MONETARY POLICY IN A NEW PARADIGM: AN INDIAN PERSPECTIVE

BY

SONALIKA SINHA

A Thesis Submitted to the University of Hyderabad in Partial Fulfilment of the Requirements for the Degree of

Doctor of Philosophy

School of Economics
University of Hyderabad
Hyderabad – 500046
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CERTIFICATE

This is to certify that the thesis titled "**Monetary Policy in a New Paradigm: An Indian Perspective**" submitted by **Sonalika Sinha**, bearing Regd. No. 13SEPH19, in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Economics is a *bona fide* work carried out by her under my supervision and guidance which is plagiarism free.

The thesis has not been submitted previously in part or in full to this or any other University or Institution for the award of any degree or diploma.

Prof. B. Kamaiah
Research Supervisor

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Prof. B. Kamaiah
Dean
School of Economics

DECLARATION

I, **Sonalika Sinha**, hereby declare that this thesis, titled "**Monetary Policy in a New Paradigm: An Indian Perspective**", submitted by me under the guidance and supervision of **Professor B. Kamaiah**, School of Economics, University of Hyderabad, is a *bona fide* research work which is free from plagiarism. I also declare that this thesis has not been submitted previously in part or in full to this University or any other University or Institution for the award of any degree or diploma. I hereby agree that my thesis can be deposited in Shodganga/INFLIBNET.

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Prof. B. Kamaiah

Research Supervisor

To Maina's Nest…

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My experience of pursuing a doctoral program in Economics has been truly rewarding. It is not every day that one is given the time, opportunity and space to be a free thinker. I could probably write a book as long as this thesis to reflect upon what this experience has meant for me. First and foremost, I am sincerely grateful to my research supervisor and teacher Prof. B. Kamaiah for investing his faith in me. The magnitude I have learnt from him, not only in his capacity as my Supervisor, but also as an individual is something I shall cherish forever. His warmth and support at every step has made this journey even more enjoyable. I am grateful to Dr Y.V. Reddy who advised to me to pursue excellence as a habit and not as an event. Dr Reddy is one of the reasons I developed an interest in monetary economics. Having a chance to be associated with him has been one of my greatest learnings. I am grateful to Prof. Ganti Subramanyam, Prof. Debashish Acharya, Prof. Phanindra Goyari, Prof. Naresh Kumar Sharma and all faculty and staff of School of Economics for their support and guidance. I thank Mr Deepak Singhal and his entire team in Reserve Bank of India for their magnanimity and help, every time I required it.

I am confident that the research issue that I explore in this thesis would be relevant to every single reader who wonders about the changes in contemporary economics. Beyond the technicalities of economic analyses, this research asks some questions which I am sure would have crossed the minds of millions of people.

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- Sonalika Sinha

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ABBREVIATIONS

AE:	Advanced Economy
AIC:	Akaike Information Criterion
BIC:	Bayesian Information Criterion
BIS:	Bank for International Settlements
CRR:	Cash Reserve Ratio
EME:	Emerging Market Economy
EPU:	Economic Political Uncertainty
FDI:	Foreign Direct Investment
FEVD:	Forecast Error Variance Decomposition
FFR:	Federal Funds Rate
GDP:	Gross Domestic Product
G-SEC:	Government Securities
HBSIE:	Handbook of Statistics on Indian Economy
HQIC:	Hannan and Quinn Information Criterion
IFS:	International Financial Statistics
IIP:	Index of Industrial Production
IRF:	Impulse Response Function
LAF:	Liquidity Adjustment Facility
LR:	Likelihood Ratio
MIBOR:	Mumbai Inter-Bank Overnight Rate
MPC:	Monetary Policy Committee
NIRPs:	Negative Interest Rate Policies
NSE:	National Stock Exchange
OMO:	Open Market Operations
PDF:	Probability Density Function
QE:	Quantitative Easing
RBI:	Reserve Bank of India

REPO:	Repurchase Option
RND:	Risk Neutral Density
RRB:	Regional Rural Banks
SBI:	State Bank of India
SBC:	Schwarz Bayesian Criterion
SCB:	Scheduled Commercial Banks
SLR:	Statutory Liquidity Requirements
SVAR:	Structural Vector Auto Regression
ULIRP:	Ultra-Low Interest Rate Policies
US:	United States of America
VAR:	Vector Auto Regression
ZLB:	Zero Lower Bound

CHAPTER 1
INTRODUCTION

1.1 Study Background

The landscape of financial markets has evolved tremendously all across the globe particularly over the last two decades. These changes can be attributed to massive advancement in technology, deregulation of controls and standards, integration of financial markets and changing incentive structures of managers (Rajan, 2005). Such shifts have enabled financial innovations, modernization of financial services and rapid institutional changes making markets deeper and more widespread. In this 'new paradigm', the role, scope and expectations from monetary policy have also evolved tremendously. It has become difficult to clearly define the contours of financial markets and its relationship with central bank policy. In such a scenario, the role of monetary policy, which is primarily aimed at price stability and boosting growth has become more complex. The objectives of central banks can no longer espouse strict inflation targeting, but advocates flexible inflation targeting. Simply put, this extends the duration for achieving inflation targets, thereby including more intermediate objectives in the short run, thereby marking a shift from a single-objective to multi-objective stance (Fischer, 2010).

The global financial crisis of 2008 brought attention to financial risk-taking that altered the course of monetary policy around the world. The phase prior to the breakout of the global financial crisis witnessed a massive build-up of financial imbalances, the breakout reasons of which have been well explored in recent literature (Reinhart and Rogoff, 2009). These imbalances were mostly led by the advanced economies that were marked with wide output gaps and low inflationary and demand conditions. Several advanced economies took recourse to unconventional monetary policies to boost demand and stimulate growth. Recent literature argues that such accommodative monetary policies and ultra-low interest rates have affected risk taking across the world. It is interesting to understand the implications of these policies to gauge upcoming challenges and the roadmap for

way ahead in monetary policy. Does excessive accommodation of foreign monetary policy add to build-up of risk in emerging market economies? If yes, then what is the role of risk in determining monetary transmission? In the course of this thesis, we answer these pertinent questions, focusing the scope of the study on the Indian context. The applicability of such a study is of significance for other emerging markets as well.

Financial markets play a bigger role than in the past in determining the macroeconomic dynamics in any economy. The link between liquidity and the financial market risk has become more prominent. As a consequence, financial market stability has assumed a larger role in the process of monetary policy framework. Intermediate objectives have widened the purview of monetary policy to include movements in capital flows, asset price bubbles and cross-border lending (Adrian and Shin, 2014). Consequentially, while long term price stability remains a primary objective for central bankers across the world, alternate intermediate objectives like financial stability paves the way for rethinking monetary instruments in the short run horizon. Stabilizing capital flows and asset price movements play a significant role in enabling financial stability. By extension, the fact that increased risk conditions have an impact of the workings of the financial system indicate the significance of incorporating these risk conditions into the monetary policy framework. Through risk, the effects of monetary policy on expenditures are impacted either directly or indirectly. Tackling this phenomenon requires complex policy decision making as finance is not limited to economic and geographic boundaries and the effects of the external sector can be immense.

I unfold the discussion of the thesis based on Schumpeter's subdivision of economic research[1]. He categorizes economic research into three broad stages: *i)* The "pre-analytical or cognitive stage", that encompasses the vision of the issue and explicates the working hypotheses of the study; *ii)* The stage of "conceptualization" which recognizes the relevant elements to be considered in the

[1] The subdivision given by Schumpter is taken from Roncaglia, A. (2006)

research; and finally, *iii)* a discussion of the "scientific models used" for the study that spells out the logical sequence of the research.

1.2 Schumpeter's subdivision of economic research

1.2.1 Pre-Analytical Stage - A New Paradigm in Monetary Policy

The conduct of domestic monetary policy has become more challenging due to integration of economic conditions across the world. Incorporating external shocks have become important for central banks as the external sector conditions are increasingly becoming synchronized with associated movements in credit and debt flows domestically (Rey, 2015). Global financial conditions have challenged several conceptions of domestic monetary policy giving way to a new normal in monetary economics. While few studies prior to the crisis in 2008 pointed out the need for revisiting the standard forms of monetary policy transmission, it was particularly after 2008 that new trends in global economic and financial conditions began to shed new light on the existing gaps in the standard forms of transmission. There are certain myths about central banking that are beginning to emerge clearly in the "new paradigm". This new paradigm in monetary policy, which is the cornerstone of this thesis, can be contextualized through changes that have occurred in the global economic conditions and the fresh new challenges that face central bankers. According to Fischer (2010), we can decode the new paradigm into three categories.

First, the use of one-instrument, one target policy of money and inflation is somewhat outdated. Looking back, one of the myths of pre-crisis monetary policy frameworks, for nearly two decades, was the one instrument (policy rate) and one target (inflation) framework (Blanchard et al., 2010). For the short term, using the policy rate through appropriate open market operations as an instrument based on predictable rules, like the Taylor rule for instance, was considered sufficient in monetary policy to achieve targets. Fischer refers to this as the "constrained

discretion" that majorly aimed at stability of long run inflationary expectations. Even today, we typically find that domestic conduct of monetary policy is assessed around concerns like stabilizing inflation levels with a lower-bias, strength of market structures, good policy measures and focus on growth stability.

However, as we argue through this thesis, the mandate of monetary policy is incomplete without addressing concerns of financial and external instability and risk. From a global standpoint before the crisis, while advanced economies were content with steady decrease in variability in inflation and output, commonly known as the "Great Moderation", emerging market economies like India focused on stabilizing inflation and output growth as part of their monetary policy mandate. However, as the present economic conditions have presented themselves, short-run interest rates and the market stability concerns have become a predominant cause of concern for monetary policy makers. Simply put, it is no longer true that as central banks have one policy instrument, they can only account for single targets. This phenomenon motivates us to examine what is the impact of monetary policy in a one instrument- multiple target regime in an economy.

Second, there exist short-run tradeoffs between inflation and output. The Philips curve tells us that there is no long-run tradeoff between inflation and output. However, as the long run can is essentially a succession of multiple short run horizons, it is crucial to take the short-run effects into consideration. As we move forward, the presence of short-run tradeoffs between growth, output and stability becomes clearer. Contextualizing monetary policy framework in India, the short-term interest rate has become the main operating objective (Mohanty, 2013).

Third, central banks must account for movements in asset prices and financial stability while setting monetary policy. In the new paradigm that became visible after the global financial crisis of 2008, we witnessed the 'contagion effect' where the crisis that seemingly broke out in the U.S. housing markets spread like wild fire to not only other sectors, but even the rest of the world. As a follow-up to the crisis, the quantitative easing stimulus that was provided along with accommodative

policy rates with the purpose of boosting aggregate demand, unfortunately could not prevent a deep and prolonged recessionary phase marked with the near-zero interest rates (also known as the zero lower bound, ZLB) in advanced economies. As advanced economies resorted to unconventional monetary policy and negative interest rates, the outlook for global growth became subdued. In this context, it is impossible to expect emerging market economies (EMEs) to remain unaffected by negative interest rates and risk manifestations. Owing to uncertainties in the external sector, the financial markets and banking sector face significant challenges that call for revisiting the monetary policy in a new paradigm.

1.2.2 **Conceptualization stage**

Economists have often debated over the key channel through which monetary impulses affect aggregate expenditure. While the standard channels of transmission are crucial to understand monetary processes, the changing characteristics of the financial system across the globe have encouraged a deeper and more robust understanding of the transmission process. The global financial crisis sparked the need to embed the role of financial system more efficiently into our monetary models. The post-crisis literature on monetary policy has overall highlighted two broad observations. First, the need to establish a link between monetary policy and the perception and pricing of risk by investors. Changes in interest rates by the central banks can influence risk-taking by economic agents, thereby impacting the perception of risk. This concept is termed as the "*risk-taking channel of monetary policy*" that was first coined by Borio and Zhu (2012). This channel represents the effects of low and accommodative interest rates on risk-taking among investors – asserting that behaviour of asset prices find a strong relationship with the conduct of monetary policy. This phenomenon can be understood better in the context of the role of excess liquidity in potentially affecting the risk level in a financial system leading to financial instability, as pointed out by Rajan (2005). The second observation is the increased role of financial intermediaries in determining monetary policy outcomes. Studies like Altunbas et al. (2009) and Adrian and Shin

(2010) underline the role of financial intermediaries in driving the booms and bust of an economy's business cycle.

Positioning these concerns in the Indian context, this thesis assesses how the conduct of domestic monetary policy deals with more integrated world economic conditions and the domestic environment. To understand the significance of the increased global integration, John Taylor argues that divergence in monetary policy stance across countries could potentially lead to adverse spillover effects that undermine macro-objectives in an economy (Taylor, 2013) – thus emphasizing the interconnectedness of financial conditions around the world. The contribution of this thesis is to extend the risk-taking channel to examine how it can impact emerging markets. While the focus of this thesis is limited to India, the relevance may be applicable to all emerging markets (See Bua, 2014).

There has been immense flight of capital after the crisis from advanced countries to emerging market economies. While there is wide heterogeneity in the nature of emerging economies who received this flight of capital, the cause of this capital flight has been common. Investors who were skeptical to invest in their own countries placed their bets on financial markets of emerging countries, based on their macroeconomic fundamentals. In other words, developed countries found a 'safe haven' in countries like India to park their funds in. Prior to the birth of the 'risk-taking channel' Calvo, Leiderman and Reinhart (1993, 1996) distinguished between the "push and pull factors" of global capital flows. According to this hypothesis, capital flows occur due to external "push" coming from global markets, as opposed to country-specific "pull" factors that attract these flows. It is therefore crucial to understand these global "push" factors that enable massive capital flows to enter emerging markets. Now, after the global financial crisis, this concept has come a full circle.

The world is witnessing increased financial integration more than ever before. Particularly after the global financial crisis of 2008, a reflection of the failure of advanced-country financial markets can be best seen in emerging markets. Over

and above their domestic challenges, emerging market economies are more coupled with the market changes unfolding in advanced economies, making them prone to external liquidity crises, default risks and information asymmetry. The rising importance of financial flows across countries has exposed India to external supply shocks, financial instability and imperfect institutions. Furthermore, the fact that excess liquidity could induce greater bank risk was not widely accepted as big a threat to financial stability prior to the crisis. However, As we explore in chapters ahead, an interesting strand of literature emerged thereafter linking the influence of monetary policy on bank risk and thereby, impacting financial stability.

1.2.3 **Scientific models (Methodology)**

The first core chapter focusses on the risk attitudes of investors that is implicit in option market prices. Prices of any asset class contain complete information about market participant's probability assessment of the outcome of the underlying asset price upon maturity, thus reveals important information about a market's future expectations. Option-pricing theory tells us that prices reflect investor expectations of the distribution of future levels of the underlying asset. Extracting probability density functions (PDFs) are a beneficial way of digging up such useful information on investors' expectations. While some investors choose to be risk-averse, some opt for greater risk-taking in search for better yields. As a result, financial market assets have the capacity to reveal important insight about future expectations of the market that can be revealed through price information. To examine whether theoretical models of option pricing reveal actual risk preferences of investors, it is crucial to have a technique that can estimate investor risk preferences. I develop a new and unique index of risk aversion for Indian markets by employing granular computation of probability density functions to measure the risk aversion among investors in the options market.

This second core chapter examines the link between external factors and financial instability through monetary impulses that occur through shifts in measures of risk.

The role of the excessive accommodative stance maintained by advanced economies raise pertinent questions for its impact on EMEs like India. This can be described as the extension of the risk taking channel of foreign monetary policy. Lenient credit conditions in the foreign banking system and increased risk taking the international financial markets get passed through to their counterparts in India. What can be commonly referred to as the impact of excess liquidity, these spillovers take the form of different channels like the capital flows, exchange rates, foreign policy interest rates and bank credit. The effects of foreign shocks combine with changes in domestic risk premia and the credit growth of the Indian banking sector. This chapter emphasizes the role of international spillovers in the transmission of monetary policy through its impact on the financial sector. I examine whether international spillovers determines the exposure to take risks, such that domestic monetary policy affects the real economy through increased risk taking in the financial sector and excessive bank credit.

The final technical chapter discerns the impulses of bank risk-taking behaviour by examining disaggregated bank behaviour. The banking system is inherently laden with risks with a fragile capital structure that undertakes great risks associated with excessive credit and bad loans. Banks are therefore often faced with the threat of default or worse, shut down. To tackle this challenge better, banks tend to limit their risks by passing on their default risks to other players in the economy in order to avoid holding on to interest rate risks all by themselves. However, even as banks transfer their risk through bad loans and default risk sales, it does not completely eliminate risk from their balance sheets. External market risks and foreign monetary policy movements impact banks' risk-taking tendencies over and above domestic monetary and financial sector conditions. I examine risk-taking and credit behaviour of all scheduled commercial banks in India owing to shifts in monetary and risk conditions, both domestically and internationally.

The methodologies used in this thesis range from simple analyses like correlations to complex techniques used in econometric and financial economics analyses. In summary, we use three scientific models to conduct this study i.e. a non-parametric

approach to handling big financial market data to extract density functions, structural vector autoregressive model and a generalized method of moments (GMM) model to analyze unbalanced panel data. Graphical and tabular representations of data have been used wherever appropriate. The thesis composes three core technical chapters, for which the techniques used for analysis are given below.

1.3 Data

Various macroeconomic and financial market data have been used to conduct the present study. The time period of the entire data sample used has been selected subject to availability for the entire sample period under consideration. The data used is of varied frequencies for different technical chapters in the study, dictated by the markets being taken into study. For instance, we employ daily frequency data for financial market analysis of the options market, while quarterly data has been used for macroeconomic analysis of monetary transmission. The thesis chapters employ daily, monthly and annual data that are sourced from International Financial Statistics (IFS, Handbook of Statistics on Indian Economy, Reserve Bank of India, National Accounts Statistics (NAS), National Stock Exchange (NSE) and Economic Policy Uncertainty Index (EPU) constructed by Baker *et al*. (2003, 2015 - India).

The time period taken under consideration in this analysis is from 2005 to 2015, a duration of eleven years. While the analyses in chapters 3 and 4 employ daily data and quarterly data for the said time period, we consider annual balance sheet information of all scheduled commercial banks in India for the analysis in Chapter 5. We avoid running into any degrees of freedom problem as we evaluate the data as an unbalanced panel set of all SCBs, taking a disaggregated view of banks in India.

1.4 **Thesis Objectives**

The central focus of this research is that the Indian economy is exposed to greater risks due to openness of financial markets to the global changes. While it may be farfetched to identify what would be the exact consequences on the real sector, the market participants in India are exposed to greater risk taking due to movements in foreign interest rates and domestic monetary policy (in addition to visible channels of international spillovers). In specific, the banks are hard-hit. In order to probe into these concerns, the focus of this thesis is threefold:

(i) To arrive at a comprehensive measure of financial risk using options data (to address the requirement of better measurement of risk by investors);

(ii) To analyze different channels through which effects of external monetary policy alters risk attitudes and credit outcomes in the short-run for Indian markets (using a macro-finance analysis);

(iii) To assess response of movements banking sector risk-taking to shifts in monetary and risk conditions, both domestically and internationally.

The novelty of this research lies in exploring a new strand of literature called the "risk-taking channel of monetary policy" and extend the scope of this phenomenon to an emerging market economy like India. While this channel has been examined for many advanced countries, the scope of this analysis is a niche area of research for the Indian economy. This study attempts to fill the gaps in addressing how Indian markets respond to international market spillovers and risk conditions. The analysis holds itself valid in the present changes witnessed in central banking across the world.

1.5 Organization of the Thesis

This thesis is developed into a total of six chapters. The first two chapters present the introduction and the review of related literature. The third chapter forms the first core analysis by computing a new and comprehensive measure of financial market risk for Indian context using option-implied measure of risk. The fourth chapter studies different channels through which effects of external monetary policy impact macro-objectives in Indian markets in the short-run by altering investors' attitude towards risk and market credit outcomes. The fifth chapter explores a rich micro panel of scheduled commercial banks in India to examine how monetary policy impacts bank risk-taking and bank lending in response to shifts in monetary and risk conditions, both domestically and internationally. Finally, the sixth chapter concludes and provides policy suggestions for the way forward.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Introduction

It is safe to say that the spillover effects of external sector shocks have become clearly visible in the aftermath of the global financial crisis of 2008. In this new paradigm of monetary policy, developments in global financial conditions and foreign monetary policy decisions can influence local financial and economic outcomes, through excessive risk-taking.

The post-crisis literature on monetary policy underlines the insufficient emphasis given to risk in the transmission mechanism. According to Borio and Zhu (2012) the measurement, management as well as pricing of risk remains elusive in monetary policy transmission literature. There is a need to establish a link between monetary policy and the perception and pricing of risk by investors. The primary motivation central to this research is twofold. The first focus is the measurement of risk by financial markets and management of that risk by financial intermediaries. This leads to the second focus of this thesis i.e. the role of external sector shocks in monetary policy framework. We provide the ongoing discussion in recent literature in the sections ahead.

2.2 Role of Risk-taking in a Monetary Policy Framework

The monetary transmission mechanism has been studied by academicians and policymakers for decades. We can identify one consensus between the monetarist and Keynesian schools of thought i.e. monetary policy affects aggregate demand through its effect on relative yields. This effect of changes in relative yield has a bearing on risk premia, or spreads as we commonly know it. The concept of relative yields is borne out of difference in rates of interest across markets. These changes in risk premia are in addition to the traditional expectations theory which explains the movements of the yield curve in the long term. As Morris and Shin (2014)

argue, shocks in monetary policy are associated with movements in the risk premium that is inherent in market prices. For instance, as interest rates remain low for long, risk premium in markets reduce as asset managers rush to trade riskier bonds for short-term assets. Therefore, one way to understand the impact of monetary policy on aggregate expenditure is through its effect on changes in perception and pricing of risk among market participants.

As observed in the case of advanced economies, changes in interest rates by the central banks can influence risk-taking by economic agents, thereby impacting the perception of risk. Termed as the "*risk-taking channel of monetary policy*", this channel represents the effect of low and accommodative interest rates on risk-taking among investors (Borio and Zhu, 2008) – asserting that behaviour of asset prices find a strong relationship with the conduct of monetary policy. Risk sensitivity focusses its attention towards two aspects – one, the market participants' attitude towards risk; and second, how that risk is measured.

The impact of accommodative policy across borders can be observed in the form of movement in asset prices - that are a major determinant of financial stability. Investor perception and valuation of these asset price movements have close ties with monetary policy. Monetary policy can be seen to have a direct effect on the risk-taking behaviour of market participants and this phenomenon is common to advanced economies as well as emerging economies (Gertler & Karadi, 2013, Rey, 2015). Bekaert et al. (2013) empirically establish the link between monetary policy rate and level of risk aversion in a financial market. Gertler and Karadi (2013) document that monetary policy can potentially impact the risk premium implicit in asset prices during the short run.

Bekaert et al. (2013) establish the empirical link between policy rate and VIX as a measure of implied volatility on US equity options. Being an emerging market economy, the risk-taking channel is not identical to that in developed countries that face the zero lower bound problem, however incorporating perception-based

measurement and pricing of risk is crucial to having a better understanding of the strength of monetary policy effectiveness.

In order to understand the how impulses in monetary policy can have an impact on risk, there is a need to transcend the classical interest rate channel in a manner that monetary policy can account for the measurement and pricing of risk in a financial system. Bernanke and Gertler (1995) described the classical interest rate channel as one that encompasses most mechanisms that are not associated with financial market frictions[2]. In other words, financial markets were assumed to be friction-less in monetary policy models[3]. Building on Bernanke et al. (1999), some macro-finance models document the positive effect between changes in policy rates and term premia. Incorporating the effects of financial disturbances can be seen as a way of strengthening the financial accelerator, discussed by Bernanke et al. (1999) by having a potentially significant impact on strength of transmission of monetary policy shocks that can allow for a more in-depth measurement and pricing of risk. Further, even the alternate channels of transmission like the broad credit channel, exchange rate channel or the bank-lending channel face changes in the wake of changing global movements of capital flows and near-zero interest rates in advanced economies. While these changes cannot be defined as exclusive channels, they may have important consequences for extant transmission, as we may know them.

For this reason, the importance of incorporating external shocks has become essential for central banks as financial conditions across borders increasingly becoming synchronized due to associated movement in credit and debt flows domestically (Rey, 2015). The risk-taking channel is a relatively new channel in literature of monetary transmission that discusses the significance of studying the link between monetary policy and the perception of risk and how it can be priced by economic agents in an economy. The risk-taking channel represents the effect

[2] Bernanke and Gertler (1995) list the shortcomings of the classical interest rate channel into three major ways: composition, propagation and amplification

[3] We define frictions as any phenomena that create a wedge between internal and external source of funding.

of low and accommodative interest rates on risk-taking among investors – asserting that behaviour of asset prices find a strong relationship with the conduct of monetary policy. This phenomenon can be understood better in the context of the role of excess liquidity in potentially affecting the risk level in a financial system leading to financial instability, as pointed out by Rajan (2005). This strand of literature indicates the importance of incorporating risk perception by economic agents while studying the transmission process. The second focus of this literature highlights the endogenous interaction that takes place between a central bank's reaction function and the level of risk-taking by agents and deserves greater attention in the new paradigm. Here, it is important to understand that this channel is not a substitute or even as significant as the interest rate channel of transmission, but can play a significant role in the short-run in impacting intermediate objectives of financial stability. The implications of risk can be understood as akin to the "persistence-enhancing" mechanism which imply that inability of central banks to account for build-up of risk can lead to persisting and unpleasant implications on an economy. The importance of incorporating external shocks are important for central banks as the financial conditions across borders are increasingly becoming synchronized with associated movement in credit and debt flows domestically (Rey, 2015). In furtherance to this effect, John Taylor argues that divergence in monetary policy stance across countries could potentially lead to adverse spillovers that undermine domestic macro-objectives in an economy (Taylor, 2013).

In order to account for both economic and financial variables in a monetary policy framework, Gertler and Karadi (2015) analyze the impact of monetary policy shocks on credit costs in the system. We consider the conventional New-Keynesian transmission mechanism model used most widely by central banks. In this model, aggregate expenditure is a function of current and expected short-term interest rates. The central bank sets the short term nominal rate of interest i_t for every period (in annualized terms). The central bank can control the nominal rates and thereby the real rate for, owing to nominal prices or wage rigidities at least for some horizon. This in turn gives central banks the influence the aggregate expenditure that eventually translates into impact on inflation and output levels. Based on the

expectations hypothesis, we can summarize the control of monetary policy actions on nominal short term interest rates by examining the response on the yield curve. Gertler and Karadi (2015) provide a loglinear expression for an *m* period zero-coupon government yields:

$$i_t^m = E_t \frac{1}{m}\left(\sum_{j=0}^{m-1} i_{t+j}\right) + \emptyset_t^m \qquad (1)$$

Where i_t^m is the annual yield on bonds and $\emptyset_t^m$ is the term premium in annualized terms. Initially, we consider a system where the term premium is constant in a closed economy in steady-state. Taking from classical literature on monetary policy framework, we can expect the long-term rate of interest to determine the short term nominal rate and expected rate. In other words, credit costs in this case operate through movements in the yield curve.

Of course, it is the real interest rate that is of ultimate concern to the central banker. Consider π_t as the change in price level between time *t* and *t+1*. The real return of the *m* period nominal bond is expressed as a function of short term and expected rates, along with the term premium in Equation (1).

$$i_t^m - E_t\pi_t^m = E_t \frac{1}{m}\left(\sum_{j=0}^{m-1}(i_{t+j} - \pi_{t+j}\right) + \emptyset_t^m \qquad (2)$$

According to standard transmission theory, nominal rigidities inhibit offsetting movements in inflation that enable the central bank to impact the real rate through adjustments in the nominal interest rates.

So far, we have analyzed a framework using government bond yields in closed-economy framework, where financial market are assumed to be frictionless. This implies that government bond yields translate directly to private borrowing rates. Owing to a need to incorporate adjustments due to financial market frictions, both internal and external, we append the model to include an external finance premium. This leads to "credit-channel" effects (Bernanke and Gertler, 1995). Once we consider credit market frictions in the system, the cost of private borrowings do not reflect government bond yields, but exceed them, denoting the

external finance premium. This is expressed below as x_t^m. The private costs of borrowing i_t^{mp}, when credit frictions are operative, is expressed as the sum of government bond yields and the external risk premium.

$$i_t^{mp} = i_t^m + x_t^m \qquad (3)$$

The behaviour of market participants towards changes in risk premium can be explained using two set of effects through which the operation of monetary policy in advanced economies can be a cause for concern. In the first effect, low interest rates in advanced economies can impact the asset market valuations and capital flows. For instance, low interest rates in the US are expected to boost asset values in emerging markets (Mohanty, 2014 and Takáts and Vela, 2014) thereby increasing the risk taking tendency among market agents. Another set of operations that the risk-taking channel enables is through the "search for yield" – that is explained by the difference between market rates and set target rates (Rajan, 2005). Target rates reflect the nature of contract that have pre-defined long term fixed rates. While the impact can occur through any of these operations, the short-run spillover effects may be divided into four categories (Takáts and Vela, 2014) - exchange rate channel; portfolio flows, bank lending channel, and policy interest rate channel. These operations across borders tend to affect the domestic credit cycle in an emerging market economy (Rey, 2015). The focus is to examine which of these channels is significant in transmitting the risk-taking channel into emerging markets and how that effect is likely to impact the domestic flow of credit as well as macro-objectives like inflation and output. According to Benigno and Kiyotaki (2015), shocks in foreign interest rates tend to generate greater volatility in emerging markets, thus indicating their vulnerability to the global financial cycle. In their analysis, the crucial transmission comes from the exchange rate channel. A rise in foreign interest rates causes the local currency to depreciate and, thus having an expansionary impact on aggregate expenditure owing to expenditure switching channel. However, over time the depreciation exposes the domestic banks to foreign currency liabilities and reduce their net worth, leading to a contraction in growth. This is further worsened as monetary

policy gets under pressure to raise rates to contain increasing inflation that hurts the bank balance sheets more. Adrian, Estrella and Shin (2010) establish a connection between the slope of the yield curve, financial intermediary balance sheet management and impact on real economic activity in the United States using a SVAR model.

2.3 **Role of financial intermediaries in the new paradigm**

Shifts in risk premia, that are closely tied to balance sheet of financial intermediaries, affects the supply of credit and by extension, the real activity. The second emphasis of this thesis examines the role of the financial intermediaries (banks) sector to explore the hypothesis that banks interact with the risk-taking channel to drive the domestic business cycle, thus affecting capital market conditions and bank credit. These movements in credit, in an emerging market, are determined by the risk exposure that banks are willing to take. Fluctuations in bank-risk taking worsen domestic concerns credit conditions in emerging markets. Analyzing the determinants of bank risks is crucial from the standpoint of understanding bank behaviour in times of financial turmoil. This phenomenon is subsumed within the risk-taking channel of monetary policy that is especially prevalent in developed financial markets that observed quantitative easing. The banking sector of the model creates an important new mechanism through which shocks propagate into our economy: movements in asset prices, nominal price level and exchange rate can amplify the initial impact of a shock by affecting the balance sheet of the banks. In simpler terms, in addition to domestic shocks, financial instability that arise from external shocks are likely to act as a drag on domestic targets of high growth and low inflation. A key channel through which shocks from advanced economies can propagate into our economy is through the banking sector. Financial intermediaries act as drivers of the engine of growth of the business cycle where balance sheets of financial intermediaries (banks) reflect the transmission of monetary policy through capital market conditions (Adrian and Shin, 2010, Altunbas et al. (2009)). Banks exposed to cross-border capital flows and foreign currency liabilities alter their risk exposures (Bruno and Shin, 2014, Aoki *et al.*

(2015)). The idea is to analyze the microfoundations of financial intermediaries (banks) within the transmission process of monetary policy by integrating the financial sector into the transmission model. The role of financial intermediaries in monetary transmission is of dual significance - *i)* for understanding financial stability and central bank agenda, and; *ii)* to understand global experiences with crises in which financial markets played a central role. While the scope of this research explores the risk-taking channel of monetary policy, we provide a summary of all channels of monetary transmission in the Appendix.

2.4 **Developments in Indian Monetary Policy Landscape**

In consequence to changes in domestic macroeconomy and financial developments around the world, the monetary policy in India has evolved tremendously since 1935. Following the classification provided by Mohanty (2013), we divide the evolution of Indian monetary policy into five phases of the Reserve Bank of India. The *first phase*, in its formative years was during 1935-1950, wherein the role of central bank focused on regulating credit demand and supply in the economy through various instruments like the bank rate, open market operations (OMOs) and reserve requirements. The *second phase* during 1951-1970, monetary policy focused on plan financing for the five-year plans in India. In this phase, the bank rate was used as an important instrument to provide credit to preferred sector to support and facilitate government planning. The *third-phase* was observed during 1971-1990, wherein central banks concentrated on credit conditions by striking a balance between government planning and the inflation pressures that arose in the economy, through use of Statutory Liquidity Requirements (SLR) and the Cash Reserve Ration (CRR). In 1990-1991, the economy witnessed massive structural changes that led the bank into a central changed paradigm of deregulating interest rates. The RBI moved to market-based determination of interest rates and exchange rates. This caused a shift from use of direct instruments to indirect market-based actions that were a part of the liquidity management operations during the time. The Liquidity Adjustment Facility was introduced in 1999 to develop interest rate as the primary instrument of transmission. The LAF, which operated through two

instruments – the fixed rate repo and reverse repo, matured in November 2004 and was reinforced again in May 2011. During this time, the repo rate was made the only independently varying policy interest rate and the weighted average call rate (WACR) was the operating target, which we call the *fifth phase*. This development assigned a greater role to the interest rate channel of transmission, expecting any changes in the policy repo rate to impact the overnight WACR through changes in bank rates as well as term structure of interest rates. The use of interest rate instrument like the repo rate have more frequent in Indian monetary policy, in comparison with the CRR. Since the interest rate channel became the most primary mode of transmission, we focus on the policy interest rate channel as a crucial component of this thesis.

2.5 **Summary**

This thesis ties together two strands of literature. Recent literature has made attempts to model both economic and financial frictions that highlight the impact of monetary policy shocks. The first emphasis of this study is on the relationship between monetary policy changes and perception and pricing of risk among financial market investors. Termed as the risk-taking channel of monetary policy, this channel originally examines the effect of low-for-long or accommodative monetary policy on risk-taking. This fledgling strand of literature that has emerged in the post-crisis era, focuses on advanced economies and how they are facing a build-up in risk-taking among economic agents owing to the regime of the zero lower bound. We extend the scope of the risk-taking channel to an emerging market economy like India. The objective is to examine how emerging markets too are being affected adversely in the process. This thesis establishes the role of international channels of spillovers and how they impact the mandate of the domestic monetary policy. We explore four channels of external impulses that are likely to play a role in impacting monetary policy conduct as well as risk-taking in the domestic economy.

The second emphasis of this thesis examines the role of risk in the financial intermediaries (banks) sector. This strand of thesis examines the hypothesis that banks interact with the risk-taking channel, to drive the capital market conditions and bank credit. That is, in addition to impulses in domestic risk conditions and monetary policy movements, we inspect how banks respond to international risk-taking channel of monetary policy through impulses in different instruments in the international markets.

For the sake of completeness, Table 2.1 gives a pictorial representation of the standard channels of monetary transmission. The purpose is also to reinstate that the instruments and channels examined in this thesis do not transcend the validity of the standard channels, but in fact, add to the understanding of existing channels in the post-crisis literature.

Table 2.1 Standard Channels of Monetary Transmission

Channel		Transmission Mechanism
(1)		**(2)**
1.	**Interest – Rate**	$M \uparrow \rightarrow i^R \downarrow \rightarrow I \uparrow \rightarrow Y \uparrow$ $M \uparrow \rightarrow p^e \uparrow \rightarrow \pi^e \uparrow \rightarrow i^R \downarrow \rightarrow I \uparrow \rightarrow Y \uparrow$
2a.	**Bank Lending**	$M \uparrow \rightarrow$ Bank Deposits $\uparrow \rightarrow$Bank loans $\uparrow \rightarrow I \uparrow \rightarrow Y \uparrow$
2b.	**Balance-Sheet**	$M \uparrow \rightarrow p^e \uparrow \rightarrow$ Adverse Selection$\downarrow$ and Moral Hazard $\uparrow \rightarrow$ Lending $\uparrow \rightarrow I \uparrow \rightarrow Y \uparrow$
3.	**Exchange Rate**	$M \uparrow \rightarrow i^R \downarrow \rightarrow e \downarrow \rightarrow (X - M) \uparrow \rightarrow Y \uparrow$
4.	**Tobin's q**	$M \uparrow \rightarrow p^e \uparrow \rightarrow q \uparrow \rightarrow I \uparrow \rightarrow Y \uparrow$
5.	**Wealth Effects**	$M \uparrow \rightarrow p^e \uparrow \rightarrow W \uparrow \rightarrow C \uparrow \rightarrow Y \uparrow$
6.	**Cash Flow**	$M \uparrow \rightarrow i \downarrow \rightarrow$cash flow $\uparrow \rightarrow$adverse selection$\downarrow$ and moral hazard $\downarrow \rightarrow$lending $\uparrow \rightarrow I \uparrow \rightarrow Y \uparrow$
7.	**Unanticipated Price level**	$M \uparrow \rightarrow$ unanticipated $P \uparrow \rightarrow$ adverse selection$\downarrow$ and moral hazard $\downarrow \rightarrow$lending $\uparrow \rightarrow I \uparrow \rightarrow Y \uparrow$
8.	**Liquidity Effects**	$M \uparrow \rightarrow p^e \uparrow \rightarrow$Value of financial assets $\uparrow \rightarrow$likelihood of financial distress $\downarrow \rightarrow$ consumer durable and housing expenditure $\uparrow \rightarrow Y \uparrow$

Symbols: M: Money supply; P^e: Expected price level; π^e: Expected inflation; i^R: Real interest rates; i: nominal interest rates; I: Investment; Y: Output; e: Exchange rate; X: Exports; M: Imports; W: Wealth, C: Consumption.

Source: Partha Ray (2008)

CHAPTER 3
ESTIMATING OPTION-IMPLIED RISK AVERSION FOR INDIAN MARKETS

3.1 Introduction

Financial markets have traditionally captured investor sentiments by studying movements in asset prices. Shifts in volatility and price movements of assets alter investor expectations in different ways. While some investors choose to be risk-averse, some opt for greater risk-taking in search for better yields. As a result, financial market assets have the capacity to reveal important insight about future expectations of the market that can be revealed through price information. However, it is important to understand that theoretical finance literature assumes markets assume investors to be neutral to risk while accounting for future expectations[4]. Can theoretical models of option pricing reveal actual risk preferences of investors? To answer this question, it is crucial to have a technique that can estimate investor risk preferences.

Prices of any asset class contain complete information about market participant's probability assessment of the outcome of the underlying asset price upon maturity. The price information of options can reveal important information about a market's future expectations. All financial market assets yield future payoffs. In particular, options market information are extensively used to gauge investor perception about future market expectations of asset prices. In today's world, it is unequivocal that financial markets must have a comprehensive way to inspect investor risk preferences and uncertainty. Risk sensitivity focusses its attention towards two aspects – one, the market participants' attitude towards risk; and second, how that risk attitude is measured.

[4] In this case, risk-neutrality implies that investors are not indifferent to prices, but adjust their price expectations to movements in domestic and global financial market events.

This chapter addresses three issues. First, while options market literature in this field has adequately developed techniques to extract risk-neutral from options market for indices like FTSE and S&P 500, the Indian options markets lack a comprehensive index that provides such information about domestic investor perceptions. The idea in this chapter is to extract two density functions – risk-neutral density function and utility-adjusted functions to estimate their forecast abilities of future densities, thus giving a forward-looking estimate of investor preferences in future. This analysis allows us to test the forecast ability of distributions of the ex-post values of the asset prices[5].

Second, while studies like Figlewski (2008) and Bliss and Panigritzoglou (2004)[6] indicate that investors in markets like FTSE and S&P 500 not risk-neutral, we cannot assume that Indian options market investors would necessarily be neutral to risk. Finally, the third problem is the limitations of the VIX index, particularly for the case of Indian options markets. In addition to computational challenges (explained in further sections), there is insufficient historical data available for INDIA VIX that can be used as a proxy of risk for various analyses. We adopt a nonparametric technique to compute an index of risk aversion for Indian markets to address the above concerns.

This chapter focuses on measurement of risk aversion to enable better estimation of investor risk preferences. This information can be extracted using risk-neutral density functions that provide forward-looking risk positions of market participants. We extract probability density functions (PDFs) of the representative investors, based on their risk preferences, and tests their forecasting ability. The contribution of this exercise is to develop an index of risk aversion that can explain the probability of distribution of future option prices[7].

[5] In the case of Indian options market, with the exception of Kumar et al. (2014), limited research has been done to estimate risk-neutral density (RND).

[7] Bliss and Panigritzoglou (2002, 2004) developed this approach by using implied volatility to compute a measure of risk aversion.

We divide the chapter as follows: Section 3.2 gives a glimpse of the literature review. Section 3.3 describes the data description of the Options index market used. Section 3.4 discusses the methodology in detail. Section 3.5 discusses the forecasting and subjective density functions. Section 3.6 discusses the empirical results testing the forecast abilities of risk-adjusted and risk-neutral PDFs to yield the risk aversion index. Finally, section 3.7 concludes.

3.2 **Review of Literature**

Central banks have widely used option market information to predict market expectations of the future asset prices. Such a technique enables them to extract an expression of the market's reaction to changes in interest rates, thus providing a detailed picture of market expectation of future monetary policy decisions. In addition to option prices, Malz (2014) provides a simplified approach to extract the RND technique and describes how the technique can be extended to asset types like futures, exchange-traded assets, currencies and gold options and swaptions asset types. (Vincent-Humphreys and Noss (2012)).

There is a vast and varied methodological literature on extracting RNDs. The simplest approach is to compute histograms. However, these histograms are rough estimations of the underlying density and is based on a discrete approach. The method of extracting RNDs can be largely divided into three categories: *i)* by fitting a parametric density function to data; *ii)* by fitting a non-parametric technique; or *iii)* by means of theoretical modelling of the return process that generated empirical RND as the maximum probability density for the value of the underlying asset upon maturity. Our approach to extracting the risk neutral probability measure follows the technique adopted by Bliss and Panigirtzoglou (2002, 2004). The primary idea behind extracting RND from option prices is that the price of the option contains complete information about market participant's probability assessment of the outcome of the underlying asset price at maturity[8]. The Black-Scholes smile

[8] The Black-Scholes option pricing model, developed in 1973, has been used extensively for extraction of implied statistical quantities from underlying assets.

interpolation technique is used to obtain risk-neutral probability density for the short-term interest rate from option prices on option futures[9].

It was Ross (1976) and Cox and Ross (1976) who first assumed that investors are risk-neutral and utilized the Black-Scholes formula to derive assets expected return. The seminal chapter by Cox and Ross (1976) revealed that if investors can be assumed to prefer more to less (assumption of local non-satiation) then, options can be priced if investors were risk-neutral, independently of their risk preferences. The techniques developed by Ross (1976), Cox and Ross (1976) and Breeden and Litzenberger (1978) have been utilized by several chapters to extend the analysis to develop more robust approaches to extract RND.

Ait Sahalia and Lo (1998) adopt a nonparametric approach to estimate state price density in asset prices thereby developing a method to determine an arbitrage-free approach to pricing new, complex and illiquid securities. In recent literature, Cheng (2010) establishes a framework to compare statistical properties of estimated RNDs among major markets like commodities market, exchange rate market, S&P 500 and the US Treasury market. Figlewski (2008) extracts twelve years of daily data and develops a new method of completing the RND with tails drawn from a generalized extreme value distribution, thus taking the analysis a step further.

3.2.1 **Advantages of the RND approach**

The defining feature of this approach relies on good quality data on implied volatility. This implies that continuous option prices are required to derive the implied volatility. Using the RND approach, we can convert the option prices to continuous functions that can further be differentiated. The VIX computation methodology, on the other hand, *assumes* the price functions to be continuous in nature. This becomes problematic particularly for Indian option price data, as the markets do not have much liquidity especially during far month maturities. There is also presence of wide bid-ask spread in the market reflecting in and have larger

[9] Originally, Shimko (1993) interpolated the Black-Scholes implied volatility smile to obtain RND.

differences between consecutive option prices, in comparison with other option markets like S&P 500 or FTSE. This approach used in this chapter overcomes the shortcomings of INDIAVIX in terms of illiquid transactions, discontinuous strike prices and low market volumes. This makes the RND approach (explained in subsequent sections) for extracting risk aversion particularly relevant for Indian markets (see Basu, Halder and Tiwari (2009)).

3.3 **Data**

The data-set includes daily data between the period January 2005 and July 2015 containing 1,42,972 observations[10]. Options index data are most preferred to study risk preferences as they have fixed maturity dates in future when payoffs are realized. The nature of granular data set used in this research enables an analysis of relative risk aversion of investors over different time horizons[11] (see Table 3.1 for the descriptive statistics of the options data used in this analysis).

This chapter uses options daily contract reports data for the options NIFTY 50 index. The data is obtained from National Stock Exchange (NSE, India). Observations with time-to-maturity of less than one day and implied volatilities greater than 100 percent are dropped. Options market in India expires on the third Thursday of every month for which we consider quarterly expiries i.e. for the months March, June, September and December each year. To eliminate excessive noise in the data, we drop all in-the-money strikes and only consider at-the-money and out-of-the-money strikes. We also consider prices only above 1/8 and trades with time to maturity of more than one day.

[10] It is important to estimate risk-neutral distribution from option index prices by employing a complete set of information that includes the past and current options market observations.
[11] The technique described in this analysis works for any asset type subject to availability of high-quality data.

Table 3.1: Descriptive Statistics of NIFTY50 Options Index market – India Period (daily): (2005 – 2015)

Variable	Obs	Mean	Std. Dev	Min	Max
Strike Price	142972	5008.045	1980.762	1700	11400
Open	142972	204.3876	483.4373	0	5907.95
High	142972	213.3641	491.1783	0	5927.1
Low	142972	194.7736	474.6198	0	5885
Close	142972	456.0268	677.2477	0.5	5886.7
LTP	142972	308.9934	598.3649	0	5885
Contracts	142972	18171.64	91631.82	0	3542939
Turnover	142972	49383.36	242362	0	7357745
Open Interest	142972	482722.3	1238109	0	1.66e+07

Source: Author's calculations. National Stock Exchange (NSE)

Options data has emerged most suitable to study risk preferences as they have fixed maturity dates in future when payoffs are realized. Also, studying the options market provides more insight of investor behaviour over different time horizons. Options offer various prices for different payoffs for the same underlying asset. This feature of options enables computation of a density function for the distribution of possible values. The risk-free rate has been obtained from daily closing price of the 3-month MIBOR data, available at NSE website. The dividend yield has been taken to be zero.

3.4 **Methodology**

The science of extracting RNDs of future asset returns based on option-implied volatility smile is a well-developed practice available for researchers in finance. However, these techniques are empirically and analytically challenging, perhaps also being the reason for lesser application of such a technique. In this chapter, we try and describe a simple yet effective approach to estimating RND. It is evident from Malz (2014) who succinctly compiles the methodological issues faced in extracting RNDs and ways to circumvent them, that we can obtain RNDs without

violating the no-arbitrage conditions. In essence, the computation involves three steps: First, interpolating the volatility smile data so that the data points are not clustered at the end points. Second, utilize the call valuation function (as explained in subsequent sections) to generate the call option value. The third step is to differentiate the call price function numerically with respect to the strike price to extract the risk-neutral probability density function.

The steps followed in this chapter to extract the RND are as under:

1. Use options observation/expiry date pairs and eliminate observations that are too far in or out of money;
2. Convert call option prices to Black-Scholes implied volatility (using inverse method);
3. Interpolate the implied volatility data using a cubic spline function;
4. Re-convert the interpolated implied volatility curve back to option prices to extract the center portion of the RND (using the technique by Breeden and Litzenberger).

The simple technique for computing RNDs follows from Breeden and Litzenberger (1978) who provide the relationship between European option call prices and the RND. The risk-neutral distribution is obtained using the second derivative of call option's value with respect to the exercise price. We interpolate the implied volatility data using a cubic spline function [Malz (2014), Monteiro and Vicente (2008)]. A cubic spline smoothing function is a standard choice for interpolation as it overcomes the clamped endpoints of the implied volatility. In an absence of arbitrage, the second partial derivative of a continuous European call price function with respect to the strike price of options is closely related to the risk-neutral probability that the future asset price will be no higher than the strike price upon option maturity. This relationship forms the central pivot of the analysis in this chapter.

The price of a European-style call option can be expressed as the discounted value of the options expected return under the risk neutral distribution:

Equation 1:

$$C = e^{-rT}\hat{E}[max(\mathrm{S} - X;0)] = e^{-rT}\int^{\infty} max(\mathrm{S} - X;0)f(F)dS$$

Where C is the option price, S is the value of the underlying asset, X is the strike price; r is the risk-free interest rate, and T is the time to maturity of the option. E here denotes the expectations operator with respect to the risk-neutral density of the future asset price *f(S)*. Equation (1) gives the expression for pricing call options. Unfortunately, it is not possible to empirically determine *f(S)*. This is where the relationship given by Breeden and Litzenberger (1976) becomes significant, that relates European option call prices and the RND. This expression given in equation (2) forms the mathematical foundation for analysis in this chapter. The relationship is of the form:

Equation 2:

$$(\partial^2 C(S, X, T, t))/(\partial X^2) = e^{-rT}f(S)$$

The call option price formula is given by:

Equation 3, 4, 5:

$$C = e^{-rT}[\mathrm{S}\Phi(d_1) - X\Phi(d_2)]$$

where,

$$(d_1 = ln(\mathrm{S}/X) + 1/2\sigma^2 T)/(\sigma\sqrt{(T)})$$

and

$$d_2 = d_1 - \sigma\sqrt{(T)}$$

σ here is the implied volatility, $\varphi(d1)$ and $\varphi(d2)$ are the respective cumulative distribution functions.

The computation of a well-behaved risk-neutral distribution function hinges on a good estimate of implied volatility. In this chapter, we follow the approach discussed in Bliss and Panigirtzoglou (2004) who smoothen the implied volatility instead of using the call option prices and then re-convert the smooth implied

volatility function into a smoothed price function, which can then be differentiated to achieve the RND, as expressed in equation (2). The Black-Scholes formula is used to extract implied volatilities for European Options. The idea is to generate a series of transformed data that may be easier to interpolate and smoothen[12]. The implied volatility can be expressed regarding the inverted Black-Scholes expression. The important thing to be noted about adopting the volatility smile method to extract RND is that the Black-Scholes formula used in the process has been used for conversion (prices to implied volatility) and reconversion (implied volatility to prices) to enable data interpolation. Doing so, in no way, assumes the Black-Scholes formula to be correct. It is, therefore, safe to say that the approach used in this chapter is model-free[13].

3.5 Forecasting and Subjective Density Functions

After computing the times series of PDFs for each option observation/expiry date pair, the objective is to test the forecast ability of these risk-neutral PDFs following Bliss and Panigritzoglou (2004). The PDFs calculated in the previous section yields one observation for each pair of option date or expiry. In other words, the risk-neutral PDFs are a time series of a single realization X_t for every options observation/expiry. To make a good forecast, the estimated PDF, $\hat{f}_t(.)$ must equal the true PDFs, $f_t(.)$. The null hypothesis to test the prediction ability treats X_t as independent and identical to the true PDFs i.e. we test the condition, $\hat{f}_t(.) = f_t(.)$. For this purpose, it is required that the inverse probability function of the realizations y_t is uniformly and independently distributed; $y_t \sim$ i.i.d. U (0,1). The inverse probability transformation is represented as the following function:

Equation 6:

$$y_t = \int_{-\infty}^{Xi} ft(u)du$$

[12] Cubic-spline method is used to smoothen the implied volatility
[13] The implied volatility is computed using the inverted Black-Scholes method (using statistical software MATLAB).

This function would be uniform only if the estimated PDF equals the true PDF. However, before we test the forecast ability of the risk-neutral estimated PDF, we estimate a *risk-adjusted* PDF in order to compare the forecasting ability of the two distribution functions.

3.5.1 **Subjective Density Function (SDF)**

This section aims to employ an exponential-utility function to convert the risk-neutral density function into a subjective function. Literature suggests that risk-neutral PDFs do not necessarily accurately forecast the future densities. This creates the need to compute subjective density functions that essentially adjusts the risk-neutral function with utility functions, thus yielding a risk-adjusted PDF. This technique follows from Ait-Sahalia and Lo (2000) who provided the following relation to estimate a subjective density function:

Equation 7:

$$\frac{p(St)}{q(St)} = \zeta(St)$$

Where $p(St)$ is the subjective density function, $q(St)$ is the risk-neutral density function and $\zeta(St)$ represent the pricing kernel or the utility function. Therefore, in order to estimate the subjective density functions, the first step is to establish a utility function that can be used for the representative agent. As shown in Table 3.3, this chapter adopts an exponential-utility function to estimate the subjective PDF, following Bliss and Panigritzoglou (2004). Substituting in Equation 7, we are now ready to estimate the SDF given the risk-neutral PDF values and the utility function.

Table 3.2 –Risk-Adjusted Utility functions for SDFs

$$\text{RRA} = -\frac{StU''(St)}{U'(St)}$$

Utility function	U(St)	U′S(t)	RRA
Exponential utility	$-\frac{e^{-\gamma St}}{\gamma}$	$e^{-\gamma St}$	γSt

Note: The functional form for the utility function has been adopted from Bliss and Panigritzoglou (2004).

Table 3.2 provides the functional form of exponential-utility and marginal utility that are used to transform the risk-neutral PDF to a subjective density function. This indicates that in order to compute Relative Risk Aversion (RRA) index, as given in the description of Table 3.2, both the value of a parameter γ as well as the realization St, are crucial. In other words, for an exponential-utility RRA, the distribution of RRA would be across the sample. We explain the parameter value of γ in the next section.

3.6 **Empirical Results**

3.6.1 **Testing forecast abilities of Risk-Neutral and Risk-Adjusted PDFs**

The methodology used in this chapter involved three steps. The first step is to estimate the risk-neutral PDF using spline interpolations technique (Breeden and Litzenberger, 1998 and Panigritzoglou, 2002). In the second step, we assess whether the risk neutral PDFs or subjective PDFs accurately forecast the distributions of ex-post realizations. Under the null hypothesis of the Chi-square test and K-S tests used, the estimated PDFs is the same as the true PDF. Finally, in the third step, we test the forecast ability of risk-neutral as well as subjective density functions by applying econometric tests. Our objective is to assess which of the two PDFs make a good fit to correctly predict the investors' future expectations of the underlying asset prices.

Based on equation 6, the null hypothesis would hold true only if the inverse probability function of the PDFs are uniform. In order to test for uniformity of the inverse probability function y_t, we propose two tests i.e. Chi-squared and Kolmogorov-Smirnov tests[14] - both of which are nonparametric in nature. We use the same approach for testing the forecast ability of the risk-neutral PDF as well as the subjective density functions. Once we establish which model can be a better fit to predict the true PDF, we can estimate the risk aversion parameter based on equation 7.

Table 3.3 – Chi-squared and Kolmogorov-Smirnov[15] *p*-values for risk neutral PDFs

PDF	Forecast Horizon	Test	*p*-value
Risk-adjusted	Four week	K-S test	0.021**
		Chi squared test	0.048**
Risk-neutral	Four week	K-S test	0.183
		Chi squared test	0.256

** 95% level of significance

The Chi-squared and K-S tests are used to compare the forecast ability of risk-neutral density with the exponential-utility-adjusted density function. Results show that risk-adjusted densities are better fit to forecast the future expectations of underlying value of option prices. The value of γ is chosen by maximizing over the *p*-value of the K-S test (since the *p*-value of K-S test is more significant than that of Chi-squared test statistic). We take the value of parameter γ to be identical to the *p*-value drawing from the method adopted in Bliss and Panigritzoglou (2004).

One obvious limitation of this analysis for Indian markets is that we are only able to perform this study for the four week horizon[16], as seen in Table 3.3. Option contracts are near expiry around the four week horizon from the date of each

[14] Like most other tests, the function is taken to be independent. Only uniformity of the function is tested.
[15] One-sample tests are used as we are comparing a reference probability distribution (Inverse probability function) with the sample probability. Two-sample tests are used when we want to compare two given samples.
[16] We consider data for monthly serial contracts of NIFTY 50 options index.

observation, in other words, their time to maturity falls within less than one week[17]. We are unable to use observations of higher time to maturity as we find low volumes of transactions and wide bid-ask spreads in the data. It is fot his reason that the technique used is this chapter can be considered more effective than the methodology used for computing INDIA VIX[18], which fails to exclude illiquid observations that are low in volume and tend to bias the volatility index (Basu et al (2009)). As a result, even though we are restricted by relatively lesser number of valid observations in our analysis, the results using this technique can be more representative of Indian market investors, and characterizes the strength of this chapter.

Results reveal that we cannot reject the hypothesis that risk-adjusted PDFs give accurate forecasts of the future realizations (*p*-values are insignificant) (from Table 3.3). The *p*-values for risk-adjusted density functions for both the K-S test and Chi-squared tests are 0.021 and 0.048, respectively. On the other hand, the risk-neutral density functions are not significant at 95 per cent level. It is therefore possible to conclude that subjective PDFs seem to better forecasts of future ex-post distributions of option realizations.

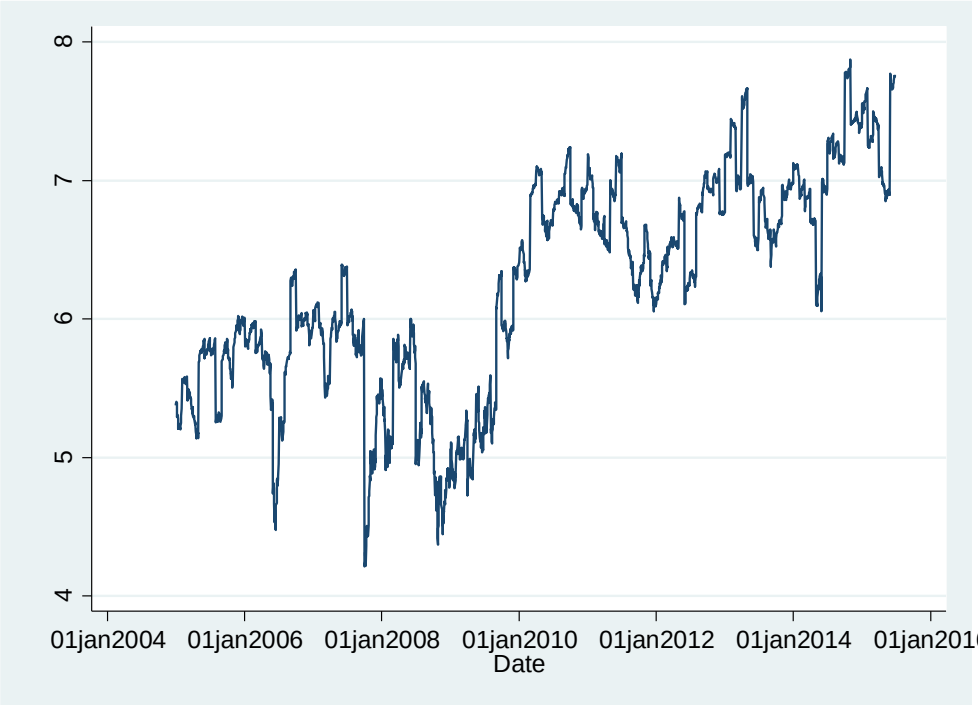
3.6.2 **Risk Aversion Index**

Finally, we substitute the relation given in equation 7 to estimate the measure of risk aversion (relative risk aversion – RRA) as the third estimation step. The parameter γ helps to obtain the best density forecast of the ex-post distributions. When the parameter is multiplied with the option market price gives us the measure of RRA, as drawn from Table 3.3. In other words, the RRA is dependent on the, the time varying St as well as the parameter γ. The RRA values computed for Indian markets are graphically depicted in Figure 3.1 below. Further, this risk aversion measure can be compared with the measure of equity risk premium. The global

[17] Time to maturity is annualized taking 252 number of trading days in a year.
[18] Refer White Paper for INDIA VIX – NSE for the methodology used in computing the VIX index.

VIX is used as a measure of equity risk, and we observe that the risk aversion measure is the inverse of the equity risk (see Figure 3.2).

Figure 3.1 – Plot of risk aversion extracted from risk-neutral PDFs



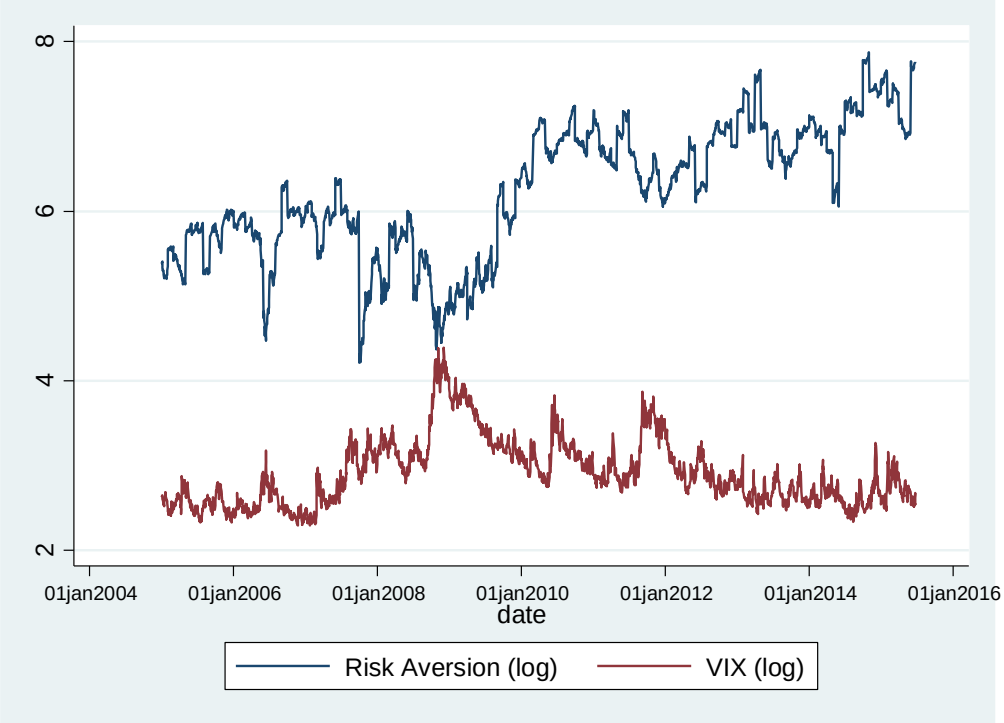
Source: Author's calculations

Figure 3.1 indicates the risk aversion index (shown here in log form). The index is calculated with the help of the relationship between relative risk aversion and the utility functions of the representative investors (based on equation 7). The viability of this index can be assessed from the fluctuations in risk aversion during the time of the global financial crisis of 2008. During the crisis period, the amount of risk multiplied in the markets, and intuitively the risk aversion is expected to have declined.

Figure 3.2 compares the performance of our risk aversion index with the global volatility index, both taken in log form. As financial markets are increasingly become more integrated, the correlation between global VIX and the risk aversion measure is 0.32, which depicts a strong relationship between the two indices. The

two indices meet at one common point in Figure 3.2, showing the impact of the global financial crisis even on Indian option market investors. As the volatility in financial markets reached its peak in 2008-09, investors became more risk-taking, thus explaining the decline in risk aversion level. The uptrend on risk aversion post 2009 shows the speculative nature of investors in Indian markets.

Figure 3.2 – Relationship between risk aversion and equity risk



Source: Author's calculations

Note: We find an inverse relationship between equity risk and risk aversion index computed in the analysis.

3.7 Conclusion

Option-pricing theory tells us that prices reflect investor expectations of the distribution of future levels of the underlying asset. Extracting probability density functions (PDFs) are a beneficial way of digging up such useful information on investors' expectations. In this chapter, we analyze two types of PDFs (determined by investor risk preferences) and arrive at a measure of risk aversion present in the

markets. We execute the following three steps – *i)* Extract investor risk-neutral and risk-adjusted probability density functions; *ii)* test the forecast ability of both the PDFs to accurately predict the true PDFs; and *iii)* compute a measure of risk aversion using both PDFs. The study is carried out for NIFTY 50 options index data over the time period between 2005 and 2015. The chapter adopts well-known techniques for extracting PDFs and measuring the risk aversion index. The main idea is to arrive at a comprehensive index to measure the level of risk aversion among Indian investors.

Our findings reveal that risk-adjusted densities are better able to forecast the future expectations of underlying value of option prices in comparison to risk-neutral density functions. In other words, risk-neutral densities cannot be taken at their face value that option prices necessarily embed the market expectations of future values of the underlying asset. This violates the theoretical assumption of option pricing that assumes investors to be risk-neutral, thus giving us reason to believe that some extent of risk aversion would be present in Indian markets, owing to varied disturbances across financial markets world over and domestically. Therefore, we estimate the risk aversion among investors. Our comprehensive measure of risk aversion reveals that investor risk preferences are time varying in nature.

Additionally, we find that as the global volatility increases, the tendency to take greater risks can be seen in Indian markets too as markets become more speculative, thus lowering investor risk aversion. The computed index of risk aversion also overcomes important limitations of the VIX index, particularly for the case of Indian options markets. The scope of this chapter is immense, and applied to other segments like currency derivatives, futures market, interest rate derivatives and exchange rate derivatives markets etc. Finally, the advantage of this index of risk aversion is that it is of a longer time series than the available INDIA VIX (provided by CBOE). We can therefore use this index as a proxy of risk for Indian markets in wider macro-financial analyses for India, as done in Chapters 4 and 5 of this thesis.

CHAPTER 4

Monetary Policy in India and the World

4.1 Introduction

In the past, domestic monetary policy decisions were made around concerns such as stabilizing inflation levels with a lower bias, strength of market structures (i.e. resilience against excessive risk), good policy measures and focus on achieving stable growth. After the currency crises of 1994-2001, the conventional wisdom made inflation targeting as the preferred monetary regime in place of exchange rate targets. However, the mandate of monetary policy is incomplete without addressing concerns of financial and external instability. This was well recognized by the RBI during 2004-05, where the economy witnessed increasing upsurge of capital flows for the first time and formation of asset bubbles in India.[19] Incorporating external shocks have therefore become crucial for central banks as the financial conditions across borders are increasingly becoming synchronized with associated movement in credit and debt flows domestically (Rey, 2015).

It is common knowledge that asset prices in financial markets are driven by global factors and events. Changes in the global financial cycle are characterized with large capital flows across countries, credit growth and asset price fluctuations, which significantly impact domestic financial markets. Given the nature of credit flows is generally pro-cyclical[20], it can be assumed that capital influx is in the direction of domestic business cycles. The world economy has become highly integrated over the past few decades. This means that advanced economies as well as emerging markets share common trends that lead to similar reaction across financial markets in particular. For instance, we find massive upsurge in capital flows across borders. While it is true that these movements of capital enhance welfare in local markets, it is worth wondering if there could also be possible fallouts. With increased global integration, financial markets of individual

[19] Refer Annual Monetary Policy statements by RBI.
[20] See Borio and Zhu (2008) and Shin (2012) for nature of credit pro-cyclicality.

countries find multiple common foundations with the rest of the world. Under such circumstances, where it has become increasingly difficult for authorities to counter prolonged periods of low interest rates, central banks are faced with the incredible challenge of meeting their policy goals and maintaining financial stability. [See Bruno and Shin (2012), Rajan (2014), Rey (2013) and Turner (2014a)]. Under such circumstances, it is important to investigate how refinancing the US dollar, in addition to domestic monetary changes impact market outcomes. The negative interest rate policies maintained by the Federal Reserve can determine changes in risk attitude of investors for an emerging market economy like India. Therefore, the primary idea of this chapter is to investigate how the ultra-low interest rate policies by the Federal Reserve (US) affects India. In other words, do external monetary conditions become a source of risk to domestic monetary and financial stability in an EME like India?

This chapter examines crucial channels of international spillovers – the policy interest rate, exchange rate, portfolio flows and banking sector flows[21]. The analysis brings out some behavioural effects of market participants due to external and internal monetary stance in determining the investor perception of risk. In other words, it encourages risk-taking among investors that cannot be controlled merely by discouraging the speculative capital flows that enter into emerging economies by adjusting currency. The challenge is much deeper. As individual countries have opened up their borders for larger and freer flows of capital across the world, there are several questions that emerge. For instance, how do local central banks and markets in EMEs respond to global accommodative monetary policy? Does this lead to build-up of risk in emerging market economies? Is there a need for greater monetary policy coordination between advanced and emerging market economies?

The primary contribution of this study is to extend the external risk-taking channel of advanced economies to examine how it impacts India. The ways in which these influences could be understood are twofold – *i)* how external monetary conditions

[21] For recent reviews on international financial spillovers, see Gagnon et al (2011), Caruana (2012), Chen et al (2012), IMF (2013a, 2013b), and He and McCauley (2013)

affect risk preferences of Indian investor; *ii)* how it impacts the independence of domestic monetary policy transmission. In addition to the effects of the US Fed Reserve monetary decisions, the Indian domestic market is influenced by the global financial cycle. The motivation behind this study is to revisit the literature on monetary transmission for two reasons. First, conventional theory treat financial markets to be free of frictions (see Gertler and Karadi, 2015)[22]. Second, the way advanced economies are maintaining their monetary policy stance. This study examines the joint response of financial and economic factors to exogenous monetary policy stance/surprises.

The chapter is organized as follows – Section 4.2 describes the role of the risk-taking channel for India. Section 4.3 articulates the channels of international spillovers. Section 4.4 provides the data description. Section 4.5 gives the methodology followed by the VAR model specifications in Section 4.6. This section includes all impulse response graphs and variance decompositions. Finally, section 4.7 concludes and Section 4.8 provides the future scope for the analysis.

4.2 **Risk-Taking Channel in India**

Major advanced economies have maintained an aggressive accommodative monetary policy stance to revive consumption demand after the crisis of 2008. The accommodative stance included lowering of policy interest rates for a long periods coupled with quantitative easing programs to stimulate demand (QE I and QE II). The policy interest rates reached a zero-lower-bound causing financial market participants in advanced economies to heavily invest in emerging markets like India in search for higher yields. This led to massive upsurge in capital inflows into the Indian economy, despite careful regulations by the RBI to calibrate the inflow of foreign capital (Mohan, 2008). The major influx of capital came in the form of portfolio flows that were non-dent creating (like FDI inflows). However, in 2013, the U.S. Federal Reserve indicated that the quantitative easing program may come

[22] See Boivin et al. (2010) for a recent survey on monetary policy transmission.

to an end, sparking a series of panic across world markets, what commonly came to be known as the ‘taper-tantrum’.

The fear of exit of capital has raised significant concerns of reversal-spillovers for emerging market economies. While the low and accommodative external monetary policy rates created an environment of heightened risk-taking among investors, coupled with massive capital inflows and currency appreciation, the second challenge came in the form of rapid capital outflows. However, once the fear of reversals kicked in, individual central banks diverged their policy stance from the US policy interest rate. Consequently, John Taylor warns that this divergence in monetary policy stance across countries could potentially lead to adverse spillovers and thereby undermine domestic macro-objectives in an economy (Taylor, 2013). Recent literature thus emphasizes the increasing interconnectedness of financial conditions around the world in the form of a global financial cycle. (Taylor, 2013 and Rey, 2015). This trend confirms the findings of Takáts and Vela who observe the US policy rate as a significant determinant of the policy rate in maximum emerging market economies. (See Bruno and Shin (2012), Rajan (2014), Rey (2013) and Turner (2014a)).

The magnitude of consequences of low for long interest rates can be gauged from the movement of Federal Funds rate in comparison with other country policy rates. Given below, in Figure 1, is a graphical representation of the ultra-low interest rate policies maintained by the US. Panel A represents to movement in short term policy interest rate. Panel B indicates the co-movement of US interest rates with that of emerging market economies and panel C shows the movements in long-term interest rates. Panel B indicates a strong co-movement of short term policy interest rates of the US economy and select emerging market economies that include India. Short term interest rates of advanced economies, especially the United States, have a significant impact on that of emerging markets. This graph clearly indicates why we choose the United States as the center-country in the empirical analysis of this chapter to examine how it impacts an EME like India through varied channels of spillover.

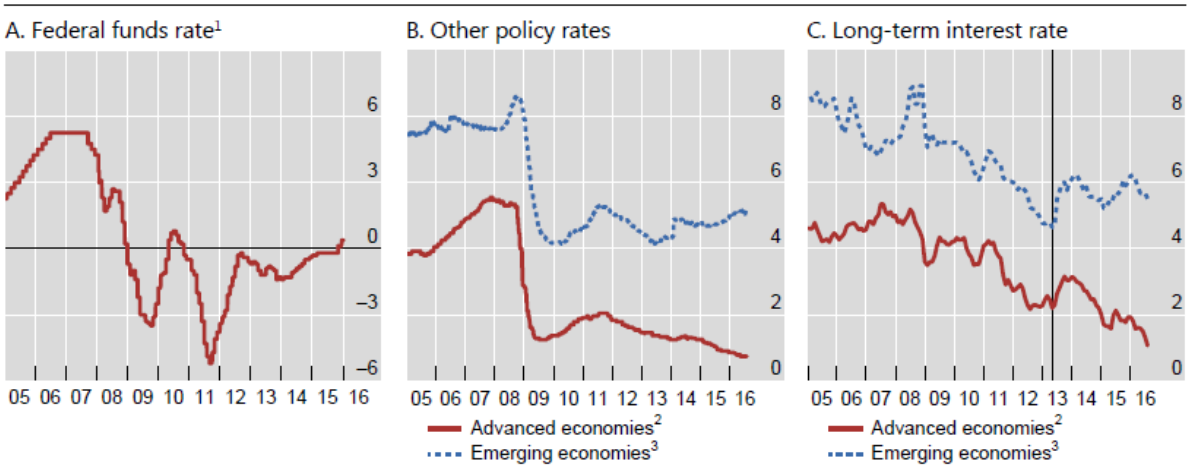


Figure 4.1: Movement in rate of interest in advanced economies versus emerging market economies.

Sources: Lombardi-Zhu (2014); Hördahl, Sobrun & Turner (2016)

In 2013, the BIS conducted a questionnaire across central banks around the world asking their view on major international channels of spillover effects. The results indicated by majority central banks reveal that transmission from advanced to emerging market economies occurs via four primary channels – the policy interest rates, exchange rate, long-term rate and portfolio flows.

This chapter brings out the behavioural effects of such external and also internal monetary stance on investor perception of risk. In other words, it encourages risk-taking among investors that cannot be controlled merely by discouraging the speculative capital flows that enter into emerging economies by adjusting currency. The challenge is much deeper.

The risk taking channel is not restricted to exchange rate channel alone but has deeper far reaching consequences, which is the contribution of this study. Exchange rate interventions can create newer forms of risk and is unlikely to replace interest rate as the major tool of managing aggregate demand. Extending the analysis by Bekaert et al. (2013) and Bruno and Shin (2015), Bua (2016) examines alternate channels of international spillover. Bua attempts to examine the impact of

international risk-taking channel on emerging markets. He performs a two-country recursive VAR to study the relationship between US long and short interest rate shocks, risk aversion and uncertainty, gross capital flows and credit[23]. Studying gross capital flows and credit is particularly important for analysing the impact of monetary policy in emerging markets. Additionally, as pointed out by Mohanty (2014) emerging market interest are strongly related with the global policy rates[24].

One way to understand the scope of international spillovers of monetary policy is to ask how capital flows, exchange rates and the banking sector are influenced. Bruno and Shin (2014) combine two important strands of literature showing bank sector leverage as the linchpin in the monetary policy transmission mechanism when observed in an international dimension that works through changes in risk. There is a vast literature on monetary policy transmission, recently augmented with including the role of capital flows, exchange rate movements and credit conditions. However, there are few specific considerations that motivate this study.

First, most studies focus on the implications of the risk-taking channel of monetary policy in advanced economies. Studies like Bruno and Shin (2014) and also Adrian and Shin (2014) focus on the investment banks in developed countries. However, the perspective of an emerging market economy is not the same. Typically, most emerging markets are dominated by commercial bank sector, wherein the role of bank credit has direct effects on the level of economic activity. Recent times have witnessed increased international debt securities and movements in capital across borders[25].

Second, the focus of this chapter is to look at the impact of both foreign as well as domestic monetary policy shocks on total gross capital inflows, credit outcomes and an index for financial market risk. The study examines the interconnectedness

[23] Bua (2016) select six emerging markets to study the impact of the international risk-taking channel. The countries included in the study are South Africa, Peru, Philippines, Indonesia, Turkey, Brazil.
[24] In this study, we assume the role of the US on policy rate.
[25] See debate on the role of long term interest rates and the questions therefore whether capital flows are impacted by policy rates or not and also the diminishing control of central banks on the long term interest rates.

of domestic rates with foreign policy stance and assess the channels through which foreign policy shocks get transmitted into Indian economy. Furthermore, the contribution of this chapter acts as a bridge between exchange rate and financial instability (see Adrian and Shin, 2014a)

4.3 The International Spillovers

Emerging markets are increasingly being more actively traded in the global markets[26], thus encouraging a deeper understanding of spillover effects and also the perception of risk among investors in a two-country setup. Bruno and Shin (2014) connect the exchange rate channel of transmission and currency appreciation with greater leverage of the banking sector. The presence of financial intermediaries (like investment banks) in advanced economies make the bank leverage cycle as the prominent determinant of financial conditions across borders. The emerging economies on the receiving end find the excessive bank capital flows in the form of huge inflow of capital flows (into different types (direct, equity, portfolio). The present nature of synchronization of financial conditions across the globe can be understood as the famous external "push" factors described by Calvo, Leiderman and Reinhart (1993, 1996) and Miranda-Agrippino and Rey (2013). Recent literature therefore points to bank leverage cycle and size of the banking sector are two factors that have emerged as the main reason associated with the increased growth in gross capital flows, as observed by Bruno and Shin (2014), Borio and Disyatat (2011) and Gourinchas and Obstfeld (2012). This gives context to the phenomenon of global liquidity that that affect emerging economies through permissive credit conditions.

While the international dimension of the risk-taking channel has been closely studied in recent literature, this chapter delves into the risk-taking channel and its effect on an emerging market economy, like India. In a recent contribution, Gertler and Karadi (2015) examine monetary policy influences credit costs and overall economic activity. Their findings reveal that even modest changes in short term

[26] Particularly the fragile five countries

rates cause large movements in credit costs, attributing the effect to credit spreads and term premia. This phenomenon is closely tied with capital flows associated risk-taking. While the EMEs faced rapid capital inflows and increasing pressure of currency appreciation, another major challenge came in the form of reversals during phases of market volatility between May 2013 and February 2014.

Taylor (2013) argues that EMEs may follow suit in lowering interest rates after advanced economies – to avoid several adverse effects such as, currency appreciation has an immediate negative effect on output while the favourable trade effect comes after a lag.

4.4 **Data**

This exercise is carried out using quarterly data for India and select variables of United States (assumed as the center country[27]) from 2005q4 to 2015q4. The selection of variables is based on i) relatively large size of US impact on Indian economy[28] ; ii) availability of quarterly data; iii) country-specific factors in India.

Time series data have been taken from various sources like – Handbook of Statistics on Indian Economy, Reserve Bank of India; National Stock Exchange, India; Bureau of Economic Analysis; International Financial Statistics, IMF; Federal Reserve Board; and, Chicago Board Option Exchange (CBOE).

Bank credit is measured as the total credit of all scheduled commercial banks in India (BC). Data on capital inflows (CAPINFL) is taken as the total foreign investment inflows into Indian economy, this is further classified into capital inflow into i) FDIs (foreign direct investments – CAPINFL_FDI) and ii) foreign portfolio investments (CAPINFL_PORT). The exchange is taken as the real effective exchange rate of the rupee per US dollar terms, which is a trade-weighted exchange

[27] Rey (2015) defines the core country as United States
[28] Refer another Mohanty (2014)

rate index[29]. Finally, the risk-aversion measure for Indian investors is based author's calculations, explained separately (see Appendix for details).

4.5 **Methodology**

The analysis uses a simple two-country recursive structural vector autoregression model to analyze the dynamic relationship between short term monetary policy measure of both domestic and center-country, risk aversion, gross capital flows, bank credit and real effective exchange rate in the domestic economy i.e. India. The methodology used builds on the work of Bruno and Shin (2014), Rey (2015) and Bekaert et al. (2013) who analyze the two-country spillover effects of risk-taking channel of monetary policy. While Bekaert et al. (2013) establish a quantitative assessment of the risk-taking channel of monetary policy, using the link between policy interest rates and the VIX as the risk-aversion measure. Rey (2015) extends the scope by studying the capital flows, asset prices and credit growth in the economy. Rey chooses credit growth as a good predictor of financial conditions in an economy, thus establishing the implications of capital that flows freely across borders[30].

First, the structural autoregression is conducted in reduced form:

$$A\ Zt = \Phi\ Zt\text{-}1 + \varepsilon t$$

where, A denotes the matrix of polynomial and εt is a vector of orthogonalized disturbances. Further, the standard Cholesky decomposition of the variance-covariance matrix results in exclusion restrictions on contemporaneous responses to fir the just-identified model. Ordering of the variables imposed is in recursive form and the lower triangular matrix A is denoted as:

[29] The exchange rate classification given by lzetzky, Reinhart and Rogoff (2009) measure its flexibility at 2 (on a scale from 1 to 6, six being the most flexible).
[30] Refer the section on related work for a detailed account of literature

$$A = \begin{bmatrix} a11 & 0 & 0 & 0 \\ a21 & a22 & 0 & 0 \\ a31 & a32 & 0 & 0 \\ a41 & a42 & a43 & 0 \end{bmatrix}$$

The main results are presented in the form of Impulse Response Functions.

This chapter investigates the dynamic link between short term policy stance with risk-aversion, gross capital flows, credit growth and real effective exchange rate. To strengthen the analysis, risk-aversion estimates are specifically mapped for Indian investors, thus giving a clearer picture of the impact of foreign capital inflows on overall risk-taking and credit growth changes in the economy. Such an analysis validates the effect of the risk-taking channel on an emerging economy like India. Different from literature on global risk-taking channels and cross-border flows and bank leverage, this analysis provides insight on an emerging market perspective[31]. The VAR model is built into two specifications to understand the link between monetary policy, risk and credit– i) domestic dimension; and, ii) international dimension.

4.6 Vector Auto-Regression estimations

4.6.1 Vector auto-regression - Domestic specification

The VAR approach is adopted as it allows imposing restrictions on the contemporaneous and lagged matrices of coefficients to improve estimation results. The impact of shocks is identifies by writing a vector autoregression in recursive form, following Sims (1980) wherein we impose restrictions on the primitive system. In the four-variable VAR, the Cholesky restrictions result in the following exclusion restrictions on contemporaneous responses in the matrix A to fit a just-identified model.

[31] A study close in spirit to this analysis is Bua (2015) – who looks at the effects on six emerging market economies. However, using global impact dilutes the country-specific risk measurement.

The ordering of the variables imposed in the recursive form implies that the variable with index 1 is not affected by the contemporaneous shocks to the other variables, while variable 2 is affected by the contemporaneous shock to variable 1, but not variables 3 and 4. The Cholesky decomposition places restrictions on the contemporaneous responses of the identified model. As a result, Cholesky decomposition of the matrix makes it a lower triangular system.

The selection of the number of variables considers Sim's methodology (1980) in selecting variables and their lag length. The lag selection procedure like AIC, HQIC and BIX suggest one lag period. The same is corroborated with the Lagrange multiplier test for autocorrelation in the VAR model residuals that indicate that at one lag period all the serial correlation in the residuals are eliminated. In addition, the VAR model is stable as the eigenvalues are less than one and lie within the unit circle. Furthermore, the bootstrapped 95% confidence intervals are based on 1000 replications. Once we perform these test on our VAR model, we are ready to run the impulse response functions.

Figure 4.2 represents the impulse response functions of the domestic dimension VAR analysis. It consists of four variable recursive VAR with 95% confidence intervals. The ordering of the variables are as follows: - *i)* Monetary policy measure (Repo); *ii)* Bank credit (BC); *iii)* Index of risk aversion (RA); *iv)* REER. We select REER as a proxy for rupee value of the currency for a deliberate reason. The REER is a trade weighted index that captures exchange rate of the Rupee with respect to select five countries with whom we have significant trade relations. This gives a relative basket of currencies that is more attuned to changes in currency movements across different countries as does not solely represent the movements in the Rupee-Dollar exchange rate. As further analyses will reveal, we consider the foreign policy rate to be that of the U.S. Federal Reserve. However, we keep the exchange rate to be more representative of changes in the rupee value with the rest of the world and not just the U.S.

The variables included in the VAR are selected according the economic interpretation. In this case, the variables are selected following the interaction of monetary policy. As a result, variables that have slower impact, like the repo rate, are better candidates to be ordered earlier than fast moving variables like REER and financial risk index. In this chapter, the monetary policy instrument is therefore ordered first, followed by bank credit, followed by risk aversion index of financial markets and REER is ordered last.

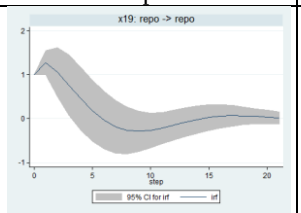
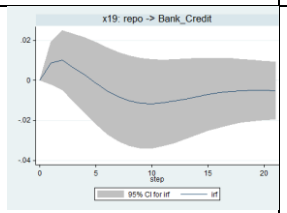
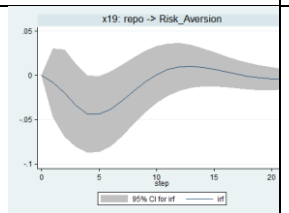
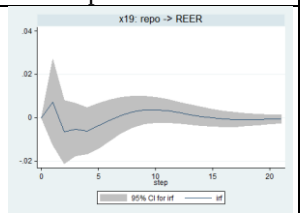
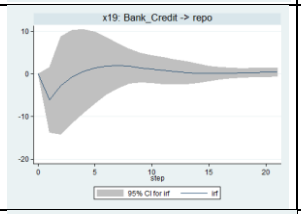
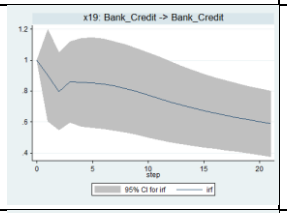
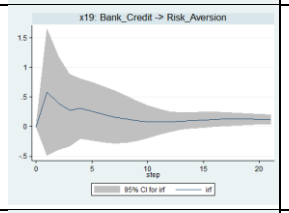
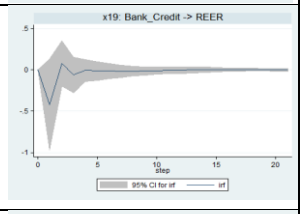
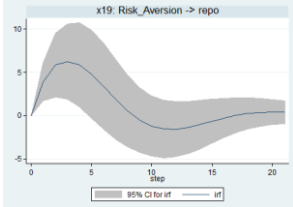
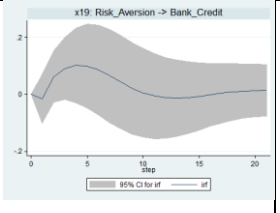
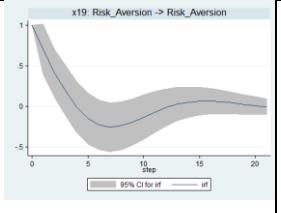
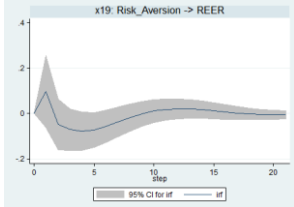
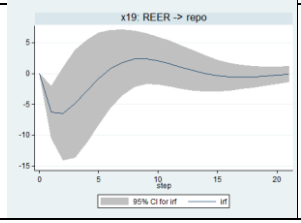
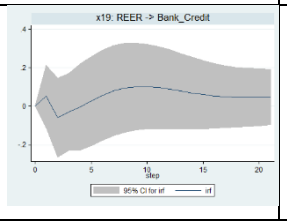
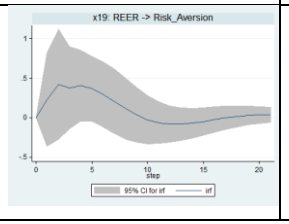
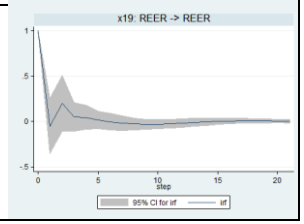
Recursive VAR	Ordering 1	2	3	4
	On Repo rate	On Bank Credit	On Risk Aversion	On Rupee Dollar REER
Repo rate				
Bank Credit				
Risk Aversion				
Rupee Dollar REER				

Figure 4.2: Impulse response functions for the domestic dimension in a recursive VAR system. This figure presents the IRFs for the domestic dimension (four-variable: Repo rate, Bank credit, Risk aversion, REER) and 95% bootstrapped confidence intervals with one lag period.

Let us examine the key panels of the narrative in the domestic dimension. Consider the impact of a positive shock to the monetary policy instrument, the repo rate, and examine the shock on the risk aversion level. The panel above shows that a shock to monetary policy rate leads to a decline in risk aversion that's remains significant for a period of 18 quarters. The impact reaches a maximum response of -.087 after 8 quarters. When we measure this with the sample average, we observe a one standard deviation shock to repo rate causes a decline in aversion from risk from 1.82 to 1.72. This decline in risk aversion clearly indicates that market participants became more risk-taking during the same period. These results are consistent with the findings of Bekaert et al (2013) who observe a similar effect on the VIX, also known as the risk-taking channel of monetary policy. This results is a crucial component of the study as it establishes the extended effect of the risk-taking channel even to emerging market economies like India. The channel is not limited to advanced countries where there is presence of ultra-low interest rate policies.

Other panels in Figure 4.2 show that tighter monetary policy lowers the bank credit after 10 quarters, reaching a maximum effect nearing 20 quarters. Another distinctive feature of the impulse response plots is the effect of a positive shock to risk aversion initially has a positive effect on bank credit outcome for nearly 20 quarters. This corroborates our hypothesis that increased aversion to risk resonates with the banking sector leading to a decline in credit in the form of loanable supply of funds[32]. The impulse response plots provide support for the proposition that credit outcomes of bank balance sheet are determined by movement in policy rates and risk perception of investors. Finally, in anticipation of the external sector spillovers, we observe that a positive shock to repo rate leads to appreciation of the India-US REER after a very long lag. This finding, as also reported in Bruno and Shin (2014), is consistent with the delayed overshooting puzzle found in Eichenbaum and Evans (1995) who find that tighter monetary policy shocks and currency appreciation do not occur contemporaneously, but

[32] The bank credit is measured only for scheduled commercial banks in India. This excludes regional rural banks.

after a lag of over 24 quarters. The IRF plots, on the other hand, indicate that a more contemporaneous relation between positive shock to REER and risk aversion in domestic financial markets. We discuss the impact of shocks to REER when we return to the international dimension of VAR specification in upcoming sections.

4.6.2 **Variance decompositions for the domestic dimension**

The impulse response plots indicate that monetary policy rates, even domestically, have a medium-term effect on bank balance credit outcomes as well as the overall risk capacity in the financial markets. As shown in Figure 4.3 below, a variance decomposition of the domestic specification of our VAR model indicates that mere domestic monetary policy shocks account for nearly 20% of risk aversion in financial markets and reach 15% of bank credit after a lag of 12 quarters. Monetary policy also account for 10% for change in Rupee-US REER exchange rates.

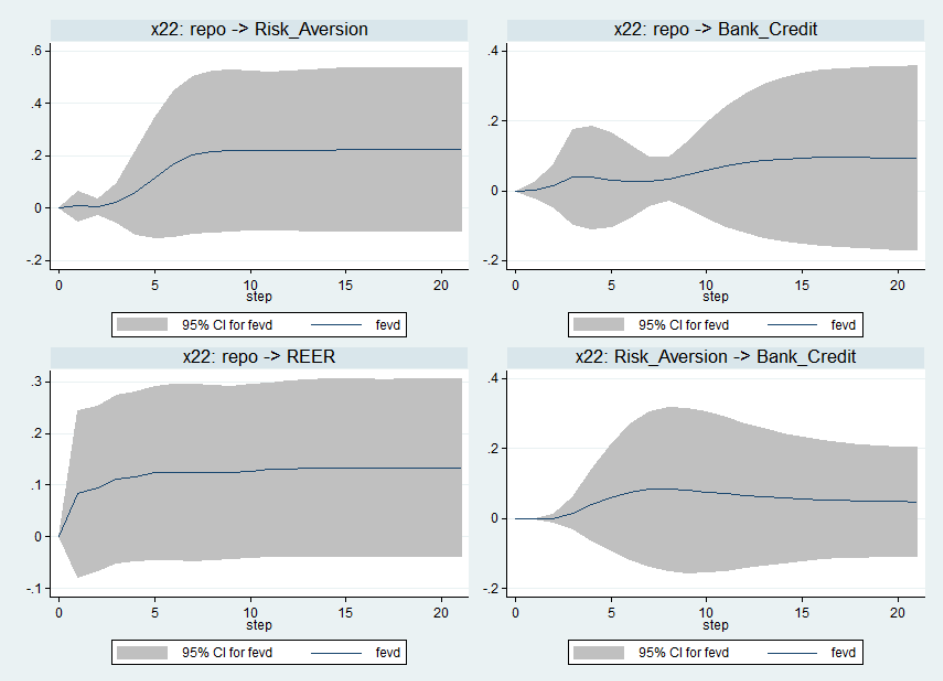


Figure 4.3: Forecast error variance decompositions. The figure presents the variance decompositions from the domestic VAR specification.

4.6.3 **Vector Auto-Regression - International dimension**

In this section, we examine the role of international market spillovers on how different channels affect domestic outcomes in India. In the previous section, we observed a significant effect of monetary policy on medium term outcomes in bank credit and investor risk-taking. In the current section, we test different channels of international spillovers to examine which channels add to domestic channels and have a significant effect.

For the international dimension, we extend the domestic VAR model to include three exogenous variables: federal funds effective rate (FFR) and foreign capital inflows (CAPINFL). In this specification, we are interested to see the effects of foreign (centre-country, US) on domestic country by means of the four channels - exchange rate channel, foreign capital inflow, portfolio channel (i.e. banking sector and financial market risk allocation) as well as the policy interest rate channel. We assess the effects of these channels over the short to medium term range.

Prior to presenting the IRF plots, it is important to present the justification for the need to examine the international channels of spillover in examining monetary transmission. First, as advanced economies (particularly, the US for the case of this study) adopted negative interest rate policies (NIRPs), the failure of emerging markets like India to follow suit have come with a cost. The interest rates, exchange rates as well as deluge of capital inflows have deepened the challenge of domestic central banks from pursuing their mandates. There is also a prominent role of global banks that channel cross border wholesale funding, which has become a crucial source of risk for India. This happens as international banks reallocate funds from their local offices to foreign intermediaries in response to domestic liquidity shocks (that may have occurred due the QE I and QE II programs).

Based on the similar VAR model developed in the previous section, we present the impulse response plots for the international dimension specification.

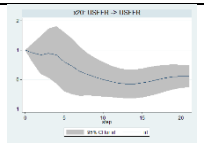
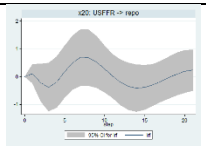
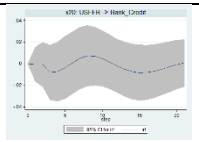
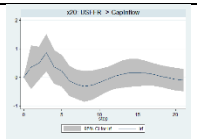
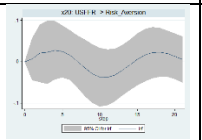
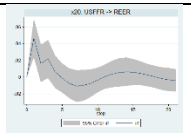
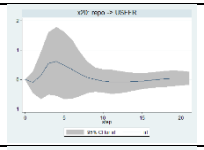
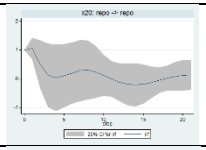
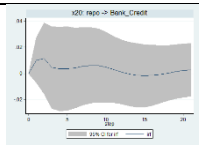
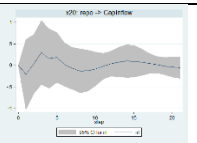
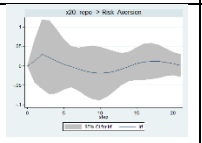
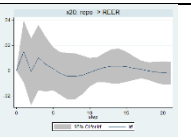
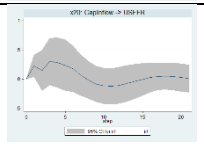
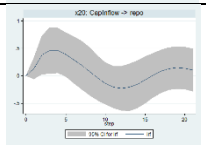
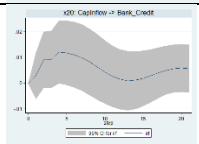
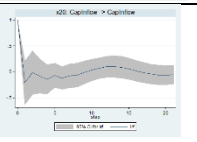
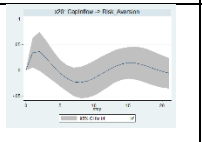
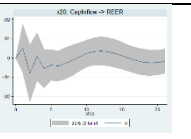
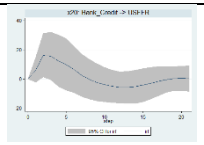
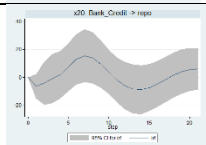
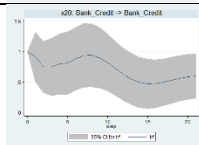
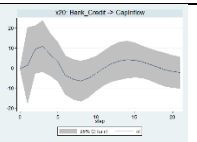
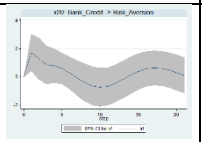
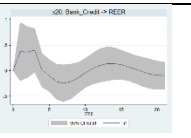
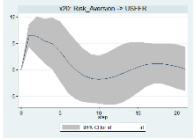
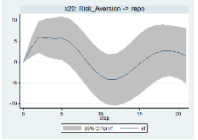
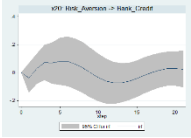
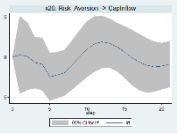
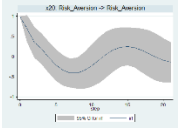
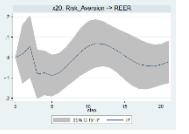
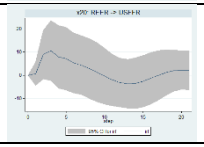
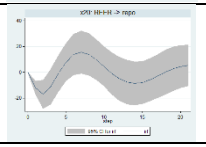
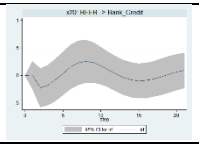
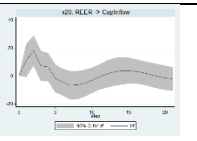
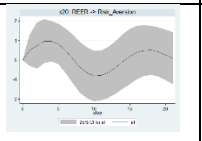
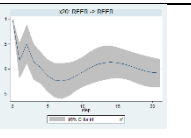
Recursive VAR	Ordering 1	2	3	4	5	6
	On USFFR	On Repo rate	On Bank Credit	On Capital Inflow	On Risk Aversion	On Rupee Dollar REER
USFFR						
Repo rate						
Capital Inflow						
Bank Credit						
Risk Aversion						
Rupee Dollar REER						

Figure 4.4: Impulse response functions for the international dimension in a recursive VAR system. This figure presents the IRFs for the international dimension (six-variable model: USFFR, (India) Repo rate, Capital Inflows (India), Bank credit, Risk aversion and REER) and 95% bootstrapped confidence intervals with one lag period again.

We append the domestic specification with USFFR as we clearly want to examine the role of ULIRPs by the US Federal Reserve. Further, capital flows through the cross-border banking system have formed a very substantive component of international debt flows. It is worth noting that Indian regulations for capital inflow are not completely open and prone to risk. This is because the capital inflow regulations lean more towards non-debt capital intake. However, there is reason to still expect a significant effect of this channel, as we examine further, owing to large increase in portfolio and credit flows.

The ordering of the variables are as follows: - *i)* USFFR; *ii)* Repo rate; *iii)* Total Capital inflow (log difference); *iv)* Bank credit (log difference); *v)* Index of risk aversion (RA); and *vi)* REER (log difference).

Figure 4.4 shows how capital inflows and REER are important channels of the risk-taking channel in the international dimension. We observe that a positive shock to the Federal Funds rate has a significant effect on risk aversion index in India, repo rate as well as banking sector credit. The effect on bank credit is more pronounced through the panel of REER and capital inflows on bank credit. A positive shock to total capital inflows into India causes bank credit to rapidly increase, reaching a maximum impact after 8 quarters. Furthermore, an appreciation of the REER causes bank credit to multiply, reaching a maximum impact of 0.26 after 16 quarters. Similar strong effects can be observed on risk aversion index. This indicates a prominent and significant medium-term impact of international channels of spillovers on Indian credit and risk environment.

4.6.4 **Variance Decompositions for the international dimension**

Variance decompositions of the international VAR specification corroborate the findings of the impulse responses. Indicated in Figure 7 below, USFFR explains more than 10% of impact on domestic monetary policy rate and nearly the same of total capital inflows into India. The Federal Funds rate also significantly impacts the level of domestic risk-aversion and thus can directly impact the investor risk

perception at both financial market level as well as in the banking sector. Finally, the effect of capital flows are found to be most significant, explaining nearly 20% of the movement in investor risk aversion. These findings indicate the criticality of the international spillover channels, where we find no channel to be insignificant on domestic outcomes. Interestingly, despite having controlled openness to capital intake, the capital inflow channel is found to have the highest impact on financial market risk environment.

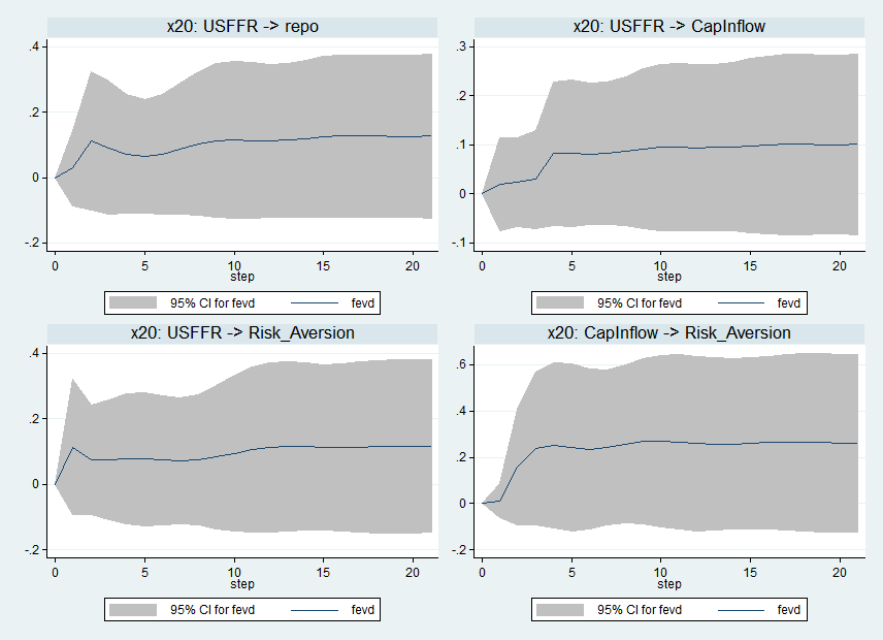


Figure 4.5: Forecast error variance decompositions of international VAR. The figure presents the variance decompositions from the international VAR specification.

4.7 Conclusion

The main contribution of this study is to incorporate the role of risk, banking sector and international spillovers in how they impact domestic monetary conditions in an EME like India. We discern different channels through which external monetary risk conditions impact monetary transmission in domestic markets through excessive exposure to risk and market volatility. The analysis confirms the findings presented in Adrian and Shin (2014), suggesting that cross-border banking flows

affect the extent of risk exposure to domestic financial intermediaries. India's rapid integration with the global financial cycle is reflected through the interactions between movements in international asset prices domestic risk premia of Indian investors. The exchange rate and global capital flows adding to the spillover of global financial and monetary conditions to India. Furthermore, credit creation within India and asset prices have strong relationship with external risk environment and monetary stance. The underlying premise being that the global financial cycle is significantly affected by the ULIRPs of the center country i.e. the US. In other words, Fed rate has important consequences on India's domestic stance in achieving its objective functions and restricts the independence of domestic monetary policy within India – thereby indicating the importance of better managing the capital account (directly, indirectly or via macroprudential policies).

The study discerns key channels through which impulses of international spillover impact the domestic monetary transmission process. Findings reveal significance of the role of the financial sector that acts as an interface between foreign spillovers and domestic monetary policy transmission. The primary contribution of this chapter is in emphasizing the role of international spillovers in the transmission of monetary policy through its impact on the financial sector. Study reveals that international spillovers significant determinants of the exposure to take risks, such that domestic monetary policy affects the real economy through increased risk taking in the financial sector and excessive bank credit.

The role of the excessive accommodative stance maintained by advanced economies raise pertinent questions for its impact on EMEs like India. This can be described as the extension of the risk taking channel of foreign monetary policy. Lenient credit conditions in the foreign banking system and increased risk taking the international financial markets get passed through to their counterparts in India. What can be commonly referred to as the impact of excess liquidity, these spillovers take the form of different channels like the capital flows, exchange rates, foreign policy interest rates and bank credit. Results indicate that the risk taking channel gives insights into the transmission of global liquidity conditions to emerging

markets. Studied for over a decade, the findings provide a benchmark for comparison at a time when two sectors i.e. banking sector activities and capital flow channels have been particularly strong in the global markets at different points in the sample period.

The effects of foreign shocks combine with changes in domestic risk premia and the credit growth of the Indian banking sector. However, in the new paradigm, it has become important to discuss the increased flow of capital and financial flows across borders[33]. Gertler and Karadi (2015) discuss how monetary policy transmission has an impact on credit costs that in turn affect economic activity. This research may be linked with the contribution of Rey (2015) – while one study discusses the role of US monetary policy in influencing capital flows that in turn affect monetary policy independence in individual countries; the other study by Gertler and Karadi (2015) discuss how international monetary policy can affect credit outcomes and therefore economic activity in individual countries.

4.8 **Way forward**

This chapter has discussed some ways in which emerging markets are affected the ULIRPs being maintained by advanced economies. We observe that failure of emerging markets like India to follow suit have come with a cost. As domestic interest rates diverge from negative rates, the interest rates, exchange rates as well as deluge of capital inflows have deepened the challenge of domestic central banks from pursuing their mandates. This calls for greater coordination among central banks to pursue similar stance of monetary policy. The role of forward guidance can also have a significant impact in hedging market from unexpected losses owing to international market uncertainty. Finally, the macroeconomic fundamentals of any country can be a safe cushion to prevent being hard hit in a volatile environment. While interest rates are a crucial tool for managing aggregate

[33] This context also addresses the work of Kenneth and Rogoff, who list out the degree of flexibility of exchange rate regimes in individual countries. For the case of India, Rogoff's paper declares India to have a flexibility of 2 (on a scale of 1 to 6 – 6 being most flexible exchange rate). Rey (2015) confirms that in presence of free capital mobility, the exchange rate role is limited, if not redundant.

demand, the role of macro-prudential reforms could significantly impact in managing risks.

A cross-country comparison of the implications of the risk-taking channel on emerging markets can make the analysis richer, enabling us to compare the effect on different EMEs and take lesson from what works for them. This branch of study is slowly catching up. Comparison of the effect on India with other countries would make a good study. (Benigno *et al.*, 2015 and Bua, 2016).

CHAPTER 5
BANK-RISK TAKING IN INDIA

5.1 Introduction

If banks are the veins of any economy, central bank is the heart. The banking system is inherently laden with risks with a fragile capital structure that undertakes great risks associated with excessive credit and bad loans (Diamond and Rajan, 2001a). Banks are therefore often faced with the threat of default or worse, shut down. To tackle this challenge better, banks tend to limit their risks by passing on their default risks to other players in the economy in order to avoid holding on to interest rate risks all by themselves[34] (Rajan, 2005). However, even as banks transfer their risk through bad loans and default risk sales, it does not completely eliminate risk from their balance sheets. Therefore, despite increased banking regulations in India with an aim to improving the capital structure, bank balance sheets and earnings have not necessarily become less risky. Needless to say, banks not reducing risks but transferring them to other players is a major concern for policymakers. To put it simply, bank risk might just be the tip of the iceberg, indicative of larger underlying or hidden risk tendencies among other financial market segments like the mutual funds markets, insurance markets etc. These risks and instability concerns were enough by themselves, the bigger concern arises out of fear the instability impacting the household sector or the real economy. Under these circumstances, what is the relationship between monetary policy and risk-taking by the financial intermediaries in a system? Do banks act as an interface between the monetary policy and the financial sector market?

The scope of this chapter deals with the open economy to examine how bank risk-taking and thereby, lending react to international spillovers. The phenomenon explored in this chapter subsumes the risk-taking channel of monetary policy that is especially prevalent in advanced economies that face low-for-long interest rates

[34] They pass on their risk to insurance and mutual fund companies that are engaged in searching for fixed flows of incomes.

as a consequence of accommodative stance in monetary policy. The banking sector of the model creates an important and new mechanism through which shocks propagate into our economy: movements in asset prices, nominal cost of borrowing and exchange rate can amplify the impact of external shocks by affecting the balance sheet of the banks.

Furthermore, banks today have more effective competition as they do not have much upside restrictions from buoying stock options, thus enabling them to play with the limits of liquidity. The landscape of banking in India is more risky now that we have increased competition among banks. In this context, Rajan (2005) suggests cycle-proof regulations and argues for "countercyclical" monetary stance[35]—raising bank cost of private borrowing and capital requirements significantly in good times, while allowing them to fall somewhat in bad times[36]. However, can counter-cyclicality of monetary policy prevent Indian banks from increasing risk and giving out bad loans? What role of external shocks play in determining the balance sheet responses of banks?

The analysis unfolds in the following manner. Section 5.2 illustrates the background that motivates the analysis on bank-risk taking in an open economy framework. Section 5.3 discusses bank risk-taking and credit in Indian economy. Section 5.4 provides details of the BSR statistics of Indian scheduled commercial banks. Section 5.5 gives the econometric model used for the analysis, followed by a detailed analysis of the results. Section 5.6 gives the robustness and finally, section 5.7 concludes. Section 5.8 discusses the limitations and way forward.

5.2 **Risk-Taking among Banks**

The idea is to analyse the micro-foundations of financial intermediaries (banks) within the transmission process of monetary policy by integrating the financial sector into the transmission model. The role of financial intermediaries in monetary

[35] By the use of counter-cyclical capital requirements.
[36] He focuses on the changes in incentives due to broader financial market participation. In other words, changes in financial sector alter managerial incentives, which in turn have affect the nature of risks undertaken in the system.

transmission is of dual significance - *i)* for understanding financial stability and central bank agenda, and; *ii)* to understand global experiences with crises in which financial markets played a central role. This chapter examines how bank risk-taking is potentially affected by shocks in monetary policy, both domestically and internationally; and, *iii)* do individual bank-specific characteristics determine how risk-taking reacts to shifts in monetary policy and spillovers?

Banks play a significant role in monetary policy transmission. According to past literature, bank responses to changes in monetary policy through occurs through changes in loans, securities and non-deposit resources as discussed in Kashyap and Stein (1995). Central bank-driven interest rates are followed with adjustments in balance sheets of banks. The focus of this study is on the bank lending behaviour in a way that attributes the effects of monetary policy to movements in supply of bank credit. Through this mechanism, banks acquire a significant role in the transmission of monetary policy inkeeping the role of the financial sector.

The Indian economy is heavily reliant on bank finance (in comparison to many other countries like the US). In addition, the financial structure in India is such that the corporate sector also is highly dependent on banks for their loan financing. While many of these issues have been studied at the aggregate level, doing so does not provide clear conclusions due to the wide confidence intervals that are associated with macro time-series estimates. In this chapter, we ask whether there exist distributional effects of monetary policy on different types of banks? In other words, do individual bank characteristics determine how they react to monetary policy?

Levels of monetary policy can affect bank risk-taking in at least two specific ways:

1. Monetary policy affects bank valuations, incomes and cash flows, which modify how bank measure risk; and

2. Impacting bank incentives to take on greater risk for behavioural, contractual and institutional reasons - with a view to meet their target nominal returns

Bruno and Shin (2014) discuss the significance of studying the link between monetary policy and the perception of risk and how it can be priced by economic agents in an economy. The primary channel through which monetary policy impulses affect aggregate expenditure was through its impact on relative yields of imperfectly substitutable assets.

Analysing bank risk-taking in an open economy framework has not been explored much for India. We undertake this analysis as it is relevant for an emerging market like India - where banks play the most significant role in providing finance. We also examine whether monetary policy influences each individual banks' risk position over and above the systemic considerations in the economy. We measure the default probabilities of individual scheduled commercial banks in India to see how they are impacted by shocks in monetary policy rates. Correlation table of all variables are provided at the end of the chapter.

5.3 Bank Risk-Taking and Credit in India

The role of commercial banks in monetary policy transmission has been incorporated in the credit channel of transmission, though it is no substitute for the interest rate channel (Bernanke-Blinder, 1988). This chapter delves into the issue of bank risk-taking that has an impact on bank credit. We investigate the relationship between monetary policy and risk-taking by banks which further impacts bank credit. The supply of loanable funds by banks is dependent on the risk-taking exposure by banks, which in turn is linked with the monetary policy. This focus on the banking sector is with a view to analyze the role of credit in facilitating economic activity more broadly. While it is difficult to incorporate the role of credit in the transmission and general equilibrium model, it is equally crucial to understand the credit risks being faced (Ray, 2008).

While the previous chapter in this thesis focussed on the overall riskiness in the economy and the impact of monetary policy in risk-taking by overall financial

markets, this chapter examines how Indian scheduled commercial banks are affected by examining their probability of default (one-year horizon) in relation with the monetary policy stance maintained by the RBI. While it is difficult to articulate that monetary policy is alone responsible for the changes in lending behaviour by banks, it majorly affects supply of loans and the risk-taking by individual banks. The changes in bank-risk taking affect bank risk-taking behaviour that are examined in detail using the micro-foundations of bank balance sheets. Changes in central-bank interest rates could induce financial imbalances by altering the risk aversion by banks and other investors in the economy.

The contribution of this analysis is to establish evidence of the same to investigate how the risk gets adjusted in the bank balance sheets and affects bank lending behaviour. The contribution of this chapter can be seen in two steps: First, to investigate the whether the stance of monetary policy affects the risk-taking level of individual banks by assessing their probability of default; and second, to examine how supply of loanable funds change in response to changes in monetary policy stance. The analysis is carried out for the Indian economy in the short run time horizon.

5.4 DATA – Banking Statistical Returns of Indian Banks

This chapter takes a domestic perspective and focuses on the banking sector by relying on publicly available balance sheet data of individual scheduled commercial banks obtained from the RBI. The data sample comprises annual balance sheet information taken from the Banking Statistical Returns of Scheduled Commercial Banks in India, Reserve Bank of India during 2005-2015. The BSR data series provide detailed balanced sheet information of all scheduled commercial banks. The dataset is an unbalanced panel. The data set is a micro panel appropriate for measuring short term impact of policy changes on bank risk. The data set is an unbalanced panel that includes balance sheet information of all scheduled commercial banks in India. The analysis excludes Regional Rural banks (RRBs) from the study and limits to individual scheduled commercial as they can tend to

bias the model results, particularly when the aim of the study is to examine the impact of international effects on bank tendencies to take on greater risk owing to imbalances in financial and monetary conditions.[37] We provide a pictorial representation of the Indian banking structure in the Figure 5.1 below.

We select the time period between 2005 and 2015 for the following reasons: *i)* the measure of probability of default (calculated as the ratio of gross NPAs over total advances) is not available for a large number of banks prior to this period, due to non-reporting of their non-performing assets; and *ii)* we use the risk aversion proxy (as calculated in Chapter 3), which forms a crucial component of the model specification used in the chapter is only available from 2005. Further, the variables chosen in for the econometric analyses are based on the following aspects: *i)* availability of data common to all years in the sample; *ii)* common base period for entire sample period[38]; *iii)* relatively significant impact of international spillovers on Indian economy through different channels; *iv)* domestic factors in India that potentially influence financial risk and bank risk-taking; and *v)* individual bank-specific characteristics that influence bank risk. For the sake of comparison, the variables used in this chapter are taken at constant prices and not current prices, keeping 2004-2005 as the base period. Also, variables that are available in greater frequencies have been aggregated to annual form[39]. A list of all variables used in the analysis in this chapter are provided in the Appendix at the end of the thesis.

We perform the analysis of this chapter individually for every bank group operating in India i.e. nationalized banks, private sector banks, foreign banks and SBI and all its associate banks.

[37] Excluding RRBs from the analysis was also suggested by referees in RBI.
[38] Many variables (or sections of variables) that were not in 2004-2005 base price have been used in the study by converting them from current prices to constant prices.
[39] Variables like VIX, risk-aversion index, uncertainty data, monetary policy variables and ten-year government securities yield rates etc.

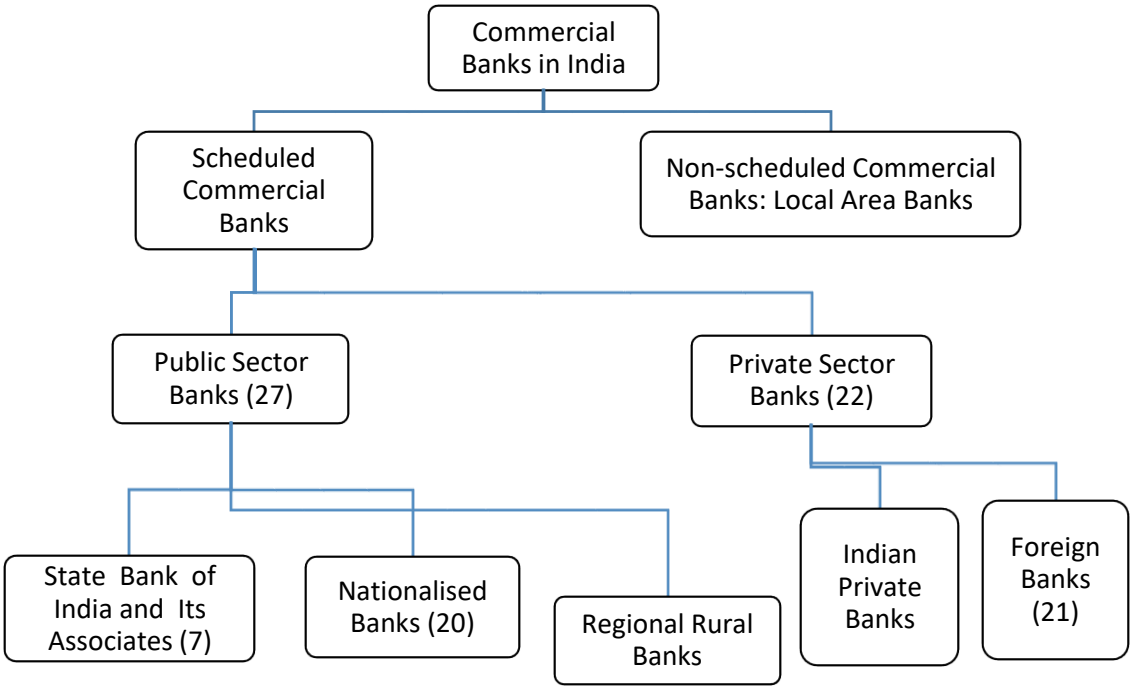


Figure 5.1: View of the banking structure in India. The image shows the breakup of public and private sector banks. The public sector banks are divided into nationalized banks, SBI and associate groups and RRBs. The private sector banks are divided into foreign banks and Indian private banks.

5.4.1 Criteria for dropping banks from panel

1. Banks that do not report NPA for more than two years are dropped from the panel. This process ensures the usefulness of using NPAs as an indicator of assessing the probability of default and helps overcome any errors that may arise due to insufficient NPA disclosure. It is noteworthy, that this problem was observed mainly with foreign banks, indicating that the remaining banks are conforming well to the disclosure regulations by the RBI.

2. Banks for less than three years of data are removed. This is done as we want to include the role of a crisis dummy to see how bank risk is responding to crisis and compare the effects with changes in monetary policy.

5.5 **Econometric Model and Results**

It is challenging to measure any direct impact of international financial sector spillovers on domestic bank risk-taking. One way of understanding this impact is by conducting the analysis in two sub-parts i.e. in the domestic (closed economy model) and the open economy model. Our analysis considers various closed as well as open-economy factors that potentially determine the capacity of banks to undertake risks. We broadly categorize these variables that may impact bank risk-taking as follows:

i) Changes in domestic macroeconomic and financial sector;

ii) Deviation of monetary policy stance from a prescribed rule-based policy;

iii) International spillover channels; and,

iv) Individual bank-specific characteristics

Consider a scenario when policy rates are lowered. This could have a dual impact on bank risk. In one way, there could be a positive effect in the form of direct expansionary effect on lending portfolios. In this scenario, a reduction in interest rates below the equilibrium rates can have a positive effect on the lending portfolios as individuals and firms have to now pay a lower interest on their mortgage and loans – thus making repayment easier which in turn implies that the default probability declines. The second effect, though indirect could be a negative effect, as banks' risk-taking tendency increases due the 'search for yield' attitude among investors. We capture this increase in tendency as measured by their probability to default. Seen in the context of the international markets, the reduction in foreign rates owing to unconventional monetary policy and accommodative monetary stance causes investors to seek higher interests in the financial markets outside their own. (Adrian and Shin, 2010). This well explains the influx of massive capital inflows into an emerging market like India, particularly in portfolio flows. While it is true that majority of capital flow in India is non-debt creating (Mohan, 2008), this implies larger magnitude of portfolio flows that directly impact the financial

sectors. Further the changes in the value of the domestic currency are further likely to have an impact on bank decisions.

When we discuss the outcomes of bank risk, there are two possibilities of risk: *i)* higher riskiness on outstanding loans, and; *ii*) new risk i.e. risk by banks on new advances. This poses an identification problem – whether the level of interest rate would have a positive or negative impact on bank risk? This nature of impact depends on the benchmark level of interest rate using which we can assess the stance of interest rates. Following Altunbas et al. (2009), we tackle this problem by computing different benchmark levels of interest rates using the Taylor rule (Taylor, 2001).

The Taylor rule is a feedback rule that proposes a simple technique to set monetary policy. According to this rule, the monetary policy interest rate can be expressed a function of $f(\pi_t - \pi_t^*, y_t - y_t^*)$, i.e. as a positive function of difference between the inflation gap and output gap. Here, the inflation gap is the difference between inflation (π_t) and its target inflation level (π_t^*), and the output gap is the equivalent for the output (y_t and y_t^* respectively). While this chapter deals with a simple form representation of the Taylor rule, there is tremendous scope for research in how this rule can be best adapted to suit the Indian markets[40] (Refer Singh, 2010 and Mohanty, 2013).

Chart 5.2 shows how the Taylor rule for Indian markets shows a wide difference between the benchmark and prevailing monetary policy rates[41].

[40] Singh (2010) and Mohanty (2013) reveal the limitations in using the Taylor rule, particularly for emerging market economies like India.

41 As a part of the discussion on rule versus discretion based monetary policy actions, we often find opposing arguments in favour of and against the use of rule-based monetary policy regime like the Taylor rule. Some arguments again use of such a rule suggest India is very complex economy and that use of any strict rule would not be best suited to our economic landscape. However, alternate arguments in favour of using a rule-based policy talk in support of having a credible commitment by the central banks that can guide inflationary expectations better.

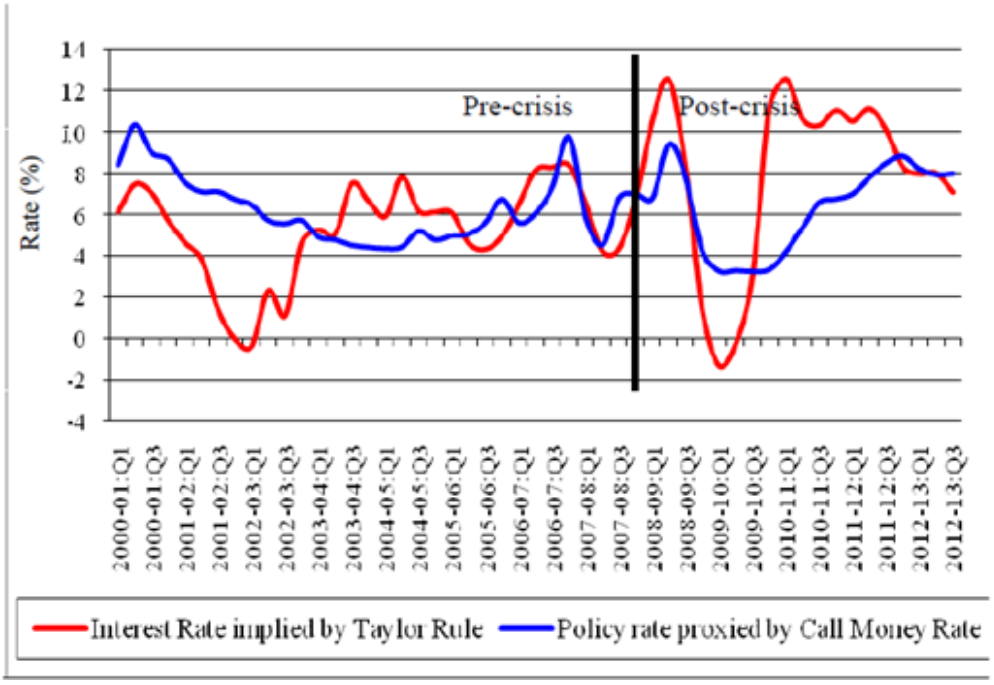


Figure 5.2: Comparison of Call Money Rate versus interest rate implied by Taylor rule. Mohanty (2013).

While the scope of this research does not delve into addressing the issues of estimation of the rule, we utilize the Taylor Gap as an important tool to examine how movements in central bank policies, both domestic as well as international, can impact bank outcomes and risk-taking in particular. The advantage of using the Taylor rule gap for the Indian context is that it allows us to capture effects of changes in monetary policy rates that are not limited to a reduction alone. That is, we capture the deviation of policy interest rate from the prescribed Taylor rule rate to assess whether banks respond to the gap. The main proxy used in this analysis for domestic monetary policy stance is the short-term nominal repo rate. The Taylor rule gap measures are used a supplementary measures of monetary policy to examine whether deviation from the benchmark rule affect bank risk-taking tendencies. Before we explain the framework used in this analysis, it is worth noting that the use of the Taylor rule gap in this analysis has not been done to prescribe to a rule-based framework for monetary policy, but as a general benchmark to gauge the deviation of the current policy stance from the prescribed rule. This enables us to capture the expectations of the market sentiments and

understand how a deviation or gap from the rule may impact bank behaviour and tendencies. For the sake of this analysis, we consider a rule that assigns more weights to inflation and less to growth, based on the monetary policy stance maintained by the Indian central bank that primarily focuses on an inflation targeting approach, as evident from the chronology of policy announcements made by the RBI over the last decade.

Algebraically, the simple form of Taylor rule can be represented as follows[42]:

$$i_t = r_t^* + \pi_t + \beta\pi(\pi_t - \pi_t^*) + \beta_y(y_t - y_t^*)$$

Where, 'i_t' is the short term nominal rate of interest, 'π_t' is the level of inflation and 'π_t^*' is the desired or target level of inflation, 'y_t' is the output or real GDP growth rate, 'y_t^*' is the potential level of output or the potential real GDP growth rate. The weights used on inflation and output gap, '$\beta\pi$' and 'βy', are assumed to be 0.8 and 0.2 respectively.

Using the Taylor rule, we examine the relative stance of domestic monetary policy against an estimated benchmark level. We use the primary instrument of monetary policy i.e. the repo rate, which has been the primary instrument used by the RBI since 2001. We follow three measures to estimate the benchmark levels[43]:

i) Measuring the difference between real short-term rate of interest and the natural rate of interest – computed using Hodrick-Prescott filter (NRGAP);

ii) Measuring the difference between nominal short-term monetary policy rate of interest and the rate generated by the Taylor rule, using equal weights on both inflation and output gap both (TR_GAP1);

iii) Measuring the difference between nominal short-term monetary policy rate of interest and the rate generated by the Taylor rule, using different weights for

[42] Here, the interest rate smoothing parameter (γ) is taken to be zero.

43 There are several alternate variations to the use of Taylor rule. These include the Taylor-McCallum type rule, forward-looking Taylor rule, non-linear framework. Such alternatives attempt to address the time-varying nature of its parameters and asymmetric behaviour of central bank policies.

inflation and output gap both. We choose to apply different weights owing to the inflation-targeting mandate of the RBI[44] (TR_GAP2).

We now turn to understanding probability of default for all categories of scheduled commercial banks. An important contribution of this chapter is to analyse different categories of bank groups separately. As shown in Figure 5.1 above, different bank groups operating in India are nationalized banks, private sector banks, foreign banks and SBI and all its associate banks. To bring out robustness of the model findings, we analyse each category separately. Bank risk-taking is examined in domestic context by investigating the effects of risk and monetary conditions in the domestic as well as an open economy framework. In both sections, we analyse two aspects: Bank risk taking control for bank specific characteristics and in response to risk conditions in the economy. For both, closed and open economy framework.

5.5.1. **Domestic Model**

We use a dynamic panel for probability of default of Indian scheduled commercial banks. In the baseline model given in equation (1), annual changes in the Probability of Default (*PD*) of individual Indian banks *i* in the year *t*, are regressed on changes in the short-term nominal interest rate set by the monetary policy (*MP)*, the Taylor rule gap (*NRGAP*), the nominal GDP growth rate *(GDP)* and the steepness of government-securities yield curve (*SLOPE*). We also introduce a crisis dummy in the model *(CD)*. The baseline empirical model used in this chapter is as follows:

$$\Delta PD_{i,t} = \alpha \Delta PD_{i,t-1} + \sum \beta_j \Delta MP_{t-j} + \sum \gamma_j \Delta TaylorGap_{t-j} + \sum \delta_j \Delta GDPN_{t-j} + \sum \lambda_j SLOPE_{t-j} + \sum \Phi_j CD + \varepsilon_{i,t} \quad (1)$$

where $i = 1,...,N$ and $t = 1,...,T$. '*N*' denotes the number of individual scheduled commercial banks and '*T*' is the time period (annual). We also include a dummy variable that takes value 1 for the crisis year of 2008. The dynamic model is

44 We use a weight of 0.8 for inflation gap (βπ) and 0.2 for output gap (βy).

dependent on its own lagged variable. That is, we include a lagged variable of the probability of default. Including this lagged dependent variable that can be correlated with the disturbance term causes complications in the model. For this purpose we estimate the dynamic model using the GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). Using this GMM estimator ensures efficiency as well as consistency in the model. We also check for presence of serial correlation in the model (of order 2) and validity of the instruments are examined using the Sargan test.

Summary statistics for all variables used in the model specifications are provided at the end of the chapter in Table 5.2. Given that there have been numerous banking regulatory interventions by the Reserve Bank of India over the years, the time period effects in the model are estimated as coefficients of time dummies for each year in the data. Some of these include capital adequacy norms and bankruptcy laws etc. This first specification assumes the individual bank-specific effects to be fixed that are modelled ahead in the second specification as given in Equation (2).

The changes in banks' probability of default are typically linked with the macroeconomic environment in the country that impact the intermediation activity of banks. Similar to Altunbas et al (2009), in the first model specification we relate changes in bank probability to default to only country-specific macroeconomic determinants, assuming that bank intermediation activity is majorly done towards residents.

The main results are reported in Tables 5.3 to 5.6 for each category of banks. Results show that, ceteris paribus, effect of changes in short term domestic monetary policy rates (*MP*) have a positive effect on bank risk-taking, indicated by the positive effect on bank probability to default. As central bank lowers its policy rate, the overall quality of loan portfolio is expected to increase (as we can expect that banks' default probability reduces their risk-taking reduces). The findings are consistent with that of Altunbas et al. (2009) and Jimenez et al. (2009) who find that a reduction in interest rates helps in reducing the credit risks of outstanding

loans and advances by banks. Such a decline in probability to default can be envisaged to due to fall in bank liquidity and marginal costs as the policy rates are transmitted to banks.

The relation between bank risk-taking and *NRGAP* is positive. This reflects the expectation among all banks for central banks to reduce interest rates, particularly relevant for the time period being considered for Indian markets. In other words, as central banks fail to lower rates as expected by commercial banks, they tend to take on greater risks by investing in risky portfolios in their search for better yields.

We observe the coefficients for ΔGDP are negative. This indicates that as economic conditions improve in the economy, banks' incentive for risk reduces, owing to better opportunities for good loans and investment projects that boost the credit portfolios of banks. Higher growth rate of GDP reduces the credit risk and bad loans in the economy, except foreign banks where the coefficient is not significant.

The coefficient for *SLOPE* are negative. This implies that as the steepness of the yield curve increases, it tends to reduce bank risk-taking. To explain it simply, as government securities offer a higher yields and bank profits tend to start increasing due to a steeper yield curve. Across every category of banks studies in our sample, banks have longer maturity assets than their liabilities, also known as maturity transformation function of banks, they tend to reduce their risk-taking as the yields go higher.

We now try to improve our model specification in Equation (1) by including individual bank-specific characteristics. The link between monetary policy and bank risk-taking capacity is also dependent on idiosyncratic features of individual banks. We include bank specific characteristics following Kashyap and Stein (1995) variables to proxy bank size, liquidity and capitalization. Further, we also improve the specification by adding controls for bank profitability (explained below).

$$\Delta PD_{it} = \alpha \Delta PD_{i,t-1} + \sum \beta_j \Delta MP_{t-j} + \sum \gamma_j NRGAP_{t-j} + \sum \delta_j \Delta GDPN_{t-j} + \sum \varphi_j SLOPE_{t-j} + \\ + \omega SIZE_{i,t-1} + \tau LIQ_{i,t-1} + \pi CAP_{i,t-1} + \vartheta_j ROA_{i,t-1} + \varphi_j CD + \epsilon_{i,t} \quad (2)$$

Where $SIZE_{i,t-1}$, $\tau LIQ_{i,t-1}$, $\pi CAP_{i,t-1}$ and $\vartheta_j ROA_{i,t-1}$ are the bank size (log of total assets), liquidity (ratio of securities and liquid assets over total assets), capitalization (capital-asset ratio), and return on asset, respectively. These specifications are based on characteristics discussed in Kashyap and Stein, 1995. All individual characteristics are taken in lagged form to avoid any endogeneity bias in the model.

As banks' receive higher returns on their assets, they have lesser incentives to engage in risky loans or projects. Thus, as bank profitability increases, their incentive to give out risky loans reduces, giving a negative coefficient for *ROA* across all groups of banks. The characteristics of size, liquidity and capitalization, however, do not yield common results across all bank groups.

Financial intermediaries borrow in order to lend, as they follow the principle of borrowing short and lending long. In the Indian context, the financial system is bank-oriented, as the majority of financial intermediaries are made up of scheduled commercial banks. We find that capitalization *(CAP)* for private sector banks and nationalized banks is either positive or insignificant. This indicates the likelihood that small national banks as well as private banks are capital constrained. We also observe that the capitalization coefficient is negative for foreign banks. It is important to understand that these foreign banks are only subsidiaries in India and that their behavioural tendencies would be typically dependent on their head office balance sheet conditions abroad. If the head office is impacted by foreign risk conditions, the subsidiary in India too would be affected adversely. However, the capitalization for SBI and associate groups is positive. However, the same is not true for SBI and its associates, which yield a positive coefficient for capitalization. SBI is the largest public sector bank group in India and is owned by the government. The positive coefficient here indicates the government's decision to invest in long-

term risky projects like infrastructure etc. based on government's liquidity requirements, thus placing a constraint on a public sector bank like SBI to perform in market-determined loan markets. Further, the coefficient for bank profitability *(ROA)*, which is negative for all groups, determines bank lending and impacts the present value of bank incomes, thereby affecting the capital-asset ratios. Improved capital-asset ratios provide lesser incentives to these bank groups to engage in risky loans. This indicates sound regulatory effectiveness amongst bank groups. The coefficient for liquidity (*LIQ*) is positive across all bank groups indicating that the more liquid the bank, the market price of bank risk increases as they tend to undertake greater risks for each category of banks.

The coefficient for bank *SIZE*, however, reveals interesting results. For nearly all categories of banks, the size of the bank balance sheet is found to be insignificant. In other words, larger banks are not necessarily protected by the size of their balance sheets from taking excessive risks, thus dismissing the too-big-to-fail hypothesis for the banking system within India. While this phenomenon does indicate a need for more development of the banking system, this also reveals that the Indian banks capacity to take risks is not conditioned on its size, but on factors such as competition, regulation and overall governance. Size, if at all, significant, is so due to arbitrage concerns, and not size of the balance sheet itself.

We also add for domestic risk (*RISK*) component to see how it impacts bank-risk taking. Including a component for domestic risk establishes a non-linear link between the financial system in India and the behaviour of financial intermediaries (Borio and Zhu, 2012). We use risk-aversion index computed by us (as described in Chapter 3). The advantage of using this index of risk aversion is that we can decompose the bank risk into two components – *i)* idiosyncratic bank risk that is specific to the bank activity and characteristics, and *ii)* systemic (market wide) risk environment:

$$\Delta PD_{it} = \alpha \Delta PD_{i,t-1} + \sum \beta_j \Delta MP_{t-j} + \sum \gamma_j NRGAP_{t-j} + \sum \delta_j \Delta GDPN_{t-j} + \sum \varphi_j SLOPE_{t-j} + \sum \mu_j \Delta RISK_{t-j} + \omega SIZE_{i,t-1} + \tau LIQ_{i,t-1} + \pi CAP_{i,t-1} + \vartheta_j ROA_{i,t-1} + \varphi_j CD + \epsilon_{i,t} \quad (3)$$

The coefficient for *RISK* is negative. A fall in the risk aversion index implies that the financial conditions have become more risky. As this happens, a negative coefficient means bank also reflect domestic financial conditions of risk and increased risk-taking. This implies an increase in bad credit in the economy as investors become prone to higher risks. In the domestic context, an increase in bad credit is also reflected by the increasing trend in NPAs among banks. In the post crisis period after 2008, the rise in NPAs was attributed to excessive fiscal stimulus in the economy to stimulate demand, and also reflects a glitch in regulatory effectiveness. Furthermore, we find mixed results as nationalized and SBI group banks are responsive to domestic financial market risk, foreign banks and private sector banks are not. This trend indicates high level of foreign ownership amongst these two bank groups in India, thus being more responsive to changes in the international risk conditions, as we explore in the next section.

5.5.2. **Open-Economy Model**

The aim of this exercise is to examine relationship between change in bank probability to default to domestic intermediation activity as well as international activities. The motivation behind this research is that international market conditions could be just as important as domestic market conditions and bank-specific characteristics in affecting intermediation activity for an emerging market like India. The specifications in the previous section assume the international markets do not have an impact on bank risk tendencies, overlooking the possibility that bank activities may also be affected by international markets and spillovers. One way to examine whether the international channel would be significant or not, is if we observe a less significant link for the model given in equation (1). In other words, the link between individual banks' probability of default would be less significant when limited to the domestic macroeconomic environment, owing to absence of international market specifications. Interestingly, we find this is indeed the case, as the model is not significant. As we observe in some instances, some group of banks are not highly responsive to changes in domestic risk, growth and

risk-free bond yields. This establishes a premise for us to explore the existence of an impact by international spillovers on bank risk. Much relevant to the 'new paradigm' discussed through this thesis, we can expect the monetary policy rates of US economy to have an effect on Indian outcomes through its impact on capital flows and currency movements. Therefore, we control for the *USFFR* to account for capital flows and exchange rate movements. The next specification helps us examine whether the risk-taking prevalent in the advanced economies, owing to the excessive monetary easing, can extend its spillover to risk-taking at the individual bank level in India. We extend the model to an open-economy framework. As discussed in Chapter 4, the main channels through which international markets can impact domestic outcomes – the policy rate channel, exchange rate channel and portfolio channel. Introducing these effects, the model can be specified as:

$$\Delta PD_{it} = \alpha \Delta PD_{i,t-1} + \sum \beta_j \Delta MP_{t-j} + \sum \gamma_j NRGAP_{t-j} + \sum \delta_j \Delta GDPN_{t-j} + \sum \varphi_j SLOPE_{t-j} + \sum \forall_j \Delta USFFR_{t-j} + \sum \exists_j \Delta REER_{t-j} + \sum \propto_j \Delta Kflow_{t-j} + \sum \mu_j \Delta RISK_{t-j} + \omega SIZE_{i,t-1} + \tau LIQ_{i,t-1} + \pi CAP_{i,t-1} + \vartheta_j ROA_{i,t-1} + \varphi_j CD + \epsilon_{i,t} \quad (4)$$

We use the US Federal Funds rate as a proxy for the foreign policy interest rate. The capital flows are used as a proxy for the portfolio flows across borders (Bruno and Shin, 2013), and REER is used as the proxy for movements in exchange rates. The crisis dummy is assigned a value of 1 for the years 2008, 2011 and 2012 where the accommodative monetary policy stance was prevalent and the quantitative easing programmes were rolled (*QE I and QE II)*, thus pushing the US economy to a zero lower bound and slow growth phase.

The model gives out results that indicate a strong presence of international spillover of the risk-taking channel. The foreign policy interest rate channel is found to be highly significant for all groups of banks in India. The coefficient for USFFR is negative that corroborates with our understanding of the risk-taking channel. A negative relationship implies that as US Fed rates remain low and accommodative for long, it increases the bank risk-taking in an emerging economy like India. The

movement in rupee-dollar exchange rate *(NEER)* also yields a negative coefficient, indicating a rise in bank risk-taking as the rupee depreciates against the US dollar.

Another way to explain the presence of international risk-taking channel is through the movement in capital flows. We find a positive relation between bank risk-taking and capital flows into Indian economy. This channel is again highly significant for all groups of banks. A positive relation implies that as more capital enters Indian markets in their 'search for yield', it causes a liquidity effect on banks as they tend to become more risky. As also observed within the domestic framework, higher liquidity makes banks riskier as they give out more bad loans. These findings indicate presence of cross-border capital flows that flow in search for higher yields owing to the low-for-long interest rates in advanced economies i.e. due to the risk-taking channel of monetary policy[45] as observed in Adrian and Shin, 2014 and Borio and Zhu, 2012. This is a crucial component that proves the spillover of the risk-taking channel into emerging markets, giving evidence how Indian banks become more prone to risk taking despite a steeper yield curve in government securities. Findings are also common for all categories of banks. The larger the inflow of capital into the economy, the greater is the risk-taking capacity of banks.

We add another variable for international market volatility as follows:

$$\Delta PD_{it} = \alpha \Delta PD_{i,t-1} + \sum \beta_j \, \Delta MP_{t-j} + \sum \gamma_j \, NRGAP_{t-j} + \sum \delta_j \, \Delta GDPN_{t-j} + \sum \varphi_j SLOPE_{t-j} + \sum \forall_j \, \Delta USFFR_{t-j} + \sum \exists_j \, \Delta REER_{t-j} + \sum \propto_j \Delta Kflow_{t-j} + \sum \partial_j \, \Delta GVIX_{t-j} + \omega SIZE_{i,t-1} + \tau LIQ_{i,t-1} + \pi CAP_{i,t-1} + \vartheta_j ROA_{i,t-1} + \varphi_j CD + \epsilon_{i,t} \quad (5)$$

Finally, we augment the model specification with a global proxy for risk i.e. global volatility index. We find similar a similar negative relationship with bank risk-taking, as we did in the domestic risk, implying that banks respond to risk conditions across the global markets for all categories.

[45] The risk-taking channel of monetary policy is in reference with the global accommodative monetary stance maintained by advanced economies, particularly the US economy. The same is not reflective of Indian monetary policy, but only those central banks that face a zero lower bound problem. In this study, we consider USA as the core economy of the impact of this channel.

Regression results for all the specifications are provided in end of the chapter.

5.6. **Robustness**

To augment some specifications in the model, we also add another variable of uncertainty in Equation (3). We add uncertainty in our model to distinguish between financial market risk conditions and overall economic uncertainty in the economy. The proxy used here is the Economic Policy Uncertainty (EPU) index provided by Baker, Bloom and Davis (2015). We find the model is robust and bank risks are responsive to domestic financial risk conditions, even when we control for macroeconomic uncertainty. This index on uncertainty is taken from the Baker, Bloom and Davis, 2015.

To proxy for alternate risk conditions, we replace the risk aversion index with global volatility index (VIX). With the exception of private sector banks, we find the results are be consistent on their impact on bank risk-taking. This robustness check is not only consistent with the model specifications used in the study, but also proves the correctness of the risk aversion index computed in Chapter 3.

Finally, we also use alternate rates of interest for both Indian and US policy rates. We use CRR as a substitute for the policy repo rate. As alternatives to the US Fed Funds rate, we proxy the policy rate with Treasury Bills rate for the US economy and also the bank lending rate. Further, we also test the models for alternate measure of the Taylor rule gaps (TR_GAP1 and TR_GAP2). Results are found to hold true for all alternative specifications. The fact that the Taylor rule gaps are found significant in our models is important for two reasons: *i)* this validates the findings that low for long accommodative policy interest rates in the US adversely affect risk outcomes and bank risk-taking in India. These results are consistent with the findings of the risk-taking channel for advanced economies, though the Taylor rule suggestions are in opposite directions for advanced economies versus India (where Taylor rule suggest higher rates for the US, it mainly suggests a reduction

in rates for India); and, *ii)* within the Indian context, the significance of bank-risk to the positive gap suggests that the gap is as valid for banks when interest rates are not being lowered. This suggests that central banks not reducing rates to control inflationary pressures has perverse effects on bank risk-taking that ultimately lead to bad loans in the economy, thereby increasing risky lending and overall risk.

5.7. **Conclusion**

In the previous chapter, we explored different channels of international spillovers that affected the transmission of domestic monetary policy through its impact on the financial sector risk. Exploring this result further, this chapter focuses on the relationship between monetary policy and the bank risk-taking tendencies, in the presence of spillover effects from the international markets. In this chapter, we discern the impulses of bank risk-taking behaviour by examining disaggregated behaviour of all scheduled commercial banks in India. We find support in evidence of a differential impact of monetary policy changes and international spillovers across different bank groups. We consider four categories of scheduled commercial banks in India based on ownership – nationalized banks, private sector banks, SBI and all its associate banks and foreign banks. We also control for individual bank characteristics namely bank size, liquidity, capitalization and bank profitability for each category of bank. The study examines the impact on risk-taking in these banks in response to changes in domestic monetary policy as well as external shocks considered in the previous. Results indicate a strong evidence of risk-taking tendencies across banks due to domestic and external market risk conditions as well as monetary policy movements.

We divide our analysis of bank risk into two components – open economy framework and the closed economy. In the domestic context, bank risk taking has a procyclical relationship with the policy interest rate, risk-free rate and the GDP growth rate. Bank risk also moves in tandem with risk conditions in the domestic financial sector, indicating increased integration of financial intermediaries with financial sector markets. This phenomenon may be a cause of concern as it indicates

the use of bank capital for carrying out financial sector reforms like revamping the derivatives and equity markets, stressing the need for more prudential regulation. Furthermore, ownership and individual bank characteristic emerge as determining factors in assessing their responsiveness to domestic risk, macroeconomic and monetary conditions. Bank ownership, liquidity, capitalization and bank profitability are significant. Interestingly, the size of the balance sheet is not a significant factor in determining bank price of risk With the exception of SBI and associates, we find that the market price of bank risk increases within banks that are more liquid and have greater capitalization, irrespective of the size of their bank balance sheet. Further, we observe the bank profitability has an inverse relationship with bank risk across all groups of scheduled commercial banks in India.

In the open-economy framework, there is evidence of differential impact of four channels of external shocks. The study reveals a strong presence of international spillover of the risk-taking channel on financial intermediaries in India. Bank risk conditions in India tend to be highly responsive to movements in policy interest rates of the US Federal Reserve. In the post 2008 era, this trend took shape in the form of excessive monetary accommodation and quantitative easing by the U.S. economy. This finding confirms an adverse effect of the ultra-low interest rate policies in the U.S. and exchange rate movements on domestic bank risk capacity. While their effect may not be direct on bank risk, the phenomenon can be understood through excessive flight of capital into India, worsening bad credit conditions and rise in bank risk capacity, when coupled with domestic macroeconomic and regulatory conditions. Further, Indian banks are also impacted by the exchange rate movements and capital flows into India. The higher the capital inflow, the more the risk exposure by SCBs. Therefore, in support of the findings in the previous chapter, where we established an extended effect of the risk-taking channel on Indian risk and financial stability, this chapter reveals how financial intermediaries too are impacted in their capacity to undertake risks. This may seem as a natural and unavoidable fallout of increased integration of the global financial cycle, but also indicates the costs emerging markets have to incur owing to divergent monetary policy stance with the U.S. economy. Of course, the

implications of international spillovers are only coupled with domestic conditions such as weakness in the banking system, lack of integration in financial markets, excess foreign ownership in banks and the position of the business cycle in India.

We discuss the policy implications in greater detail in Chapter 6.

5.8. **Limitations and Way forward**

While this study deals with a simple form representation of the Taylor rule, there is tremendous scope for research in how this rule can be best adapted to suit the Indian markets. Further in addition to ownership and individual bank-specific characteristics that determine how banks respond to risk-taking tendencies, the within-bank characteristics are worth exploring. These within-bank characteristics have been examined by Mishra et al. (2015), though not to study the risk taking among banks.

By studying the risk-taking tendencies, we account for the non-linear link between the financial system and monetary policy actions that impact bank lending outcomes and by extension, the real economy. However, such a study could also involve non-linear examination of individual bank characteristics to account for indirect effects, if at all.

Table 5.1: Correlation Matrix for analyzing bank risk-taking in India

	PD	MP	NRGAP	USFFR	GDP	SLOPE	SIZE	Liquid~y	Capita~e	Risk	ROA	Capflow	REER
PD	1												
MP	-0.0266	1											
NRGAP	-0.0044	0.0262	1										
USFFR	0.0154	-0.0809	0.0262	1									
GDP	0.0205	-0.6176	-0.099	0.7039	1								
SLOPE	0.0016	-0.9065	-0.1247	-0.1437	0.4545	1							
SIZE	-0.4551	-0.0235	-0.0116	-0.0355	-0.0087	0.0421	1						
Liquidity	0.4994	0.0139	0.0841	0.0514	-0.0051	-0.0695	-0.5952	1					
Capitalize	0.2627	0.021	-0.0287	-0.0106	-0.0049	-0.0104	-0.511	0.0726	1				
Risk	-0.0763	0.2589	0.2665	-0.4877	-0.5726	0.0371	0.0366	-0.0611	0.0056	1			
ROA	-0.1959	0.0081	0.0031	0.0678	0.0537	-0.0188	0.0398	0.1568	-0.2211	-0.0217	1		
Capflow	-0.0427	-0.1214	0.3511	-0.2436	-0.018	0.3635	0.0359	-0.0477	-0.0089	0.4031	-0.0164	1	
REER	-0.0392	-0.5084	0.3218	0.1381	0.5046	0.6158	0.0338	-0.043	-0.0076	0.1911	-0.0008	0.7645	1

Source: Author’s calculations.

Table 5.2: Summary statistics of variables used for bank analysis

Variable	Mean	Std. Dev.	Min	Max
PD	0.051657	0.068303	0.015433	0.707229
MP	7.004039	1.06274	4.895	8.125
NRGAP	1.291621	2.62136	-2.82632	5.590688
USFFR	1.375258	1.992034	0.125	5.25
GDP	7.463843	1.748455	4.5	9.6
SLOPE	0.810852	0.696504	-0.07194	2.317963
RiskIndex	6.271505	0.716278	5.28266	7.31963
CapitalFlow	3271.851	1480.343	967.334	5814.04
REER	1.487731	5.390584	-8.70133	9.576606

Source: Author's calculations

REGRESSION RESULTS

Table 5.3: Risk-Taking in Nationalized Banks

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
PD	-0.4453***	0.0334	-0.3877***	0.0298	-0.3943***	0.0297	-0.4204***	0.0380	-0.3931***	0.0306
MP	0.0219***	0.0013	0.0203***	0.0012	0.0201***	0.0012	0.0154***	0.0013	0.0198***	0.0013
TR_GAP	0.0066***	0.0008	0.0058***	0.0007	0.0055***	0.0007				
GDP	-0.0021***	0.0011	-0.0015***	0.0010	-0.0011	0.0010	0.0009	0.0014	0.0019*	0.0011
GSEC	-0.0165***	0.0024	-0.0159***	0.0021	-0.0148***	0.0022	-0.0233***	0.0031	-0.0332***	0.0029
SIZE			-0.0019*	0.0323	-0.0003	0.0323	-0.0026*	0.0412	-0.0039	0.0328
LIQUIDITY			0.0420***	0.0076	0.0416***	0.0076	0.0494***	0.0096	0.0436***	0.0077
CAPITALIZATION			-0.0021*	0.0022	-0.0021	0.0022	-0.0012	0.0029	-0.0015	0.0023

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
RETURN ON ASSET			-0.0071***	0.0027	-0.0070***	0.0028	-0.0119***	0.0034	-0.0080***	0.0028
RISK-AVERSION					-0.0041***	0.0020			-0.0521***	0.0080
USFFR							0.0008***	0.0005	-0.0147***	0.0020
NEER							0.0007*	0.0054	-0.0016***	0.0005
CAPITAL FLOWS							0.0091*		0.0167***	0.0045
Sample period	2005-2015		2005-2015		2005-2015		2005-2015		2005-2015	
No. of groups	18		18		18		18		18	

Notes: Author's calculations. Standard errors are robust. The signs *, ** and *** signify 10%, 5% and 1% level of significance, resp.

Table 5.4: Risk-Taking in SBI and all its associates

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
PD	-0.5190***	0.0867	-0.4701***	0.0807	-0.4707***	0.0785	-0.5074***	0.1018	-0.4749***	0.0780
MP	0.0145***	0.0022	0.0148***	0.0020	0.0152***	0.0020	0.0116***	0.0021	0.0158***	0.0019
TR_GAP	0.0032***	0.0011	0.0033***	0.0009	0.0037***	0.0009				
GDP	0.0001	0.0013	0.0006	0.0012	0.0009	0.0011	0.0024	0.0017	0.0039***	0.0014
GSEC	-0.0129***	0.0032	-0.0120***	0.0031	-0.0093***	0.0032	-0.0150***	0.0045	-0.0228***	0.0040
SIZE			0.0847	0.0604	0.0728	0.0589	0.0736	0.0771	0.0681	0.0587
LIQUIDITY			0.0205**	0.0107	0.0170*	0.0105	0.0195*	0.0138	0.0174*	0.0105
CAPITALIZATION			0.0043**	0.0023	0.0047***	0.0023	0.0046*	0.0029	0.0044***	0.0022

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
RETURN ON ASSET			-0.0061*	0.0042	-0.0077**	0.0042	-0.0071*	0.0054	-0.0058*	0.0041
RISK-AVERSION					-0.0054***	0.0021			-0.0368***	0.0100
USFFR							-0.0043**	0.0022	-0.0117***	0.0026
NEER							0.0002	0.0006	-0.0015***	0.0007
CAPITAL FLOWS							0.0063	0.0072	0.0119***	0.0057
Sample period	2005-2015		2005-2015		2005-2015		2005-2015		2005-2015	

Notes: Author's calculations. Standard errors are robust. The signs *, ** and *** signify 10%, 5% and 1% level of significance, resp.

Table 5.5: Risk-Taking in Private Sector Banks

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
PD	-0.4324***	0.0386	-0.3307***	0.0477	-0.3283***	0.0487	-0.3353***	0.0572	-0.3287***	0.0502
MP	0.0236***	0.0016	0.0192***	0.0018	0.0188***	0.0019	0.0152***	0.0020	0.0181***	0.0020
TR_GAP	0.0041***	0.0008	0.0031***	0.0007	0.0029***	0.0008				
GDP	0.0014	0.0012	0.0010	0.0011	0.0010	0.0012	0.0017	0.0016	0.0028***	0.0014
GSEC	-0.0197***	0.0026	-0.0152***	0.0027	-0.0157***	0.0028	-0.0176***	0.0037	-0.0232***	0.0038
SIZE			-0.0789***	0.0336	-0.0812***	0.0341	-0.0944***	0.0406	-0.0873***	0.0358
LIQUIDITY			0.0090	0.0108	0.0094	0.0110	0.0118	0.0131	0.0095	0.0115

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
CAPITALIZATION			-0.0062***	0.0031	-0.0060***	0.0032	-0.0088***	0.0038	-0.0075***	0.0033
RETURN ON ASSET			-0.0065***	0.0021	-0.0069***	0.0022	-0.0093***	0.0025	-0.0074***	0.0023
RISK-AVERSION					0.0018	0.0025			-0.0303***	0.0092
USFFR							-0.0002	0.0020	-0.0062***	0.0026
NEER							0.0009*	0.0005	-0.0008	0.0007
CAPITAL FLOWS							-0.0024	0.0059	0.0048	0.0056
Sample period	2005-2015		2005-2015		2005-2015		2005-2015		2005-2015	
No. of groups	18		18		18		18		18	

Notes: Author's calculations. Standard errors are robust. The signs *, ** and *** signify 10%, 5% and 1% level of significance, resp.

Table 5.6: Risk-Taking in Foreign Banks

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
PD	-0.6370***	0.1337	-0.3375***	0.0884	-0.3357***	0.0933	-0.3505***	0.0977	-0.3696***	0.0884
MP	0.0456***	0.0073	0.0336***	0.0043	0.0337***	0.0046	0.0337***	0.0062	0.0339***	0.0056
TR_GAP	0.0239***	0.0100	0.0163***	0.0056	0.0162***	0.0059				
GDP	-0.0125	0.0175	-0.0091	0.0103	-0.0093	0.0108	-0.0083	0.0154	-0.0013	0.0142
GSEC	0.0012	0.0317	-0.0018	0.0198	-0.0028	0.0231	-0.0449***	0.0288	-0.0543***	0.0263
SIZE			0.0758	0.1510	0.0776	0.1569	0.0115	0.1734	0.1223	0.1617
LIQUIDITY			0.1368***	0.0444	0.1354***	0.0482	0.1290***	0.0655	0.1521***	0.0597
CAPITALIZATION			-0.0398***	0.0078	-0.0399***	0.0083	-0.0370***	0.0088	-0.0349***	0.0079

Dependent variable: Annual change of the Probability of Default (1-year horizon)	Baseline model (specification 1)		Specification II : Closed economy Bank Specific characteristics		Specification III : Closed economy including Risk		Specification IV : Open economy (external shocks)		Specification V : Open economy (external shocks including risk)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
RETURN ON ASSET			-0.0131***	0.0067	-0.0132***	0.0071	-0.0169***	0.0083	-0.0191***	0.0075
RISK-AVERSION					0.0016	0.0178			-0.1717***	0.0629
USFFR							-0.0092	0.0169	-0.0440***	0.0199
NEER							-0.0007	0.0062	-0.0105*	0.0066
CAPITAL FLOWS							0.0820*	0.0533	0.1156***	0.0497
Sample period	2005-2015		2005-2015		2005-2015		2005-2015		2005-2015	
No. of groups	18		18		18		18		18	

Notes: Author's calculations. Standard errors are robust. The signs *, ** and *** signify 10%, 5% and 1% level of significance, resp.

CHAPTER 6
CONCLUSION

6.1 Introduction

It is well known that changes in the international financial conditions have altered the domestic conditions in financial markets. This phenomenon poses new dilemmas and threats to monetary policy that is originally focused on three aspects in the domestic context – i) stabilizing inflation, ii) maintaining growth and minimizing the output gap, and; iii) assisting in structural transformations of the financial sector (like the banking system etc.). In the new paradigm of monetary economics that is the central theme of this thesis, we refer to a "new normal" of monetary policy that extends into incorporating international spillovers and short-term or intermediate objectives over and above its standard objectives. Some of these issues have been widely discussed in recent literature and also by policymakers for one simple reason – i.e. extending the scope of monetary policy mandate comes at the price of certain tradeoffs. For a central bank, this tradeoff is between preserving financial stability in the global setting or maintaining macroeconomic stability, as it is usually stipulated to do. As would be the case for any other country, this tradeoff is not be an easy one for India too.

While this thesis addresses a part of the above question, it is important to understand the process of monetary policy in determining short-term and long-term outcomes in an economy. Before we provide a summary of the findings of this research, we attempt to understand the above issue vision using a five-point framework in the Indian context.

6.2 Assessment Framework for Monetary Policy

6.2.1 Policy and legislative implications:

The recent amendment to the RBI Act announced in the budget for 2016-2017 provided a roadmap for statutory and institutionalized framework of monetary policy. In the preamble to the RBI Act, the primary objective of the central bank is to "maintain price stability, while keeping in mind the objective of growth, and to meet the challenge of an increasingly complex economy". With this roadmap, it is unclear whether the role of risk and financial imbalances, which have grown rapidly in the aftermath of the financial crisis of 2008, have been taken into consideration as a critical element or not.

This guideline provided by the central bank further adds strength to the intent of this thesis which argues in favour of incorporating the role of risk (external and internal) in our monetary transmission processes. The reality is that the role of monetary policy is now much larger in maintaining financial as well as macroeconomic stability, of which risk is a prominent factor. The short-term interest rate has become one the most crucial operating objectives of monetary policy. The "risk-taking channel of monetary policy" stems from the adverse implications of low and long nominal interest rates in advanced economies on financial market outcomes for India. Central banks must respond to rising asset prices and financial market instability by using regulatory instruments like countercyclical capital. As described by Fischer (2010), central banks are not just lenders of last resort, but can also be "market makers of last resort".

6.2.2 Institutional effectiveness and accountability:

As we extend the understanding of the role of monetary policy given the current global challenges, we find the issue of monetary trilemma to be an important one (Rey, 2015). The issue of autonomy of the central bank is not just relevant in an international dimension, but also holds itself valid in managing the interest of the state versus pursuing its own mandate inflation targeting. While the

institutionalization of the Monetary Policy Committee (MPC) has been done with a view to enhance transparency of monetary policy decisions, there are several concerns about how far the autonomy of the central bank can be maintained in a regime of freer capital flows and a flexible exchange rate. Nevertheless, the role of central bank must focus on effective transmission to banks and by extension impact the total aggregate expenditure. Regulatory measures required to improve the transmission to banks must be maintained and further improved.

6.2.3 **Strategic planning and financing:**

The concern that monetary policy must take into consideration the volatility in asset prices and financial instability also deals with macroprudential reforms and supervision and regulatory reforms. In other words, monetary policy alone is in no way sufficient to tackle the spillovers from external sectors. The answer to this problem lies in using more than one monetary instrument even in the short term. Today, intermediate objectives have widened the purview of monetary policy to include concerns such as capital flows, foreign exchange interventions and also macroprudential instruments like reserve requirements etc. (like CRR and SLR).

6.2.4 **Policy design and implementation:**

The debate between a rule-based or discretionary-based model for optimal monetary policy has been furthered with the challenge of managing external risks in addition to economic, political pressures. This thesis directs us to an important question - Is there a need for greater monetary policy coordination between advanced and emerging market economies? John Taylor argues that divergence in monetary policy stance across countries could potentially lead to adverse spillovers that undermine domestic macro-objectives in an economy (Taylor, 2013) – thus emphasizing the interconnectedness of financial conditions around the world.

6.2.5 **Sustainability and continuity:**

Raising concerns over an excessive burden on monetary policy, literature suggest the need to balance the role of monetary policy with macroprudential as well as micro-prudential reforms (Benigno and Kiyotaki (2015), Bayoumi et al. (2014)). In this regard, a focus on strengthening market structures, performing reforms and sound domestic policies to boost infrastructure and growth remain out best bet for India. India is on the path of recovery and we have plenty to look forward to – but we need to worry of the limit to certain kinds of policy. Excessive reliance or burden on interest rates is not the way forward.

6.3 **Summary of Findings**

This thesis revolves around the interaction between monetary policy and financial sector markets. The novelty of this contribution in in understanding the role of monetary policy in a new paradigm that brings out the interconnectedness of monetary policy and financial risk conditions across the world. The focus of the thesis can be broadly categorized into two aspects – the role of risk and the role of external shocks in monetary transmission.

Let us examine the role of external shocks first. In the post crisis period, advanced economy central banks took recourse to an accommodative stance on monetary policy i.e. low for long rates of interest. This triggered concerns over the possible outcomes of cross-border spillovers effects on emerging markets economies that face potential risks in the form of policy rates implications, massive upsurge in capital flows and instability across global financial markets.

The second scope of the analysis in this thesis can be summarized as an examination of the measurement of risk and how that risk can be managed by the financial intermediaries. This thesis delves into measurement and management of risk in the process of monetary policy transmission. This ‘risk’ can be both external as well as internal and the central idea to capture the perception into our monetary frameworks. We explore the importance of incorporating risk perception by

economic agents while studying the monetary transmission process, highlighting the endogenous interaction that takes place between a central bank's reaction function and risk-taking by financial market participants. This analysis extends into examining the role of risk in the financial intermediaries (banks) sector as we explore how banks interact with the risk-taking channel, to drive the capital market conditions and bank credit.

These issues raise some pertinent questions – if an extended impact of the risk-taking channel is observed in India, how then should monetary policy tackle the adverse effects of international spillover? In this regard, we study the effect of low nominal interest rates on risk taking in India. This channel can be understood in the context of a larger debate on the challenges that monetary policy faces in today's global economy.

The primary motivation central to this research is insufficient emphasis given to risk in the transmission mechanism, role of credit and bank riskiness in central bank reaction functions. After discussing the context of the new paradigm in monetary policy within which this thesis has been positioned, we present the review of literature in Chapter 2. We discuss a new channel in literature of transmission of monetary policy, which supplements the standard channels as we know them.

To proceed with our analysis, we first create an index for measurement of risk aversion to enable better estimation of investor risk preferences in Chapter 3. This chapter addresses three issues. First, while options market literature in this field has adequately developed techniques to extract risk-neutral from options market for indices like FTSE and S&P 500, the Indian options markets lack a comprehensive index that provides such information about domestic investor perceptions. We extract two density functions – risk-neutral density function and utility-adjusted functions to estimate their forecast abilities of future densities, thus giving a forward-looking estimate of investor preferences in future. This analysis allows us to test the forecast ability of distributions of the ex-post values of the asset prices. Second, since we cannot assume that Indian options market investors would

necessarily be neutral to risk, the need for a new index of risk aversion to capture the preferences of Indian investors is further justified. Finally, the third problem is the limitations of the VIX index, particularly for the case of Indian options markets. In addition to computational challenges, there is insufficient historical data available for INDIA VIX that can be used as a proxy of risk for various analyses. We overcome the above issues to compute an index of risk aversion for Indian markets to address the above concerns using a nonparametric technique. Validity of the computed index is established by comparing with existing measures of risk and the relationships are found to be consistent with market expectations.

Once we compute the index for risk aversion, we use a macro-finance analysis to highlight the role of risk, foreign capital inflows and credit growth in determining domestic monetary conditions in Chapter 4. The unprecedented monetary easing by advanced economies has led to a high degree of correlation between asset prices and interest rates across the globe. Under such circumstances, emerging market central banks are faced with the incredible challenge of meeting their policy goals, maintaining financial stability and countering prolonged periods of ultra-low interest rate policies. This study is conducted for an emerging market like India, and examines the dynamic relation between different spillover channels of international monetary conditions and domestic short-term policy stance. We use a vector autoregressive model to determine the link between external factors and financial instability as seen through shifts in risk attitudes and credit outcomes. Findings indicate that global liquidity conditions spillover across borders to impact risk exposure and monetary conditions in India. Study reveals that international spillovers are significant determinants of the risk-taking capacity, such that domestic monetary policy affects the real economy through increased risk taking in the financial sector and excessive bank credit. The effects of foreign shocks combine with changes in domestic risk premia and the credit growth of the Indian banking sector, which navigates the analysis for the next and final chapter.

In the fifth chapter, the banking sector of the model creates an important new mechanism through which shocks propagate into our economy: movements in asset

prices, nominal price level and exchange rate can amplify the initial impact of a shock by affecting the balance sheet of the banks. We assess the role of banking sector as a driver of the boom-bust cycle, as opposed to past views seeing banks as a channel through which the central banks implement monetary policies. The role of bank balance sheet adjustments have emerged as the keystone in monetary policy transmission mechanism that works through fluctuations in risk-taking.

In the domestic context, bank risk taking has a procyclical relationship with the policy interest rate, risk-free rate and the GDP growth rate. Bank risk also moves in tandem with risk conditions in the domestic financial sector, indicating increased integration of financial intermediaries with financial sector markets. This phenomenon may be a cause of concern as it indicates the use of bank capital for carrying out financial sector reforms like revamping the derivatives and equity markets, stressing the need for more prudential regulation. Results indicate heterogeneity across different types of sizes and bank groups. As we discern the disaggregated bank behaviour, results reveal that ownership of banks take precedence over individual characteristics like size, liquidity, capitalization or even profitability in determining their risk-taking tendencies.

In the open-economy framework, there is evidence of differential impact of four channels of external shocks. The study reveals a strong presence of international spillover of the risk-taking channel on financial intermediaries in India. Bank risk conditions in India tend to be highly responsive to movements in policy interest rates of the US Federal Reserve. Therefore, in support of the findings in the previous chapter, where we established an extended effect of the risk-taking channel on Indian risk and financial stability, this chapter reveals how financial intermediaries too are impacted in their capacity to undertake risks. This may seem as a natural and unavoidable fallout of increased integration of the global financial cycle, but also indicates the costs emerging markets have to incur owing to divergent monetary policy stance with the U.S. economy. Of course, the implications of international spillovers are only coupled with domestic conditions such as weakness in the banking system, lack of integration in financial markets,

excess foreign ownership in banks and the position of the business cycle in India. An important policy suggestion that is clear from this analysis is the need for domestic regulatory supervision to develop greater resilience of the banking system from within to be better prepared against external shocks. For instance, before permitting excessive freedom for entry of foreign banks, policy must ensure resilience of the domestic banking system. One way of doing this can be to allow diversification of branches before giving new licenses to new entrants. The study emphasizes the need for central banks to consider the level of risk-taking that is not limited to their own economy, but include the effect of international spillovers in order to better gauge the dynamics of the financial system.

While it may not be possible to attach specific weights to different sectors in a monetary policy framework, the analysis of this thesis reveals one way of getting closer to allocating proper weights. The Reserve Bank of India has taken external sector management into account, as is evident in their Annual Reports. However, when we examine consequences of various shocks by incorporating the measurement and the management of that risk, the investor perception of risk can be better visualized. This issue is akin to the importance of incorporating expectations of the market and modeling them into monetary policy decisions.

6.4 **Policy suggestions and Way Forward**

While no economy can remain insulated from global financial shocks, the Indian economy has tremendous scope strengthen the resilience of domestic financial system. Doing so would make our economy better prepared for external volatility spillovers and lesser reliance on external finance. The policy should aim at having a market-oriented regulatory approach across different market segments.

1. As global financial markets are increasingly becoming integrated with the domestic markets, there is a need for proper assessment of risk. A grip of risk perception of economic agents in the financial sector or the household sector would be helpful for monetary policy decisions. The calculation of the risk

aversion index from option market data in this thesis (Chapter 3) is one step in that direction. However, we must extend the assessment of that risk to other financial markets as well as other segments. For instance, it would be useful to calculate the risk index for interest rate derivatives market or the currency derivative markets. Further, assessment of risk-averse agents like the household sector is crucial for assessment of their behaviour in response to policy changes.

2. In order to increase the operational efficiency of monetary policy, it is important to improve structural regulatory measures tending to deregulate markets. This is required to promote market-based competitive outcomes in financial markets. At the same time, regulatory supervision and compliance measures must also be adhered to. Some examples are the capital adequacy ratios, KYC norms and the recently instated bankruptcy laws. Taking from the above point, it is crucial to have a roadmap for future institutions by prioritizing the nature of institutions that we want to improve upon.

3. As modernization of financial services is taking place all over the globe, we must give special attention to development of technological and institutional infrastructure. For instance, several banking systems, particularly the nationalized and government-owned banks still have traditional non-modern services. Revamping these with new 'fin-tech' services would ensure deepening of market services, better efficiency and competition among markets, improved transparency and reduced transaction costs etc.

4. Monetary authorities must improve upon the credit quality in Indian financial system by expanding the capital base of markets. This would not only improve the resilience of the financial system from volatile capital flows and external sector shocks. A better capital structure and base for financial markets would also improve the spread between markets and increase attractiveness of markets as an investment for longer term durations.

5. It is also important to diversify financial institutions. For instance, the mutual funds and insurance markets must be made more competitive. In India, majority capital base for these financial services comes from banks. Regulatory and policy changes are required so as to make these lesser developed sectors more market-oriented.

6. Finally and most importantly, it is crucial to understand that despite excessive burden on monetary policy to deliver objectives and prevent the economy from external sector shocks, the role of fiscal management and prudential regulations cannot be ignored. In order to build resilience of our markets from external spillovers and improve domestic transmission of policies, the monetary and fiscal policies must go hand-in-hand. While the scope of this view is beyond the scope of this thesis, a sense of its significance is explained in papers like Basu (2014) and Aoki et al. (2015) and Bruno and Shin (2014a).

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APPENDIX

List of Proxies and Data Sources (alphabetically)

BC: Bank credit of Indian scheduled commercial banks, Reserve Bank of India, Handbook of Statistics on Indian Economy

CAP: Capitalization of scheduled commercial banks, Banking Statistical Returns data, Reserve Bank of India

CAPINFL: Capital inflows into Indian economy, Reserve Bank of India, Handbook of Statistics on Indian Economy

CAPINFL_FDI: Foreign direct investments, Reserve Bank of India, Handbook of Statistics on Indian Economy

CAPINFL_FDI: Capital inflows directly into Foreign Direct Investments in India, Reserve Bank of India, Handbook of Statistics on Indian Economy

CAPINFL_PORT: Capital inflows directly into Portfolio Investments in India, Reserve Bank of India, Handbook of Statistics on Indian Economy

EPU Index: Economic Policy Uncertainty (Baker, Bloom and Davis (2003, 2015 – India))

FFR: Federal Funds (effective) rate, U.S. Federal Reserve Board

GVIX: End of the period readings for global risk measure, "Chicago Board Option Exchange" (CBOE)

LIQ: Liquidity of scheduled commercial banks, Banking Statistical Returns data, Reserve Bank of India

MP: Short-term nominal interest rate set by the monetary policy

NRGAP: Difference between real short-term rate of interest and the natural rate

PD: Probability of Default, Banking Statistical Returns data, Reserve Bank of India

REER: Real effective exchange rate of Rupee per US dollar, Reserve Bank of India, Handbook of Statistics on Indian Economy

REPO: Policy repo rate, Reserve Bank of India, Handbook of Statistics on Indian Economy

RA: Risk Aversion Index; Option-implied risk-aversion estimate using Indian options data, (computed in chapter 3)

RISK: Risk Aversion Index; Option-implied risk-aversion estimate using Indian options data, (computed in chapter 3)

ROA: Bank profitability size (log of total assets), Banking Statistical Returns data, Reserve Bank of India

SIZE: Size of bank balance sheet of scheduled commercial banks, Banking Statistical Returns data, Reserve Bank of India

SLOPE: Government-securities yield curve, Reserve Bank of India, Handbook of Statistics on Indian Economy

TR_GAP1: Difference between nominal short-term monetary policy rate of interest and the rate generated by the Taylor rule (using equal weights)

TR_GAP2: Difference between nominal short-term monetary policy rate of interest and the rate generated by the Taylor rule (using different weights to inflation and output gap)

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CORRESPONDING AUTHOR: Sonalika Sinha
ADDRESS: Sonalika Sinha, Senior Research Fellow, School of Economics, University of Hyderabad, Telangana

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