No. 17934*, DOI: 10.3386/w17934

Kiyotaki, N., & Moore, J. H., (1997) Credit cycles. *Journal of Political Economy*, 105

(2), pp. 211-248.

Kiyotaki, N., (2012) A mechanism design approach to financial frictions. In: Allen F., Aoki M., Fitoussi JP., Kiyotaki N., Gordon R., Stiglitz J.E. (eds) *The Global Macro Economy and Finance*. International Economic Association Series. Palgrave Macmillan, London

Lahiri, A. and Patel, U. (2016) The challenges of monetary policy in emerging economies, in *Monetary Policy in India: A Modern Perspective*, Springer Verlag: India, December.

Mandelman, F. S., (2010) Business cycles and monetary regimes in emerging economies: A role for a monopolistic banking sector. *Journal of International Economics*, 81 (1), pp. 122-138, May.

Markovic, B., (2006) Bank capital channels in the monetary transmission mechanism. *Bank of England Working Paper No. 313*, November.

Mateju, J. (2013) Explaining the strength and the efficiency of monetary policy transmission: A panel of impulse responses from a time-varying parameter model. *IES Working Paper*, (No. 18/2013).

Mendoza, E., (2010) Sudden stops, financial crises, and leverage. *American Economic Review*, American Economic Association, 100 (5), pp. 1941-1966, December.

Merola, R. (2015) The role of financial frictions during the crisis: An estimated DSGE model. *Economic Modelling*, 48, pp. 70-82.

Mian, A., Sufi, A. & E. Verner (2017) Household debt and business cycles worldwide. *The Quarterly Journal of Economics*, 132 (4), pp. 1755–1817.

Mishra, P., Montiel, P., & Sengupta, R., (2016) Monetary transmission in developing countries: Evidence from India, In *Monetary Policy in India: A Modern Macroeconomic Approach* (Eds.) Chetan Ghate and Ken Kletzer, pages 59-110, Springer Verlag: New Delhi.

Mishra, P., & Montiel, P., (2013) How effective is monetary transmission in developing countries? A survey of the empirical evidence. *Economic Systems*, 37 (2), pp. 187-216.

Mishkin, F. S., (1996) Channels of monetary transmission and lessons for monetary policy. *NBER Working Paper No.5464*, National Bureau of Economic Research.

Mohan, R., 2006 Evolution of central banking in India, based on lecture delivered at a seminar organized by the London School of Economics and the National Institute of Bank Management at Mumbai, India, on January 24.

Mohanty, M., & Kumar, R., (2016) Financial intermediation and monetary policy transmission in EMEs: What has changed since the 2008 crisis ?. In *Monetary Policy in India: A Modern Macroeconomic Approach* (Eds.) Chetan Ghate and Ken Kletzer, pages 111-150, Springer Verlag: New Delhi.

Mohanty, M.S., & Turner, P., (2008) Monetary policy transmission in emerging market economies: What is new?, in *Transmission Mechanisms For Monetary Policy In Emerging*



*Market Economies*, BIS Papers No. 35, Bank for International Settlements.

Mohanty, D., (2012) Evidence of interest rate channel of monetary policy transmission in India. *RBI Working Paper Series No. 06*

Normandin, M., 2006. The Effects of Monetary-Policy Shocks on Real Wages: A Multi-Country Investigation. Available from: <https://core.ac.uk/download/pdf/6689285.pdf>

Pandit, B. L., & Vashisht, P., (2011) Monetary policy and credit demand in India and some other EMEs. *ICRIER Working Paper No. 256*, ICRIER, New Delhi.

Pandit, B.L., Mittal, A., Roy, M., & Ghosh, S., (2006) Transmission of monetary policy and the bank lending channel: Analysis and evidence for India. *Development Research Group Study No. 25*. Department of Economic Analysis and Policy Reserve Bank of India Mumbai (January).

Patra, M., & Kapur, M., (2010) A monetary policy model without money for India. *IMF Working Papers, Working Paper No. 10/183*.

Available at SSRN: <https://ssrn.com/abstract=1669864>

Prasad, A. & Ghosh, S., (2005) Monetary policy and corporate behavior in India, *IMF Working Paper No. 25*, Washington DC.

Quadrini, V., (2011) Financial frictions in macroeconomic fluctuations. *Economic Quarterly*, 97 (3), pp. 209–254.

Rajan, R. G., (2005) Has financial development made the world riskier?. Proceedings - Economic Policy Symposium - Jackson Hole, Federal Reserve Bank of Kansas City, issue August, pp. 313-369.

Rotemberg, J., (1982) Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, Vol. 49(4), pp. 517-531.

Sahu, J. P., (2013). Inflation dynamics in India: A hybrid New Keynesian Phillips Curve approach. *Economics Bulletin*, 33 (4), pp. 2634-2647.

Sen Gupta, A., & Sengupta, R., (2014) Is India ready for flexible inflation-targeting? *MPRA Paper 56430*, University Library of Munich, Germany.

Available at: [https://mpra.ub.uni-muenchen.de/56430/1/MPRA\\_paper\\_56430.pdf](https://mpra.ub.uni-muenchen.de/56430/1/MPRA_paper_56430.pdf)

Silva, M. da., Andrade, J., Silva, G., Brandi, V., (2012) Financial frictions in the Brazilian banking system: A DSGE model with Bayesian estimation, Annals of Brazilian Econometric Society Meeting.

Singh, B., (2011) How asymmetric is the monetary policy transmission to financial markets in India? *Reserve Bank of India Occasional Papers*, 32 (2), Monsoon.

Singh, K., & Kalirajan, K., (2007) Monetary transmission in post-reform India: an evaluation. *Journal of the Asia Pacific Economy*, 12, 158–187.

Sousa, J. M., & Zaghini, A., (2007) Global monetary policy shocks in the G5: A SVAR

approach. *Journal of International Financial Markets, Institutions and Money*, 17 (5), pp. 403-419.

Stiglitz, J.E., & Weiss, A., (1981) Credit rationing in markets with imperfect information. *American Economic Review*, 71 (3), pp. 393-410.

Taylor, J. B., (1995) The monetary transmission mechanism: An empirical framework. *Journal of Economic Perspectives*, 9 (4), pp. 11-26.

Townsend, R., (1979) Optimal contracts and competitive markets with costly state verification. *Journal of Economic Theory*, 21 (2). pp - 265-293.

Turner, P., (2012) Weathering financial crisis: domestic bond markets in EMEs. *BIS Papers chapters*, In: Bank for International Settlements (ed.), *Weathering financial crises: bond markets in Asia and the Pacific*, 63, pp. 15-34.

RBI (2014): Report of the expert committee to revise and strengthen the monetary policy framework, Reserve Bank of India.

Van den Heuvel, S. J., (2002) Does bank capital matter for monetary transmission? *Economic Policy Review*, Federal Reserve Bank of New York, pp. 259-265, May.

Vlcek, J. , & Roger, S., (2012) Macrofinancial Modeling At Central Banks: Recent Developments and Future Directions. *IMF Working Papers* 12/21, International Monetary Fund.

Woodford, M., (2003) *Interest and prices foundations of a theory of monetary policy*. Princeton: Princeton University Press.

## 7 Appendix A: Alternative Channels of Monetary Transmission

As mentioned in Section 2.1, there are six different channels of monetary transmission proposed in the literature. We provide a brief summary of these channels in the following text.

The first one is the conventional *money channel*, through which monetary tightening raises the short-term interest rates, changes the composition of demand for monetary and non-monetary financial assets, reduces the demand for investment and impact on output growth and inflation in the economy (Kletzer, 2012).

Second, the Keynesian view of *interest rate channel* of transmission mechanism suggests that a policy-induced increase in the short-term nominal interest rate leads to an increase in the longer-term nominal interest rates. The reason is investors act to arbitrage away the differences in the risk-adjusted expected returns on debt instruments of different maturities as described by the expectations hypothesis of the term structure. Given the nominal rigidity in place, the movements in nominal interest rates sluggishly translate into movements in real interest rates. Such changes in real interest rates alter the relative price of future consumption to current consumption, user cost of capital for fixed investment, relative price of domestic goods in terms of foreign goods, and impact on economic activity in the economy.

Third, according to the *credit channel* of monetary transmission, design of financial contract departs from the Modigliani-Miller axioms under the circumstances of market incompleteness and heterogeneity among the economic agents, and leads to various kinds of frictions. These frictions give rise of a wedge between the cost of capital incurred by the capital users and the return from capital received by the capital providers. Due to presence of such wedge, changes in the monetary policy instruments can create its impact on the real activity by changing the price of credit or credit limits in the credit market with an additional strength. It does so through two ways: (i) the *balance sheet channel*, in which monetary policy affects borrowers' net worth and debt collateral, and (ii) the *bank lending channel*, in which policy instrument impacts on the level of intermediated credit. These channels have been widely incorporated into general equilibrium models and found to be empirically relevant to explain the propagation mechanism of the policy shocks.<sup>24</sup>

Fourth, in the open economies under flexible exchange rate framework, *exchange rate channel* operates through capital flows in response to policy interest rate changes. A key

---

<sup>24</sup>Evidence on credit channel of monetary policy transmission can be found in Fazzari et al. (1988), Bernanke and Blinder (1992), Kashyap et al. (1993), and Bernanke, Gertler, and Gilchrist (1999) for advanced countries, and in Mohanty and Turner (2008), Agenor and Pereira da Silva, (2014) for the EMDEs.

assumption underpinning this relationship is the Uncovered Interest rate Parity (UIP) condition, which suggests that a policy-led cut in the interest rate makes domestic interest bearing assets less attractive vis-à-vis foreign assets and leads to capital outflows. This entails to depreciation of the nominal exchange rate. In a sticky-price environment, it turns into a real depreciation and an increase in the price of tradeable relative to non-tradeable. Finally, it impacts on output and inflation, though with a lag, depending on the share of imported goods in consumption basket. This exchange rate channel can trigger first and second round effects on inflation via the cost of production as many intermediate goods coming through imports may become expensive.<sup>25</sup>

Fifth, the *asset price channel* works through the impact of monetary policy on the domestic asset prices which include bond, stock and real estate prices. Changes in the policy interest rate affect the households and the firms through valuation of equities. Higher interest rates bring down the equity prices, reduces the present value of financial wealth, and leaves contractionary impact on consumption of the economic agents. Besides, the drop in equity prices also impacts on the Tobin's Q. Low value of the equities relative to the replacement cost of capital results in reduced investment spending in the economy.<sup>26</sup>

Sixth, changes in the policy rate can influence the time path of real activity through the *expectation channel* and the confidence with which those expectations are held. Such changes in perception will affect participants in the commodity, labour and financial markets. According to Blinder (2000), a successful monetary policy emerges as a result of the effective management of expectations instead of the policy rate alone. Depending on the perception of households and firms about intertemporal rates of substitution, the expectation channel can transmit the impact of monetary policy shocks. Mohanty and Turner (2008) argued that depending on the degree of credibility, predictability of actions, and commitment to vary the policy instrument consistently by the central bank, the expectation channel contributes to speed up the adjustment and impacts the transmission lags significantly.

---

<sup>25</sup>Since 2010, the problem of currency mismatches in many emerging markets has increased – notably because of a substantial increase in the foreign currency borrowing by the non-financial companies (Chui et al, 2016). This has made the exchange rate channel more relevant in the monetary policy debate of the post global financial crisis. The channel has magnified for both large commodity exporting countries such as Brazil and Russia, as well as the commodity importing countries like India, Indonesia and Thailand.

<sup>26</sup>The empirical evidence of many advanced and emerging market economies suggests that monetary policy and asset prices had some relationship, especially pertaining to house prices and stock market movements. However, this channel has weakened substantially in the post-financial crisis period (Turner, 2012).

## 8 Appendix B: Econometric Specification of SVAR Analysis

The system of equations representing SVAR framework can be written in vector form as:

$$B_0x_t = A_0 + B_1x_{t-1} + B_2x_{t-2} + \dots + B_px_{t-p} + u_t \quad (75)$$

where,  $x_t$  is an  $n \times 1$  vector of endogenous variables,  $A$  is an  $n \times 1$  vector of constant terms, and  $u_t$  is an  $n \times 1$  vector of structural disturbances, and  $p$  denotes the number of lags. In the reduced form, it can be rewritten as:

$$x_t = A_1 + \Phi_1x_{t-1} + \Phi_2x_{t-2} + \dots + \Phi_px_{t-p} + e_t \quad (76)$$

where,  $e_t$  is the reduced form residuals and equals to  $B_0^{-1}u_t$ .

For our analysis, we have chosen:  $x_t = [y_t \ \pi_t \ b_t \ i_t^d \ i_t^b \ i_t]^t$  where,  $y_t$  is real GDP at factor cost,  $\pi_t$  is CPI inflation,  $b_t$  denotes non-food credit growth,  $i_t^d$  stands for deposit rate,  $i_t^b$  lending rate and call money rate is denoted by  $i_t$ .

The relationship between  $u_t$  and  $e_t$  :

$$u_t = B_0e_t \quad (77)$$

Based on the above relation, the scheme of identification is summarised below:

$$\begin{bmatrix} u_t^y \\ u_t^\pi \\ u_t^b \\ u_t^{i^d} \\ u_t^{i^b} \\ u_t^i \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & b_{35} & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_t^y \\ e_t^\pi \\ e_t^b \\ e_t^{i^d} \\ e_t^{i^b} \\ e_t^i \end{bmatrix} \quad (78)$$

where,  $u_t$  is the vector of structural innovations,  $e_t$  is the vector of reduced form residuals and  $b_{ij}$  represents contemporaneous structural parameters.

## 9 Appendix C: Data Sources and Computations

Quarterly data on real sector variables measured at constant prices with base 2011-12, viz. Gross Value Added (GVA), Gross Domestic Products (GDP), Private Final Consumption Expenditure, Government Final Consumption Expenditure and Gross Fixed Capital Formation have been extracted from the Central Statistics Office (CSO), Government of India. As the quarterly data for the new series with base 2011-12 are available from 2011-12: Q1, the back series prior to 2011-12 are derived by splicing.

The quarterly data for the price index is derived as the average of the respective monthly price index during the quarter. Data on Consumer Price Index (CPI) with base year at 2012 are collected from the website of CSO, Government of India. As the historical data on CPI are not available prior to the year 2011, the same are spliced using the CPI for Industrial Workers (CPI-IW), published by the Indian Labour Bureau, Government of India.

Data on banking and interest rate variables such as bank credit, non-food credit, repo rate, call money rate, cash reserve ratio, SLR, deposit rates and weighted average lending rates were collected from the website of the RBI. The RBI has been disseminating the monthly Weighted Average Lending Rate (WALR) on outstanding loan from Feb-12. For compilation of lending rates prior to Feb-12, the end quarter interest rate (Term loan interest rate other than export credit) for five scheduled commercial banks has been used.<sup>27</sup> The simple average of the maximum and minimum lending rate for each of the banks has been considered and the lending rate is obtained as the weighted average of each these banks interest rate, with weights being proportion to the average outstanding credit amount as on end 2010-11 and 2011-12. As a proxy of investment in housing sector, housing price data are taken from the RBI database. The steady-state share of bank deposit to GDP ratio is obtained from the database of St. Louise FRED (<https://fred.stlouisfed.org>).

The quarterly Net Interest Margin (NIM) was derived using the Chow-Lin method from annual NIM data. The annual NIM data were collected from the annual publication Statistical Tables relating to Banks in India, published by the RBI. The current and lag quarters of nominal GDP was used to derive the quarterly NIM estimates.

---

<sup>27</sup>The banks selected for this purpose includes three nationalised banks (State Bank of India, Bank of Baroda and Punjab National Bank), one private bank (ICICI Bank Ltd.) and one foreign bank (Citibank).

## 10 Appendix D: Log-linearised Model and Description of Steady-state

### 10.1 Liquidity-constrained Household

$$\hat{C}_{R,t} + \sigma_L \hat{L}_{R,t} = \hat{\omega}_{R,t} \quad (79)$$

$$\hat{C}_{R,t} = \hat{\omega}_{R,t} + \hat{L}_{R,t} \quad (80)$$

### 10.2 Patient Household

$$\hat{\lambda}_{P,t} = - \left( \frac{1}{1 - \bar{\sigma}_h} \right) \left( \hat{C}_{P,t} - \bar{\sigma}_h \hat{C}_{P,t-1} \right) \quad (81)$$

$$\hat{L}_{P,t} = \left( \frac{1}{\sigma_L} \right) \left( \hat{\omega}_{P,t} + \hat{\lambda}_{P,t} \right) \quad (82)$$

$$\hat{\varepsilon}_{H,t} - \hat{H}_{P,t} = \left\{ \frac{1}{1 - \beta_P (1 - \delta_h)} \right\} \left( \hat{\lambda}_{P,t} + \hat{Q}_t^h \right) - \left\{ \frac{\beta_P (1 - \delta_h)}{1 - \beta_P (1 - \delta_h)} \right\} \left( \hat{\lambda}_{P,t+1} + \hat{Q}_{t+1}^h \right) \quad (83)$$

$$\hat{\lambda}_{P,t} = (i_t^d - \hat{\pi}_{t+1}) + \hat{\lambda}_{P,t+1} \quad (84)$$

$$\begin{aligned} & \left\{ \left( \frac{C_P}{C} \right) \left( \frac{C}{Y} \right) \right\} \hat{C}_{P,t} + \left\{ Q^h \left( \frac{H_P}{H} \right) \left( \frac{H}{Y} \right) \right\} \left[ \left( \hat{Q}_t^h + \hat{H}_{P,t} \right) - (1 - \delta_h) \left( \hat{Q}_t^h + \hat{H}_{P,t-1} \right) \right] \\ & + \left( \frac{D}{Y} \right) \hat{D}_t + \left( \frac{TX_P}{TX} \right) \left( \frac{TX}{Y} \right) \widehat{TX}_{P,t} \\ & = \left\{ \frac{(1 - \gamma_R) \gamma (1 - \alpha)}{X} \right\} \left( \hat{\omega}_{P,t} + \hat{L}_{P,t} \right) + \left\{ \left( \frac{1 + i^d}{\pi} \right) \left( \frac{D}{Y} \right) \right\} \left( i_{t-1}^d - \hat{\pi}_t + \hat{D}_{t-1} \right) \end{aligned} \quad (85)$$

### 10.3 Impatient Household

$$\hat{\lambda}_{I,t} = - \left( \frac{1}{1 - \bar{\sigma}_h} \right) \left( \hat{C}_{I,t} - \bar{\sigma}_h \hat{C}_{I,t-1} \right) \quad (86)$$

$$\hat{L}_{I,t} = \left( \frac{1}{\sigma_L} \right) \left( \hat{\omega}_{I,t} + \hat{\lambda}_{I,t} \right) \quad (87)$$

$$\begin{aligned}\hat{\varepsilon}_{H,t} - \hat{H}_{I,t} &= \varpi_H \left( \hat{\lambda}_{I,t} + \hat{Q}_t^h \right) - \{ \beta_I (1 - \delta_h) \varpi_H \} \left( \hat{\lambda}_{I,t+1} + \hat{Q}_{t+1}^h \right) \\ &\quad - \left[ \frac{\varepsilon_{LV}^H (1 - \delta_h) \{ \pi - \beta_I (1 + i^{bH}) \} \varpi_H}{\pi (1 + i^{bH})} \right] \left( \hat{\mu}_{I,t} + \hat{Q}_{t+1}^h + \hat{\varepsilon}_{LV,t}^H \right)\end{aligned}\quad (88)$$

$$\text{where, } \varpi_H = \left( \frac{\lambda_I H_I}{\varepsilon_H} \right) = \left[ \{ 1 - \beta_I (1 - \delta_h) \} - \left\{ \frac{\varepsilon_{LV}^H (1 - \delta_h) \{ \pi - \beta_I (1 + i^{bH}) \}}{\pi (1 + i^{bH})} \right\} \right]^{-1}$$

$$\hat{\lambda}_{I,t} = \left\{ \frac{\beta_I (1 + i^{bH})}{\pi} \right\} \left( \hat{i}_t^{bH} - \hat{\pi}_{t+1} + \hat{\lambda}_{I,t+1} \right) + \left\{ 1 - \frac{\beta_I (1 + i^{bH})}{\pi} \right\} \left( \hat{i}_t^{bH} + \hat{\mu}_{I,t} \right)\quad (89)$$

$$\begin{aligned}&\left\{ \left( \frac{C_I}{C} \right) \left( \frac{C}{Y} \right) \right\} \hat{C}_{I,t} + \left\{ Q^h \left( \frac{H_I}{H} \right) \left( \frac{H}{Y} \right) \right\} \left[ \left( \hat{Q}_t^h + \hat{H}_{I,t} \right) - (1 - \delta_h) \left( \hat{Q}_t^h + \hat{H}_{I,t-1} \right) \right] \\ &+ \left\{ \left( \frac{1 + i^{bH}}{\pi} \right) \left( \frac{B_H}{B} \right) \left( \frac{B}{Y} \right) \right\} \left( \hat{i}_{t-1}^{bH} - \hat{\pi}_t + \hat{B}_{H,t-1} \right) \\ &= \left\{ \frac{(1 - \gamma_R) (1 - \gamma) (1 - \alpha)}{X} \right\} \left( \hat{\omega}_{I,t} + \hat{L}_{I,t} \right) + \left\{ \left( \frac{B_H}{B} \right) \left( \frac{B}{Y} \right) \right\} \hat{B}_{H,t}\end{aligned}\quad (90)$$

$$\left( \hat{i}_t^{bH} + \hat{B}_{H,t} \right) = \hat{\varepsilon}_{LV,t}^H + \hat{\pi}_{t+1} + \hat{Q}_{t+1}^h + \hat{H}_{I,t}\quad (91)$$

#### 10.4 Wholesale Goods Producing Entrepreneur

$$\hat{\lambda}_{E,t} = - \left( \frac{1}{1 - \bar{\sigma}_h} \right) \left( \hat{C}_{E,t} - \bar{\sigma}_h \hat{C}_{E,t-1} \right)\quad (92)$$

$$\hat{Y}_{E,t} = \hat{\varepsilon}_{A,t} + \alpha \left( \hat{u}_t + \hat{K}_{t-1} \right) + (1 - \alpha) \hat{L}_t\quad (93)$$

$$\hat{r}_t^k = \hat{Y}_{E,t} - \hat{x}_t - \hat{u}_t - \hat{K}_{t-1}\quad (94)$$

$$\hat{r}_t^k = \left( \frac{\psi_b}{\psi_a} \right) \hat{u}_t\quad (95)$$

$$\hat{\omega}_{R,t} = \hat{Y}_{E,t} - \hat{X}_t - \hat{L}_{R,t}\quad (96)$$



$$\hat{\omega}_{P,t} = \hat{Y}_{E,t} - \hat{X}_t - \hat{L}_{P,t} \quad (97)$$

$$\hat{\omega}_{I,t} = \hat{Y}_{E,t} - \hat{X}_t - \hat{L}_{I,t} \quad (98)$$

$$\hat{\lambda}_{E,t} = \left\{ \beta_E \left( \frac{1 + i^{bE}}{\pi} \right) \right\} \left( \hat{i}_t^{bE} - \hat{\pi}_{t+1} + \hat{\lambda}_{E,t+1} \right) + \left\{ 1 - \beta_E \left( \frac{1 + i^{bE}}{\pi} \right) \right\} \left( \hat{i}_t^{bE} + \hat{\mu}_{E,t} \right) \quad (99)$$

$$\begin{aligned} \left( \hat{\lambda}_{E,t} + \hat{Q}_t^k \right) &= [1 - \beta_E \{ \psi_a + (1 - \delta_k) \}] \left( \hat{\mu}_{E,t} + \hat{\varepsilon}_{LV,t}^E + \hat{Q}_{t+1}^k + \hat{\pi}_{t+1} \right) \\ &\quad + (\beta_E \psi_a) \left( \hat{\lambda}_{E,t+1} + \hat{r}_{t+1}^k + \hat{u}_{t+1} \right) + \{ \beta_E (1 - \delta_k) \} \left( \hat{\lambda}_{E,t+1} + \hat{Q}_{t+1}^k \right) \\ &\quad - \beta_E \left( \hat{\lambda}_{E,t+1} + \psi_a \hat{u}_{t+1} \right) \end{aligned} \quad (100)$$

$$\begin{aligned} &\left\{ \left( \frac{C_E}{C} \right) \left( \frac{C}{Y} \right) \right\} \hat{C}_{E,t} + \left( \frac{I^k}{\delta_k Y} \right) \left( \hat{Q}_t^k + \hat{K}_t \right) - \left\{ \left( \frac{1 - \delta_k}{\delta_k} \right) \left( \frac{I^k}{Y} \right) \right\} \left( \hat{Q}_t^k + \hat{K}_{t-1} \right) \\ &+ \left\{ \left( \frac{1 + i^{bE}}{\pi} \right) \left( \frac{B_E}{B} \right) \left( \frac{B}{Y} \right) \right\} \left( \hat{i}_{t-1}^{bE} - \hat{\pi}_t + \hat{B}_{E,t-1} \right) + \left( \frac{\psi_a I^k}{\delta_k Y} \right) \hat{u}_t \\ &= \left( \frac{\alpha}{\bar{X}} \right) \left( \hat{Y}_{E,t} - \hat{X}_t \right) + \left\{ \left( \frac{B_E}{B} \right) \left( \frac{B}{Y} \right) \right\} \hat{B}_{E,t} \end{aligned} \quad (101)$$

$$\left( \hat{i}_t^{bE} + \hat{B}_{E,t} \right) = \hat{\varepsilon}_{LV,t}^E + \hat{\pi}_{t+1} + \hat{Q}_{t+1}^k + \hat{K}_t \quad (102)$$

## 10.5 Final Goods Producing Retailer

$$\pi_t = \left\{ \frac{-\varepsilon_y}{X \vartheta_p \pi^2 (1 + \beta_P \theta_p)} \right\} \widehat{X}_t + \left( \frac{\beta_P}{1 + \beta_P \theta_p} \right) \widehat{\pi}_{t+1} + \left( \frac{\theta_p}{1 + \beta_P \theta_p} \right) \widehat{\pi}_{t-1} \quad (103)$$

## 10.6 Capital Goods and Housing Goods Producing Sectors

$$\hat{I}_t^k = \left( \frac{\varrho_k}{1 + \beta_P} \right) \hat{Q}_t^k + \left( \frac{\beta_P}{1 + \beta_P} \right) \hat{I}_{t+1}^k + \left( \frac{1}{1 + \beta_P} \right) \hat{I}_{t-1}^k - \left( \frac{\beta_P}{1 + \beta_P} \right) \left( \hat{\varepsilon}_{i^k,t+1} - \hat{\varepsilon}_{i^k,t} \right) \quad (104)$$

$$\hat{I}_t^h = \left( \frac{\varrho_h}{1 + \beta_P} \right) \hat{Q}_t^h + \left( \frac{\beta_P}{1 + \beta_P} \right) \hat{I}_{t+1}^h + \left( \frac{1}{1 + \beta_P} \right) \hat{I}_{t-1}^h \quad (105)$$

$$\hat{K}_t = (1 - \delta_k) \hat{K}_{t-1} + \delta_k \hat{I}_t^k \quad (106)$$

$$\hat{H}_t = (1 - \delta_h) \hat{H}_{t-1} + \delta_h \hat{I}_t^h \quad (107)$$

## 10.7 Retail Banking Sector Operations

$$\hat{i}_t^d = \hat{i}_t^s - \left\{ \frac{\phi_d}{(\varepsilon^d + 1) i^d} \right\} (\hat{i}_t^d - \hat{i}_{t-1}^d) + \left\{ \frac{\beta_P \phi_d}{(\varepsilon^d + 1) i^d} \right\} (\hat{i}_{t+1}^d - \hat{i}_t^d) \quad (108)$$

$$\hat{i}_t^{bH} = \hat{i}_t^b - \left\{ \frac{\phi_{bH}}{(\varepsilon^{bH} - 1) i^{bH}} \right\} (\hat{i}_t^{bH} - \hat{i}_{t-1}^{bH}) + \left\{ \frac{\beta_P \phi_{bH}}{(\varepsilon^{bH} - 1) i^{bH}} \right\} (\hat{i}_{t+1}^{bH} - \hat{i}_t^{bH}) \quad (109)$$

$$\hat{i}_t^{bE} = \hat{i}_t^b - \left\{ \frac{\phi_{bE}}{(\varepsilon^{bE} - 1) i^{bE}} \right\} (\hat{i}_t^{bE} - \hat{i}_{t-1}^{bE}) + \left\{ \frac{\beta_P \phi_{bE}}{(\varepsilon^{bE} - 1) i^{bE}} \right\} (\hat{i}_{t+1}^{bE} - \hat{i}_t^{bE}) \quad (110)$$

## 10.8 Wholesale Banking Sector Operations

$$\hat{i}_t^s = \left\{ (1 - \alpha_c - \alpha_s) \left( \frac{i}{i^s} \right) \right\} \hat{i}_t + \left( \frac{\alpha_s i^g}{i^s} \right) \hat{i}_t^g \quad (111)$$

$$\hat{i}_t^b = \hat{i}_t - \phi_z \kappa_b^3 (\hat{Z}_t - \hat{B}_t) \quad (112)$$

$$\hat{B}_t = (1 - \alpha_c - \alpha_s) \hat{D}_t + \left( \frac{B^{IB}}{B} \right) \hat{B}_t^{IB} + \left( \frac{Z}{B} \right) \hat{Z}_t \quad (113)$$

$$\hat{\pi}_t + \hat{Z}_t = \left( \frac{1 - \delta_b}{\pi} \right) \hat{Z}_t + \left\{ 1 - \left( \frac{1 - \delta_b}{\pi} \right) \right\} \hat{\Pi}_{t-1}^b \quad (114)$$

$$\begin{aligned} \hat{\Pi}_t^b &= \left\{ \frac{i^{bH}}{\kappa_b (\pi - 1 + \delta_b)} \left( \frac{B_H}{B} \right) \right\} (\hat{i}_t^{bH} + \hat{B}_{H,t}) + \left\{ \frac{i^{bE}}{\kappa_b (\pi - 1 + \delta_b)} \left( \frac{B_E}{B} \right) \right\} (\hat{i}_t^{bE} + \hat{B}_{E,t}) \\ &+ \left\{ \frac{\alpha_s i^g}{\kappa_b (\pi - 1 + \delta_b)} \right\} (\hat{i}_t^g + \hat{D}_t) - \left\{ \frac{i^d}{\kappa_b (\pi - 1 + \delta_b)} \right\} (\hat{i}_t^d + \hat{D}_t) \\ &- \left\{ \frac{i}{\kappa_b (\pi - 1 + \delta_b)} \left( \frac{B^{IB}}{B} \right) \right\} (\hat{i}_t + \hat{B}_t^{IB}) \end{aligned} \quad (115)$$

## 10.9 Fiscal Policy Block

$$\left( \frac{G}{Y} \right) \hat{G}_t + \left\{ \left( \frac{1 + i^g}{\pi} \right) \alpha_s \left( \frac{D}{Y} \right) \right\} (\hat{i}_{t-1}^g - \hat{\pi}_t + \hat{D}_{t-1}) = \left( \frac{TX}{Y} \right) \widehat{TX}_t + \left\{ \alpha_s \left( \frac{D}{Y} \right) \right\} \hat{D}_t \quad (116)$$

## 10.10 Monetary Policy Block

$$\hat{i}_t = \varphi_i \hat{i}_{t-1} + (1 - \varphi_i) \left[ \varphi_y \hat{Y}_t + \varphi_\pi E_t \{ \hat{\pi}_{t+1} \} \right] + \hat{\varepsilon}_{m,t} \quad (117)$$

## 10.11 Aggregation & Market Clearing Conditions

$$\hat{C}_t = \left( \frac{C_R}{C} \right) \hat{C}_{R,t} + \left( \frac{C_P}{C} \right) \hat{C}_{P,t} + \left( \frac{C_I}{C} \right) \hat{C}_{I,t} + \left( \frac{C_E}{C} \right) \hat{C}_{E,t} \quad (118)$$

$$\hat{L}_t = \gamma_R \hat{L}_{R,t} + (1 - \gamma_R) \gamma \hat{L}_{P,t} + (1 - \gamma_R) (1 - \gamma) \hat{L}_{I,t} \quad (119)$$

$$\hat{\omega}_t = \gamma_R \hat{\omega}_{R,t} + (1 - \gamma_R) \gamma \hat{\omega}_{P,t} + (1 - \gamma_R) (1 - \gamma) \hat{\omega}_{I,t} \quad (120)$$

$$\hat{H}_t = \left( \frac{H_P}{H} \right) \hat{H}_{P,t} + \left( \frac{H_I}{H} \right) \hat{H}_{I,t} \quad (121)$$

$$\hat{B}_t = \left( \frac{B_H}{B} \right) \hat{B}_{H,t} + \left( \frac{B_E}{B} \right) \hat{B}_{E,t} \quad (122)$$

$$\hat{B}_t = \hat{D}_t \quad (123)$$

$$\begin{aligned} \hat{Y}_t &= \left( \frac{C}{Y} \right) \hat{C}_t + \left( \frac{I^k}{Y} \right) \hat{I}_t^k + \left( \frac{I^h}{Y} \right) \hat{I}_t^h + \left( \frac{G}{Y} \right) \hat{G}_t + \\ &\quad \left\{ \left( \frac{\psi_a}{\delta_k} \right) \left( \frac{I^k}{Y} \right) \right\} \hat{u}_t + \left\{ \left( \frac{\delta_b \kappa_b}{\pi} \right) \left( \frac{B}{Y} \right) \right\} (\hat{Z}_{t-1} - \pi_t) \end{aligned} \quad (124)$$

## 10.12 List of Shock Variables

The set of shock variables  $\left\{ \hat{\varepsilon}_{A,t}, \hat{\varepsilon}_{i^k,t}, \hat{\varepsilon}_{m,t}, \hat{G}_t, \hat{\varepsilon}_{h,t}, \hat{\varepsilon}_{LV,t}^H, \hat{\varepsilon}_{LV,t}^E, \hat{\varepsilon}_{y,t} \right\}_{t=0}^{\infty}$ , incorporated in the model, follow AR(1) process.

## 10.13 Description of Steady-state

$$\left( \frac{B_H}{B} \right) = \left\{ 1 - \left( \frac{B_E}{B} \right) \right\} \quad (125)$$

$$\left( \frac{H_I}{H} \right) = \left( \frac{1}{\varepsilon_{LV}^E} \right) \left( \frac{\delta_h}{1 - \delta_h} \right) \left\{ \left( \frac{B}{Y} \right) \right\} \left( \frac{1 + i^{bH}}{\pi} \right) \left( \frac{B_H}{B} \right) \quad (126)$$

$$\left(\frac{H_P}{H}\right) = 1 - \left(\frac{H_I}{H}\right) \quad (127)$$

$$\left(\frac{C_E}{C}\right) = \frac{1}{(C/Y)} \left[ \left(\frac{\alpha}{X}\right) - \left(\frac{1+i^{bE}-\pi}{\pi}\right) \left(\frac{B_E}{B}\right) \left(\frac{B}{Y}\right) - \left(\frac{I^k}{Y}\right) \right] \quad (128)$$

$$\left(\frac{C_I}{C}\right) = \frac{1}{(C/Y)} \left[ \left\{ \frac{(1-\gamma_R)(1-\gamma)(1-\alpha)}{X} \right\} - \left(\frac{1+i^{bH}-\pi}{\pi}\right) \left(\frac{B_H}{B}\right) \left(\frac{B}{Y}\right) - \left(\frac{H_I}{H}\right) \left(\frac{I^h}{Y}\right) \right] \quad (129)$$

$$\left(\frac{C_P}{C}\right) = \frac{1}{(C/Y)} \left[ \left\{ \frac{(1-\gamma_R)\gamma(1-\alpha)}{X} \right\} + \left(\frac{1+i^d-\pi}{\pi}\right) \left(\frac{D}{Y}\right) - \left(\frac{H_P}{H}\right) \left(\frac{I^h}{Y}\right) \right] \quad (130)$$

$$\left(\frac{C_R}{C}\right) = \left\{ 1 - \left(\frac{C_P}{C}\right) - \left(\frac{C_I}{C}\right) - \left(\frac{C_E}{C}\right) \right\} \quad (131)$$

# 11 Appendix E: Figures on Counterfactual Experiments

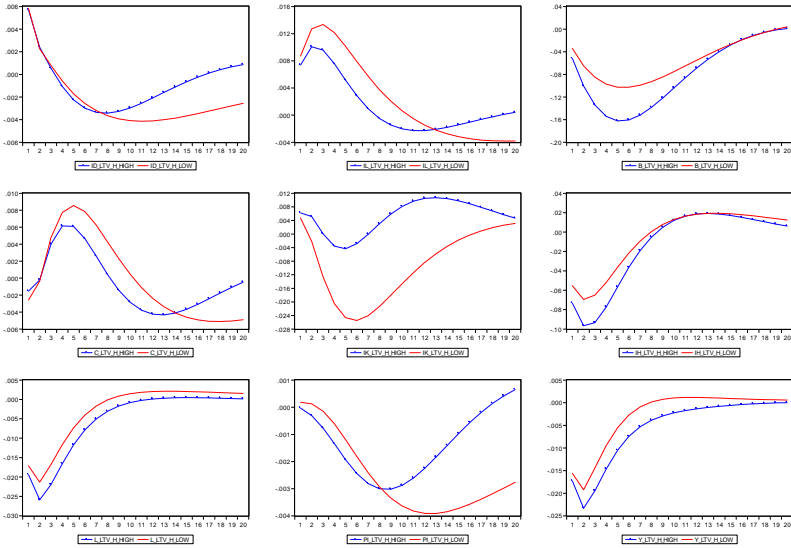


Figure 13: Effects of Change in Collateral Constraint for Households (LTV)

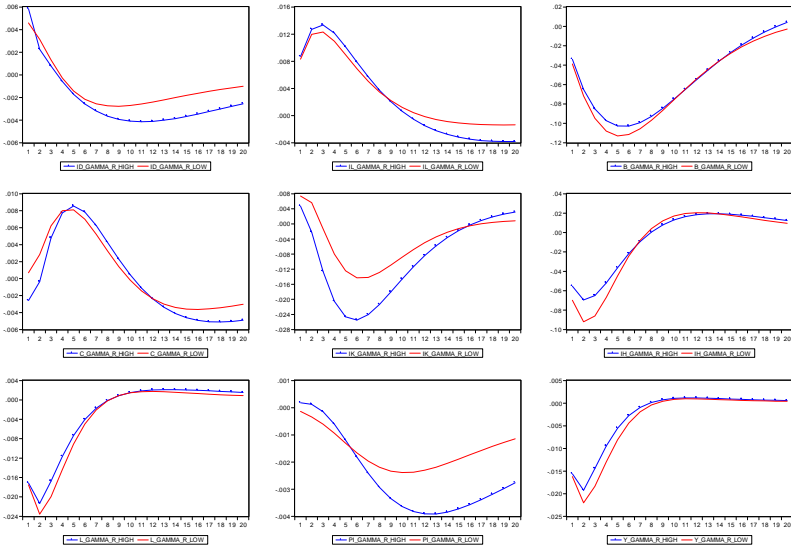


Figure 14: Effects of Change in Proportion of Liquidity Constrained Household

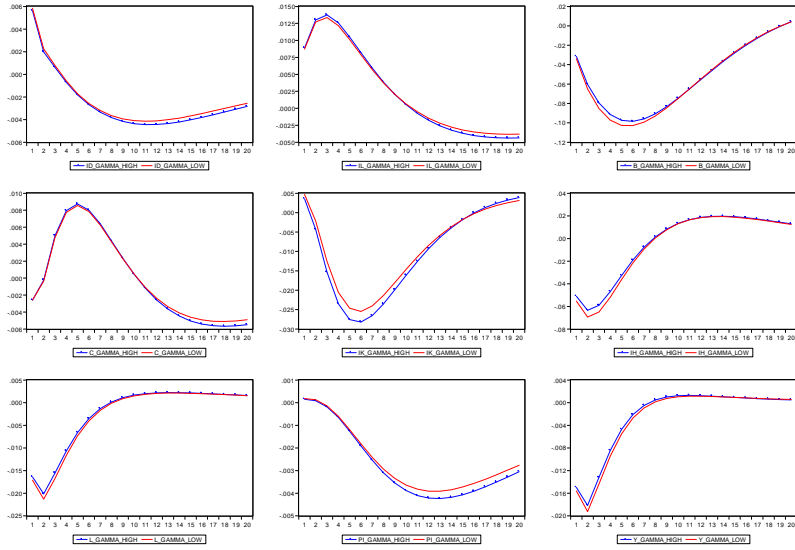


Figure 15: Effects of Change in Proportion of Patient Household

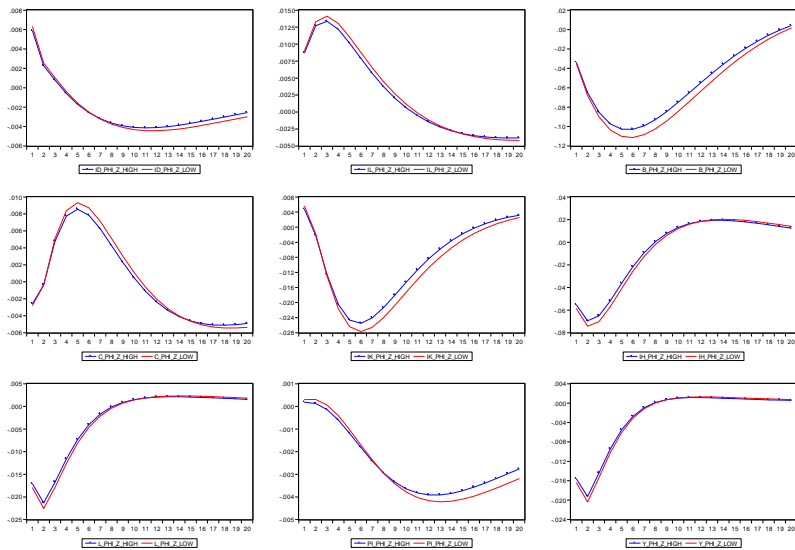


Figure 16: Effects of Change in Bank Capital Adjustment Cost

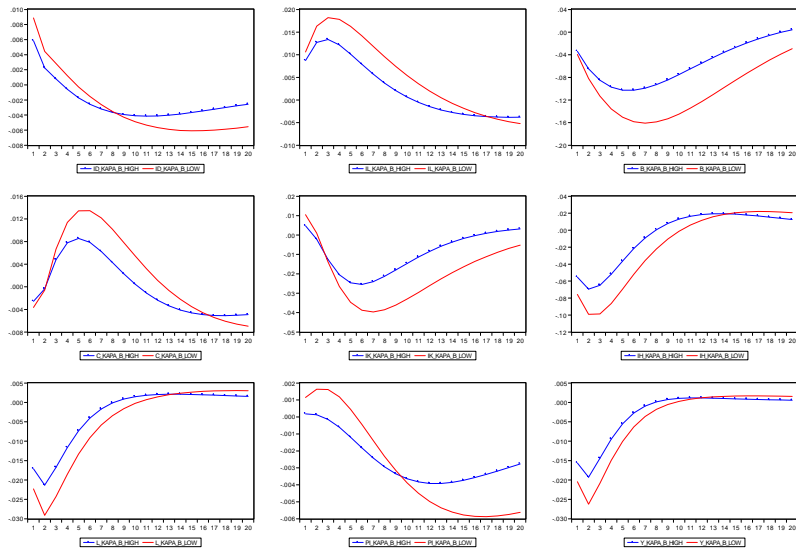


Figure 17: Effects of Change in Capital Adequacy Ratio