Chetan Ghate · Kenneth M. Kletzer
Editors

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A Modern Macroeconomic Perspective

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ISBN 978-81-322-2838-7 ISBN 978-81-322-2840-0 (eBook)
DOI 10.1007/978-81-322-2840-0

Library of Congress Control Number: 2016947196

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer (India) Pvt. Ltd.

Foreword

Chetan Ghate and Ken Kletzer have created an important and timely volume *Monetary Policy in India: A Modern Macroeconomic Perspective*. They have brought together an impressive group of distinguished and experienced monetary experts, each of whom has contributed essays dealing key contemporary problems in monetary policy in India. The contributions are carefully reasoned—whether using theory, data, or practical examples—and they are exposited clearly. In this regard the book in keeping with a tradition that goes back to John Maynard Keynes 1913 book, *Indian Currency and Finance*, which long ago recommended the creation of a central bank for India. Moreover, Ghate and Kletzer have added an important value not only by assembling this group of experts and choosing highly relevant subjects, but also by organizing the essays in a helpful and logical way.

The book starts with the evidence of the impact of changes in the monetary instrument as well as changes in monetary policy rules, building on research on other emerging market economies. Emphasis is placed on both empirical work in an open economy setting and theoretical modeling, about which there is a special section in the book on models for evaluating monetary policy in India.

The book also considers regulatory issues and how monetary policy fits into the overall framework of Indian economic policy where the government has played a large role in the financial sector. Here monetary reform is a part of an overall move to economic reform which is essential to the success of the Indian economy. The book rightly reexamines special features of the Indian economy including the use of capital controls and the role of exchange rate management.

Some of the most useful and relevant parts of the volume are in the chapters which delve into the impact and the spillovers of monetary policy in other countries on India. The spillovers of unconventional monetary policies like quantitative easing are especially important. The issues are controversial and have generated candid commentary by the current governor of the Reserve Bank of India, Raghuram Rajan and other central banking officials around the world. Some, including (former) Governor Rajan and also the former head of the Federal Reserve, Paul Volcker, are calling for international monetary reform, including the possibility of greater policy coordination or cooperation. The work in the volume on monetary policy rules is particularly welcome because one option for reform is for each central bank to be more transparent in stating its monetary policy strategy or rule and its international impact.

By providing a better understanding of the role of Indian monetary policy in a global context the book is highly relevant for discussions of international monetary reform in general. In this regard the Ghate–Kletzer book is also in keeping with the important classic on international economic reform and its relationship with India and other emerging market economies—the *North-South Debate*, written by economist and former governor of the Reserve Bank of India, L.K. Jha in 1981. Jha argued for reforms that avoided interfering with the principles of free and open markets, but also contributed to the common good of global stability and growth. *Monetary Policy in India*, like *Indian Currency and Finance* and the *North-South Debate* will help guide policy makers and their economic advisers and achieve this important goal.

Stanford University John B. Taylor

Acknowledgements

There are 20 contributions to this volume (including the introduction and foreword). We extend thanks to the authors of all the chapters for their friendly and helpful cooperation.

This volume has also benefitted from comments and feedback from several individuals: Joshua Aizenman (University of Southern California); Abhiman Das (IIM Ahmedabad); Ravi Bansal (Duke University); Errol D'Souza (IIM Ahmedabad); Pawan Gopalakrishnan (ISI Delhi); Sargam Gupta (ISI Delhi); Hiro Ito (Portland State University); Nikhil Patel (BIS); Rajeswari Sengupta (IGIDR); Kanhaiya Singh (Reserve Bank of India); Nirvikar Singh (UC Santa Cruz); Radheshyam Verma (Reserve Bank of India). We are extremely grateful for their excellent inputs. We also thank the Policy and Planning Research Unit (PPRU) for partial financial support related to the volume.

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Kenneth M. Kletzer is Professor of Economics at the University of California, Santa Cruz. His primary areas of research are international economics and macroeconomics, and many of his publications concern financial frictions in open economies, sovereign debt, and macroeconomic policy coordination. Kletzer has written on capital account liberalization and monetary policy for India, and is a member of the research panel for the India Policy Forum of the National Council for Applied Economics Research and Brookings Institution.

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Part I
Overview

Introduction

Chetan Ghate and Kenneth M. Kletzer

This volume brings together contemporary research on monetary economics and policy in India. Monetary policy has attracted significant attention from Indian and international macroeconomists over the last several years. Interest in how monetary policy influences economic performance and how monetary policy is conducted in India is also growing. The prospects of further financial sector reform, exposure to volatile international capital flows, inflation persistence, and importance of structural rigidities raise the focus of economists, policymakers, and students on the role of money and monetary policy in India. The purpose of this volume is to bring together contemporary analyses of monetary economics in India that can provide a foundation for further research on monetary policy and reforms. The chapters concentrate on the current state of the monetary side of the Indian economy and on recent reforms affecting the environment for and conduct of monetary policy in India. The intended audience for the volume includes both academic and policy economists as well as policymakers and economics students. The volume should appeal to economists interested in monetary economics other than India because the study of contemporary monetary economics in India, a major emerging market, can apply to many other developing and emerging market economies.

1 Monetary Policy in India: Background

India has undertaken a series of financial sector reforms in gradual steps since 1991. Considerable progress has been made in developing domestic financial markets and in financial market integration with the rest of the world. The deregulation of

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_1

interest rates, reduction in the repression of financial intermediation, relaxation of entry barriers in banking, and development of nonbank financial institutions have all changed the environment for monetary policy over the last 25 years. This process began with the introduction of the government securities market and the gradual relaxation of capital controls. Private ownership in banking is now important, the nascent corporate bond market has shown modest growth, and India experiences surges of capital inflows and sudden outflows along with other emerging market economies. Most recently, the Reserve Bank of India (RBI) adopted an inflation targeting framework foreshadowing greater independence from fiscal authorities and policies.

Fiscal dominance and financial repression have been hallmarks of Indian monetary policy for decades. The Reserve Bank of India was designated as the banker for the government and authorized to grant advances to the Government of India in the Reserve Bank of India Act of 1934. These advances became ad hoc 3-month Treasury Bills continuously held by the RBI in a process of automatic monetization of government debt. The reserve bank simply funded the public sector budget deficit through periods of rising public debt and inflation until the 1990s. In 1997, the authorization to issue such ad hoc Treasury Bills ended and replaced by a system of Ways and Means advances. The RBI continues in its debt management role for the Government of India. In 2006, RBI participation in the primary market for government debt ceased, and India completed the transition to market determined yields on government bonds.[1]

Although these institutional reforms reduce the dominance of fiscal authorities over the central bank, public debt monetization continues to be a burden on monetary policymakers as the overall deficit of the public sector trends around 3 % of GDP and the public debt to GDP ratio rose sharply after the Global Financial Crisis. Financial repression has been an essential part of financing deficits. The RBI continues to require scheduled commercial banks to hold government securities against the Statutory Liquidity Ratio, although the SLR level substantially declined since the early 1990s. A legacy of directed lending, notably to the agricultural sector, means that the public sector banks hold nonperforming assets and renegotiated loans that are effectively nonperforming.[2]

After the balance of payments crisis in 1991, India gradually liberalized trade and transactions on the current account. Since the early 2000s, capital controls have been relaxed primarily by raising limits for approval and automatic approval. Inflow controls on foreign direct investment, portfolio equity inflows, and debt-creating flows have been relaxed the most. Some outflow controls have also been relaxed. India has taken route of liberalizing inflows before outflows, and capital flow liberalization has been sequenced to favor flows most strongly associated with

[1]A full overview of fiscal dominance in India and of these reforms is provided by Reserve Bank of India (2013), “Report on Currency and Finance,” March 4, 2013. The narrative here draws from the Report.

[2]These points are made in the Chapter of this volume by Viral Acharya and Krishnamurthy Subramanian.

economic growth for emerging markets.[3] The liberalization of capital flows now poses challenges for monetary management, which is common to emerging market economies as a whole.[4]

After the official de-pegging of the rupee in March 1993, the RBI concentrated on stabilizing the value of the rupee, and the exchange rate of the rupee against the U.S. dollar persisted as an objective and typical nominal anchor for monetary policy. Since 2006, the volatility of the exchange rate has increased significantly, and monetary policy has focused more on price stability. Beginning in January 2014, the Reserve Bank's policies have followed a flexible inflation target, and inflation targeting became official policy in March 2015. The implementation of an inflation targeting framework relies on the increasingly sophisticated and successful liquidity management by the RBI.[5] The transition to "modern" central banking is a major motivation for the timing and focus of this volume. As this transition is not yet complete (as of writing, the RBI does not have formal independence), the research in this volume will hopefully inform an increasing flow of analysis of monetary policy going forward.

2 Current Issues in Monetary Economics for India

India has experienced average inflation rates of more than 9 % between 2006 and 2013. The long episode of inflation has led to an unmooring of inflationary expectations requiring prolonged periods of low inflation for inflationary expectations to come down (Rajan 2015). As Rajan (2015) notes, the real policy rate was below the neutral rate for several years and coincided with a pick-up in inflation. As we write this (in March 2016), low inflation is finally becoming a reality in India. Compared to the difficulties of the taper tantrum episode of 2013, growth is stronger, the current account deficit has narrowed significantly, real policy rates are positive, and the fiscal deficit is on a consolidation path. However, while some of the factors behind India's current disinflation may be structural in nature, the high inflation in India during 2006–2013 has widely been attributed to poor management of the economy during this period.[6] Government policies had effectively placed a

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[3]See the Chapter of this volume by Atish Ghosh, Mahvash Qureshi and Eun Sung Jang.

[4]India's recent experience with capital flow surges and stops is the subject of the Chapter of this volume by Poonam Gupta.

[5]Background for the inflation targeting framework adopted by the RBI is provided by Reserve Bank of India (2014), "Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework," January 21, 2014.

[6]In India, there is open ended procurement of grains such as rice at the minimum support price (MSP). As a result, the wholesale market price cannot generally fall below the MSP. This policy also pre-empts the re-allocation of land and other resources from agriculture commodities to products that have support prices. Inflation is therefore fueled not only by demand pressures because of the mismatch between GDP growth and agricultural growth, but also the existing system of price support and procurement.

rising floor on food and wages leading to rampant food inflation. This created a wage-price spiral with rising wage expectations since rural wages are effectively indexed to food inflation. In the context of emerging market economies like India, understanding the dynamics of inflation and how it becomes generalized is therefore particularly relevant for a volume on monetary policy in India.

Second, flexible inflation targeting is now the official monetary policy framework of the Reserve Bank of India. This will bring formal accountability and transparency to future actions that are the hallmark of modern central banking.[7] One issue that arises is whether flexible inflation targeting is appropriate for an economy with multiple supply constraints. Because items like food comprise a lion's share of the CPI (approximately 46 %) and are not supported by credit, one criticism of flexible inflation targeting in the Indian context is that it heightens the chance of tight monetary policy.[8] Another issue is that on top of their usual mandate of controlling inflation, central banks are made responsible for all types of cyclical policy duties that are not completely addressed by other policymakers in an economy (Davig and Gurkaynak 2015). These range from unemployment, financial stability, and current account deficits among others. This has effectively make central bank policymakers of last resort, or "residual claimants of macroeconomic policies" which compromises efficiency (Davig and Gurkaynak 2015). Inflation targeting with "lexicographic mandates" requires the inflation mandate to be met before it can help the government in other policy pursuits (Davig and Gurkaynak 2015). Being tasked to pursue multiple mandates will compromise the RBIs ability to be an inflation fighter.

Third, monetary policy transmission is weak in India. The aggregate demand channel is weak because of bank's reluctance to cut loan rates following reductions in the repo rate. This is because loans given out by banks are largely funded by a bank's own capital and customer deposits, not by borrowing funds from the Repo window. For loan interest rates to come down, bank deposit rates need to come down, and/or the cost of capital needs to come down. The move to marginal cost pricing and the reduction in a variety of administered rates with a move to reset small savings rates more frequently (starting April 2016) will improve transmission. The exchange rate channel does not work in textbook fashion. The interest rate

[7]Rajan (2015) argues that because of the RBIs past focus on WPI inflation, this put weight on internationally traded goods like commodities as opposed to domestic nontraded goods like services. This meant that whenever international inflation came down, pressure for a rate cut increased, leaving inadequate attention to domestic sources of inflation.

[8]Food price dynamics are very different in emerging market economies (EMEs) than in advanced economies (AEs). In EMEs food price shocks are more persistent and propagate strongly into nonfood inflation. Such second round effects are important in economies (such as India) where food is a high share in a household's consumption basket. Therefore, for economies with important second round effects food inflation should not be ignored in the formulation of monetary policy.

impact on exchange rates is weak, and is more likely to be effective as a cost-push channel since it affects the cost of intermediate goods and food imports. Finally, as various chapters highlight, the banking industry (especially the public sector banks) is under severe stress, making banks reluctant to cut loan rates. If public sector banks do not cut rates, there is little competition for private sector banks to follow suit. One issue that arises here is whether interest rates are the binding constraint on investments. Infrastructure and regulatory bottlenecks also need to be addressed to get the full benefit of a decline in interest rates.

Fourth, maintaining orderly conditions in the foreign exchange markets is an official objective of the Reserve Bank of India (RBI). As various chapters in the volume show, an important concern about capital flows for EMEs is that short-term and foreign currency-denominated liability inflows pose significant risks of volatility and amplification due to exposure to external shocks or external responses to domestic shocks. What policies are available for managing India's external capital inflows? The volume highlights several approaches for reducing vulnerability to volatile capital flows while allowing gains from access to international capital markets.

Fifth, credit and financial markets in India exhibit segmentation between formal and informal markets, significant rationing of credit, and regulation of financial intermediation that is critical to understanding how money affects the economy. Indeed, one lesson from the Great Financial Crisis (2007–2009) is that financial and monetary stability cannot necessarily be targeted independent of each other and that monetary policy transmission mechanisms are very much dependent on the state of the banking system Beck et al. (2014). The analysis of monetary policy therefore must be tailored to the financial environment of India to be useful. Applying advances in monetary economics and econometrics, the contributions to this volume demonstrate the importance of the Indian economic environment for understanding monetary policy in India and the directions future reforms may take.

Sixth, "empirical" research in the quantitative macro-tradition on Indian macroeconomic issues is in its infancy. Various chapters in the volume—some in the DSGE tradition—look at monetary policy design in the Indian context using calibrated or estimated models. Indeed, one goal of the volume is to feature theoretical modeling of the Indian macro-economy that highlights the frictions that are relevant in thinking about monetary policy design.

3 Organization of the Volume

Reflecting the above themes, chapters in the volume are divided into 6 sections covering the topics: prerequisites for effective monetary transmission; liquidity management and financial structure; constraints on normal central banking; theoretical frameworks for monetary policy analysis; and future challenges for monetary policy. All chapters present research apply contemporary monetary theory and state-of-the-art econometric methods to the analysis of the monetary policy on India's economic performance. The intended audience for the volume includes both academic and policy economists as well as policymakers and economics students. The volume should appeal to economists interested in monetary economics outside India because the study of contemporary monetary economics in India, a major emerging market, can apply to many other developing and emerging market economies.

4 Prerequisites for Effective Monetary Transmission

The chapters of the first section address the effectiveness of monetary policy for India in an evolving policy environment. The liberalization of finance in India has proceeded gradually with the relaxation of restrictions on entry into banking, creation of new markets for government bonds and other securities, and the reduction of quantitative controls on international capital flows. Banks and other financial institutions are still subject to mandated holdings of government bonds, and large public sector deficits continue to impact financial markets. Amartya Lahiri and Urjit Patel consider the importance of large reserve requirements on intermediaries and how persistent fiscal deficits interfere with the transmission of monetary policy to market interest rates. The opening of the capital account has progressed to the point at which India is exposed to the volatility of international capital inflows realized by other emerging market economies. The recent liberalization of the capital account and India's experience with capital inflows and outflows is the subject of the second chapter. Atish Ghosh, Mahvash Qureshi, and Eun Sun Jang give an overview of these reforms, analyze the magnitude and composition of capital flows, and consider the new challenges for monetary policy effectiveness and priorities posed by greater financial integration.

The next 3 chapters of this section directly address the transmission of monetary policy to inflation and real economic activity. The existing empirical evidence on monetary transmission in India finds limited pass-through from policy interest rate changes to market interest rates, inflation, and output. Monetary policy does affect the exchange rate but the transmission from exchange rate movements to output growth and inflation through this channel is still muted. The weak transmission of monetary policy in India is frequently attributed to repression of the formal financial center, involving both banks and nonbank financial institutions, and the fragmentation of financial markets between the formal and informal sectors. Policy distortions in the real economy also affect how changes in interest rates influence inflation and output growth. The first of these chapters, by Rahul Anand, Sonali Das, and Purva Khera, explores the importance of regulation of product and labor markets in India for the effectiveness of monetary policy. Empirical analyses of how well monetary is transmitted in India and through which channels monetary policy operates are limited in number. The second chapter, by Prachi Mishra, Peter Montiel, and Rajeswari Sengupta, investigates the mechanisms of monetary policy transmission in India and provides new estimates of the pass-through of policy rate changes to monetary policy targets. The last of these three chapters, by M.S.

Mohanty and Kumar Rishabh, addresses the changes in monetary policy transmission to the EMEs and to India in particular after the global financial crisis.

Financial repression has been a signature of policy toward banking and other forms of financial intermediation in India. The role of the Reserve Bank of India as short-term, on demand, financier of the Treasury through 90-day bills has ended, but fiscal dominance of monetary policy continues through the subtler, and traditional, means of running persistent government budget deficits that eventually must be monetized. The scheduled commercial banks, insurance companies, and pension and other funds are required to hold public debt on their balance sheets. The most prominent of these mandates is the Statutory Liquidity Ratio (SLR) that has been imposed for decades on the commercial banks. Amartya Lahiri and Urjit Patel analyze how the SLR and the persistence of fiscal deficits impact the transmission of monetary policy to market interest rates in the first chapter of this volume. The (SLR) requires the schedule commercial banks to hold a minimum of eligible securities, primarily centre and state government debt, in reserve against deposit liabilities on top of cash reserves. Further, the Government of India has been running overall public sector budget deficits persistently for more than four decades, and these have frequently exceeded 6 % of GDP (combined central government and state governments) since the early 1990s. Although there is a liberalized private market for government debt, banks and other financial institutions still hold a substantial share of public debt, largely as a consequence of the SLR.

Lahiri and Patel consider the combined effects of repression of the formal financial sector, fiscal dominance, and international financial market integration on the effects and efficacy of monetary policy for India. At the end of the 1990s, the SLR requirement was 30 % and remains a substantial share of deposit liabilities at 21.5 % at present. Even with private participation in the primary and secondary debt markets, the SLR requirement reduces equilibrium returns on public debt by imposing a minimum quantitative constraint on holdings of government bonds. The costs of holding mandated levels of government debt in lieu of other banking assets can impair the financial viability of banks and distort the pass-through of monetary policy to loan and deposit interest rates. Other means of financial repression also adversely affect the health of banks and efficacy of monetary policy. Required priority sector lending at subsidized rates increased sharply over the first decade of the 2000s. These mandates contribute to nonperforming assets on bank balance sheets and can raise the potential for moral hazard in bank lending. Administered savings deposit rates can also reduce the pass-through of repo rate changes.

In their chapter, Lahiri and Patel develop a model of monetary policy with bank intermediation that illustrates troubling effects of the SLR on the link between policy rates and bank lending or deposit rates. The model shows that when the SLR is a binding constraint, a decrease in the policy rate leads to an increase in the loan rate and an output contraction. Similarly, a rise in the money supply growth rate raises inflation but contracts output. Further, a reduction in the SLR leads to an increase in bank lending when the SLR binds because loan rates exceed equilibrium bond yields. These reverse monetary policy effects arise because policy rate reductions decrease public debt yields. The model implies that implicit bank subsidies to the government through the SLR can reverse the direction of how monetary policies affect intermediate policy targets and, ultimately, output growth and inflation. If deposit rates are not flexible, as under administered savings deposit rates, then a reduction in the policy rate, for example, could lead to bank insolvencies compounding the contractionary effects of normally expansionary monetary policies.

The model provided by Lahiri and Patel demonstrates that the SLR can lead to unpredictable outcomes from monetary policy actions by confounding the interest rate channel of monetary policy transmission. They expand their analysis by introducing fiscal dominance over monetary policy. In this case, the central bank needs to monetize exogenous nominal public sector deficits. In the presence of the SLR constraint, a decrease in inflation is associated with an increase in output, and the policy interest rate has an ambiguous effect on inflation. As they point out, this result echoes and elaborates on the implications of Sargent and Wallace (1981) for the timing of debt monetization under fiscal dominance.

This section of the volume continues with a chapter by Atish Ghosh, Mahvash Qureshi, and Eun Sun Jang on India's experience with capital account liberalization, the growth of external capital flows, and the consequences for macroeconomic policy. The chapter begins by summarizing the progress of gradual liberalization of international financial transactions and documenting the growth and composition of external capital flows for India. India began liberalizing capital inflows after the balance of payments crisis of 1991 by raising caps on quantities and relaxing approval reviews for foreign direct investment and portfolio equity inflows. While the relaxation of controls on capital inflows has been substantial, many controls remain on outward capital flows. Reforms have led to a significant increase in total capital inflows over the last 25 years as a share of GDP and relative to other EMEs. However, the composition of inward flows to India is rather different from most EMEs: the share of FDI in total inflows is currently less than one-half that for EMEs as a whole. Short-term debt inflows for India have been rising relative to other emerging markets consequent to the liberalization of short-term inflows over the last decade. India restricts capital outflows much more than most EMEs and continues to rely on quantitative restrictions rather than price-based controls.

Ghosh, Qureshi, and Jang then turn attention to the experience of capital account liberalization in emerging markets and the evidence on growth benefits from liberalization. Although the net benefits of financial openness continue to be debated, the empirical literature reveals that the composition of flows matters. Ghosh et al. show that the strong association between net inward FDI and the growth of real GDP holds for India as for other emerging markets. They find that a 1 % increase in net FDI is correlated with a rise of real output of 1.5 % for India. An important concern about capital flows for EMEs is that short-term and foreign currency-denominated liability inflows pose significant risks of volatility and amplification due to exposure to external shocks or external responses to domestic shocks. A rule-of-thumb is that long-term debt flows, portfolio equity flows, and foreign direct investment ought to be favored as these create less risk exposure for an open economy. Overall, emerging market flows have become increasingly sensitive to external disturbances as capital account liberalization has progressed globally.

Ghosh et al. evaluate policies that are available for managing India's external capital inflows. Several approaches for reducing vulnerability to volatile capital flows while allowing gains from access to international capital markets apply to India's circumstances. Policies for capital flow management include recommendations to accumulate international reserves for future use as a buffer in the face of capital inflows, and to avoid real appreciation of the currency. Thus, a flexible balance between exchange rate intervention and allowing exchange rate adjustment is recommended. Other roles for monetary authorities include using countercyclical monetary policy to mitigate the volatility of capital flows and the adoption of macroprudential policies to maintain financial stability. The sustainability and cyclicality of fiscal policy are important factors for maintaining stable capital inflows and allowing monetary authorities to manage capital inflow volatility. Ghosh et al. note the growing consensus in favor of keeping capital controls in the policy mix.

In recent experience, India ran persistent current account deficits, tightly managed exchange rates, and accumulated international reserves on par with other EMEs. Capital inflows have largely financed current account deficits. The RBI's monetary policy was challenged by the surge of capital inflows in 2008–2010 following the global financial crisis. The RBI actively intervened to maintain the exchange rate through this period of capital inflows and the sudden outflows of May and June 2013. However, the rise in policy interest rates to fight inflation during capital inflows left the RBI constrained in its room to tighten monetary policy in the combination of capital outflows, exchange rate depreciation, and diminishing output growth. Over this recent period, capital controls were adjusted to counter the cycles in capital inflows. For example, during the surge of inflows, inward capital controls were tightened and outward controls relaxed. The burden of the policy response was placed on monetary authorities as a fiscal response to the current account dynamics was absent. Ghosh et al. conclude that India seems to have managed a mix of capital account liberalization, exchange rate stability, and monetary policy autonomy in the aftermath of the GFC. The challenge for the RBI will be maintaining the stability of the financial sector and meeting domestic goals of monetary policy as India becomes increasingly integrated in international capital markets.

Labor market regulation continues to be an important feature of the Indian economy which constrains incentives for employment, investment, and enterprise entry in the formal sector. Regulatory and institutional barriers to firm entry and innovation in product markets persist despite other economic reforms over recent years. The Industrial Disputes Act, Factories Act, Shops Act, and Contract Labor Act, along with various state-level labor laws, constrain labor turnover in the formal sector by imposing costly procedures for laying off workers. The World Bank index of the ease of doing business ranks India 130th out of 189 countries, well behind the other large EMEs. Barriers to entry and restrictions on product market competition reduce the flexibility of output markets and relative prices over cycles and time.

Employment regulations and state control over product market competition in the formal sector tend to increase employment and production in the informal sector past economically efficient levels. Approximately, 90 % of workers are employed in the informal sector which produces about half of national output.

Anand, Das, and Khera model how costly firm entry and exit in product markets and labor regulations in the formal sector affect the transmission of monetary policy actions to inflation and output in a dynamic stochastic general equilibrium (DSGE) model. In their model, entry by firms and hiring and firing of workers are more costly in the formal sector than in the informal sector. To explore how differences in regulation of the two sectors impact on monetary policy, Anand, Das, and Khera include nominal wage rigidity and monopolistic competition in a new Keynesian DSGE framework of a small open economy. Using a matching model of employment transitions, frictions in the formal and informal labor markets are represented by differences in hiring and firing costs, and differences in the division of bargaining power between workers and firms. The calibration of the model based on Indian data assumes that worker bargaining power is 8 times as great in the formal sector over the informal sector, hiring costs are 6 times higher, and firing costs are 7.5 times higher. Firm entry costs are more than 3 times higher in the formal sector than in the informal sector. In simulations, a monetary shock is represented by a rise in the repo rate in a flexible inflation targeting regime.

The results for the calibrated model show that a decrease in the marginal costs of expanding formal sector employment (a reduction in both hiring and firm entry costs) significantly reduces the output cost of reducing inflation. However, lowering just hiring costs or entry costs singly has little effect on the output costs of reducing inflation. Reducing marginal disincentives to both employment and new firm entry into the formal sector improves the transmission of monetary policy shocks to inflation. This chapter demonstrates the importance and role of market frictions, not just financial frictions, for monetary policy effectiveness.

The weak transmission of monetary policy in India mirrors that of other emerging market and developing economies, and the probable reasons are similar. India lacks large and liquid secondary markets in public sector and corporate debt. The transmission of monetary policy to aggregate demand needs to work primarily through the bank lending channel. Formal banking, however, is small and does not intermediate finance for a large fraction of the economy. State ownership, financial repression, and a lack of competition result in high costs of financial intermediation and a weak relationship between policy and loan interest rates. Although a floating exchange rate allows the RBI to exercise monetary autonomy, incomplete international financial integration and foreign exchange market intervention by the RBI limit the strength of the exchange rate channel of monetary policy transmission. All of these observations suggest an a priori case for a weak transmission of monetary transmission in India.

The chapter by Mishra, Montiel, and Sengupta examines the empirical evidence on the strength of monetary transmission in India, using structural vector autoregression (SVAR) methods that are commonly use to study the effects of monetary policy shocks. Monthly VARs are estimated for data from 2001 through 2014 imposing structural restrictions to identify exogenous movements in the policy rate. The chapter shows that positive shocks to the policy rate result in statistically significant movements of bank lending rates in the predicted direction. Tightening monetary policy leads to a rise in bank lending rates providing evidence for the first stage of transmission in the bank lending channel, but increase in the bank lending rate is just one-quarter of the increase in the policy rate. The effects of exogenous monetary policy shocks on the real effective exchange rate are extremely weak and not statistically significant for any of the identifying restrictions considered. The estimations do not find any evidence for effects of monetary policy shocks on aggregate demand as measured by the gap in the index of industrial production (computed using a deviation of the log of this series from a smoothed version computed using a two-sided HP filter) or the rate of inflation.

Monetary transmissions for the EMEs and for India are examined in the chapter by Mohanty and Rishabh as well. This chapter looks at how the efficacy of monetary policy changed after the global financial crisis. The simplest models of monetary transmission assumed no financial market frictions, perfect asset substitutability, and rational expectations. The interest rate, asset market, and exchange rate channel should all effectively translate an increase in the monetary policy rate to reductions in inflation and output in these models, and the central bank balance sheet plays no role. The introduction of the financial accelerator with the external finance premium and imperfect substitutability between reservable deposits and other bank liabilities to the simple model leads to credit supply effects on transmission.

The GFC motivates the reassessment of these models for the EMEs. The events since 2008 demonstrated the importance of quantity instruments for central banks and the possibility of a risk-taking channel for monetary transmission. The correlation of long-term interest rates between the EMEs and the high-income economies increased significantly after the crisis. Greater influence of global markets on long-term interest rates should reduce transmission from the policy rate to long-term rates and could increase volatility by raising the exposure of EMEs to external shocks. Mohanty and Rishabh document the changing monetary environment of the EMEs and examine how the transmission of monetary policy has evolved. The first half of the chapter examines how international financial market integration, growth in global debt markets, and the role of nominal exchange rate volatility for bank balance sheets affect the transmission of monetary policy in the EMEs.

Mohanty and Rishabh provide an empirical analysis of monetary transmission for India using quarterly data for 1996 through 2014. In contrast with the study by Mishra, Montiel, and Sengupta, they measure output using nonagricultural nongovernment GDP which is available quarterly from 1996 instead of the index of industrial production. The SVARs include variables representing the credit channel, the asset price channel, a separate bond price channel, and the exchange rate channel alternatively using real exchange rates and nominal exchange rates. The bond price channel captures effects on lenders, as bonds are significant on the asset side of bank balance sheets. They find large negative effects of increasing the call money rate on output and inflation consistent with prior evidence. The effect of U.S. monetary policy on Indian monetary policy is measured by the effect of a rise in the U.S. long-term bond premium on the call money rate and output. Neither is affected in sharp contrast to other Asian emerging market economies. The lack of integration of India's bond markets with global markets, as documented in Ghosh et al., is the likely reason for the absence of an effect of the U.S. term premium on India. The credit channel is identified using nonfood credit to detect effects of external finance premiums and is found to be operative, as is the asset price channel.

5 Liquidity Management and Financial Structure of the Indian Economy

The four chapters of this section take a closer look at the structure of Indian financial markets and their role in monetary policy effectiveness. The chapter by Chakrabarti surveys the environment for investment finance, the development of bond and equity markets, the importance of internal enterprise finance, and the impact of monetary policy on enterprise investment in India. Acharya and Subramanian pay particular attention to the health of the public sector banks and the challenge these pose for financial stability. The empirical analysis shows that the health of the state banks should be of serious concern. In their chapter, Mehra and Sinha investigate the term structure of interest rates in the bond market after providing an empirical look at the nascent nature of the corporate bond market. Their empirical analysis includes the first test of the expectations hypothesis for India, to our knowledge. Patra, Kapur, Kavediya, and Lokare survey the evolution of liquidity management by the Reserve Bank of India and econometrically assess how well the current systems of liquidity management work for transmitting changes in instrument interest rates to operational target interest rates.

The chapter by Rajesh Chakrabarti explores the transmission mechanism for monetary policy by investigating the role of financial markets, and of financial market frictions, in investment finance in India. A primary theme of the chapter is that the allocation of funds differs greatly between the formal and informal sectors and between large enterprises and small or medium enterprises. A second major observation is that saver participation in financial markets differs greatly between residents of the major urban centres and of rural India. Chakrabarti provides a detailed survey of financial market development and regulation since the early 1990s. Although private entry into the mutual fund and insurance industries, access by foreign institutional investors, liberalization of equity markets, and opening of derivatives markets all occurred in past decades, financial markets intermediation still plays a modest role for enterprise investment and the bond market remains a minor source of corporate finance. Financial market regulation is entity based rather than function based leading to overlapping regulation of some activities and gaps in regulation of others.

Large enterprises rely on bank loans and capital markets for 37 % of their financial needs, with internal finance accounting for 50 % of their investment resources. These shares are similar across manufacturing and service sector firms. In contrast, internal finance accounts for just 15 % of financial resources for small and medium enterprises. Small and medium enterprises' finance relies on internal finance for 15 % of investment and on equity markets for 32 %. Bank loans follow equity issues in relative importance for financing small and medium enterprises, but trade credit is a major source of finance suggesting that SMEs are quantity constrained in bank borrowing. The equity market ranks second to internal finance for large enterprises. Stock market capitalization is up to 2/3 of GDP, but the corporate bond market provides less than 4 % of corporate finance.

The pass-through from monetary policy to lending rates and investment is hampered by bond market underdevelopment and regulations that work against liquidity and expansion. Equity markets remain a major source for investment finance, most probably because the equity and derivative markets are large and liquid. The dominance of state-owned banks and ongoing repression of bank intermediation are primary reasons for the low and unreliable transmission of policy rate changes to loan and deposit rates. The overwhelming reliance on internal finance by large established firms indicates the high cost of external funding. Large interest spreads between external and internal investment finance could well absorb policy rate changes weakening the credit channel. The importance of equity finance for small and medium firms ought to strengthen the asset price channel, as is seen in the SVAR estimation in the previous chapter by Mohanty and Rishabh.

The financial health of India's public sector banks has become a subject of deep concern for policy. In their chapter, Viral Acharya and Krishnamurthy Subramanian investigate the financial status of the public sector banks by comparing them to new private sector banks. Their empirical analysis raises several issues of concern, including the viability of the banks, the costs of recapitalization, and implications for the health of the banking sector as a whole. The chapter uses wide-ranging data to compare the capital positions, contribution to systemic risks, and profitability of public sector banks to new private sector banks. The newer private sector banks provide a useful benchmark because their balance sheets do not carry legacy nonperforming assets.

Acharya and Subramanian consider first the consequences of adjusting to the Basel III capital adequacy norms for Indian banks. While the public sector banks meet current capital adequacy standards, the RBI has provided forbearance on restructured assets which Acharya and Subramanian argue should be classified as nonperforming as these are in imminent default. They estimate that 40 % of the public sector banks would not meet current standards absent forbearance. The amount of additional capitalization needed by the banks for upcoming Basel standards is estimated using three, decreasingly strict, standards for risk weighting. Most of the new private sector banks currently meet all three standards. The public sector banks will require a 30 % increase in capital in total under the weakest standard and 160 % increase under the strictest. The fiscal costs of recapitalizing the public sector banks might be offset in part by reducing the government's equity share in the banks to the mandated minimum 52 % stake. Acharya and Subramanian estimate this would yield 8 % of the amount needed under the weakest standard. Without a capital infusion, overall growth of the public sector banks must decline and actually shrink under the strictest risk-weighting scenario.

Another perspective on the health of the public sector banks is given by estimating their contribution to systemic risk. Following Acharya (2009) and Acharya et al. (2012), a measure of a financial institution contribution to systemic risk, SRISK, is estimated. SRISK measures the capital shortfall of a bank in a stress test using the market value of equity. This allows for the fall in bank market value in a crisis unlike a regulatory stress test that uses the book value of equity. The stress test is a fall of 40 % in the global stock market value over a 6-month period. Acharya and Subramanian estimate the Indian financial sector has a capital shortfall equal to 3 % of GDP, which is over 25 % of the market equity of the firms, as of May 2015. However, at the time of the taper tantrum in May 2013, the shortfall estimate was 6 % of GDP. Other factors of concern for systemic risk include the large holdings of bank equity by the Life Insurance Corporation of India and the concentration of bank lending across borrowers, sectors, and industries. Acharya and Subramanian also estimate the relationship between bank performance and systemic risk and find that the public sector banks are significantly more susceptible to systemic risk than are the new private sector banks. The chapter includes a comprehensive set of comparisons of the financial status of public sector and of the private banks.

Policy consequences of the impaired health of the public sector banks in the approach to Basel III standards include the fiscal costs of recapitalization or the alternative of shrinking their balance sheets. Several steps for resolving or reducing the banking sector's exposure to systemic risk are given. These start with recapitalization of the banks with the highest gearing as these have the strongest market equity values. Acharya and Subramanian point out that deep discount rights issues could be used to raise capital from equity holders rather than through the public budget. A second is to strengthen bank governance, and a third is to reduce the subsidization of the public sector banks by raising deposit insurance premiums or requiring additional capital to receive public funding. Finally, they recommend privatization of some banks and the closing of others.

The bond market has a very small presence in India and is dominated by the government securities market. Until 1991, the market for government debt was illiquid as adjustments to the SLR ensured that government debt was held by commercial banks or monetized by the RBI. Market borrowing by the GOI grew continuously from less than 20 % in 1991 to over 100 % of the gross fiscal deficit in 2013. As of 2015, outstanding government debt securities were about 35 % of GDP. The growth of the corporate debt market began in 2005 and outstanding corporate debt equals just 5 % of GDP. The chapter by Rajnish Mehra and Arunima Sinha studies the bond market in India and the implications of the term structure for monetary policy. This chapter bridges a significant gap in the analysis of Indian financial markets by presenting an empirical analysis of the term structure of interest rates for India in comparative context (to the U.S.).

The term structure of interest rates is central to the transmission of changes in overnight rates to long-term rates and, hence, aggregate demand. Of particular interest for monetary policy is whether the relationship of long-term to short-term rates is predictable and stable. Mehra and Sinha test whether the expectations hypothesis, that the term premium is constant, holds for the Indian bond market following Campbell and Shiller (1991). The expectations hypothesis implies that the long-term bond yield equals the average of expected future returns over the maturity of the bond. This means that the variance of returns should be lower for long-term bonds than for short-term bonds. An important finding in finance is that the expectations hypothesis is rejected for U.S. nominal bond yields. Similarly, decreasing variance of nominal yields with bond maturity is rejected (called the "volatility puzzle"). Possible reasons for these failures have been investigated and include that risk premiums are time varying, bounded rationality or a lack of credibility of the central bank prevail, or small sample properties matter.

Mehra and Sinha find that the expectations hypothesis is rejected for nominal yields for India, consistent with studies for other countries. As for the U.S. bond market, an increase in short-term yields leads to a fall in nominal yields on long-term bonds over the maturity of the short-term bonds, contrary to the expectations hypothesis. However, the estimates reveal strong evidence for predictability of nominal bond yields and for first differences in the yields to maturity on long-term bonds. This implies that a naïve trading strategy of buying and selling long-term bonds before maturity would result in large capital gains. Further, Mehra and Sinha find that the volatility puzzle does not hold for India: the variance of yields falls over the yield curve.

The term structure matters for monetary policy because policies ought to work by changing short-term nominal interest rates and influence real activity by predictably moving long-term real interest rates. As Mehra and Sinha point out, predictability is not enough. The mapping from short-term nominal yields to long-term real yields needs to be stable, and they find that it is not. Interestingly, their analysis does find that the relationship between real short-term yields and real long-term yields is stable for India.

A liquid market in the instruments used by central banks in open market operations is essential for conducting monetary policy effectively and usefully. The management of liquidity in short-term money markets is a critical part of implementing monetary policy and a core issue in central bank operations. Liquidity management focuses on the crucial link between the central bank's policy instrument, what it controls, and its operational target, what the market responds to. The chapter by Michael Dedabrata Patra, Muneesh Kapur, Rajesh Kavediya, and S.M. Lokare studies the role of liquidity management in central banking and how the RBI's management of liquidity has evolved in recent years. They begin by discussing the difficulties created by lags in the transmission of monetary policy instruments to short-term money market rates and the challenge for liquidity management by central banks. The practice of liquidity management and monetary policy implementation in both mature and emerging markets is examined as well.

The RBI began to manage liquidity to facilitate the transmission of monetary policy to the overnight money market through the Liquidity Adjustment Facility (LAF) in 2000. In 2004, the RBI moved to operating only in the overnight repo/reverse repo market and used the LAF to keep the call money rate (operational target) within a corridor centred on the desired rate. Experience showed that the corridor allowed substantial volatility in the call money rate because the policy rate alternated between the repo and reverse repo rates. In 2011, the repo rate became the single policy instrument, but the introduction of the marginal standing facility rate into the corridor became problematic by impeding the transmission of monetary easing and leading to liquidity easing in tightening phases. The framework was revised to its current mode in 2014 when the RBI began conducting liquidity operations using repo rates of various tenors allowing finer tuning for meeting call money targets and to develop the term money market. The RBI also ended unlimited access to liquidity at the LAF repo rate. The operating target is now set in a narrow band and a liquid term repo market allows the RBI to practice what the chapter's title refers to as marksmanship.

Patra, Kapur, Kavediya, and Lokare use a simple econometric model to investigate how liquidity management by the RBI meets its two primary goals: achieving the target and minimizing volatility in the target rate. They use an autoregressive distributed lag model augmented with dummy variables for different policy regimes. They find that asymptotically the call money rate follows the policy rate closely throughout the entire sample. The estimated short-run rate of convergence declines substantially moving from the corridor to the present framework using the term repo market. Volatility of the call money rate has diminished greatly achieving a reduction of 95 % over 9 years. Finally, evidence is shown that overall volatility in money markets seems to have declined.

6 The Constraints on Normal Central Banking in India

Central bank policymakers are challenged by the persistence of inflation in India and the increasing global interdependence of the Indian economy. The four chapters in this section address these issues and how they affect monetary policy in India.

The chapter by Bhatt and Kishor looks at the measurement of trend inflation and assessment of the effectiveness of monetary policy to stabilize inflation around a long-term target. Two chapters, by Hutchison and Pasricha and by Gupta, look at how exchange rate volatility, capital account liberalization, and rising exposure of India to international capital flows have affected monetary policy. Hutchison and Pasricha analyze the dynamics of exchange rates, capital control reforms, and monetary policy autonomy. Gupta focuses on the volatility and management of capital inflow surges and reversals and examines the impact of increasing interdependence on monetary policy actions. In the fourth chapter of this section, Chinoy, Kumar, and Mishra focus on the recent disinflation in India and provide an econometric analysis of how inflation expectations evolved and the role of minimum price supports, food inflation, and rural wage affects the inflation process.

In their chapter, Vipul Bhatt and N. Kundan Kishor study the long-run dynamics of Indian inflation and propose a new measure of trend inflation for India. They begin with the conceptual approach that inflation can be approximated by a sum of two components, permanent and transitory, with trend inflation identified as the permanent component. Bhatt and Kishor estimate trend inflation using a multivariate unobserved components model using three components: CPI inflation excluding food and fuel, food inflation, and fuel inflation. Food and fuel prices are substantial shares of consumer price indices for India, and persistent changes in food and fuel inflation can be important for persistence in overall CPI inflation in India. Their measure is based on the CPI-IW because the comprehensive CPI is available only from 2011; they show that the CPI-IW tracks the CPI-C well. The decomposition of inflation into trend and transitory components follows Stock and Watson (2007) and provides a measure of inflation persistence using the inflation gap defined as the difference between inflation and time-varying trend inflation.

Bhatt and Kishor first show that monthly CPI inflation displays a unit root confirming strong persistence in Indian inflation. Second, trend inflation estimated from the unobserved components model outperforms other measures of long-run inflation dynamics. In particular, the mean-squared forecast error is much smaller for the estimated trend inflation than for the RBI's survey measure of inflation expectations over 1- and 2-year forecast horizons. When the base model is augmented by adding the survey measure, Bhatt and Kishor find that the trend estimated in its absence has a lower mean-squared error than the trend estimated in its presence for long horizons. This appears to be the first analysis of how well the RBI survey measure of inflation expectations explains the dynamics of CPI inflation. The econometric results also show that food and fuel inflation are important factors in trend inflation in India. These results imply that the inflation trends estimated from the unobserved components model are a superior measure of inflation expectations in the Indian case.

A common interpretation of trend and transitory components of inflation is that monetary policy determines trend inflation and that transitory inflation is governed by the intricacies of price-setting behavior and exogenous shocks. However, Cogley et al. (2010) argue that persistence in the inflation gap is a more meaningful measure of how well monetary policy achieves long-run inflation targets. The unobserved component model allows the measurement of the persistence of shocks to the inflation gap, thus measuring the effectiveness of monetary policy for closing the gap. Bhatt and Kishor estimate the time-varying inflation gap using their estimated measure of trend inflation and find that the persistence of inflation in India varies significantly over time.

The chapter by Michael Hutchison and Gurnain Pasricha provides an analysis of exchange rate dynamics and the role of the exchange rate for monetary policy in India. Exchange rate intervention and capital account restrictions have been a prominent feature of monetary policy for India. As international trade and financial integration grew rapidly over the last two decades, stabilizing the exchange rate of the rupee against the U.S. dollar continued to be a prominent objective for monetary policy. Hutchison and Pasricha begin with a statistical analysis of rupee exchange rates comparing in particular the bilateral exchange rate against the U.S. dollar and the trade-weighted multilateral rate. Over the period 1998–2014, the rupee depreciated substantially in nominal terms as trend inflation in India was higher than inflation in the U.S. and, more modestly so, major trading partners. In real terms, the rupee appreciated significantly against the dollar but the real multilateral rate remained fairly constant. Hutchison and Pasricha note that these patterns vary quite a bit over time and break the data into distinct periods. They show that exchange rate volatility was relatively low except for 2008–2013. The RBI's focus on stabilizing the rupee–dollar rate is demonstrated by the much higher volatility of the rupee against the British pound and the Euro. Cointegration between exchange rates and prices in India and the U.S. are rejected showing that there is no long-run relationship between trends in the rupee–dollar rate and relative prices. They find evidence for convergence to purchasing power parity over long horizons for the broad, trade-weighted index.

Hutchison and Pasricha turn their attention to the role of exchange rate management and capital controls in monetary policy. They investigate whether foreign exchange market intervention and the relaxation or tightening of capital controls are consistent with exchange stabilization goals. Despite an increase in exchange rate flexibility, the RBI engages in extensive intervention in the exchange market and has tended to resist appreciation but avoid expending reserves to mitigate depreciations. As they note, the RBI exhibits a "fear of losing reserves." Because India runs perpetual current account deficits, accumulated reserves are a useful precaution against capital flow reversals as the capital account is increasingly liberalized. Allowing the rupee to depreciate has kept the real exchange rate stable and exports competitive during periods of high domestic inflation. It has also afforded greater monetary autonomy at the same time as India gradually liberalizes external capital movements. Hutchison and Pasricha conclude that the exchange rate does serve as a nominal anchor of monetary policy.

The gradual restriction of controls on external capital inflows and outflows is documented by Hutchison and Pasricha. They find that the timing of policy changes directed at capital flows appears to be related to nominal exchange movements. Twice when the rupee was appreciating against the dollar (in 2003–2004 and 2006–2007) restrictions on capital inflows were tightened while some restrictions on capital outflows were relaxed. Between 2008 and 2013 there were notable liberalizations of capital inflows during periods of rapid depreciation, and outflow restrictions were tightened in the tapering tantrum episode of 2013. They do not find empirical evidence that these capital account measures influenced exchange rate changes. Finally, Hutchison and Pasricha consider monetary policy independence quantitatively and show that monetary autonomy increased substantially over the decade from 2004 to 2014. They conclude that increasing financial openness has led to an acceptance of exchange rate flexibility in favor of monetary autonomy.

Since the early 1990s, India has gradually liberalized capital account transactions and become increasing integrated in international financial markets. Although the pace of this integration has been much slower than for most emerging markets, India is now a more interdependent economy and experiences similar cycles of external capital flows as other EMEs. Capital flows to India follow global financial cycles, and India has experienced the surges and reversals of net capital inflows that have challenged most EMEs for some time.

The chapter by Poonam Gupta investigates the extent to which India's monetary policies are affected by international capital flows. The entire period from the beginning of financial liberalization in the early 1990s is divided into three phases defined by capital flows: the period of small but increasing capital inflows from the early 1990s to the early 2000s, the surge of capital inflows between the early 2000s and 2007–2008, and the volatile phase from 2008–2009 to 2013–2014 in which India experienced both capital inflow surges and stops. The analysis reveals that monetary policy focused on price stability in the first of these phases but did respond to external capital flow cycles after the millennium. Gupta provides complimentary evidence to Hutchison and Pasricha that monetary policies were eased during inflow surges and tightened when capital flows reversed. These policy responses consisted of reserve management, RBI liquidity measures, and the tightening or relaxation of capital controls. The RBI accumulated reserves, relaxed controls on outflows, and tightened constraints on capital inflows between 2003 and 2008 when capital inflows increased sharply. It tightened monetary policy, did expend some reserves to mitigate rupee depreciation, and increased liberalization of inward capital controls while tightening outward controls during the capital flow reversal phases during the global financial crisis of 2008–2009 and the taper tantrum episode of 2013.

Overall, Gupta finds policy rates reflect domestic objectives of monetary policy (stabilizing inflation and output growth) and respond little to external capital flows and exchange rate movements. Other instruments of monetary policy play a greater role in managing capital flow surges and reversals. Gupta reflects that the adoption of inflation targeting by the RBI is likely to strengthen the predominance of domestic goals for monetary policy. The capacity to use capital flow restrictions ought to diminish as capital account liberalization progresses. The implications drawn include the prospective rising importance of reserve management and macroprudential policies, other than external capital controls, for managing capital flow cycles. The RBI has shown a more relaxed stance toward exchange rate movements, although a greater tolerance for exchange rate volatility may in the offing.

Between 2006 and 2013, India experienced inflation that was persistently high by comparison to very low global inflation and despite the global financial crisis and contractions of the advanced economies. After reaching a year-on-year increase of 12.1 % in November 2013, CPI inflation fell to 4.3 % over 2014. In their chapter, Sajjid Chinoy, Pankaj Kumar, and Prachi Mishra provide an empirical investigation of the disinflationary episode. They estimate a Phillips curve for India adopting a hybrid specification of expectations formation that incorporates backward-looking adaptive and forward-looking rational expectations. The econometric model includes several domestic and global factors that could generate fluctuations to inflation not measured by an output gap. Among these variables are changes in the minimum support prices for agriculture, rural wages, rainfall shortages, exchange rate movements, and global food and oil prices. Rural wages ought to be influenced by the output gap, but these are included to account for administratively set minimum wage changes or rural wage guarantees (MNREGA) that will not be captured by the output gap.

The chapter includes several findings of interest. The largest share of the disinflation between fiscal 2013–2014 and 2014–2015 is explained by the backward-looking component of inflation. This accounts for 45 % of the reduction in inflation and captures both adaptive inflation expectations and institutional structure of wage and minimum support price setting (indexation) that directly imparts inflation persistence. Forward-looking expectations account for almost 35 % of the disinflation, possibly reflecting expectations of future global commodity prices or the anticipated consequences of the adoption of the inflation targeting framework. About 20 % of the disinflation can be attributed to large decreases in the growth rate of the minimum support prices. Exchange rate changes and global prices explain less than 15 % of the inflation reduction. The offset for these effects comes from the positive output gap providing positive inflationary pressure. Chinoy, Kumar, and Mishra conclude that exogenous shocks to inflation were propagated through the backward-looking component of inflation expectations and domestic policies that effectively index minimum support prices or rural wages.

7 Toward a Theoretical Framework for Monetary Policy in India

The contemporary analysis of monetary policy frequently uses quantitative general equilibrium models to generate dynamic responses to macroeconomic shocks and provide welfare comparisons of policy rules and interventions. Dynamic stochastic general equilibrium (DSGE) models are a standard tool for understanding policy effects in theoretical models calibrated to macroeconomic data. In recent years, models for both advanced and emerging market economies have begun to incorporate frictions in labor, product, and financial markets. Financial imperfections and financial market fragmentation are major features of the Indian economy that need to be included in useful but manageable models for policy analysis in India. Financial frictions are particularly salient for India and have significant implications for monetary policy transmission to price levels and economic growth.

This volume includes three chapters that propose and develop similar DSGE models for India. Each of these emphasizes different aspects of monetary policy in the presence of financial frictions. The chapter by Gabriel, Levine, and Yang shows how the inclusion of financial frictions and the manner in which traded goods are priced helps these models to track Indian data and simulate shocks. Chadha and Kang develop a model of bank intermediation that allows a heuristic examination of monetary policy operations in the presence of financial market frictions. The Banerjee and Basu model examines the effects of quantitative easing abroad on a small open economy model calibrated for India and shows how external interest shocks affect the economy through the terms of trade.

Vasco Gabriel, Paul Levine, and Bo Yang develop an open economy DSGE model of the Indian economy with and without financial frictions and then estimate it using Bayesian maximum likelihood methods. The frictions included the small open economy including domestic financial frictions and dollarization of external liabilities. The estimation is used to assess whether the inclusion of financial frictions, failures of exchange rate pass-through, and external dollar debt improve the fit of a DSGE model to Indian data. The model is built on a standard new Keynesian framework in a baseline version without domestic financial frictions and with complete exchange rate pass-through. Financial frictions are introduced by adding limited asset market participation by households and the financial accelerator due to agency costs in financial intermediation for producers. Incomplete pass-through is modeled by assuming exporters and importers both set nominal product prices in domestic currency.

The chapter shows that the inclusion of the simple stylized models of financial frictions significantly improves the capacity of the DSGE model to track the Indian economy. Frictions amplify the propagation of shocks in the simulated economy. Exchange rate volatility plays an important role due to external liability dollarization, but the exchange rate does not affect the economy through expenditure switching because the law of one price for tradable goods fails. Monetary policy is modeled using a generalized inflation targeting interest rate rule with forward- and backward-looking expectations. Several extensions of the DSGE model and applications to deriving optimal monetary policy are also discussed.

Jagjit Chadha and Youngkwan Kang develop a different DSGE model of financial frictions that highlight financial segmentation and credit rationing and characterize how these frictions can affect optimal monetary policy. This chapter adopts the standard limited asset market participation model for households and extends the financial accelerator model for goods producing firms as well. The premium for external over internal finance for firm investment and for household lending is determined by the cost structure of banks as well as the borrower's leverage. Banks are producers of loans hiring labor to monitor borrowers and adjusting collateral requirements to make loans. The external finance premium is endogenous to deposit rates and the monetary policy rate in this framework. In this

DGSE model, monetary policy affects a number of short-term interest rates. Thus, the monetary transmission mechanism acts through both the spread between the policy rate and deposit rates and the spread between lending rates and the policy rate. Ultimately, the endogenous loan production decision of the commercial banks determines the behavior of these spreads.

Chadha and Kang show that bank reserves, which are a counterpart to central bank assets, play an important role in how financial shocks affect optimal monetary policy. They then consider a Taylor-type rule augmented by an additive term responsive to financial shocks. If banks meet a fixed reserve requirement, then a Taylor rule that raises the policy rate in response to a positive financial shock raises welfare relative to a rule that only responds to inflation and the output gap. But when banks can adjust their reserves by optimally borrowing them at a penalty rate, welfare is not necessarily improved by adding the financial shock term to the monetary policy rule.

Quantitative easing (QE) by the Federal Reserve and other advanced economy central banks led to capital flow surges to the EMEs in general and to India in particular. A concern for monetary policy in the EMEs has been the possibility that ending QE would create negative spillovers for economies with fragile financial sectors and large external imbalances. For example, Rajan (2014) argued that the phasing out of QE could lead to unnecessary volatility in global markets, as seen in the tampering tantrum of 2013 for India. The effects of the entire period of QE on the Indian economy and monetary policy responses are a topic of interest. At the start of QE the repo rate for India followed the decline of the Fed funds rate, but the repo rate began rising in 2010 apparently as domestic inflation and output targets took precedence over exchange stabilization in monetary policy.

The chapter by Shesadri Banerjee and Parantap Basu develops a DSGE model for the Indian economy to analyze how QE affects a small open economy with financial frictions, sticky prices, and endogenous terms of trade. They model QE as a negative foreign interest rate shock and the expected phasing out of QE as the mean reversion of this shock. The approach for modeling the impact of QE on the EMEs contrasts with an existing literature that emphasizes transmission to these economies through cross-border capital flows and fragile banking sectors. Banerjee and Basu argue that QE shocks may work primarily through the terms of trade. The negative foreign interest rate shock initially results in exchange rate depreciation and reduction in the terms of trade. Anticipated tapering reverses the terms of trade response and is contractionary.

The DSGE model incorporates standard frictions modeled by aggregate habit persistence, investment adjustment costs, home bias in consumption and in investment, imperfect capital mobility, and financial frictions through limited asset market participation. Monetary policy is modeled by a forward-looking inflation targeting Taylor rule. In simulations, this model replicates the initial decline and subsequent reversal in the terms of trade and the divergence between foreign and domestic policy interest rates. Banerjee and Basu argue that the model is broadly consistent with the deflationary episode for the Indian economy after 2012.

8 Future Challenges

Economic reforms have contributed significantly to Indian economic growth and integration in the global economy. India is now facing opportunities and challenges from international financial markets and domestic financial development that many other emerging market economies have experienced and continue to share. The final section of this volume includes two chapters looking on issues of immediate concern for monetary policy in India from a global perspective. The Reserve Bank of India recently adopted flexible inflation targeting signaling that price level stability is a prime objective of monetary policy and that the exchange rate is not the nominal anchor. Klaus Schmidt-Hebbel and Martín Carrasco consider how emerging market economies and developing countries have adopted inflation targeting frameworks and how these have fared in the next chapter.

In the wake of the global financial crisis, the Federal Reserve and other major central banks dramatically increased their balance sheets through unconventional monetary policies as policy interest rates reached their zero lower bound. In this low return environment, global capital flows turned toward the emerging markets including India. The subsequent volatility of these flows and of exchange rates in response to advanced economy policy actions and announcements raised perennial concerns about the need for macroeconomic policy coordination in an interdependent world economy. In the closing chapter, Barry Eichengreen considers international policy coordination problems and prospects from the view point of the emerging markets. The chapter begins by interpreting the theory and practice of coordination and concludes with observations and thoughts on the prospects for international coordination going forward, particularly concerning mechanisms for promoting international financial stability.

The adoption of an inflation targeting framework by the Reserve Bank of India in 2015 started a significant episode in monetary policy practice in India. The success of India's experiment with inflation targeting is yet to seen, but the RBI has the advantage of the cumulative experience of 34 other inflation targeting central banks around the world. Many of these are emerging market economies that adopted IT regimes at least a decade ago (for example, Brazil, Chile, Colombia, South Africa, and Turkey). The framework and implementation of inflation targeting have changed over time since the Reserve Bank of New Zealand first adopted inflation targeting in 1990.

In their chapter, Klaus Schmidt-Hebbel and Martín Carrasco examine the international experience with inflation targeting, current frameworks used, macroeconomic outcomes, and prerequisites for success. Their analysis provides a number of insights into how inflation targeting is implemented and works in emerging market and developing economies. Of particular attention are the institutional environments of central banking, including independence, transparency, accountability, and specification of goals. An important factor for successful adoption of an inflation targeting regime is the absence of fiscal dominance of the monetary authority and of monetary policy. The history of fiscal dominance and reality of monetization of sizable public sector budget deficits pose a challenge for inflation targeting in India. The RBI continues to lack independence from political and fiscal authorities, although transparency and accountability standards are in place.

Schmidt-Hebbel and Carrasco review the record of inflation targeting central banks for managing inflation, meeting real economy goals, and reducing macroeconomic volatility. Overall, adopters of inflation targeting have succeeded in reducing inflation levels and volatility relative to nonadopters. Inflation targeting frameworks have also been challenged because several major economies attained the zero lower bound for interest rates following the global financial crisis. The effects for the emerging market economies are discussed. Several lessons from the emerging market inflation targeting central banks are drawn that are of interest for India and for other countries. Prerequisites for success include central bank institutional independence, central bank technical infrastructure, economic structure, and financial system development and health. With regard to the financial system, conditions conducive to starting an inflation targeting regime include a moderate degree of monetary transmission, operational independence in the conduct of monetary policy, and the absence of an exchange rate target. Each of these is relevant to the recent adoption of inflation targeting in India.

Barry Eichengreen observes, in the closing chapter of this volume, that the volatility associated with the global financial crisis strained relationships between national policymakers. After the initial coordinated monetary and fiscal expansions in response to the crisis, quantitative easing by the Federal Reserve began to have repercussions for emerging market economies through interest rates and exchange rates that were unwelcome. From the claims that a currency war had begun to the news that Fed tapering of its large-scale asset purchases might be in the offing, the sense that international monetary cooperation was no longer a concern of the U.S. became widespread and bluntly voiced, including by Indian policymakers.

Eichengreen provides an overview of the theory and practice of macroeconomic policy coordination over the years. The theoretical and empirical literature evolved as international financial integration and international trade linkages progressed. The importance of policy spillovers and global financial management have been on the agendas of national policymakers and the international financial institutions through many crisis episodes. Eichengreen discusses the importance of information sharing as international policy cooperation and notes that the reaction to Fed Chair Ben Bernanke's "tapering talk" speech was that it was unexpected—the groundwork had not been laid. The global crisis did lead to an increasing emphasis on international financial cooperation in the establishment and adoption of global prudential standards and of national macroprudential policies. Access to swap lines between emerging markets and the Federal Reserve is an ambition of many central bankers, but the Fed's reluctance on this is clear.

In closing, Eichengreen offers a guide to what emerging markets might expect in terms of macroeconomic policy cooperation with the advanced economies and what actions they can take. First, cooperation seems most likely when it addresses technical issues such as prudential supervision and regulation and can be delegated to specialists rather than to political responsible parties. Second, cooperation is more likely when it can be institutionalized, for example in a durable set of rules. Third, preserving an existing set of policies and behaviors can be easier than coordinating changes in policy regimes. Fourth, comity in political relations is important for achieving monetary, macroeconomic, and financial cooperation. Eichengreen closes with the observation that the U.S. may no longer be a sufficiently dominant country to play the economic hegemon.

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Part II
Pre-Requisites for Effective Monetary Transmission

Challenges of Effective Monetary Policy in Emerging Economies

Amartya Lahiri and Urjit R. Patel

1 Introduction

Modern monetary policy theory and practice have been heavily influenced by the experiences of developed countries, both large and small. A number of these ideas have also made their way into policymaking at central banks in emerging economies, mostly due to the absence of local intellectual alternatives. However, the realities of emerging economies are often at odds with the circumstances of developed economies that provide the backdrop for the intellectual underpinning of modern central banking. Specifically, the compulsions of unique institutional details as well as the thinness of financial markets in the context of increasing global integration often tends to render the monetary transmission mechanism in emerging economies both unstable and nonstandard.

The goal of this paper is to highlight the implications of specific institutional constraints and inherited practices that characterize emerging economies. We do so by focusing on India and fleshing out a number of confounding institutional and legacy issues that characterize the policy environment in the country. We then illustrate the consequences of these frictions for the monetary transmission mechanism by exam-

We would like to thank Rajesh Singh for an extremely insightful discussion of the paper as well as for his general comments which greatly improved the paper. Thanks also to Willem Buiter, an anonymous referee, the editors of the book, and seminar participants at the 2015 RBI-CAFRAL monetary policy conference for helpful suggestions and comments. We are grateful to Bhupal Singh and the Monetary Policy Department, RBI for invaluable help and assistance. The views expressed here do not necessarily reflect the views of the Reserve Bank of India.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_2

ining two features of the policy environment in India: the statutory liquidity ratio (SLR) requirements imposed on banks and long-standing chronic fiscal deficits of the government. The SLR forces banks to hold a minimum fraction of their deposits in the form of government bonds.

We show that the SLR requirement can completely invert the monetary transmission mechanism: a reduction in the policy rate can end up raising lending spreads and thereby cause a contraction instead of an expansion in the economy. Effectively, a binding SLR requirement removes all substitutability between bank assets: banks are forced to keep loans to the private sector and to the government in fixed proportions. Consequently, the reduction in the deposit base that is induced by a fall in the interest rate then forces a reduction of loans to the private sector as well. We also show that in environments where the monetary authority is forced to monetize the fiscal deficit due to dominance of the fiscal authority, a binding SLR requirement renders both output and employment *independent* of the policy rate: monetary policy has no real effects.

These results are very stark due to the admittedly stylized nature of the model. However, they illustrate quite vividly the consequences of the policy-induced SLR friction in the financial system. In general, when the SLR is binding it is a form of financial repression. A lowering of the rate on government bonds in such an environment is tantamount to increasing the tax on banks since the rate on government bonds is lower than the lending rate to the private sector. Consequently, it can have the effect of causing a shrinking of bank balance sheets with the resultant contractionary effect on credit.

The more general message of our results is that the choice of policy goals cannot be divorced from the specifics of the monetary transmission mechanism as it operates in the country in question, both in terms of its theoretical and quantitative linkages. Country or region-specific factors that impact the transmission mechanism will have implications for which variables should or should not be targeted by policy in addition to dictating the quantitative magnitudes of the changes in the policy instrument that are required for attaining the policy target. The mapping between the policy instrument and the policy targets are susceptible to institutional design, market structure, and penetration of capital markets, international linkages, and global business cycle considerations. Our discussion of the challenges of monetary policy conduct in emerging economies like India will focus on a detailed breakdown of the specific issues surrounding the transmission mechanism from the policy instrument to each of the three stages and their subcomponents.

In the next section we describe and discuss in some detail some of the unique and confounding aspects of the institutional setting within which monetary policy is conducted in India. In Sect. 3 we formalize a standard model of an open economy with banks and formalize the impact of monetary policy in this benchmark economy. In Sect. 4 we illustrate the effect on the monetary transmission mechanism of imposing a statutory liquidity ratio requirement (SLR) on the banking sector in our model economy. In Sect. 5 we examine the effect of an exogenous fiscal spending constraint on this economy over and above the SLR requirement. We then examine the evidence on the behavior of banks in India with respect to their SLR holdings in Sect. 6. The last section contains concluding thoughts.

2 An Overview of the Issues

The conduct of monetary policy in emerging economies is problematic along (at least) three dimensions. First, the policy and institutional environment is characterized by an inordinate number of constraints as well as large and persistent shocks. Second, the scope and capacity for (first-best) implementation of policies is circumscribed by legacy structures, cross-cutting objectives, and a dearth of analytical and practical tools. Third, the reality of external financing for funding the current account deficit and investment needs, implies that foreign analysts' world view regarding conduct of monetary/macroeconomic policy cannot be wished away, i.e., it has to, willy-nilly, be internalized, or, taken as given. Bond investors typically look for an anchor to predict the interest rate path.

There are two interrelated sets of drivers for a reinforced focus on its central bank in respect of policy conduct and concomitant outcomes. It is apparent that between 2007 and 2013, inflation has come unhinged. In recent years India has emerged as an outlier compared to its own past (see Darbha and Patel (2012), for example); inflation as measured by consumers cost of living has averaged 9 % over the last six years. Even the much narrower wholesale price index inflation has, for an extended length of time since 2009, been well above the RBI's erstwhile "comfort level" of 5 %. India's performance along this metric stands in contrast to other comparable emerging economies which appear to have managed better the challenges associated with keeping inflation under check. This point has been forcefully made by the expert panel in RBI (2014) in its far reaching recommendations for changing the monetary policy framework in India. The concern with chronically high inflation should not be viewed solely as a concern of academics and policy hawks. Opinion polls around the May 2014 national elections confirmed and reinforced the Indian voters' traditional aversion to high inflation and priority on price stability (see Pew (2014)).

In January 2014 the central bank undertook a formal root and branch review of the monetary policy framework. Since the last such comprehensive review in 1985, the Indian economy has undergone a sea change. For one, it is unrecognizably more open to international trade and capital flows, a process set in motion since the early 1990s. Recent debates on inflation control in India have centered around a gamut of issues. For instance, whether it is even possible to manage/control inflation as measured by the CPI, or, whether a "core" measure without food and some other items should be considered, or, deploy the wholesale price index which has no services component despite the latter constituting over 60 % of the economy (perhaps retrograde?). Some have averred that India is *sui generis*, hence lower policy rates will bring about lower inflation, which is a monetary policy analogue of the Laffer curve argument. The same line of thinking has also advocated that a nominal anchor for the central bank is a luxury that the Indian economy cannot afford. In other words, the central bank can afford not to strive for price stability as a primary objective.

In light of the above, an important motivation for this Chapter is to understand the context for monetary policy conduct in EMEs generally, and India more specifically. This encompasses four themes, viz., theory, policy, institutions, and practical aspects. We would like our discussion in this Chapter to spur debate around two broad areas: (a) how important is it for the RBI to rebalance its reform agenda from high-profile subjects like a monetary policy framework to addressing relatively more mundane policy-induced impediments/distortions that undermine monetary policy efficacy/transmission; and (b) whether it would be better to possibly have a central bank that is tasked with a somewhat narrower remit that is more internally consistent given the institutional environment within which policy is conducted in India.

2.1 The Elephant in the Room

When we started writing this paper in early September of 2014, it coincided with the season of visits by rating agencies to India for their annual review of the economy. Some areas of usual concern in recent years like the current account deficit and declining growth have been reassessed, but observations on the fiscal side and inflation were cited by some as the main reasons standing in the way of a further rating upgrade.

At a conceptual level, the fiscal deficit is a concern for any economy on three dimensions: (i) solvency; (ii) crowding out; and (iii) spillover into unsustainable external imbalances. From the perspective of the RBI, two more can be added: (i) the entailed financial repression and associated repercussions for allocative efficiency on account of RBI's twin roles in this context, viz., as merchant banker to the government and in developing the government debt market; and (ii) the quantum of monetization.

Only once in the last 40 years has the central government's fiscal deficit been as low as 3 % of GDP (2007/08). This is sobering given that several government consolidation plans since the early 1990s have had a terminal date target of this magnitude. It has been exceedingly uncommon for India's general government fiscal deficit to be lower than 6 % of GDP over the last four decades or so (see Fig. 1a). As a corollary, not surprisingly, in recent years the public sector's contribution to the country's savings rate has been modest, at best (see Fig. 1b). The extant challenge on the fiscal front has its antecedents in the post-2007/08 stimulus packages (see Buiter and Patel (2012) for a discussion of this); the general government fiscal deficit more than doubled during the course of one year from 4 % of GDP in 2007/08 to 8.3 % in 2008/09 and further to 9.3 % of GDP in 2009/10. While some adjustment was undertaken in subsequent years, it was only in late 2012 that a multiyear path for central government fiscal consolidation was put in place (see Kelkar (2012)). It is widely recognized that, at least in part, an important factor behind this was the possibility of a credit rating reassessment against the backdrop of a large and

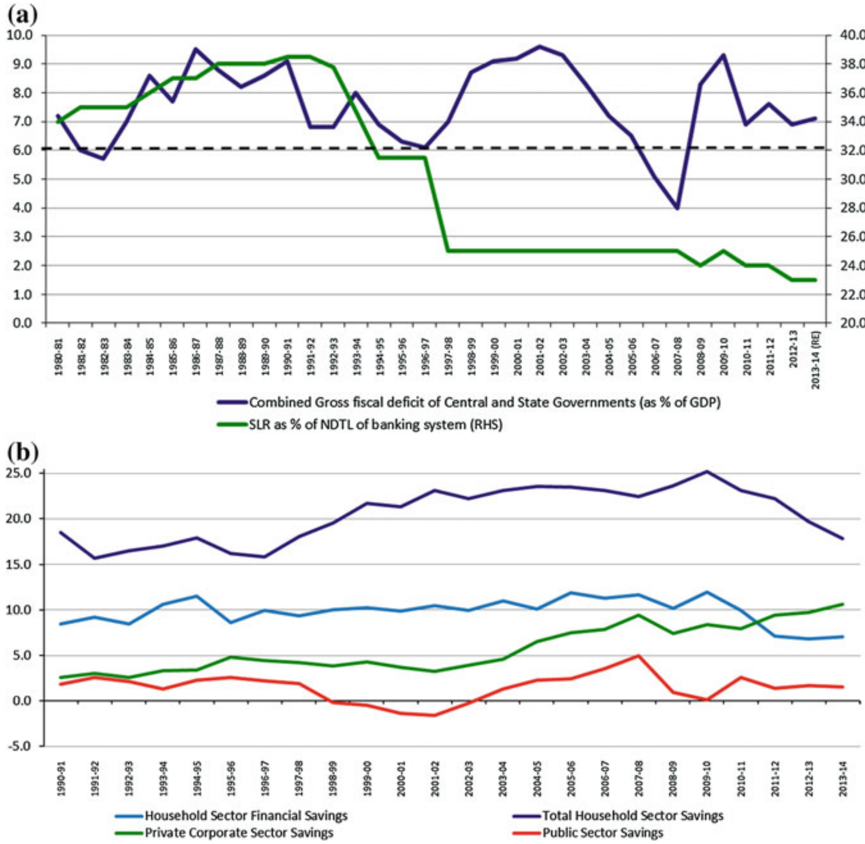

Fig. 1 Fiscal deficits, SLR requirements, and sectoral saving. **a** Fiscal deficit and SLR. **b** Saving rates, by sector. *Notes Panel a* of the figure shows the general government (Central and State Governments' consolidated) fiscal deficit (as % of GDP) on the left axis and the prescribed SLR of on the right axis. *Panel b* shows the sectoral saving rates in India (Saving–GDP ratio in percent)

widening current account deficit, which crossed 4 % of GDP in 2011/12. For the first time since the 1997 Asian crisis, questions were raised by some about India's external payments sustainability in light of tapering of the Fed's US$ 85 billion per month asset purchase program.

2.2 *Fiscal Dominance: Upshot of "Sophie's Choice" Confronted by the Central Bank?*

Sargent (1986) formally poses the aforementioned choice between a rock and a hard place as a game of Chicken. The question is who blinks between a monetary authority that is adhering to price stability while also being apprehensive about financial stability and the fiscal authority, who, while appreciating price and financial stability, is not keen to correct an unsustainable primary fiscal deficit through spending cuts or tax increases (including normal and ad hoc transfers from the central bank) and prefers to have the monetary authority directly monetise (accommodate) the public debt. If neither caves in, the deficit is financed by debt issuance and a confrontational outcome ensues. If the central bank does not monetise the fiscal deficit and the sovereign defaults, banks holding large amounts of sovereign debt may collapse, triggering a financial crisis with serious attendant spillovers to the rest of the economy. A monetary authority is unlikely to let this happen; the central bank will instead monetise the public debt and deficits. This is well known as Fiscal Dominance (see, e.g., Buiter (2010)). There are two reasons—one institutional, and the other practical—for this (almost) inevitable outcome. First, regardless of the extant legal position of the central bank, the sovereign has the political sway to compel the central bank to do its bidding. Second, the central bank when it assesses which "mess" is larger/more difficult to clean up, viz., the default of the sovereign, or, higher inflation, it may conclude that the latter is relatively easier to deal with in the larger scheme of things.[1] In contrast, monetary dominance occurs if the fiscal authority gives in and cuts public spending and/or raises taxes to stabilize or reduce the public debt to GDP ratio. In extreme situations, the central bank may be forced to "accommodate" up to the seigniorage-maximizing rate of inflation.

Even if the aforementioned extreme scenario is not reached, frictions associated with large fiscal deficits are felt strongly in the Indian context. Policy-induced frictions are primarily on account of the Statutory Liquidity Ratio (SLR), which earmarks a fraction of liabilities of banks for investment in central and state government securities. This has been a long-standing feature of the Indian economic landscape. As shown in Fig. 1, the SLR was consistently upwards of 30 % till the late 1990s. Despite a reduction in recent years it is still at a remarkably high 21.5 % currently. Given the nature of the SLR requirement, it is a far cry from the Liquidity Coverage Ratio (LCR) envisaged as a form of prudential regulation under Basel III—a potential liquidity fallback during times of stress.

The friction in credit allocation induced by the SLR requirement has come about on account of the importance accorded to the placement of government debt at the most economical interest rate possible. This compromises the financial viability of the banking sector as an apposite risk-aligned return/yield is not forthcoming on a large part of banks' balance sheets. It bears repetition that this is only one example of factors that undermine the banking sector, particularly public sector banks. The recent rise in the share of non-performing loans (NPLs) of public sector banks is yet another symptom of the role of frictions introduced by the complex institutional setting in which the banking sector operates in India. Moreover, since these frictions feed off each other operationally on a day-to-day basis they, almost inevitably, albeit through no fault of anyone, undermine the effectiveness of the central bank's policy instruments. Ultimately, the sanctity of the central bank's publicly announced policy

[1]In this context, it is pertinent to recall the observation of Ben Bernanke, the former Chairman of the Federal Reserve Board, that central banks cannot be in the business of brinkmanship.

goal posts may also start to be questioned by financial markets. In other words, the disjunction between number of instruments and targets becomes too hard to sustain.

Another adverse upshot of the government's long-standing fiscal stance is that provident & pension fund, as well as insurance company investment guidelines favor lending to government. Since long-term (usually 10-year) paper is favored, much of the long-term investment appetite of these entities is met through this. Asset-liability maturity mismatches, which are borne by commercial banks on long gestation highly cyclical projects (for example, most infrastructure projects) could be mitigated if financial institutions specializing in long-term savings products had more elbow-room to invest in these assets. Crowding out of funding has been a feature. At least in part, the increase in external commercial borrowing in the mid-2000s coincided with the escalation in the infrastructure investment-GDP ratio during that period.

2.3 Subsidized Agricultural Credit

Beyond the distortions implicit in SLR requirements, the dictates of priority sector lending have imparted an additional friction in the credit allocation process in the country. One example of this is agricultural credit allocation. The last 15 years has seen a policy driven sharp uptick in agriculture credit provision. In fact, in June 2004 the central government announced a "Comprehensive Credit Policy", which sought to double agriculture credit in a span of three years. Subsequent Union budgets established targets for credit to agriculture; since 2003/2004 flow of credit to agriculture has consistently exceeded the budgeted targets. In 2006/2007 the government implemented an Interest Subvention Scheme to make short-term crop loans of up to Rs. 3 lakhs to farmers at an interest rate of 7 %/year. Recent modifications to these subvention laws based on timely repayment of loans have reduced the effective cost of the loan for farmers to 4 %. Furthermore, state government subventions take the interest even lower. Combined with the loan waiver scheme in 2008/2009, the moral hazard that has been imparted into the agriculture credit subcategory (undermining incentives for both borrowers and bankers) is possibly unprecedented. Over the last decade and a half, agricultural credit grew by 21 %/annum compared to about 11 %/annum in the previous decade. Accordingly, the credit-GDP ratio in the agriculture sector witnessed a sharp increase; the ratio of outstanding agriculture loans to agriculture GDP increased from 9.8 % in the 1990s to 13 % in 2001/2002 to 38.7 % in 2012/2013 (see Fig. 2).

It is unclear however whether this increase in credit allocation to agriculture has helped achieve the socioeconomic policy objectives of enhancing crop productivity and helping small and marginal farmers, especially given the indirect evidence of leakage. For one, the share of indirect credit in total agriculture credit has increased. Moreover, the share of large borrowers in both direct and indirect credit to agricultural has also risen. Given the scarcity of overall credit supply, the distortions implicit in the subsidized credit extension to agriculture would appear to have possibly compromised both the monetary policy and financial stability objectives of the Reserve Bank. The fact that there is scarce (if any) evidence on the productivity effects of

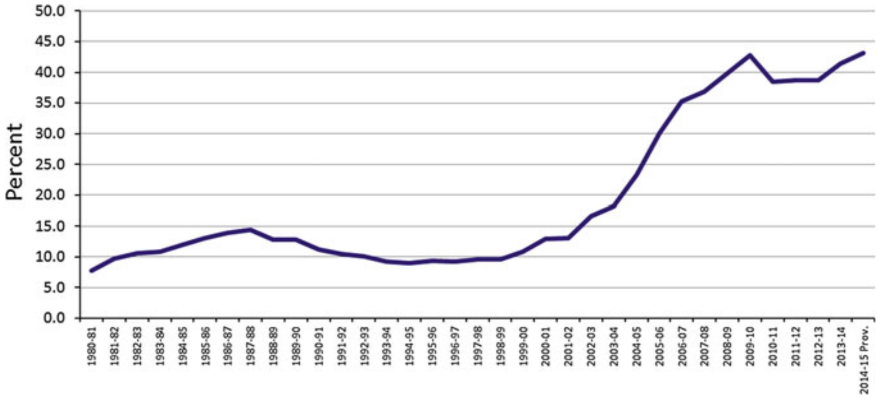

Fig. 2 Total bank credit to agriculture as ratio to agricultural GDP. *Note* The figure shows Scheduled Commercial Banks' (SCBs) total credit outstanding to agriculture and allied activities as ratio to GDP from agriculture and allied activities at current market prices

subsidized agricultural credit allocation through banks makes these policies even more problematic from a public policy standpoint.

2.4 Administered Interest Rates

We would be remiss if we did not mention an additional dimension, which is quasi-fiscal in nature, to the impediment of the monetary transmission mechanism, viz., the panoply of savings instruments whose interest rates are administered by the government (see Table 1). While yields on most of these instruments are broadly linked to government securities, the reset is annual and hence hinder the timely transmission of changes in policy rates to the liabilities' side of banks and financial institutions. It would seem that a quarterly or monthly reset based on, say, the average of market closing yields recorded over the last five days, would hasten and assist the transmission. Presently, banks are, to an extent, constrained on lowering deposit rates by the effective floor on rates that the system of administered rates on savings instruments imposes at the margin on the entire financial sector.

In the next few sections we shall outline the implications of a couple of these institutional distortions for the conduct of monetary policy. Specifically, we shall examine the consequences of a binding SLR requirement in banks in an environment of chronically high and exogenously given fiscal spending levels on the monetary transmission mechanism.

Table 1 Administered saving rates

Scheme	Formula		Announced rate	Tax deductions allowed
	Benchmark	Spread		
Post office savings deposits	No benchmark		4	No
1-year post office time deposits	364-day T-Bill cut-off	0.25	8.4	No
2-year post office time deposits	Linear Interpolation	0.25	8.4	No
3-year post office time deposits	Linear Interpolation	0.25	8.4	No
5-year post office time deposits	5 year G-sec yield	0.25	8.5	Yes
5-year recurring deposit	5 year G-sec yield	0.25	8.4	No
5-year senior citizens savings scheme	5 year G-sec yield	1	9.3	Yes
5-year monthly income scheme	5 year G-sec yield	0.25	8.4	No
5-year national savings certificate (NSC)	5 year G-sec yield	0.25	8.5	Yes
10-year NSC	10 year G-sec yield	0.5	8.8	Yes
Public provident fund—15 years	10 year G-sec yield	0.25	8.7	Yes
Kisan Vikas Patra—8 years 4 months	New scheme		8.7	No
Sukanya Samridhi account—21 years	New scheme		9.2	Yes

Notes 1. Interest rates applicable on small savings schemes are reset annually by the Government of India at the start of each financial year (FY)

2. G-sec yields are computed based on average of month-end yields (January to December)

3. PPF accumulation and withdrawal are also exempt under Sect. 10 of IT Act

4. Interpolated rate is the linear interpolation between 364-day T-Bill and 5-year G-sec rates

5. Post Office Savings Deposits interest income above Rs. 10,000 is taxable

6. Tax deductions if permitted are under Sec. 80C of the Income Tax Act

7. All interest rates are in percent per annum

3 Model

The goal of the model we develop here is to highlight two key aspects of monetary policy conduct and its transmission in India. The first is the effect of policy-induced institutional constraints on the transmission process. The specific constraint we shall use to illustrate the resulting complications is the Statutory Liquidity Ratio (SLR) provision which forces banks to hold a fraction of their deposits in the form of government bonds. The second is the role played by fiscal dominance on the transmission mechanism in small economies. The model we use is a variant of the structure formalized in Lahiri and Vegh (2007).

Consider a small open economy producing and consuming a single tradable good. Assume that the economy is perfectly integrated in goods markets so that $P_t = E_t P_t^*$ where P is the domestic currency price of the good, E is the nominal exchange rate (rupees/dollar) and P^* is the dollar price of the good. For convenience we set $P_t^* = 1$ for all t which is just a normalization. Time is continuous and there is no uncertainty. The economy consists of four actors: households, banks, firms, and a government (which is an integrated fiscal and monetary entity).

There is a continuum of identical households in the economy. We normalize the households to be of measure one. Private agents can access perfectly competitive international capital markets where they can buy and sell real bonds denominated in terms of the traded good at an constant world real interest rate r. Households own international bonds and also hold deposits in banks which pay interest i^d at every instant. Deposits can be used for carrying out domestic transactions. Transactions are costly and can be reduced using deposits.

3.1 Households

With no loss of generality we shall analyze the behavior of the representative household. The representative household maximizes lifetime utility

$$V = \int_{t=0}^{\infty} e^{-\rho t} u\left(c - \zeta x^{\nu}\right) dt \tag{3.1}$$

where ρ is the rate of time preference, c is consumption, and x is labor supply. Here we have suppressed time subscripts to economize on notation. In the following, we shall continue with this convention wherever there is no risk of confusion. The utility function $u(.)$ is twice-differentiable and concave in its argument.[2] The household's flow budget constraint in real terms is

$$\dot{b} = rb + wx + \tau - c - \dot{d} + \left(i^d - \pi\right) d - s(d) + \Omega^b + \Omega^f \tag{3.2}$$

where b denotes international bonds, d denotes demand deposits, w is the real wage, τ are lump-sum transfers received from the government, π is the rate of inflation (also the rate of depreciation in this one good model), Ω^b and Ω^f are dividends received

[2]Our utility specification, also known as GHH preferences due to their formalization in Greenwood et al. (1988), imply that labor supply only depends on the wage rate and is independent of any wealth effects. We employ these preferences here since they greatly enhance the analytical tractability of the model. We should add that this abstraction does not come at a great cost of realism since there is scant micro evidence that suggests the presence of significant wealth effects on labor supply.

from banks and firms which the households own. $s(d)$ is the transactions cost technology. We assume that $s' < 0$ and $s'' > 0$ implying that these costs are decreasing and convex in the household's holding of demand deposits. A dot over a variable indicates its time derivative. Defining $a \equiv b + d$ and $i = r + \pi$ (the nominal interest rate), we can rewrite this flow constraint as

$$\dot{a} = ra + wx + \tau - c + \left(i^d - i\right) d - s(d) + \Omega^b + \Omega^f$$

The household chooses perfect foresight paths for c, x, b and d to maximize lifetime welfare subject to its flow budget constraint taking as given the paths for $\tau, w, i^d, i, \Omega^b$ and Ω^f. The first-order conditions for household optimality are

$$u'\left(c - \zeta x^{\nu}\right) = \lambda \tag{3.3}$$

$$\nu \zeta x^{\nu - 1} = w \tag{3.4}$$

$$-s'(d) = i - i^d \tag{3.5}$$

$$\dot{\lambda} = (\rho - r)\lambda \tag{3.6}$$

In the following we shall maintain the standard small open economy assumption $\rho = r$ to prevent secular trends in marginal utility. Hence, $\dot{\lambda}_t = 0$ for all t. These first-order conditions imply two key relations

$$d = S\left(I^d\right), \; S' < 0, \; I^d \equiv i - i^d \tag{3.7}$$

$$x = \left(\frac{w}{\nu \zeta}\right)^{\frac{1}{\nu - 1}} \tag{3.8}$$

Equation (3.7) gives deposit demand as a decreasing function of the opportunity cost of holding deposits I^d while Eq. (3.8) gives labor supply as an increasing function of the wage rate. The wage elasticity of labor supply in this formulation is $\frac{1}{\nu-1}$. We shall maintain the assumption throughout the paper that $\nu > 1$.

3.2 Firms

Firms hire labor to produce output using the technology

$$y = Ax$$

where A is productivity. To introduce a productive role for credit, we assume that firms also face a credit-in-advance constraint to finance the wage bill

$$n = \phi w x$$

where ϕ is the fraction of wages that has to be paid before the realization of output. This fraction has to be financed through a working capital loan from banks. Firms maximize

$$\Omega^f = Ax - wx - \left(i^l - i\right) n$$

The first-order condition for the firm's problem is

$$A = \left(1 + \phi I^l\right) w \tag{3.9}$$

where $I^l \equiv i^l - i$ is the real lending spread.

3.3 Banks

Banks in this economy perform four functions: they accept deposits from households, they lend to firms, they hold as required reserves a fraction δ of deposits, and they buy government bonds. The key restriction we impose is that banks are not allowed to access international capital markets, i.e., this is a banking system that is closed to international capital flows. This restriction will allow us to break interest parity between international bonds and government bonds. More specifically, the assumption introduces a sheltered domestic market for government bonds in which these bonds can trade at a price different from the international interest rate on similar bonds.[3]

Let Z denote nominal government bonds held by the bank and M denote required reserves that the bank is mandatorily required to hold. Their real counterparts are given by $z = \frac{D}{P}$ and $m = \frac{M}{P}$. The closed banking system implies that the bank's balance sheet identity is

$$n + z + m = d$$

The bank's flow constraint (in real terms) is

$$\dot{n} + \dot{z} + \dot{m} - \dot{d} = \left(i^l - \pi\right) n + \left(i^g - \pi\right) z + \left(\pi - i^d\right) d - \pi m - \Omega^b$$

Adding and subtracting $r(n + z + m - d)$ from the right-hand side and using the bank's balance sheet identity, this reduces to

[3]In these small open economy environments, one has to break interest parity on government bonds in order to have an independent interest policy in the model. Our assumption that the banks hold government bonds and are also closed to international capital markets is an extreme way of achieving this. Less restrictive approaches to achieving this same goal would be to introduce costly banking along the lines of Diaz-Gimenez et al. (1992), Edwards and Vegh (1997) and Hnatkovska et al. (2013). Our approach here is analytically simpler.

$$\Omega^b = \left(i^l - i\right) n + (i^g - i) z + \left(i - i^d\right) d - i\delta d$$

where we have used the fact that $m = \delta d$. This is assuming that the reserve requirement constraint is always binding on the bank. Since reserves are noninterest bearing, this will hold as long as $i > 0$, i.e., the cost of holding reserves is positive.

$$\Omega^b = \left(i^l - i\right) n + (i^g - i) z + \left[i (1 - \delta) - i^d\right] \left(\frac{n + z}{1 - \delta}\right)$$

It is easy to check that bank optimality dictates that we must have

$$i^l = i^g \tag{3.10}$$

$$i^d = (1 - \delta) i^g \tag{3.11}$$

The intuition behind these conditions is straightforward. Since loans and government bonds are perfect substitutes for the bank, at an optimum they will demand the same returns from each, which gives Eq. (3.10). Moreover, for every dollar of deposits the bank receives, it can only lend out a fraction $1 - \delta$ which earns the going return on bank assets i^g. Under a competitive banking system, zero profits for banks then dictates that the deposit rate must equal the loan rate net of the reserve requirement ratio. Before proceeding, it is useful to note that any changes in i^g are transmitted fully to both the lending and deposit rates, i.e., the monetary transmission mechanism is seamless.

3.4 Government

The central bank in this economy prints money, holds international reserves, and issues government bonds. The fiscal authority makes transfers to households. The government's flow constraint is given by

$$\dot{R} = rR + \dot{m} + \pi m + \dot{z} - (i^g - \pi) z - \tau \tag{3.12}$$

The central bank's balance sheet identity is $R + q = m$ where q denotes real net domestic credit. Since we will be considering flexible exchange rate regimes, the central bank does not intervene in the foreign exchange market so that $\dot{R} = 0$. Without loss of generality we also assume that $R = 0$.

Given the flexible exchange rate regime, the government in this economy has potentially three policy instruments available to it—τ, $\dot{Q}/Q$ and i^g where Q is nominal domestic credit. Of these, only two can be freely chosen and the third will get determined from Eq. (3.12). We assume that the government sets i^g and $\dot{Q}/Q = \bar{\pi}$, while τ adjusts endogenously to make Eq. (3.12) hold. Notice that this assumption precludes any fiscal dominance. This is an issue that we shall return to below.

3.5 Equilibrium Relations

We now combine the optimality conditions of households, firms, and banks to derive the key macroeconomic equilibrium relationships. First, combining the household and firm conditions for optimal labor supply and demand, Eqs. (3.4) and (3.9) respectively, gives

$$x = \left[\frac{A}{\nu\zeta\left(1+\phi I^{l}\right)}\right]^{\frac{1}{\nu-1}} \equiv \tilde{x}\left(I^{l}\right) \tag{3.13}$$

$$n = \phi\nu\zeta\left[\frac{A}{\nu\zeta\left(1+\phi I^{l}\right)}\right]^{\frac{\nu}{\nu-1}} \equiv \tilde{n}\left(I^{l}\right) \tag{3.14}$$

where $I^l = i^l - i$ is the real lending spread. Note that the equilibrium condition $i^l = i^g$ also implies that $I^l = I^g$ where $I^g \equiv i^g - i$ is the real spread on government bonds.

Finally, combining the flow constraints of households, firms, banks and the consolidated government gives the evolution equation of net country assets

$$\dot{f} = rf + Ax - c - s(d) \tag{3.15}$$

where $f = b + R$ denotes net country assets. The right-hand side of Eq. (3.15) is also the current account equation for this economy.

It is straightforward to show that under flexible exchange rates with constant domestic credit growth $\bar{\mu}$ and interest rate i^g, this is a stationary economy that jumps to its steady state immediately at date 0. The steady state inflation rate is just the rate of growth of money which the economy attains immediately. Consequently, i jumps to its constant long run steady state level $\bar{\imath} = r + \bar{\mu}$ at date 0 itself.

3.6 Some Comparative Statics

What are the effects of monetary policy innovations in this economy? There are three independent instruments that the central bank can potentially use to affect the economy: i^g, μ and the reserve requirement ratio δ. The effects of changing the policy rate i^g are straightforward. A permanent, one time, unanticipated *reduction* in i^g reduces I^g and I^l, raises I^d while leaving the rate of inflation unchanged at $\bar{\mu}$. The fall in I^l causes loans, output and employment to rise while deposits decline due to the rise in the opportunity cost of holding them. Banks rebalance their portfolios by reducing their holdings of government bonds z to accommodate the rise in n in the face of a reduction in deposits. Clearly, a reduction in the policy rate is expansionary.

The second policy instrument available to the policymaker is the rate of money growth μ. A reduction in μ reduces inflation immediately. For a given and unchanging i^g, this causes both I^g and I^l to rise while the deposit spread I^d declines. Consequently, loans, employment, and output all fall while deposits and bank holdings of government bonds rise. Intuitively, the opportunity cost of loans rises due to the lower inflation rate which raises the cost of working capital for firms. As a result firms reduce their employment levels and output. Hence, a cut in the money growth rate in this economy is also contractionary.

The third instrument that the central bank can use to affect the economy is the required reserve ratio δ. An unanticipated, permanent increase in δ reduces the deposit rate i^d. Since, μ is unchanged, the nominal interest rate i also remains unchanged. Hence, with unchanged i^g and μ, an increase in δ raises the deposit spread $I^d = i - i^d$ but leaves I^g and I^l unchanged. Deposits fall but loans, employment, and output stay unchanged. Banks respond to the lower level of deposits in the system by reducing their holdings of government bonds z.

4 Statutory Liquidity Ratio

We now consider a different environment relative to the one analyzed above. Suppose banks face an additional constraint wherein they have to hold at least a fraction β of their deposits in government bonds. In India this is known as the *Statutory Liquidity Ratio* (SLR). The constraint can be written as $z \geq \beta d = \frac{\beta}{1-\delta}(n + z)$ where the second equality follows from the bank balance sheet identity and the fact that $m = \delta d$. The SLR constraint can be rewritten as

$$z \geq \frac{\beta}{1 - \beta - \delta} n \tag{4.16}$$

The representative bank's problem is to maximize

$$\Omega^b = \left(i^l - i\right) n + (i^g - i) z + \left[i (1 - \delta) - i^d\right] \left(\frac{n + z}{1 - \delta}\right)$$

subject to the inequality constraint given by Eq. (4.16). The optimality conditions for this problem are

$$i^l - \frac{i^d}{1 - \delta} = \kappa \frac{\beta}{1 - \beta - \delta} \tag{4.17}$$

$$i^g - \frac{i^d}{1 - \delta} + \kappa = 0 \tag{4.18}$$

$$\kappa \left[z - \frac{\beta}{1 - \beta - \delta} n\right] = 0 \tag{4.19}$$

where $\kappa \geq 0$ is the Kuhn–Tucker multiplier on Eq. (4.16). Note that $\kappa = 0$ when the constraint is not binding and $\kappa > 0$ when Eq. (4.16) binds.

When the constraint is binding, we can combine the two first-order conditions to eliminate κ and get

$$i^d = \beta i^g + (1 - \beta - \delta)\, i^l \tag{4.20}$$

Equation (4.20) must hold along all paths where the SLR requirement binds. The condition says that at an optimum banks will set the deposit rate equal to a weighted average of the returns from its two assets. In contrast to the case without any SLR requirement in which $i^d = (1 - \delta)\, i^g$, here the bank's return on its portfolio reflects the share of each component in the bank's portfolio. Out of every rupee of deposits, the bank has to put aside a fraction β in government bonds which earns the nominal rate i^g. A fraction $1 - \beta - \delta$ of every unit of deposits is available to be lent out to the private sector which earns the going nominal lending rate i^l. One can now immediately begin to see that changes in i^g may not be transmitted seamlessly to deposit rates in this environment.

Under a binding SLR requirement we have

$$z = \beta d \tag{4.21}$$

Further, since $z + n = (1 - \delta)\, d$, we also have

$$d = \frac{n}{1 - \beta - \delta} \tag{4.22}$$

For future reference, it is useful to rewrite Eq. (4.20) as

$$I^d = \delta i - \beta I^g - (1 - \beta - \delta)\, I^l \tag{4.23}$$

where, as before, $I^d = i - i^d$ and $I^l = i^l - i$.

Since we know that $z = \frac{\beta n}{1-\beta-\delta}$ and $d = \frac{n}{1-\beta-\delta}$ we can use the solution for loans given in Eq. 3.14 to get

$$z = \left(\frac{\beta}{1 - \beta - \delta}\right) \phi \nu \zeta \left[\frac{A}{\nu\zeta\left(1 + \phi I^l\right)}\right]^{\frac{\nu}{\nu-1}} \equiv D\left(I^l\right) \tag{4.24}$$

$$d = \left(\frac{\phi\nu\zeta}{1 - \beta - \delta}\right) \left[\frac{A}{\nu\zeta\left(1 + \phi I^l\right)}\right]^{\frac{\nu}{\nu-1}} \tag{4.25}$$

Recall from the household's optimal choice of demand deposits we also have the relation $d = S\left(I^d\right)$ which, when combined with Eq. (4.23), gives

$$d = S\left((\delta + \beta)i - \beta i^g - (1 - \beta - \delta)\, I^l\right) \equiv S\left(I^l; i^g, i\right) \tag{4.26}$$

We interpret Eq. (4.25), which is derived from the demand for loans by firms n, as the demand function for loanable funds $D\left(I^l\right)$. It is declining in the lending spread I^l. Conversely, Eq. (4.26) can be interpreted as the supply function of loanable funds $S\left(I^d\right)$ as it is derived directly from the supply of deposits by households. It is increasing in both I^l and i^g. We call it the supply function of loanable funds because an increased supply of deposits creates larger balance sheets of banks who look for opportunities to invest in loans. The equilibrium in the loan market will be at the intersection of the two functions.

Since i is determined by the rate of money growth, once I^l is known I^d is known as well. Hence, the individual interest rates in this economy (i^d, i^l, i^g and i) are known. All the other endogenous variables in the model are functions of these interest rates and/or productivity. Consequently, they are determined too. Solving for the equilibrium I^l as a function of parameters of the model and the policy variables i^g and μ thus solves the entire model.

The rest of the equilibrium relations remain unchanged relative to the no-SLR case as does the fact that the dynamics of the economy around the steady state are unstable implying that the only feasible perfect foresight equilibrium paths in this economy are those with a constant inflation rate π which equals the rate of money growth μ at all points in time. We can now analyze the effects of three shocks in this economy: (a) a decrease in the policy interest rate i^g; (b) an increase in the money growth rate μ; and (c) an increase in the SLR β.

4.1 Decrease in i^g

Suppose, starting from an initial steady state, the government permanently cuts the interest rate on government bonds. A decrease in i^g leaves the demand function for loans unaffected but reduces the supply of loans S. Consequently, the equilibrium I^l rises. Given that the nominal interest rate i is unchanged, this implies that the lending rate i^l must rise. As a result employment, output, deposits, loans, and holdings of government bonds all decline. This is a remarkable result since it shows that under a binding SLR constraint, a cut in the policy rate can be highly contractionary.

Intuitively, the cut in i^g causes the deposit spread I^d to rise (see Eq. (4.20)). This reduces the demand for deposits, or the supply of loanable funds available with the banking system. Under a binding SLR, loans and government bonds have to always be in a fixed proportion. Hence, they must both fall in order to accommodate the smaller deposit base of the bank. Consequently I^l has to rise since loan demand is a function of the lending spread.

To understand these results better, recall that in the environment without a binding SLR requirement, a cut in i^g simultaneously induced a fall in demand deposits and a rise in loans to firms. The expansion in loans by banks despite a fall in the deposit base was facilitated by a reduction of bank holdings of government bonds z. This was possible due to perfect substitutability between the two components of bank assets. Once the SLR constraint binds however, government bonds and loans to firms have to move in fixed proportions to each other, i.e., there is no substitutability between the two assets at all. Consequently, a fall in bank deposits has to be met with an accompanying decline in both components of bank assets, i.e., n and z both fall. An alternative way of making the point is to note that under a binding SLR constraint, reducing the interest rate on government bonds acts like a higher tax on banks. Consequently, they respond by reducing the size of their balance sheet.

4.2 An Increase in the Rate of Money Growth

Now consider an unanticipated and permanent increase in the rate of money growth μ. This shock raises the market nominal interest rate i which increases the deposit spread I^d. Consequently, the supply of loanable funds S to the market falls. The lower supply of loanable funds along with an unchanged demand for loans implies that the lending spread I^l has to rise in order to ration the lower supply of funds to the market. This is again a counterintuitive result in that an expansionary monetary shock causes deposits, loans, output, employment, and consumption to decline.

4.3 Rise in the SLR β

Suppose the government permanently raises the statutory liquidity ratio β. This unambiguously raises the demand for loanable funds (see Eq. (4.24)). The effect on the supply of loanable funds is however ambiguous and depends on parameters. If $i^l > i^g$ (which is the typical case in the data) then the supply of funds declines. In this case the lending spread unambiguously rises. However, the equilibrium effect on deposits is ambiguous.

The upshot of this though is that when the SLR constraint is binding the monetary transmission mechanism becomes so scrambled that it can end up inverting the effects of changes in the policy rate on the key interest rate spreads—raising the policy rate could reduce lending spreads while lowering rates could raise the lending spread. In such circumstances, changing the SLR level (β in our model) itself is more likely to yield conventional effects of monetary policy, i.e., a fall in β would act like a monetary expansion while an increase in β would be a monetary contraction.

5 Fiscal Dominance

A recurrent issue that plagues monetary authorities everywhere is its relationship with the fiscal authority. The tendency of the fiscal authority moving unilaterally to set a path for the fiscal deficit and forcing the monetary authority to validate that path through an accommodative monetary stance has led to movements in many countries to institutionalize the independence of the central bank from the fiscal authority. This movement though still remains incomplete with central bank governors in many countries, including India, still reporting to the treasury/finance wing of the government. Effectively, this tends to create conflicting objectives for the central bank.

Fiscal dominance has three important consequences. First, if the government runs a fiscal deficit then it tends to get monetised by the central bank and consequently leads to inflation. Second, the existence of a fiscal deficit itself can induce inflationary expectations (independent of whether or not the fiscal authority actually expects the central bank to accommodate the deficit or not) and thereby put upward pressure on inflation immediately. Third, in the presence of fiscal dominance the monetary transmission mechanism tends to get scrambled. An example of this is the well known "unpleasant monetarist arithmetic" wherein a tightening of monetary policy could end up raising inflation rather than the intended goal of reducing it.

We illustrate the issues involved by introducing an exogenous fiscal constraint in the model above. Recall that the model thus far had fiscal spending τ adjusting endogenously to balance the government budget. Suppose instead that τ is exogenously given at the constant level $\bar{\tau}$. In effect we are now assuming that fiscal authority moves first and chooses fiscal spending $\bar{\tau}$. The monetary authority reacts by choosing monetary policy to balance the budget taking the fiscal stance as given.

The change in model specification leaves the optimization problem of households, firms, and banks unaffected and thereby leaving the optimality conditions derived above unchanged. The crucial change is in the government's problem. Recall that the consolidated government's flow budget constraint (in real terms) is given by

$$\dot{R} = rR + \dot{m} + \pi m + \dot{z} - (i^g - \pi) z - \bar{\tau}$$

The government's potential policy choices are the exchange rate regime, the money growth rate μ, the interest rate i^g and fiscal spending τ. Given the assumptions of perfect capital mobility and a flexible exchange rate regime we must have $\dot{R} = 0$. The remaining choices for the government are μ, i^g and τ. Previously, under an endogenous τ, the government could choose μ and i^g while τ would adjust to make the flow constraint hold at every date.

When $\tau_t = \bar{\tau}$ for all t, only one out of i^g and μ are exogenous. Indeed, without a domestic interest bearing bond, an exogenous τ would immediately imply an endogenous rate of money growth μ. However, here the central bank can choose one out of i^g and μ freely. In keeping with modern central banking practices, we shall assume that i^g is chosen independently by the central bank while μ adjusts endogenously to make the flow constraint hold at every point in time.

The central bank balance sheet identity implies that $\dot{R} + \dot{q} = \dot{m}$ where q denotes real domestic credit. Substituting this in to the consolidated government's flow constraint and rearranging the result gives

$$\delta \dot{d} = \bar{\tau} - rR - \pi \delta d - \dot{z} + (i^g - \pi) z$$

where we have used the fact that real money balances (or high-powered money) in this economy are just required reserves held by the banking system since there is no cash by assumption, i.e., $m = \delta d$. As before, we continue to assume, without loss of generality, that $R = 0$. Using this and the SLR requirement $z = \beta d$, the above reduces to

$$\dot{d} = \frac{\bar{\tau}}{\delta+\beta} + \left(\frac{\beta i^g}{\delta+\beta} - \pi\right) d$$

To determine the dynamic behavior of this economy, differentiate the first-order condition for optimal deposit demand to get $\dot{d} = \frac{\dot{I}^d}{-s''(d)}$. Substituting this in the above and rearranging the result yields

$$\dot{I}^d = -s''(d)\left[\frac{\bar{\tau}}{\delta+\beta} + \left(\frac{\beta i^g}{\delta+\beta} - \pi\right) S\left(I^d\right)\right]$$

where we have used the relation $d = S\left(I^d\right)$ from Eq. (3.7) above.

Recall that $I^d = (\delta+\beta)(r+\pi) - \beta i^g - (1-\beta-\delta) I^l$ from the bank first-order condition given by Eq. (4.20).[4] Differentiating this expression with respect to time gives

$$\dot{I}^d = (\delta+\beta)\dot{\pi} - (1-\delta-\beta)\dot{I}^l$$

where we have again retained the operating assumption that i^g is exogenously chosen by the government at a constant level. The lending spread I^l is also a function of I^d which can be seen from the fact that the bank balance sheet identity combined with a binding SLR constraint implies that $n = (1-\delta-\beta)d$. Totally differentiating this expression and noting that the equilibrium levels of d and n are given by Eqs. (3.7) and (3.14), respectively, we can solve for I^l as an implicit function of I^d: $I^l = \Gamma\left(I^d\right)$ with

$$\Gamma'\left(I^d\right) = (1-\delta-\beta)\frac{\tilde{d}'}{\tilde{n}'} > 0 \tag{5.27}$$

Using this in the expression for $\dot{I}^d$ above gives

$$\dot{I}^d = \left(\frac{\delta+\beta}{1+(1-\delta-\beta)^2\frac{\tilde{d}'}{\tilde{n}'}}\right)\dot{\pi}$$

Further, we can use the function Γ in the expression $I^d = (\delta+\beta)(r+\pi) - \beta i^g - (1-\beta-\delta) I^l$ to derive the implicit solution for I^d as a function of π and i^g: $I^d = p(\pi, i^g)$ with

[4] In deriving this we have also used the relation $I^g = i^g - i$ and the interest parity condition $i = r + \pi$.

$$p_\pi = \frac{\partial p}{\partial \pi} = \frac{\delta + \beta}{1 + (1 - \delta - \beta)\,\Gamma'} > 0; \;\; p_{i^g} = \frac{\partial p}{\partial i^g} = \frac{-\beta}{1 + (1 - \delta - \beta)\,\Gamma'} < 0 \quad (5.28)$$

We can now combine this with the differential equation for I^d derived above and rearrange the result to get

$$\dot{\pi} = \chi \left[\left(\pi - \frac{\beta i^g}{\delta + \beta} \right) S\left(p\left(\pi, i^g\right)\right) - \frac{\bar{\tau}}{\delta + \beta} \right] \quad (5.29)$$

where $\chi \equiv s''(d) \left(\frac{1+(1-\delta-\beta)\Gamma'}{\delta+\beta} \right) > 0$. Equation (5.29) is the equilibrium differential equation in π that describes the equilibrium dynamics of this economy. Note that i^g and $\bar{\tau}$ are both exogenous policy variables that are assumed to be constant over time. Setting $\dot{\pi} = 0$, It is easy to check that the steady state equilibrium level of inflation is defined implicitly by the expression:

$$\left(\hat{\pi} - \frac{\beta i^g}{\delta + \beta} \right) S\left(p\left(\hat{\pi}, i^g\right)\right) = \frac{\bar{\tau}}{\delta + \beta} \quad (5.30)$$

In this model, the key endogenous variable is π. Once the equilibrium path for π is determined, the equilibrium levels of all the other endogenous variables can be determined recursively. To see this more clearly, recall that employment, output, and deposit demand are functions I^l and I^d while consumption is determined from the country resource constraint which is obtained by combining the flow constraints for households, banks, firms, and the government

$$\dot{f} = rf + A\tilde{x}\left(I^l\right) - c - s\left(S\left(I^d\right)\right) \quad (5.31)$$

where $f = b + b^f + R$ denotes net country assets. Given that $I^l = \Gamma\left(I^d\right)$ and $I^d = p\left(\pi, i^g\right)$, given an exogenous level of i^g, determining π determines all the other endogenous variables of the system.

To determine the equilibrium dynamics, we differentiate Eq. (5.29) with respect to π. Evaluating it around the steady state inflation rate $\hat{\pi}$ gives

$$\left.\frac{\partial \dot{\pi}}{\partial \pi}\right|_{\pi=\hat{\pi}} = \chi \left[1 - \left\{ \frac{\hat{\pi} - \frac{\beta}{\delta+\beta} i^g}{p\left(\hat{\pi}, i^g\right)} \right\} \eta_d p_\pi \right] S\left(p\left(\hat{\pi}, i^g\right)\right) \quad (5.32)$$

where $\eta_d \equiv -\frac{S'(I^d)}{d} I^d$ denotes the elasticity of deposit demand with respect I^d (which is opportunity cost of holding deposits). The dynamic behavior of π depends on the sign of $\left.\frac{\partial \dot{\pi}}{\partial \pi}\right|_{\pi=\hat{\pi}}$. If this derivative is positive, then Eq. (5.29) defines an unstable differential equation associated with explosive dynamics. As is standard in monetary models of this type, we shall impose the condition

$$1 > \left\{ \frac{\hat{\pi} - \frac{\beta}{\delta+\beta} i^g}{p\left(\hat{\pi}, i^g\right)} \right\} \eta_d p_\pi \tag{5.33}$$

throughout, which will guarantee that Eq. (5.29) is unstable. Hence, all perfect foresight equilibrium paths must have a constant π, i.e., the inflation rate must jump to its long run steady state level at $t = 0$. If this condition fails to hold then the model will permit indeterminacy of equilibrium all of which converge to the same steady state.

5.1 Effect of Raising the Interest Rate

The key question that we would like to address is about the effect of the policy rate i^g on this economy. As before, our focus of attention is on the effect of monetary policy on output and employment. However, in contrast to the economy with an endogenous fiscal spending level, here $\bar{\tau}$ is exogenous and consequently, the rate of inflation is also endogenous. Hence, we are also interested in the effect of changes in the policy rate on inflation along with its effects on loans, employment, and output. Proposition 5.1 illustrates the key result[5]

Proposition 5.1 *Under a binding SLR constraint and exogenous fiscal spending $\bar{\tau}$, deposits and loans to firms are both independent of the policy rate i^g. Consequently, employment and output are unaffected by changes in the policy rate. The inflation rate is strictly increasing in the policy rate.*

Proof The government flow constraint is, as before, $\bar{\tau} = \pi m - (i^g - \pi) z$. Since $m = \delta d$ and $z = \beta d$, this can be rewritten as $\bar{\tau} = [(\delta + \beta)\pi - \beta i^g] d$. The bank optimality condition (Eq. 4.20) can be rewritten as $I^d + (1 - \beta - \delta) I^l - (\delta + \beta) r = (\delta + \beta)\pi - \beta i^g$. Using the expression for $\bar{\tau}$ derived above this reduces to $\left[I^d + (1 - \beta - \delta) I^l - (\delta + \beta) r\right] d = \bar{\tau}$. From Eqs. 3.7 and 3.14 we know that $d = S\left(I^d\right)$ and $n = \tilde{n}\left(I^l\right)$. The SLR constraint is $n = \beta d$. These three relationships jointly imply $I^l = \Gamma\left(I^d\right)$. Consequently, we have $\left[I^d + (1 - \beta - \delta)\, \Gamma\left(I^d\right) - (\delta + \beta) r\right] S\left(I^d\right) = \bar{\tau}$. The left hand side of this equation only depends on I^d. Hence, the equilibrium deposit spread I^d only depends on $\bar{\tau}$ and the other parameters. Consequently, both I^d and I^l are independent of i^g. Lastly, differentiating both sides of $I^d + (1 - \beta - \delta) I^l - (\delta + \beta) r = (\delta + \beta)\pi - \beta i^g$ with respect to i^g gives $\frac{d\pi}{di^g} = \frac{\beta}{\delta+\beta} > 0$ where we have used the independence of I^d and I^l from i^g. Since $\frac{d\left(i - i^d\right)}{di^g} = 0$ it follows that $\frac{di^d}{di^g} = \frac{d\pi}{di^g} = \frac{\beta}{\delta+\beta}$. ■

The proposition is stark along two margins. First, in the joint presence of an exogenous fiscal constraint and a binding SLR, interest rate policy has no effect on

[5]We are indebted to Rajesh Singh for pointing out and proving the results in this proposition.

employment and output since the lending spread is independent of i^g. Intuitively, the government budget dictates a unique deposit spread in order to finance the fiscal spending which, through the SLR constraint, renders the lending spread invariant to changes in the policy rate as well. Effectively, the imposition of an exogenous fiscal spending on top of the binding SLR constraint removes all degrees of freedom from the banking sector.

To understand this result better, note that $\frac{d(i^l - i)}{di^g} = 0$ implies that $\frac{d(i^l - i^g)}{di^g} = \frac{-\delta}{\delta+\beta}$ where we have used the fact that $\frac{di}{di^g} = \frac{d\pi}{di^g} = \frac{\beta}{\delta+\beta}$. Clearly the wedge between the lending rate to firms and the rate on government bonds declines as i^g rises. Moreover, recall that the bank optimality conditions in this case are $i^l - \frac{i^d}{1-\delta} = \kappa \frac{\beta}{1-\beta-\delta}$ and $i^g - \frac{i^d}{1-\delta} + \kappa = 0$ which imply that $i^l - i^g = \left(\frac{1-\delta}{1-\beta-\delta}\right)\kappa$. Differentiating these with respect to i^g gives $\frac{d(i^l - i^g)}{di^g} = \left(\frac{1-\delta}{1-\beta-\delta}\right)\frac{d\kappa}{di^g}$. Combining these two expressions for $\frac{d(i^l - i^g)}{di^g}$ implies that the Kuhn–Tucker multiplier κ declines secularly as i^g rises since $\frac{d\kappa}{di^g} = -\left(\frac{\delta}{1-\delta}\right)\left(\frac{1-\delta-\beta}{\delta+\beta}\right) < 0$. Hence, there exists a threshold upper level of i^g beyond which the SLR constraint ceases to bind. Intuitively, the return on government bonds becomes so high that banks voluntarily choose to hold excess SLRs.

Second, in this environment raising the policy rate i^g unambiguously *raises* the inflation rate. This again runs contrary to the accepted wisdom regarding monetary transmission wherein a rise in the policy rate depresses aggregate demand and consequently reduces the domestic inflation rate. This is a type of unpleasant monetary arithmetic result that has been made by many authors before (see, amongst others, Sargent and Wallace (1981) and Hnatkovska et al. (2013)).

In summary, our results indicate that in the presence of a binding SLR, the transmission of monetary policy in general becomes scrambled with cuts in policy rates generating inducing hikes in lending rates and contractions in real activity. When a binding SLR requirement is combined with a situation of fiscal dominance by the fiscal authority, the transmission of monetary policy to the economy becomes even more scrambled with inflation also potentially responding to changes in the policy rate in nonstandard ways.

6 Some Confounding Evidence

The analysis in the model above was conducted based on a binding SLR requirement. It is instructive to note that in contrast with the case of no SLR constraint analyzed in Sect. 3 (or equivalently, the case where the SLR constraint does not bind), under a binding SLR constraint when $\kappa > 0$, Eqs. (4.17) and (4.18) in Sect. 4 imply that $i^l > \frac{i^d}{1-\delta} > i^g$. This contrasts with the case where the constraint does not bind when $i^l = i^g$. The upshot of this is that in environments where the SLR constraint is binding

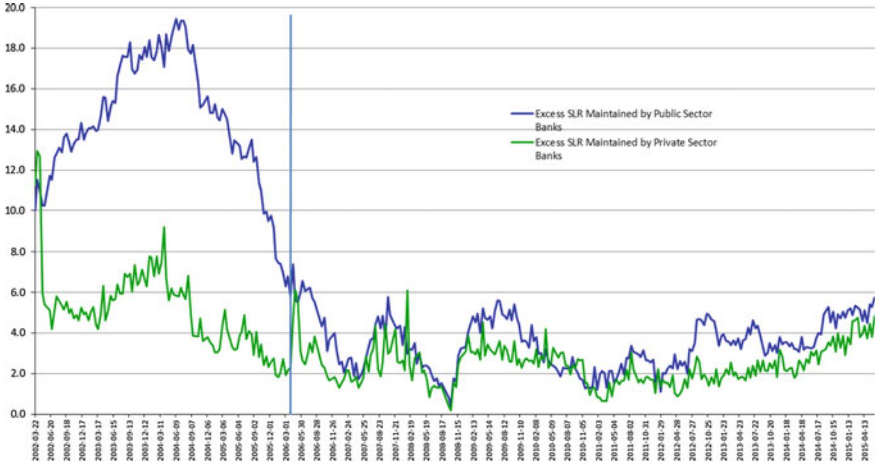

Fig. 3 Excess SLR held by scheduled commercial banks

the lending rate should be strictly greater than the rate on government bonds while in situations where the constraint is not binding the two rates should be equated.

What does data pertaining to the Indian experience with SLR requirements reveal about the trade-offs identified by the model? Fig. 3 shows the excess SLR held by public sector and private sector banks separately since March 2002. The excess SLR is computed as difference between the ratio of the actual SLR held by the bank to its net demand and time liabilities (NDTL) and the ratio required by policy. Three key features of the data are worth pointing out: (a) the amount of the excess SLR held by the banking system overall declined between 2002 and 2010 but started rising from 2011 onwards; (b) the amount of excess SLR held by public sector banks (around 6.8 % on average) has consistently exceeded that of private sector banks (around 3.3 % on average) throughout this period; and (c) the difference between public and private sector banks in their holdings of excess SLRs had almost disappeared between 2007 and 2010 but the period since 2010 has witnessed a faster increase in the excess SLR holdings of the public sector banks. Thus, the average excess SLR holdings of public sector banks has averaged 3.5 % since 2010 while private banks have held only 2.4 % excess SLRs during this period.

We should point out that since scheduled commercial banks can borrow from the Marginal Standing Facility (at a 100 basis points premium over the repo rate) against its excess SLR over and above what they can borrow from the repo market, there is a well-defined precautionary liquidity management reason for banks to hold some excess SLRs. This can possibly explain the 1–2 % excess SLRs that have been typically held by private banks. The puzzle though is the rather high excess SLRs holdings of public sector banks (which have now reached 5.5 %). It is worth pointing out that given the approximately 4 % point spread between the average lending rate of public sector banks, and 10-year government securities, the back-of-the-envelope (risk unadjusted) losses implicit in these excess SLR holding of public sector banks in the fiscal year 2014–2015 amounted to around \$17 billion (Rs. 102 billion). To put this number in perspective, the combined profits of public sector banks in 2013–2014 was about \$6 billion.

One explanation for these excess SLR holdings could be that the return on bank loans to the private sector are sufficiently close to those on government securities so that banks choose to hold their assets in relatively safer government bonds. However, this is not borne out in the data. The weighted average lending rates of public sector banks in 2014–2015 have been in the range 12.01–12.13 % while the return on ten-year government securities has been in the range 7.68–9.15 %. For comparison purposes, the average lending rates of private sector banks this year have been in the range 12.25–12.56 %. Clearly, lending rates are greater than the rates on government securities for both groups, and by around the same amount. The data suggests some degree of nonoptimizing behavior on the part of public sector banks.

A potential rationalization for the hesitance of the public sector banks to extend credit to nongovernment entities is the quality of its existing asset portfolio. Figure 4 shows the non-performing assets (NPA) of public and private sector banks as a proportion of their assets. The striking feature of the figure is the sharp increase in the share of non-performing loans of public sector banks since 2009 while the corresponding NPAs of private sector banks have stayed relatively unchanged. This is precisely the period when the excess SLR holdings of public sector banks have also increased sharply. A working hypothesis then is that public sector banks have chosen to increase their SLR holdings at lower interest rates instead of lending on account

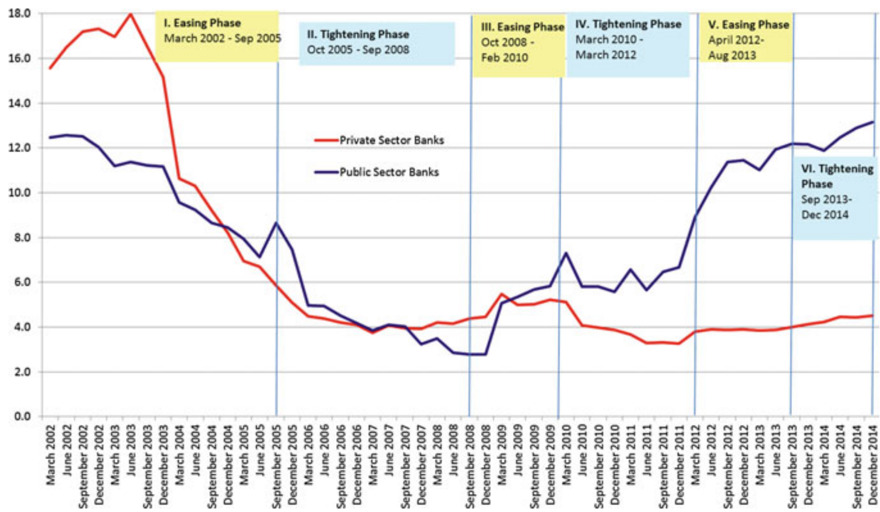

Fig. 4 Non-performing assets of scheduled commercial banks. *Note* The figure shows the gross non-performing assets and restructured advances of PSBs and private sector banks as percent of gross advances

of the overhang of NPAs on their balance sheets. This, of course, is costly to the tax payer as the banks are potentially losing profits that they could make while they are also contributing to a liquidity squeeze in the economy. A third deleterious effect of this banking strategy is that the lower return on bank assets tends to get passed on to bank depositors as lower deposit rates and consequently tends to lower saving rates as well. In a developing economy that is starved for investable funds, this is very damaging.

7 Conclusion

The primary motivation for the paper was to highlight the effects of policy-induced frictions, particularly those that are likely to impact open emerging economies like India, in the transmission of monetary policy, with consequent implications for the efficacy of policy action. These include, inter alia, interest rate subventions/subsidies, slow adjusting administered floors on diverse savings instruments, intermittent loan waivers to specific sectors and allocative guidelines to banks (the distortions are multidimensional and affect both the assets and liabilities side of bank balance sheets). In the last category, the paper sought to formally explore, specifically, the implications of "regulatory" instruments that are designed to facilitate government borrowing. The statutory liquidity ratio (SLR) is particularly insidious given its size, viz., 21.5 % of an individual bank's net demand and time liabilities have to be earmarked for buying government securities. Back-of-the-envelope cost to banks of the SLR presented in the paper is not insignificant.

The theoretical model that has been sketched in the paper allows us to make several formal inferences

- The possibility of inverted monetary policy outcomes in the presence of a binding SLR. For example, a cut in the policy rate (government bond yield) reduces the demand for deposits (by the same token, the supply function of loans shifts to the left). A binding SLR implies that banks cannot reallocate the scarce deposits between higher return private loans and government bonds. The constraint implies that assets have to be held in fixed proportions (like a Leontief technology) which causes both components of bank assets to fall. The fall in loans implies output and aggregate demand gets depressed in response to the interest rate reduction. A lower interest rate on government bonds effectively acts like a higher tax on the banking sector in the presence of a binding SLR constraint. Consequently, their balance sheets contract.
- An exogenous fiscal constraint and a binding SLR may result, under some conditions, to inflation rising in response to an increase in the policy rate. However, the additional constraint of an exogenous fiscal spending also implies that interest rate changes have no real effects whatsoever as the both the deposit spread and the lending spread remain invariant. This is an even starker illustration of the scrambling effects of SLR requirements on monetary policy transmission.

- When the SLR is binding, a conventional outcome is more likely to emerge by changing the SLR rather than tweaking the policy rate.

The scrambled outcomes that are shown to be possible underscore the importance of formally modeling and understanding the succession choices made by various stakeholders, including banks optimizing in the midst of profound regulations.

Among other extensions that may be helpful in understanding the process better, introduction of policy driven interest caps/floors on financial intermediation, asymmetry between the objectives of public sector banks ("blunter" top-line driven orientation) and those of private sector banks ("sharper" bottom-line driven orientation), and the role of benchmarks formula that links the policy rate with lending rates. In exploring the chain that constitutes monetary policy transmission, it is not inconceivable that (a sort of) general equilibrium approach that is rich in regulatory details, in combination with distortions and skewed incentives may throw up more surprises. Further, against the background of large fiscal deficits the "optimum" choice between taxing banks versus recourse to the printing presses of the central bank is an interesting subject for closer scrutiny.

For the central bank, the tasks ahead are twofold. First, perhaps rebalance the reform agenda from high-profile subjects such as legislative amendments, like a monetary policy framework and associated institutional changes, to addressing policy-induced distortions that undermine monetary policy efficacy and transmission. Second, address the challenge of multiple roles/objectives and limited instruments.

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Monetary Transmission in Developing Countries: Evidence from India

Prachi Mishra, Peter Montiel and Rajeswari Sengupta

1 Introduction

Monetary policy is the most actively used tool for macroeconomic stabilization in countries with independent currencies. Yet, as the Global Financial Crisis (GFC) has made manifest, the effectiveness of monetary policy in influencing aggregate demand varies with circumstances. This is as true from one country to another as it is, at different times, for the same country. To be effective, therefore, central banks pursuing an activist monetary policy (as would be true, for example, for any central bank that pursues some version of the Taylor Rule) therefore require at least an approximate—quantitative as well as qualitative—understanding of the effectiveness of monetary transmission in the specific country and under the specific circumstances in which they operate.

Cross-country differences in the effectiveness of monetary transmission are likely to be important. As is well understood, the channels through which monetary policy affects aggregate demand depend on a country's financial structure. Relevant factors include the extent of the country's links with external financial markets, its

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_3

exchange rate regime, the size and composition of its formal financial sector, the degree of development of its money, bond, and stock markets, the liquidity of its markets for real assets such as housing, and both the costs to its banks of doing business as well as the competitive environment in its banking sector. These characteristics differ significantly among countries.

These differences become especially dramatic when comparing high-income and low-income countries. As a consequence, there is no reason to expect that mechanisms of monetary transmission in low-income countries would be similar to those that have been found to operate in high-income ones. Indeed, in contrast with results for high-income countries, careful studies of the effectiveness of monetary transmission in low-income countries have often found monetary policy effects that are counterintuitive, weak, and/or unreliable.[1]

These issues are quite relevant for the case of India. Despite its size and relative economic success over the past two decades, India remains a lower middle-income country (by the World Bank's classification) with an institutional environment and domestic financial system not dissimilar from that of many countries at comparable income levels. Moreover, the Reserve Bank of India (RBI) recently implemented an inflation-targeting regime that requires it to hit publicly announced inflation targets. Effective monetary transmission is potentially crucial to the success of this regime. In the absence of effective and reliable links between the policy instruments controlled by the RBI and aggregate demand in the Indian economy the public may lack confidence that the RBI is able to deliver on its announced inflation target, making the target more difficult (and costly) to achieve.

The objective of this paper is to explore the effectiveness of these links in the Indian context, using the structural VAR methodology that has commonly been applied to investigate monetary policy effectiveness not only in advanced and emerging economies, but also in many low-income ones. A brief survey of the existing literature on India is provided in the Appendix. This paper focuses on the bank lending channel of monetary transmission, which is relatively less studied in the literature on India. Das (2015) is a recent study which also provides evidence on the bank lending channel of monetary policy transmission in India, though it focuses only on the first stage of the transmission process from monetary policy to lending rates, whereas we look at the transmission of monetary policy not only to lending rates, but also to ultimate target variables such as output and inflation.

We estimate a monthly VAR with data from April 2001 to December 2014. Applying a variety of methods to identify exogenous movements in the policy rate in the data, we find consistently that positive shocks to the policy rate result in statistically significant effects (at least at confidence levels typically used in such applications) on the bank lending rate in the direction predicted by theory. Specifically, a tightening of monetary policy is associated with an increase in bank lending rates, consistent with evidence for the first stage of transmission in the bank lending channel. While pass-through from the policy rate to bank lending rates is in

[1]See, for example, Mishra and Montiel (2013).

the right (theoretically expected) direction, pass-through is incomplete. When the monetary policy variable is ordered first, effects on the real effective exchange rate are also in the theoretically expected direction on impact, but are extremely weak and not statistically significant, even at the 90 % confidence level, for any of the four measures of monetary policy that we investigate. Finally, we are unable to uncover evidence for any effect of monetary policy shocks on aggregate demand, as recorded either in the industrial production (IIP) gap or the inflation rate. None of these effects are estimated with strong precision, which may reflect either instability in monetary transmission or the limitations of the empirical methodology.

The rest of the paper is organized as follows. Section 2 reviews India's financial architecture, with the objective of identifying key components of that architecture that are likely to affect the monetary transmission mechanism. As indicated above, such components include the strength of linkages between the domestic and foreign financial markets and the evolution of the country's exchange rate regime, as well as the size and composition of the formal financial sector. These characteristics of the Indian economy constitute the context in which monetary transmission operates in the country. Section 3 describes the evolution of monetary policy in India. The purpose of the discussion in this section is to provide guidance in the selection of monetary policy instruments to be used in the empirical work, as well as to indicate the types of variables to which the RBI has responded in setting the values of that instrument (RBI's reaction function). Section 4 discusses the empirical methodology, and the variety of issues concerning the specification of the VAR from which the dynamic responses of several macroeconomic variables to monetary policy shocks will be estimated. Section 5 presents the estimation results in the form of impulse responses. Section 6 concludes. An appendix presents a brief review of the literature on India.

2 Capital Account Regime, Exchange Rate Regime, and Domestic Financial Structure

As indicated above, the effectiveness of monetary transmission in any country depends on a variety of characteristics of its economy. These are usefully classified into macroeconomic and microeconomic factors. Macroeconomic factors include the economy's degree of integration with external financial markets as well as its exchange rate regime, and microeconomic factors refer specifically to the structure of its financial system. This section describes the roles of both factors in the Indian economy.

2.1 Macroeconomic Factors

A standard approach in macroeconomic modeling—at least until the current international financial crisis—has been to assume away financial frictions in the domestic economy, so that returns on all domestic interest-bearing assets (that is, on all assets but money) are assumed to be perfectly arbitraged—i.e., risk-adjusted returns are equalized among all domestic nonmonetary assets. Under these circumstances, all nonmonetary assets can be treated as perfect substitutes. In this case, the effectiveness of monetary transmission depends only on macroeconomic factors, in the form of the degree of integration between domestic and foreign financial markets and the exchange rate regime.

The "impossible trinity" of Mundell provides the main result: with fixed exchange rates, the effectiveness of monetary policy *decreases* as the degree of integration between domestic and foreign financial assets increases. In the limit, with perfect integration, monetary policy has no effect on aggregate demand. Under floating rates, on the other hand, monetary policy is transmitted to aggregate demand through two channels: through domestic interest rates (which affect the overall level of absorption) and through the exchange rate, which affects the composition of absorption between domestic and foreign goods. In this case, as the degree of financial integration increases, the power of monetary policy to affect aggregate demand *increases* with it. The reason is that increased integration implies a reduced scope for monetary policy to create rate-of-return differentials between domestic and foreign assets. This means that a given policy-induced change in the domestic interest rate must create a larger offsetting expected change in the exchange rate (i.e., an expected depreciation of the domestic currency in response to an increase in the domestic interest rate, and an expected appreciation in response to a decrease) the greater the degree of financial integration. Holding the expected future exchange rate constant, the exchange rate must depreciate today in order to create the expectation of an appreciation tomorrow, and it must appreciate today in order to create the expectation of depreciation tomorrow. Since increases in domestic interest rates are therefore associated with exchange rate appreciations, while decreases are associated with depreciations, these exchange rate changes reinforce the effects of policy-induced interest rate changes on aggregate demand. The upshot is that the higher the degree of financial integration, the greater the extent to which exchange rate changes reinforce the effects of interest rate changes on aggregate demand, and therefore the stronger the monetary transmission mechanism.

To form an ex ante expectation of the strength of monetary transmission in India, we therefore begin by considering its economy's degree of financial integration with the rest of the world, as well as its exchange rate regime.

2.1.1 International Financial Integration

Capital account liberalization in India has taken place in a gradual and calibrated manner. It has been a continuous process rather than a one off event (Sen Gupta and Sengupta 2014). India prioritized certain kinds of flows in the liberalization process (Reddy 2008 and Mohan and Kapur 2009). In particular, the liberalization process favored nondebt flows such as FDI and portfolio investment over debt flows.

Currently, barring a few sectors, FDI is allowed universally. Some of the sensitive sectors such as banking and insurance are subject to caps.

Portfolio flows have also witnessed significant liberalization, although there exist separate investment caps on sub accounts of foreign institutional investors (FIIs), individual FII and aggregate FII investment in a company. In contrast, debt flows are subject to numerous restrictions including borrowers and lenders having to satisfy eligibility conditions, minimum maturity period, cap on all-in-cost payments made by corporates as well as end-use restrictions.

The calibrated approach toward liberalization is reflected in the steady increase in India's extent of financial integration with the rest of the world. Yet India has not kept pace with other emerging markets. The extent of capital account liberalization has been primarily determined using two kinds of measures. The first set of measures looks at the de jure openness, and focuses on laws governing the movement of capital in and out of the country.

A well-known index of de jure capital account restrictions was constructed by Abiad and others (2008) and is presented for India in Fig. 1a. The index is constructed on the basis of information in the IMF's *Annual Report on Exchange Rate Arrangements and Exchange Restrictions,* and increases as the capital account becomes more liberalized. The index finds a step change in India's capital account regime in 1993, followed by another step change in 1996; and another one in 2004.

However, another commonly used index of capital account openness is the Chinn-Ito index—is static for India between 1970 and 2012, with a value of –1.18 and does not capture any capital account liberalization that took place since the

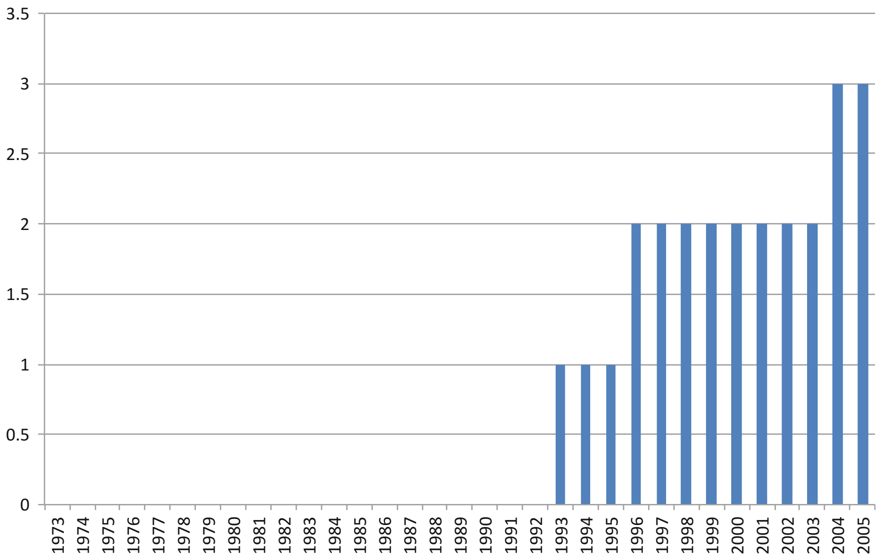
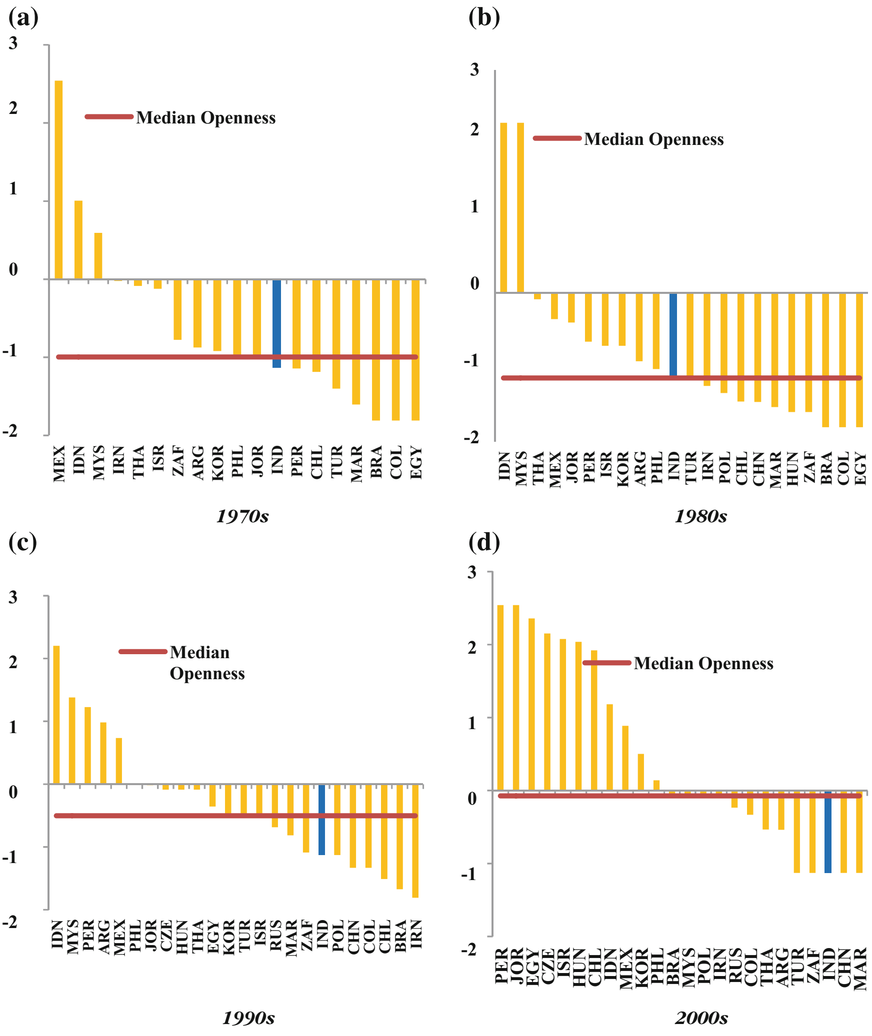


Fig. 1 **a** De Jure indicator of capital account openness **b** Cross-country comparison of De Jure openness. **a** 1970s **b** 1980s **c** 1990s **d** 2000s. *Source* Chinn and Ito (2008)



Source: Chinn and Ito (2008)

Fig. 1 (continued)

early 1990s. For comparison, the index takes a value of 2.54 for the US over the entire period. Figure 1b looks at the degree of de jure capital account openness index developed in Chinn and Ito (2008) across emerging markets. It is evident that over the last 40 years, on average, there has been an increase in the extent of capital account openness, reflected in the upward shift of the median line. However, India has not liberalized at the same pace as the average emerging market, as a result of which it has shifted from being in the middle of the distribution of countries, ranked according to their openness, during the 1970s and 1980s, toward the more restrictive end of the spectrum in the last two decades (Sen Gupta and Sengupta 2014).

However, financial integration requires more than the absence of de jure restrictions on capital movements. The existence of de jure regulations often does not accurately capture the actual level of financial integration as they depend critically on the effectiveness of the enforcement and macroeconomic fundamentals. A country with strict controls but lax enforcement can experience large private capital flows. Alternately, a country with an extremely liberal capital account regime can witness limited flows due to limited opportunities for economic returns. Therefore, it is important to look at de factor, or outcome-based measures of financial integration, which are calculated as the sum of gross flows or gross stocks of foreign assets and liabilities as a ratio of GDP.

Figure 2a, b examine the size and composition of capital flows into the country. The evolution of gross capital flows over the last five decades is shown in Fig. 2a. It increased 81 times between 1970 and 2011. The real takeoff in value terms seems to have taken place in the early 2000s. As a percent of GDP, gross flows increased from 17 % in 1970 to more than 60 % before the global financial crisis, falling to 47 % in 2011. Capital flows increased substantially in net terms as well. While debt flows decreased, equity flows increased as a percent of GDP since the early 1990s. FDI flows have also increased though at a much slower pace than equity.

Despite the sharp increase in capital flows over the last five decades, India still has a relatively closed capital account in de facto terms, compared to other emerging markets. In all, gross capital flows to India in 2011 were 47 % of GDP. As it can be seen in Fig. 3a, this is substantially lower than in most emerging markets, with the exception of Pakistan.[2]

Overall, therefore, while India has progressively liberalized the de jure restrictions on its capital account since 1991 and while de facto indicators also suggest increased financial openness—especially on the equity side—both in de jure and in de facto terms India still enjoys only a limited degree of integration with international financial markets compared to other emerging economies.[3]

2.1.2 Exchange Rate Regime

India's de jure exchange rate regime has been classified as "managed floating" in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions since 2009. Effective from February 2, 2009, the classification of the de facto

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[2]Emerging market economies are those that are included in the Morgan Stanley Capital International (MSCI) index. As pointed out by an anonymous referee, scaling gross capital flows by GDP may not be ideal as GDP is affected by business cycles. In order to address this issue, we look at the measure averaged over 5 years and get a similar picture.

[3]This finding is also consistent with other work on India such as Ghosh et al. (2016). They argue that "India's capital account restrictions-which are mostly quantitative rather than price-based appear to have been largely effective in limiting both inward and outward flows."

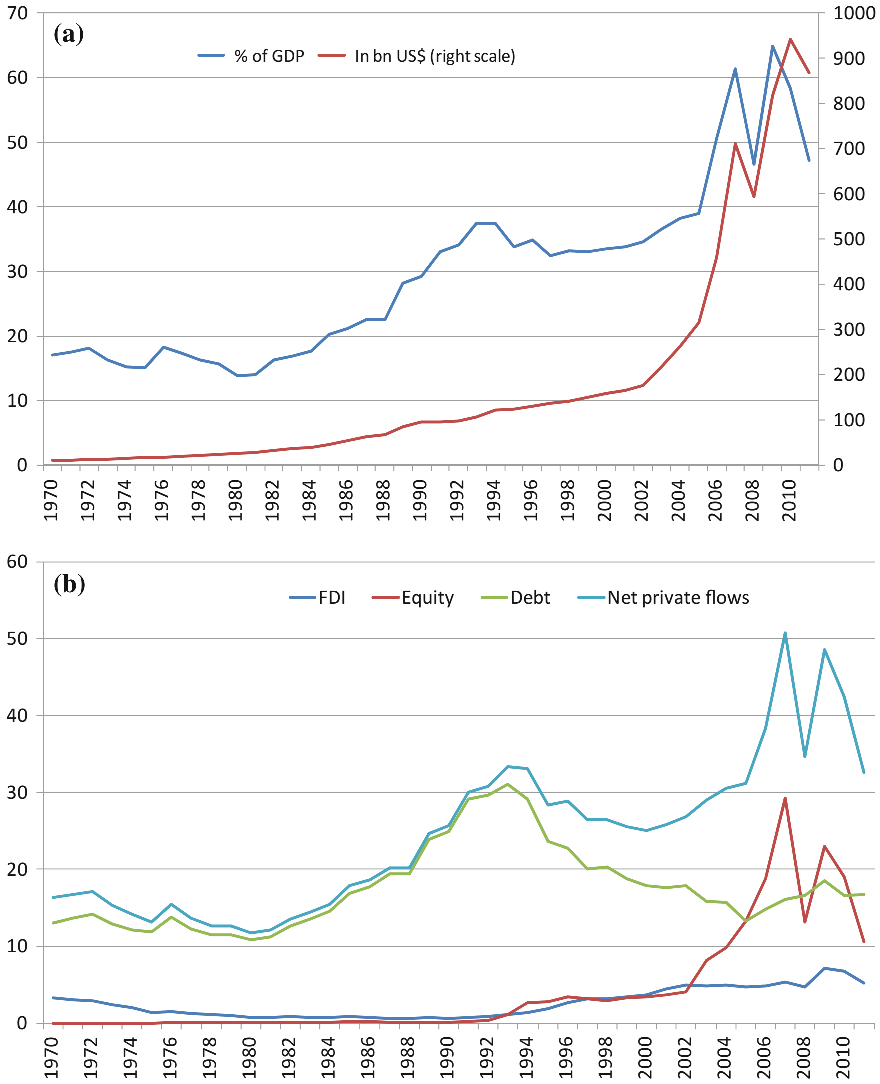

Fig. 2 **a** Gross capital flows to India **b** Size and composition of net capital flows to India (as % of GDP)

exchange rate arrangement was changed from “managed floating with no predetermined path for the exchange rate” to “floating”, retroactively to April 30, 2008, due to a revision of the classification methodology.[4]

[4]The change reflects only a methodological modification and does not imply a judgment that there has been a substantive alteration in the country’s exchange arrangement or other policies.

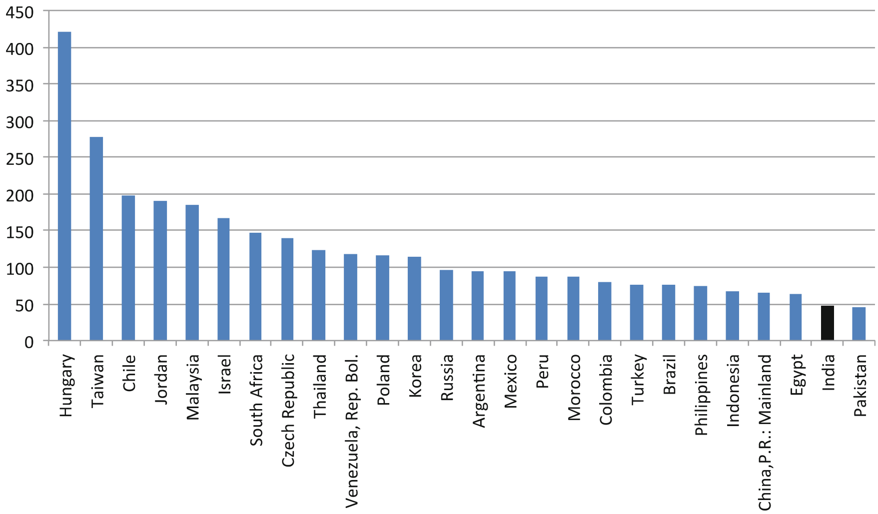

Fig. 3 Gross capital flows to emerging markets (in % of GDP). *Notes* Figure 3 is for 2011

The exchange rate of the rupee is determined in the interbank market. Though the RBI periodically intervenes in that market, buying and selling both spot and forward dollars at the market exchange rate, its interventions are designed to reduce volatility in the market rather than to target any specific exchange rate. As shown in Fig. 4, the rupee–dollar rate has displayed substantial volatility since 2008, when the exchange rate was classified as floating. In short, the behavior of the rupee–dollar rate passes a simple eye-ball test as a floating rate.[5]

Thus, the evidence suggests that the effectiveness of monetary transmission has not been undermined by a loss of monetary autonomy in India. While de jure capital account restrictions have been relaxed since early 1990s and capital flows have indeed grown, both gross and net capital flows remain small relative to other emerging markets. Using other emerging markets as a benchmark, therefore, India still appears to exhibit a limited degree of integration with international financial markets. Coupled with evidence that the country has maintained a floating exchange rate regime, we conclude that macroeconomic factors have not undermined monetary autonomy in India.

However, this does not necessarily imply that macroeconomic factors favor strong monetary transmission in India. Given the country's floating exchange rate, its limited degree of integration with international financial markets would tend to weaken the exchange rate channel of monetary transmission that typically supplements the interest rate channel under floating exchange rates.

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[5]Sen Gupta and Sengupta (2014) use the methodology introduced by Frankel and Wei (1994) to create an index of exchange rate stability for India. They also find that exchange rate flexibility went up significantly since the global financial crisis.

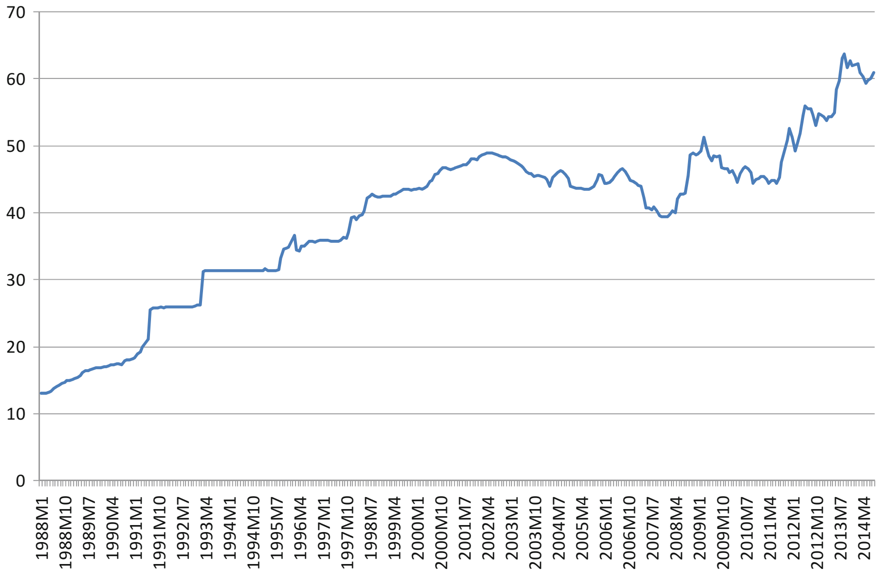

Fig. 4 India. Rupee/Dollar rate. 1990–2013

This suggests that, relative to other emerging economies more of the burden of monetary transmission is likely to fall on the interest rate channel in India. This naturally raises the question of whether the structure of the Indian financial system is consistent with effective monetary transmission through interest rate effects.

2.1.3 Structure of the Domestic Financial System

The key issues are three (Mishra and Montiel 2013)

- The size and reach of the system.

Specifically, how important is the formal financial system in the Indian economy—i.e., how much financial intermediation in India actually occurs through the formal financial system? Since monetary policy operates through the terms on which the financial system conducts formal intermediation, the larger the system and the more it dominates the process of financial intermediation in India, the larger the impact that monetary policy is likely to have on the Indian economy.

- The magnitude of financial frictions.

Financial intermediation is a costly activity because of the importance of asymmetric information and costly contract enforcement in financial transactions. These frictions require financial intermediaries to incur a variety of costs (loan evaluation costs, monitoring costs, and contract enforcement costs). The magnitude

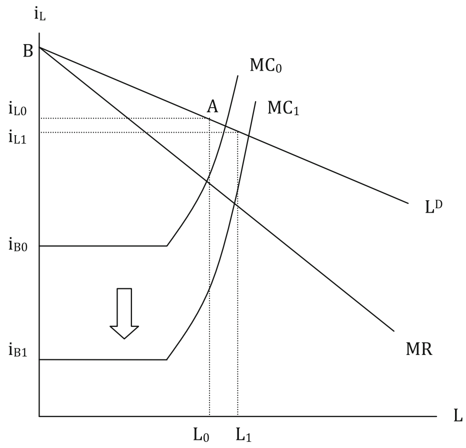

Fig. 5 Financial frictions, monopoly power, and monetary transmission

of these costs depend on the quality of the domestic institutional environment (the security of property rights, the quality and enforcement of its accounting and disclosure standards as well as of its bankruptcy laws, and the efficiency of the domestic legal system), as well as on the characteristics of domestic borrowers (specifically their collateralizable net worth and opacity).

These considerations have implications for the shape of the marginal cost of lending for financial intermediaries in low-income countries. The production structure in many developing countries tends to be dualistic, with the economy consisting of a small number of large and transparent firms with significant collateralizable net worth and a large number of small, opaque enterprises with little collateralizable net worth. Under these conditions, the marginal cost of lending tends to be relatively flat over the range of lending to large firms and then to quickly become very steep when lending is extended to smaller firms. Figure 5 illustrates this situation. The figure depicts a profit-maximizing equilibrium for a financial intermediary possessing some monopoly power and operating in a low income-type environment. Its marginal cost curve MC_0 has a flat range corresponding to loans extended to large, relatively transparent firms, but then a sharply rising range when the intermediary extends its lending to small and opaque borrowers. When the marginal cost curve has this shape, changes in the opportunity cost of funds to financial intermediaries, such as those caused by monetary policy, may shift the marginal cost curve vertically (e.g., in the case of a monetary expansion, to MC_1 in Fig. 5), but have little effect on the total supply of funds and therefore on the terms offered by financial intermediaries, weakening the power of monetary policy to affect the economy.

- The degree of competition in the formal financial sector.

For a given shape of the marginal cost of lending curve for each financial institution, the less competitive the financial sector (the steeper the demand curve facing each individual financial intermediary), the less responsive the supply of funds will be to changes in monetary policy. The reason is that steep demand curves are associated with steep marginal revenue curves, and since firms with monopoly power maximize profits by setting marginal revenue equal to marginal cost, the steeper the marginal revenue curve facing an individual financial intermediary, the less responsive its supply of lending to the private sector will be to a change in its marginal cost of lending caused by a change in monetary policy.

To see this, imagine rotating the loan demand curve L^D in a clockwise direction around the point A in Fig. 5. Doing so makes the loan demand curve steeper, decreasing its elasticity and increasing the bank's degree of monopoly power. As L^D become steeper, the point B moves vertically upward along the vertical axis, and MR becomes steeper as well. Consequently, the profit-maximizing points of intersection between marginal revenue and marginal cost move to the southwest along their respective marginal cost curves MC_0 and MC_1. The effect is to narrow the horizontal distance between those points, thereby reducing the expansion of the bank's loans for a given reduction in its opportunity cost of funds.

How relevant might these considerations be for India? As mentioned previously, the institutional environment in which financial intermediaries operate—the security of property rights, the efficiency and impartiality of the legal system, the adequacy of accounting and disclosure standards—has strong effects on the costs of overcoming financial frictions, especially for lending to smaller and more opaque borrowers. Direct measures of these factors are not available, but since they are all particular aspects of a country's general institutional environment for the conduct of economic activity, more general indicators of such institutional quality are likely to be correlated with them. Table 1 reveals where India ranks compared to other countries in terms of such indicators.

While not all of the indicators listed in the table are of equal relevance for the costs of doing financial business in India, the key point that emerges from the table is that India does not rank significantly above the median on most of the indicators listed. Particularly worrisome is India's low ranking in the areas of regulatory quality and control of corruption, where it ranks at the 33rd percentile. This suggests that the types of government-provided public goods on which the financial

Table 1 India: indicators of institutional quality

Indicator	Percentile rank
Rule of law	52.61
Government effectiveness	47.37
Regulatory quality	33.97
Control of corruption	34.93
Voice and accountability	58.29
Political stability and absence of violence/terrorism	11.85

Notes These figures are for 2012

Table 2 India. Indicators of financial development

	Advanced	Emerging	Low-income	India
Deposit money bank assets of GDP (%)	149.8	76.1	41.2	64.0
Nonbank financial institutions assets to GDP (%)	140.5	36.2	14.4	0.0
Private credit by deposit money banks and other financial institutions to GDP	138.5	67.7	33.8	46.3
Bank branches per 100,000 adults (commercial banks)	36.4	21.2	13.1	10.6
Stock market capitalization to GDP (%)	90.3	82.4	26.8	58.5
Number of listed companies per 10,000 people	34.7	21.4	24.1	4.2
Stock market turnover ratio (value traded/capitalization) (%)	68.6	60.5	7.1	57.4

Source Mishra and Montiel (2013), and Global Financial Development Database. All figures are for 2011, except stock market capitalization, which is for 2005

system depends (enforcement of property rights, of accounting and disclosure standards, of legal contracts) may not be as readily available in India as in some other countries. The relative scarcity of such public goods would tend to make financial intermediation a costly activity.

There are two implications of high-cost intermediation for the likely effectiveness of monetary transmission. The first is based on the resulting small size of the formal financial sector. To the extent that monetary policy actions affect only the share of the economy that is served by the formal financial sector, the small size of that sector limits the reach of monetary policy, thus reducing its impact on the economy. The second is that costly intermediation likely implies a sharply rising marginal cost of intermediation as banks try to serve smaller and more opaque borrowers, so even for the share of the economy that is served by the formal financial sector, central bank actions may have weak effects on the supply of bank lending.

Is this borne out by the structure of India's financial system? Some of the relevant data are presented in Table 2, which compares some characteristics of the Indian financial system with those in high, middle, and low-income countries.

A first important observation is that, as shown by the last three rows of Table 2, the stock market plays a relatively limited role in India, particularly compared to advanced economies. While the market appears to be relatively liquid compared to other low-income countries (the turnover ratio in the Indian market is much higher than LICs, and comparable to emerging economies), very few companies are listed in the market, and total market capitalization is significantly lower than that in both advanced and emerging economies. Note that the number of listed companies per 10,000 people in India is not only significantly lower than in high-income countries, but at 4.2 it is even lower than the average for all LICs (23.3). This has the important implication that the asset channel of monetary transmission, which operates through monetary policy effects on the price of marketable financial (and real) assets, is unlikely to be strong in India.[6]

This means that if changes in policy interest rates are to have important effects on aggregate demand in India, those effects are likely to have to operate through the lending rates charged to their customers by formal financial intermediaries. But how important is the role of such intermediaries in the Indian economy? Consistent with financial intermediation being a costly activity in India, the reach of the formal financial system appears to be significantly less extensive than that in emerging and advanced economies. In total size as measured by conventional indicators, (such as the ratio of deposit bank assets and the assets of nonbank financial institutions to GDP, the ratio of private credit from formal financial institutions to GDP, the number of bank branches scaled by population, or the fraction of adults with accounts at formal financial institutions) the formal financial system is relatively small in India.[7] In terms of the reach of its formal financial sector, it is therefore clear that India operates in a very different domestic financial environment than that which tends to characterize advanced and emerging economies.

While the small size of the formal financial sector in India should be expected to weaken the links between lending rates in that sector and total Indian aggregate demand, limited competition in the banking sector may in turn weaken the links between policy rates and formal sector lending rates, as shown in Fig. 5. There are several indications that the banking sector in India is highly concentrated. First, a striking feature of the Indian financial system is that it is dominated by public sector banks. Based on IMF (2013), public sector banking assets constitute close to three quarters of the total banking sector assets, and 43 % of total financial sector assets. Second, banks' net interest margin is quite high in India. This may in part be due to the high costs of financial intermediation in the country. That this may not be the sole reason for the high spreads, however, is suggested by the fact that returns to

[6]India also lags behind advanced and emerging economies in developing its long-term corporate debt market. Bank finance, equity markets and external borrowings are the preferred funding sources for companies. The size of the corporate debt market is very small. In 2000–2001, banks in India accounted for 14.4 % of the financing of large firms and this increased to 17.8 % in 2010–2011. On the other hand, bond market financing accounted for only 3.5 % of the source of funds of large Indian companies in 2000–2001, and this increased only marginally to 3.9 % a decade later (Banerji et al. 2012). The long-term debt market in India consists largely of government securities. In 2011, the size of the Indian corporate bond market in terms of outstanding issuances was INR 8,895 billion, only 31 % of government securities (SEBI Handbook 2012; Anand and Sengupta 2014).

[7]See also Banerjee et al. (2003), and Burgess and Pande (2005), who establish that the formal reach of bank finance is limited in India. In a similar vein, Allen et al. (2012) show that most Indian firms rely on financing by friends or family members and the extent of avoiding formal financial markets is even more prevalent than Chinese or other counterparts in emerging market economies.

equity in the Indian banking sector are high, not only by the standards of high-income countries, but also by those of LICs.[8]

In short, microeconomic factors pertaining to the structure of the country's domestic financial system suggest that (a) a relatively small share of the Indian economy may be affected by the impacts of monetary policy on the formal financial system, and (b) those impacts may themselves be limited by sharply rising costs of lending to the private sector at the margin, as well as by imperfect competition in the banking sector.

3 Monetary Policy Instruments in India

While these considerations create ex ante reasons to suspect that the power of monetary transmission may be limited in India, the issue is ultimately an empirical one. A key step in any empirical investigation of this issue is to identify monetary policy shocks (exogenous changes in monetary policy) in the data, in order to examine their effects. To do so, we need both to determine which monetary policy variable the RBI has been controlling as well as to separate out endogenous movements in this variable from exogenous ones.

A complicating factor in this regard is that the evolution of monetary policy in India has historically been characterized by the use of multiple instruments. Two broad groups of instruments have been used by to conduct monetary policy: (i) price-based instruments that affect the cost of funds for banks, in the form of the: repo rate and the reverse repo rate, and (ii) quantity-based instruments, which directly affect the volume of lending by banks, in the form of the cash reserve ratio (CRR) and the statutory liquidity ratio (SLR).

3.1 Price-Based Instruments: Repo and Reverse Repo

Since 2001, the RBI has conducted monetary policy through the Liquidity Adjustment Facility (LAF), which allows banks to borrow money through repurchase agreements. LAF consists of repo and reverse repo operations. Repo (for "repurchase option") is essentially collateralized lending to banks—i.e., banks borrow money from the RBI to meet short-term needs by selling securities to RBI with an agreement to repurchase the same at a (higher) predetermined price at a specified future date. The rate charged by RBI for this transaction, implied by the difference between the repurchase and selling prices, is called the repo rate. Repo

[8]Note that the financial sector in India also includes NonBank Financial Companies (NBFCs). Based on IMF (2013), there are 578 NBFCs, much larger than the number of banks, but they comprise only 6.5 % of total financial sector assets, and 8.7 % of GDP. The NBFCs are therefore more likely to be competitive than the banking sector.

operations therefore inject liquidity into the system. An increase in the repo rate raises the rate RBI charges for lending to banks, reduces liquidity (or the rate of injection of liquidity) in the system, and therefore constitutes tightening of monetary policy. A reverse repo operation occurs when the opposite transaction takes place: the RBI borrows money from banks by lending securities, and therefore absorbs liquidity from the system. The interest rate paid by RBI is in this case is called the reverse repo rate. An increase in the reverse repo rate increases the incentives for banks to park funds with the RBI, and represents a tightening of monetary policy. The collateral used for repo and reverse repo operations takes the form of Government of India securities.

Repo and reverse repo rates were announced separately until May 2011. Since then, the reverse repo rate is not announced separately, but is linked to the repo rate. The liquidity adjustment facility corridor—that is, the excess of repo rate over reverse repo—has varied between 100 to 300 basis points. This corridor is used to contain volatility in short-term interest rates.

Currently, the width of the corridor is 100 basis points. The evolution of repo and reverse repo rates since 2001 is shown in Fig. 6. Both have typically moved in the same direction, indicating that they have effectively functioned as a single instrument over most of the sample, establishing a corridor for short-term interest rates. Importantly, there exists significant variation in the repo and reverse repo rates over time, which allows us to identify the effect of monetary policy on bank lending.

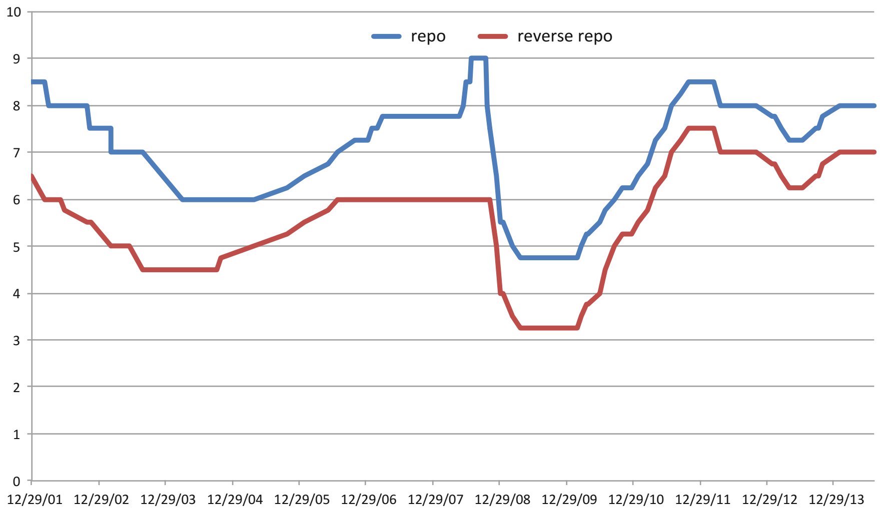

Fig. 6 Monetary policy: price instruments. 1996–2013

3.2 Quantity-Based Instruments: CRR and SLR

CRR is a certain fraction of bank deposits which banks are required to keep with RBI in the form of reserve balances. An increase in CRR directly reduces the volume of resources that banks have available to lend, and therefore constitutes a tightening of monetary policy. In addition to CRR, at each point in time every bank has to maintain a certain quantity of liquid assets expressed as a fraction of their net time and demand liabilities. These assets can be maintained in the form of cash, gold, or as unencumbered "approved" securities. In practice, they are predominantly held in the form of government securities. The ratio of these liquid assets to time and demand liabilities is called the Statutory Liquidity Ratio (SLR). A reduction in SLR, for example, increases the resources that banks have available to lend, and therefore constitutes "loosening" of monetary policy. SLR declined sharply from 31.5 to 22 % between 1996 and 2013 (Fig. 7). There was a sharp decline in SLR to 25 % in 1997; and then it stayed flat till 2008, before beginning to decline again. CRR has exhibited more fluctuations, but has also declined from 14 to 4 % between 1996 and 2013. Combining both CRR and SLR, about half of commercial banks' liabilities were withheld from lending to the private sector in 1996; this figure has reduced to a quarter in 2013.

It is possible, of course, that the RBI has conducted monetary policy solely through the repo (and reverse repo) rate, and that the CRR and SLR have been adjusted with other goals in mind (e.g., as a component of financial liberalization). But because the CRR and SLR have effects on the supply of banks' loanable funds, it is also possible that the repo rate, CRR and SLR would all have been used by the RBI as instruments of monetary policy. To examine this issue, following Das et al.

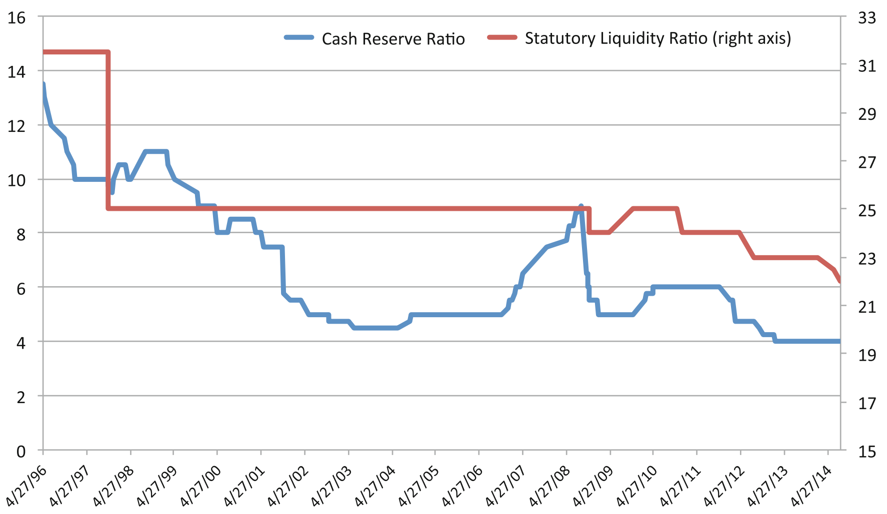

Fig. 7 Monetary policy: quantity instruments. 1996–2013

Fig. 8 Monetary policy: quantity and price instruments. 1996–2013

(2015), we create composite measures for price and quantity instruments and examine their co-movements. The price instrument is specified as a simple average of repo and reverse repo rates. The quantity instrument, on the other hand, is the sum of CRR and SLR. As shown in Fig. 8, price and quantity instruments have generally moved in the same direction during our sample period. The exception is between 2011 and 2012, when sharp increases in the policy rates suggested a tightening of monetary policy while the quantity indicator continued to move in a loosening direction. This suggests that for most of our sample period the RBI has indeed treated the CRR and SLR as instruments of monetary policy.

3.3 *Alternative Measures of Stance of Monetary Policy*

To address this complication, we construct three alternative measures of the overall stance of monetary policy. First, we extract the first principal component from the repo and reverse repo rates, as well as the CRR and SLR. The first principal component explains about 50 % of the total variance in the four variables; and mirrors closely the evolution of the first principal component based only on the repo and reverse repo rates (Fig. 9), reflecting the strong co-movement in these rates caused by the "corridor" approach and the use of the quantity instruments as complements to the price instruments.

Following Das et al. (2015), we construct two other measures of the overall stance of monetary policy based on assigning scores to quarterly changes in the instruments. Scores of 0, +1, –1, are respectively assigned if there is no change, an increase, or a decrease in the values of individual instruments. In an alternative

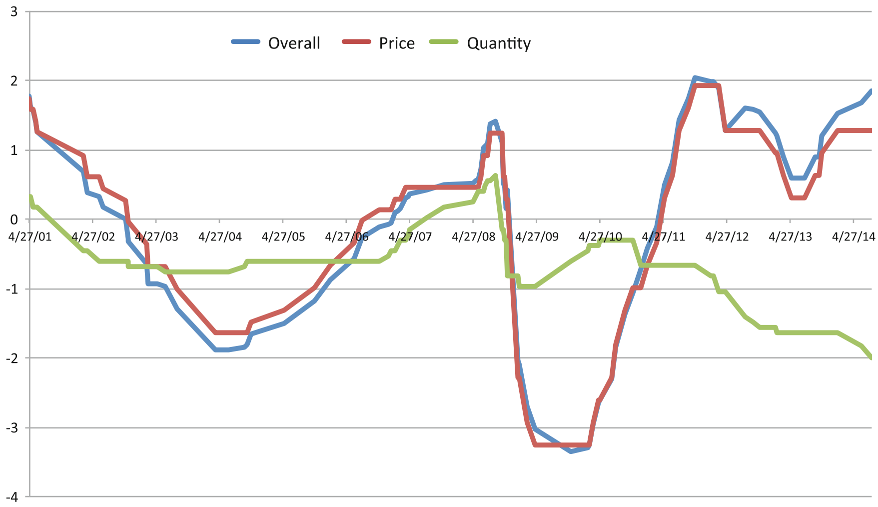

Fig. 9 Overall stance of monetary policy: first principal component

measure, we assign different scores based on the magnitudes of the changes. Scores of 0, +1, +2, –1, –2 are assigned, respectively, to each instrument. A score of zero is assigned for no change. A score of +1, and +2 are respectively assigned for quarterly increases of less than 25 basis points, and between 25–50 basis points. A score of –1, and –2 are assigned for quarterly decreases of less than 25 basis points, and between 25–50 basis points, respectively. The overall stance of monetary policy is calculated by taking an unweighted sum of the scores for the individual instruments. Figure 10 shows the evolution of the two score-based measures of the overall stance of monetary policy. Based on either of these measures, monetary policy was loose following the global financial crisis, but has tightened since then.

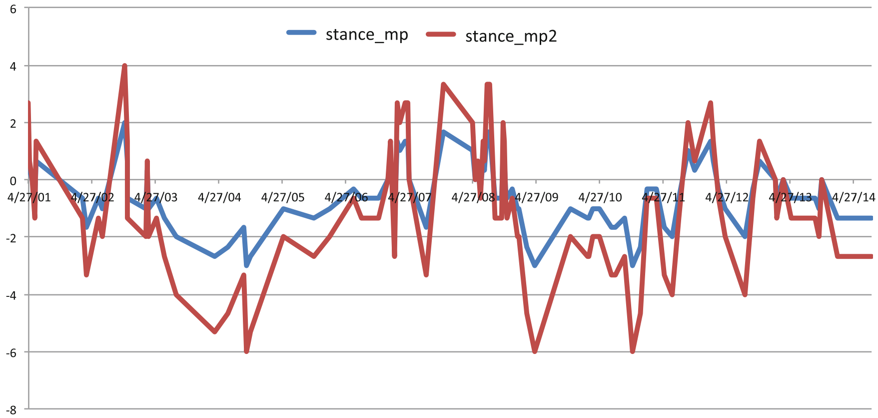

Fig. 10 Overall stance of monetary policy: score-based methodology (3-month moving averages)

4 Empirical Methodology

To explore monetary transmission, we will use a structural vector autoregression (SVAR) approach. This approach has been widely implemented in a variety of settings—including OECD, emerging and low-income countries—to explore the effectiveness of monetary transmission. In this section we describe the approach in general terms. In subsequent sections we implement it for the case of India.

In the SVAR methodology, the dynamic behavior of endogenous macroeconomic variables is assumed to be determined by a structural model of the form:

$$A_0 x_t = A(L) x_{t-1} + \varepsilon_t. \tag{1}$$

where x_t is a column vector containing observations on n endogenous variables at time t, A_0 is an $n \times n$ matrix that captures the contemporaneous interactions among these variables, $A(L)$ is an $n \times n$ matrix of polynomials in the lag operator L, and ε_t is a column vector of structural shocks. In order to define these shocks unambiguously, the elements of ε_t are assumed to be *i.i.d.* and mutually uncorrelated. They can be normalized without loss of generality to have unit variances, so that $(E[\varepsilon_t \varepsilon_t^{'}] = I)$. What the researcher is ultimately interested in are the dynamic effects of specific structural shocks (in our case, of a monetary policy shock) on the endogenous variables. These effects can be traced out from the reduced-form representation of this system. As long as A_0 is invertible, the reduced form can be obtained by pre-multiplying Eq. (1) by A_0^{-1}. This yields

$$x_t = B(L) x_{t-1} + u_t, \tag{2}$$

where $B(L) = A_0^{-1} A(L)$ and $u_t = A_0^{-1} \varepsilon_t$. Since this equation expresses the vector of endogenous variables as an autoregression, it constitutes the VAR representation of the system. Notice that the random shocks in (2) behave very differently from those in (1) since every element of u_t is a linear combination of the elements of ε_t, the elements of u_t will in general be contemporaneously correlated, but serially uncorrelated.

Conveniently, the elements of the matrix $B(L)$ can be estimated consistently by OLS. However, estimation of (2) is not sufficient to allow us to describe the dynamic effects of specific structural shocks on the endogenous variables. To do so, we need to determine how the structural shocks in (1) affect the reduced-form shocks in (2). As indicated above, this relationship is given by $u_t = A_0^{-1} \varepsilon_t$. It follows that to determine how structural shocks affect the dynamic responses of the endogenous variables in the system we require an estimate of the elements of A_0.

Estimation of the VAR is helpful in estimating the elements of A_0, since it yields some useful restrictions that the elements of A_0 must satisfy. Specifically, since $u_t = A_0^{-1} \varepsilon_t$, the variance covariance matrix of the VAR residuals is given by

$$\Omega = E_t u_t u_t' = E_t(A_0^{-1}\varepsilon_t\varepsilon_t' A_0^{-1'}) = A_0^{-1}A_0^{-1'}.$$

The estimate Ω of the variance covariance matrix of the reduced-form residuals thus provides a set of restrictions on the elements of A_0. Since Ω is an $n \times n$ symmetric matrix, it contains $n(n+1)/2$ distinct elements, which provide an equal number of restrictions on the n^2 elements of A_0. Thus an additional $n^2 - n(n+1)/2 = n(n-1)/2$ restrictions are required to estimate all of the elements of A_0. This identification challenge is most commonly met by using theoretical reasoning to impose $n(n-1)/2$ additional restrictions on the contemporaneous interactions among the endogenous variables (referred to as short-run restrictions). These usually take the form of setting $n(n-1)/2$ of the elements of A_0 equal to zero, on the grounds that information and/or response lags prevent some endogenous variables from reacting contemporaneously to changes in others.

4.1 VAR Estimation

Implementing this methodology for the purpose of examining the effectiveness of monetary transmission in India requires several steps

i. *Specification of the VAR*

The first step in implementing the approach described above is to determine the specification of the VAR—i.e., to choose the variables that will appear in the VAR. We will motivate that choice by drawing on the family of small New Keynesian structural models that are used for monetary policy analysis by many central banks around the world. Though there are a wide variety of such models, we will focus on a version that contains little more than the specific elements that tend to be common across all such models. The reason is that the limited sample period that is available for India and the large number of lags typically required to produce well-behaved residuals in estimated VARs suggest that degrees of freedom are likely to be at a particular premium in this case. Accordingly, the set of variables to be included in the VAR should be chosen as parsimoniously as possible.

The specific model that we will use to motivate our choice of endogenous variables in the VAR is a slightly modified version of the simple open economy New Keynesian model developed by Adam et al. (2015). The model is presented below. It consists of an IS Eq. (3), a New Keynesian Phillips curve (4), an uncovered interest parity condition (5), an interest rate pass-through Eq. (6), and a Taylor-type monetary policy rule (7)

$$\begin{aligned}\tilde{y}_t = {} & \alpha_1 \cdot E_t[\tilde{y}_{t+1}|I_t] + (1-\alpha_1)\cdot\tilde{y}_{t-1} - \alpha_2\cdot[\alpha_3\cdot\left(i_t^L - E_t[\pi_{t+1}|I_t - \bar{r}\right) \\ & + (1-\alpha_3)\cdot\tilde{e}_t] + \varepsilon_t^y,\end{aligned} \tag{3}$$

$$\pi_t = \beta_\rangle \cdot E_t[\pi_{t+1}|I_t] + (1-\beta_1)\cdot\pi_{t-1} + \beta_2\cdot\tilde{y}_t - \beta_3\cdot\tilde{e}_t + \varepsilon_t^\pi, \tag{4}$$

$$\tilde{e}_t = E_t[\tilde{e}_{t+1}|I_t] - (1/4)\cdot[i_t^L - E_t[\pi_{t+1}|I_t] - \bar{r}^*] + \varepsilon_t^e, \tag{5}$$

$$i_t^L = \gamma_1 \cdot i_t + \varepsilon_t^L, \tag{6}$$

$$i_t = \tau_1\cdot(\bar{r} + 1.4\cdot E_t[\pi_t|I_{t-1}] + \tau_2\cdot E_t[\tilde{y}_t|I_{t-1}]) + \tau_3\cdot i_{t-1} + \varepsilon_t^i. \tag{7}$$

This model contains five observable macroeconomic variables: the GDP gap $\tilde{y}_t$, the inflation rate π_t, the real exchange rate gap $\tilde{e}_t$ (the deviation of the real exchange rate from its long-run equilibrium value), the commercial bank lending rate i_t^L, and the central bank policy rate i_t. The symbol $E_t[x_{t+i}\big|I_{t+j}]$ is an expectations operator denoting expectations formed at time t for a variable x to be observed at time $t + I$ conditional on information available at time $t + j$, Greek letters denote positive structural parameters, and the ε_t's are the unobservable random structural shocks.[9]

Consistent with this model, we will estimate a VAR for India that contains the five endogenous variables contained in the model. Thus the column vector x_t will be assumed to be given by $x_t = (\tilde{y}_t,\ \pi_t,\ \tilde{e}_t,\ i_t^L,\ i_t)'$. As it stands, however, the model described above treats all supply shocks as unobservable to the econometrician. They are captured by the random term ε_t^π in Eq. (4). Contrary to this assumption, shocks to world food and energy prices may exert important effects on inflation in India, and since these variables are observable, they should in principle be identified separately in Eq. (4). Since India is less likely to affect world food and energy prices, these prices measured in US dollars can be considered to be exogenous to developments in India, and we will accordingly include these as exogenous variables in some versions of the estimated VARs.[10] Doing so is particularly important in the present context, because to the extent that shocks to either of these variables may help predict future headline CPI inflation in India, by Eq. (7) excluding them from the model would tend to undermine the identification of monetary policy shocks in India.

ii. *Sample period*

As already indicated, the sample period is April 2001 to December 2014—i.e., the period during which monthly data on industrial production are available, and before the new flexible inflation-targeting regime was put in place. The RBI formally announced an inflation target only in 2015.[11] The reason for restricting

[9]For discussion of the individual equations, see Li et al. (2015).

[10]In the baseline version of the VAR, we include several lags of world food and energy price inflation as exogenous variables. The choice of lag length for these two variables was somewhat arbitrary, and we will consider alternative choices in Sect 5.

[11]See http://finmin.nic.in/reports/MPFAgreement28022015.pdf on agreement between Government of India and Reserve Bank of India on new monetary policy framework.

attention to this period is that macroeconomic theory (including in the form of the model above) suggests that the effectiveness of monetary transmission depends critically on the effects that monetary policy shocks have on expectations of future interest rates (see, for example, Woodford 2001), and the effects of current shocks on such expectations in turn depend on the monetary policy regime that is in place. Thus, if the change in India's monetary policy regime in January 2014 was a credible one, we should expect monetary transmission in India to be quite different post-January 2014 from what it was pre-January 2014. Including the data post the regime change would therefore result in unstable VAR parameters and unreliable inference about the nature of monetary transmission in India under IT.

iii. *Data*

An exploration of the effectiveness of monetary transmission requires estimating the effects of a shock to the monetary policy instrument on aggregate demand. Based on the discussion in Sect. 3, the RBI has used multiple instruments historically to conduct monetary policy. We consider the effects of four instruments in the empirical analysis: (i) the repo rate, (ii) the average of repo and reverse repo rates, (iii) the sum of CRR and SLR, and (iv) the composite score-based indicator of monetary policy stance described above.

The second issue is how to measure the effects of monetary policy on aggregate demand. In principle one wants to use both an indicator of real economic activity and the price level, because using just one or the other risks biasing the exercise against a finding of effective monetary transmission by making the results depend on the shape of the economy's aggregate supply curve. For example, if the price level is used as the sole indicator of aggregate demand and the economy's aggregate supply curve is very flat, then a monetary policy shock that has a strong impact on aggregate demand would nevertheless have little impact on prices, and the finding of minimal effects on the price level would be erroneously interpreted as weak monetary transmission. We therefore include both the price level (in the form of the CPI) and an indicator of aggregate economic activity in the VAR.

Unfortunately, the latter presents a problem. The obvious indicator to choose is real GDP. However, real GDP numbers are available only on a quarterly basis, starting from 1996. For reasons explained in the next subsection, we have opted to use monthly data. We use the index of industrial production (IIP) as a proxy for real economic activity, as it is the only indicator for which monthly data are available. The drawback of using IIP, however, is that it is partial, and covers only the manufacturing sector. The results on transmission to output should, therefore, be interpreted with adequate caution.

We first seasonally adjusted the series using the Census Bureau's X-12 routine and then computed a monthly IIP gap as the deviation of the log of this series from a smoothed version computed using a two-sided HP filter. For the measure of the aggregate price level we used the headline CPI (from the Central Statistical Organization of India). The measure of inflation used in the VAR was seasonally

Table 3 Unit root tests for endogenous variables

	ADF		Phillips-perron	
	Statistic	P-value	Statistic	P-value
IIP gap	–3.150	0.099*	–7.202	0.01***
Inflation	–6.693	0.01***	–17.662	0.01***
Real exchange rate gap	–3.109	0.114*	–3.339	0.0671*
Bank lending rate	–2.177	0.502	–2.384	0.416
Policy repo rate	–3.528	0.356	–2.150	0.514

***Significance at 1 % level; **Significance at 5 % level; *Significance at 10 % level

adjusted (using the same procedure as for economic activity), and the monthly percentage change in this series was expressed as an annual rate. The real effective exchange rate (REER) is taken from the RBI, and the REER gap is calculated as the deviation of the log of this series from a smoothed version constructed, as with the IIP gap, using a two-sided HP filter.

Finally, the commercial bank lending rate data are taken directly from the *IFS*. It refers to the "benchmark prime lending rate" till June 2010, and to the "base rate" thereafter. The benchmark prime lending rate (BPLR) regulated all interest rates charged by the commercial banks on various categories of loans. Till 2010 most of the variable rate loans, like home loans and some of the term loans, etc., were pegged against the PLR. Beginning in July 2010, BPLR was replaced by the average base rate charged by India's five largest commercial banks. The base rate is fixed on the basis of the average cost of funds of the banks, and is the minimum rate for all commercial loans, with banks not being permitted to resort to any rate below it.

iv. *Estimating the VAR*

The first decision in estimating the VAR is whether to do so in level, first difference, or vector error correction form. The answer depends on the time series properties of the included endogenous variables. The first step, therefore, was to check the time series properties of the endogenous variables. The results of standard Augmented Dickey–Fuller and Phillips–Perron tests for all the variables are reported in Table 3. The null hypothesis for these tests is that the variables in question contain a unit root. As can be seen from the table, this hypothesis is rejected for the IIP gap, inflation, and the real exchange rate gap, but not for the policy repo and bank lending rates.

In principle, therefore, a VAR estimated in these five variables over the relevant sample period would be unbalanced in a time series sense. However, a Johansen cointegrating test indicates that the policy repo rate and the bank lending rate are cointegrated, so estimating the VAR in levels can be expected to yield statistically valid results.[12]

The next step in estimation is to determine the appropriate lag length for the VAR.[13] Appropriateness is determined in this case by the requirement that sufficient lags are included in the VAR so as to render its residuals serially uncorrelated. We began with 12 lags and applied the full set of information criteria provided by Eviews to determine the appropriate lag length for the VAR. None of the five relevant criteria suggested more than 6 lags. Joint lag exclusion tests rejected the null of zero coefficients for lags 1, 5, 6, and 11. Guided by these results, we decided to include six lags in the baseline estimation. Lagrange multiplier (LM) tests suggested that the resulting residuals are serially uncorrelated.

4.2 *Identification*

As indicated above, the VAR captures the full dynamic interactions among the variables included in the model, so given a shock to the policy rate it is possible to trace out the empirical response of all five variables to that shock period by period. But this cannot be done by simply shocking the residual in the reduced-form equation for the policy rate, because a structural shock to the policy rate (in the form of ε_t^i) may affect the residuals in at least some of the other equations in the VAR at the same time, as given by the relationship $u_t = A_0^{-1}\varepsilon_t$. The residuals from the estimated VAR represent the innovations in the autoregressive representation of each variable in the VAR, but they cannot be interpreted as the orthogonal structural shocks in the underlying data-generating process (DGP) unless they are contemporaneously uncorrelated (i.e., unless the A_0 matrix is diagonal), since the structural shocks may appear in more than one of the reduced-form equations of the underlying DGP represented by the VAR.

However, the import of this observation depends on the strength of the contemporaneous correlation among the VAR residuals. The weaker such correlations, the less the extent to which the VAR residuals will represent an amalgam of structural shocks. We find that the innovations in the policy rate are only weakly correlated with the innovations in the other equations. This suggests that the impulse responses should not be overly sensitive to the identification strategy chosen.

[12]Both the trace and maximum-eigenvalue statistics reject the absence of a cointegrating vector with a P-value of less than 1 %.

[13]Note that Eq. (1) is simply a generalized version of the model given by Eqs. (3)–(7) in state-space representation. It is generalized in the sense that it allows for longer lags than the state-space representation of the model of the last section would generate in the presence of serially uncorrelated shocks. Taken literally, the state-space representation of that model would contain a single lag arising from the setting of monetary policy based on time $t-1$ information, and the estimated VAR should contain a single lag as well.

As mentioned previously, the most common way to impose identifying restrictions on the A_0 matrix is to restrict the contemporaneous interactions among the endogenous variables in the model, typically by sprinkling the required number of zeros ($n(n - 1)/2$ of them) among the elements of the matrix. Access to this identification strategy is what makes the use of monthly data desirable in this case. It is plausible to assume that the central bank cannot observe the variables that enter its monetary policy reaction function contemporaneously within the month, so that contemporaneous shocks to the other endogenous variables in the model would not affect the current policy rate, enabling all of the nonpolicy rate elements in one row of the A_0 matrix to be set equal to zero. But it is less plausible to assume that they cannot do so within the quarter, and even less that they cannot do so within the year, so the same restrictions could not be imposed with equal confidence in the context of low-frequency data. Similarly, it is plausible to assume that monetary policy actions do not affect some subset of macroeconomic variables within the month, enabling the nonpolicy rate elements of the column of the A_0 matrix corresponding to the policy rate to be set equal to zero, but as the relevant unit of time becomes longer, this procedure becomes less and less justifiable. In short, the assumption that the central bank cannot observe all of the variables that enter its reaction function within the month yields exclusion restrictions on shocks to nonmonetary variables in the equation linking nonmonetary structural shocks to innovations in the policy rate, while the assumption that structural shocks in the policy rate do not affect specific other variables within the month yields exclusion restrictions in the equations linking innovations in those other variables to monetary policy shocks. This is the rationale for using monthly observations in this exercise.

However, while the use of monthly data makes a plausible case for a variety of exclusion restrictions based on information and reaction lags, thereby facilitating the process of identification, it may not be necessary to impose all of the available restrictions for present purposes. Specifically, Christiano et al. (1999) have shown that estimating all of the elements of the A_0 matrix is not required in order to recover the impulse responses to monetary policy shocks. Instead, the responses can be recovered from the reduced-form VAR under the much weaker condition that A_0 is block-lower-triangular, with the monetary policy instrument (the policy interest rate in this case) occupying its own diagonal block. The intuition is straightforward: as long as this condition is met, variables that contemporaneously affect the policy rate will not be affected contemporaneously by it, and variables that the policy rate affects contemporaneously will not simultaneously affect it. What this means is that the contemporaneous effects of a monetary policy shock on the first set of variables must be zero, while that on the second set of variables can simply be estimated by running OLS regressions on VAR residuals.[14]

[14]The monetary policy shock can be extracted from the residual in the VAR policy rate equation by regressing that residual on the residuals of the equations corresponding to the first set of variables. The monetary policy shock is the OLS residual from that regression. In turn, the contemporaneous effects of the monetary policy shocks on the remaining set of variables can be

Our identification strategy will actually be somewhat simpler than allowed for by the Christiano, and Eichenbaum, and Evans analysis. It is based on a timing convention for the implementation of monetary policy. We assume that the central bank sets the systematic part of its policy interest rate at the beginning of each period t, before shocks specific to that period arrive. Thus, the bank's policy rate is based on information dated $t - 1$. The implication is that the policy rate is not affected by *any* contemporaneous shock. This places the policy rate in the top left-hand corner of the A_0 matrix, with all other elements in that row equal to zero. This immediately satisfies the Christiano, and Eichenbaum, and Evans conditions, no matter how many zeros arise in the remaining rows of the A_0 matrix—i.e., the matrix is lower block triangular whether its remaining elements are fully identified or not.

Note that the identification strategy would be satisfied by a Choleski decomposition with the interest rate ordered first, but it is more general than a Choleski decomposition, since in the present case it requires only four zeros along the top row of the A_0 matrix, rather than 10 zeros above the diagonal. Nonetheless, since the only structural shocks that we are interested in are those to monetary policy, with all others set to zero, we can most easily implement our identification by imposing it in the form of a Choleski decomposition with the interest rate ordered first. The impulse responses reported below are constructed in that manner.

5 Results

5.1 Main Results

Our results are presented in Figs. 11, 12, 13, 14, 15, 16, 17, and 18. We present results for two alternative identification schemes. One in which the monetary policy variable is ordered first, reflecting the assumption that the RBI does not observe (or does not react to) macroeconomic variables within the month, but macro variables are potentially affected by monetary policy shocks contemporaneously (monetary policy variable ordered first). The bank lending rate, output gap, CPI inflation, and REER gap are ordered after the monetary policy variable in this scheme. For robustness, we also report the results from an alternative identification scheme in which the RBI can respond to macro variables within the month, but those variables in turn can respond to monetary policy only with a lag. The ordering of the other variables remains the same. Four impulse response functions are presented in each case, each using a different definition of the monetary policy variable: the repo rate, the average of the repo and reverse repo rates (the price indicator), the sum of the CRR and SLR (the quantity indicator), and the composite score-based monetary

(Footnote 14 continued)

estimated from OLS regressions of the VAR residuals of the equations for those variables on the monetary policy shock estimated in the first step.

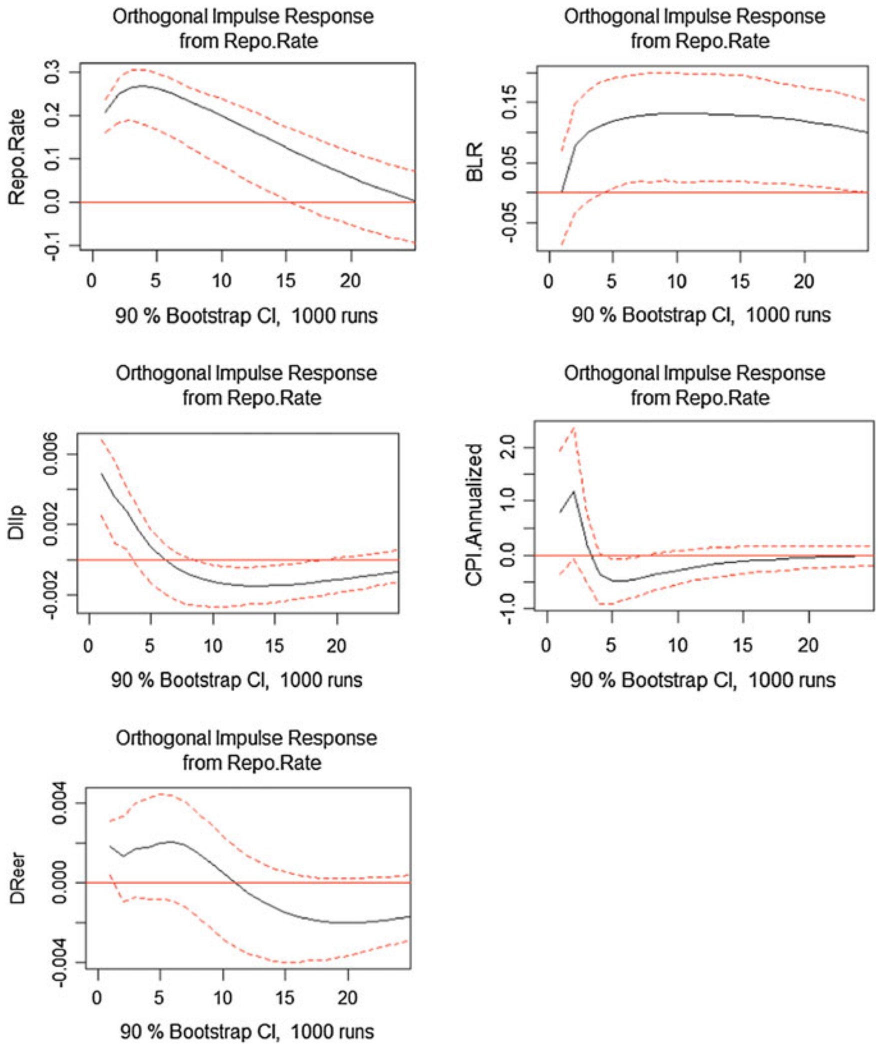

Fig. 11 Response to Cholesky one S.D. innovations ± 1 S.E: repo rate (Ordered First)

policy indicator based on changes in all four instruments, constructed as described above. Figures 11, 12, 13, 14, 15, 16, 17, and 18 show the impulse response functions for the identification scheme when the monetary policy variable is ordered first and last, respectively.

The results reveal some clear patterns:

First, across both identification schemes and for all four indicators, a tightening of monetary policy is associated with an increase in bank lending rates, consistent with evidence for the first stage of transmission in the bank lending channel. The effect is hump shaped, with peak effects on bank lending rates appearing between

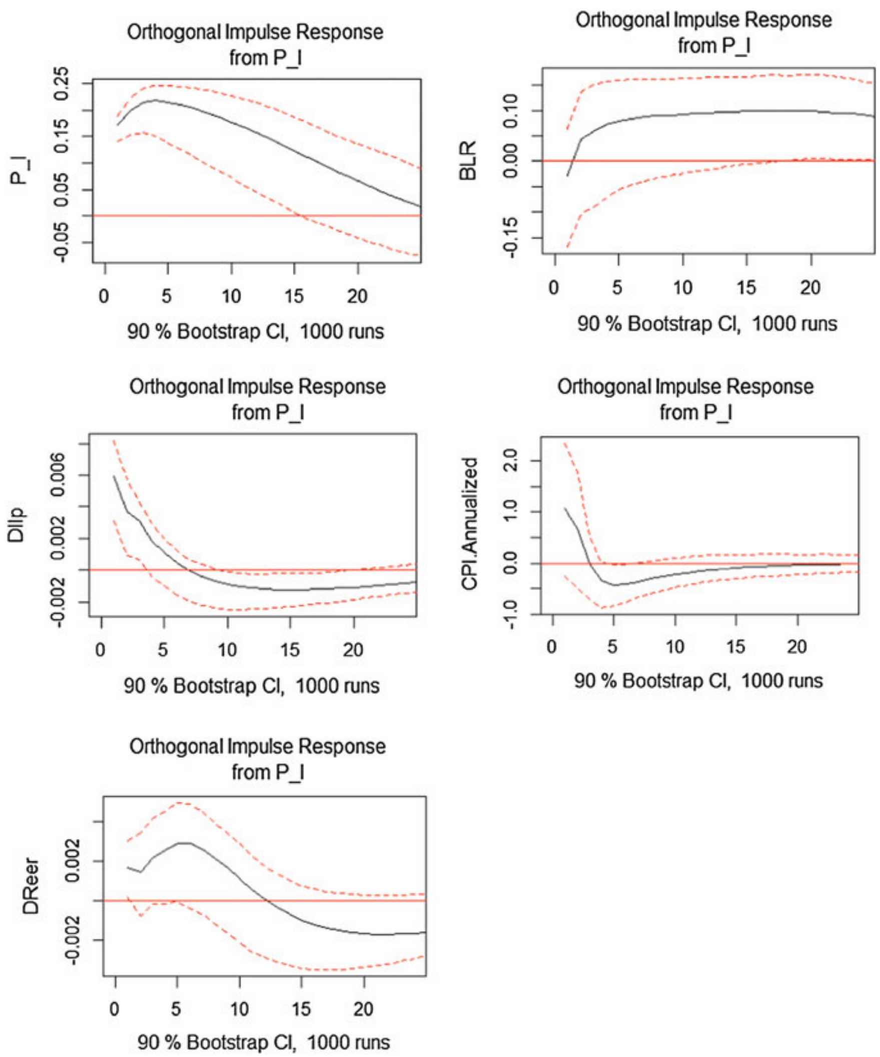

Fig. 12 Response to Cholesky one S.D. innovations ± 1 S.E: average of repo and reverse repo rates (Ordered First)

5–10 months in every case. As is conventional, the confidence bands in Figs. 11, 12, 13, 14, 15, 16, 17, and 18 are at the 90 % level, so these effects are estimated somewhat imprecisely: while they are statistically different from zero at the 90 % confidence level in every case when the monetary policy variable is ordered last, they are only significant at this level in two cases when the policy variable is ordered first.

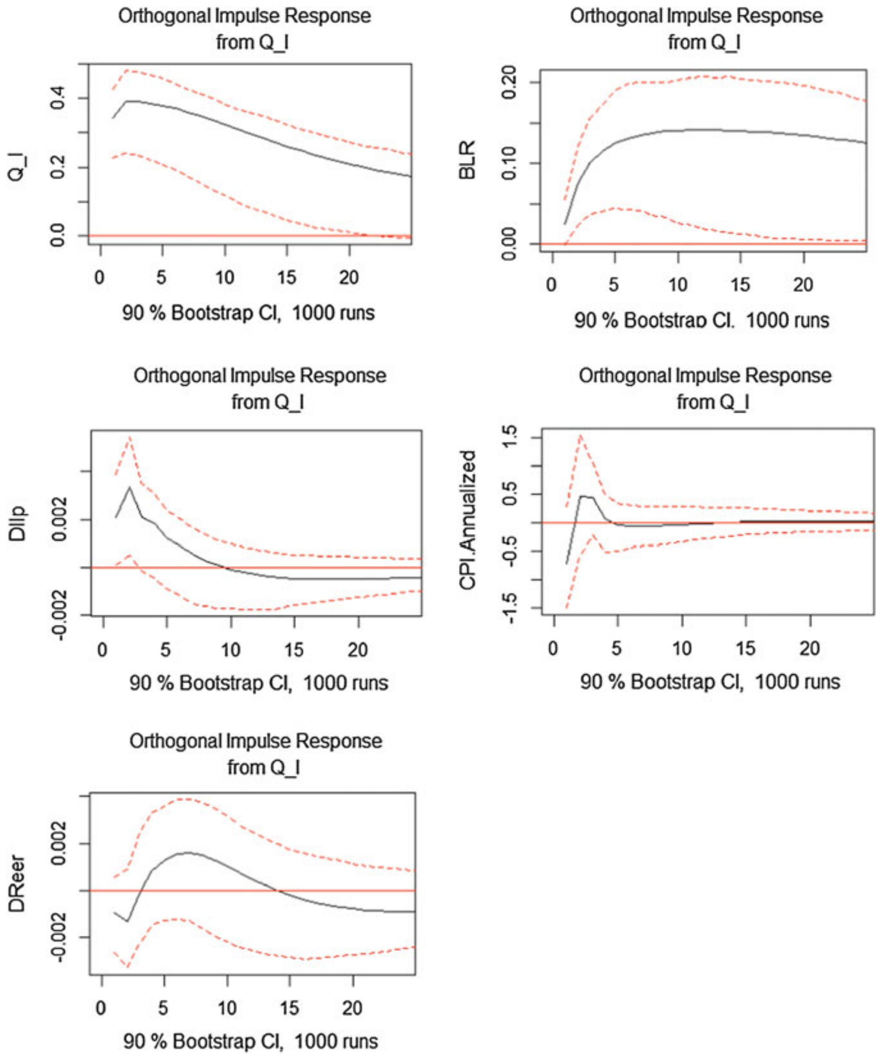

Fig. 13 Response to Cholesky One S.D. innovations ± 1 S.E: sum of CRR and SLR (Ordered First)

Second, while pass-through from the policy rate to bank lending rates is in the right (theoretically expected) direction, pass-through is incomplete. A peak increase of 25 basis points in the repo rate, for example, is associated with a peak increase in the bank lending rate of only about 10 basis points, whether the policy variable is ordered first or last.

Third, when the monetary policy variable is ordered first, effects on the real effective exchange rate are also in the theoretically expected direction on impact, but are extremely weak and not statistically significant, even at the 90 % confidence

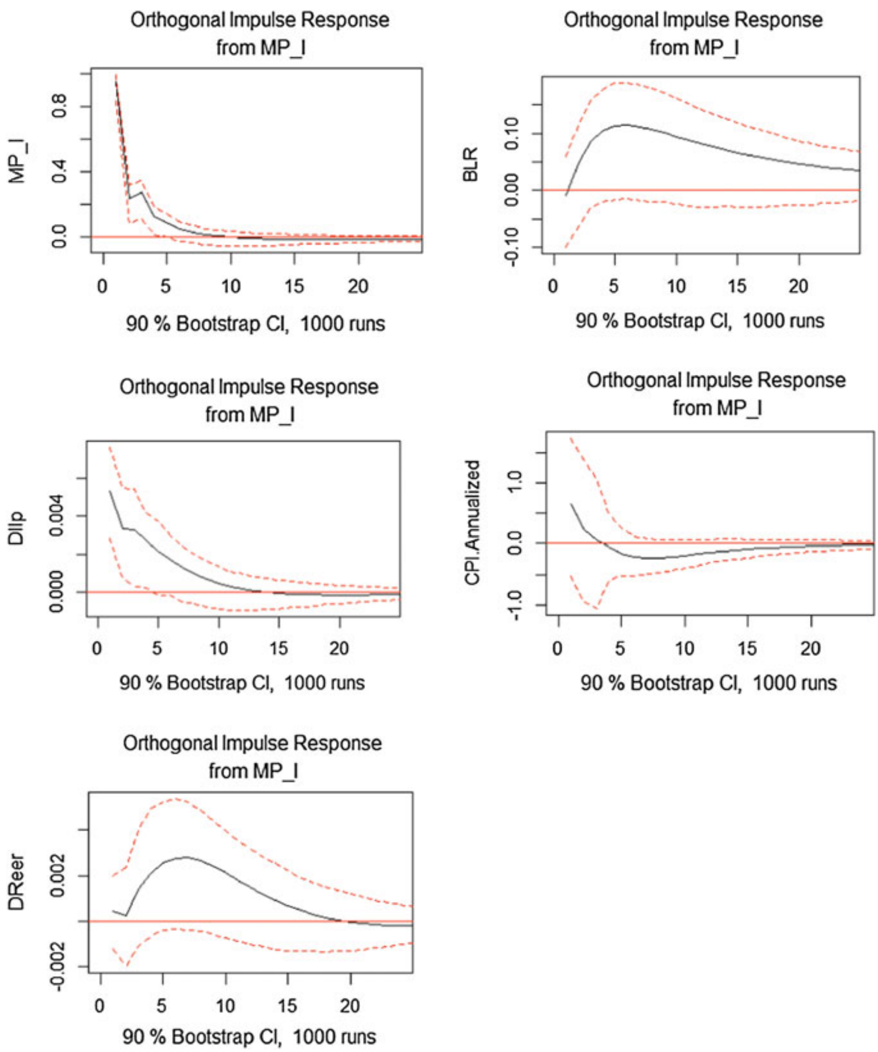

Fig. 14 Response to Cholesky one S.D. innovations ± 1 S.E: composite monetary policy stance (Ordered First)

level, for any of the four monetary policy variants. However, when the monetary policy variable is ordered last, effects on the real effective exchange rate are not just very weak, but also in the wrong direction (a contractionary monetary policy shock causes the real effective exchange rate to depreciate). Consistent with out ex ante expectation, this suggests a very weak exchange rate channel in India.

Fourth, our results provide no support for any effect of monetary policy shocks on aggregate demand, as recorded either in the IIP gap or the inflation rate. Indeed, our most disturbing finding is a consistent pattern of counterintuitive effects of

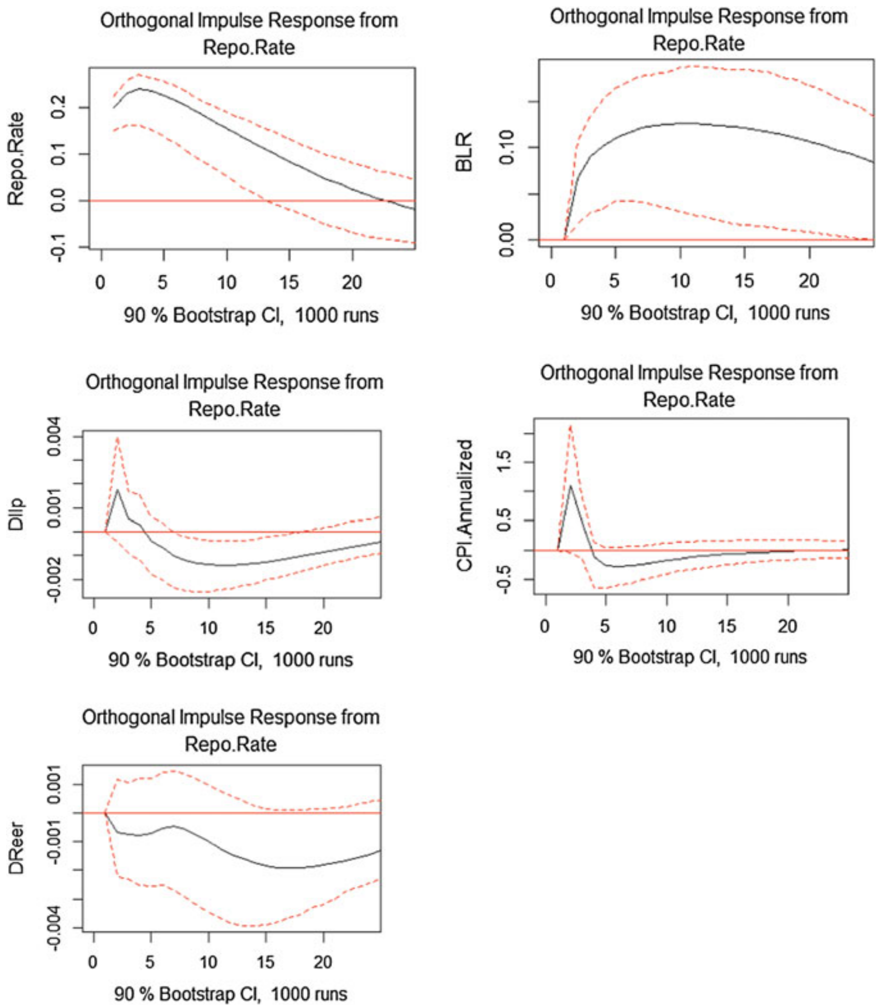

Fig. 15 Response to Cholesky one S.D. innovations ± 1 S.E: repo rate (Ordered Last)

monetary policy shocks on both the GDP gap and the inflation rate. In all but one of our eight cases, a contractionary monetary policy shock tends to *increase* both the IIP gap and the inflation rate on impact. While both effects are quantitatively negligible in every case, it is surprising that when the monetary policy variable is ordered first the counterintuitive effects on the IIP gap are statistically significant at the 90 % confidence level for all four of the monetary policy variables considered.

These results admit of an internally consistent interpretation: The RBI is indeed able to affect bank lending rates in India, but consistent with the analysis in section II, pass-through from the policy rate to bank lending rates is relatively weak. Similarly, India's relatively low degree of financial integration—possibly abetted by

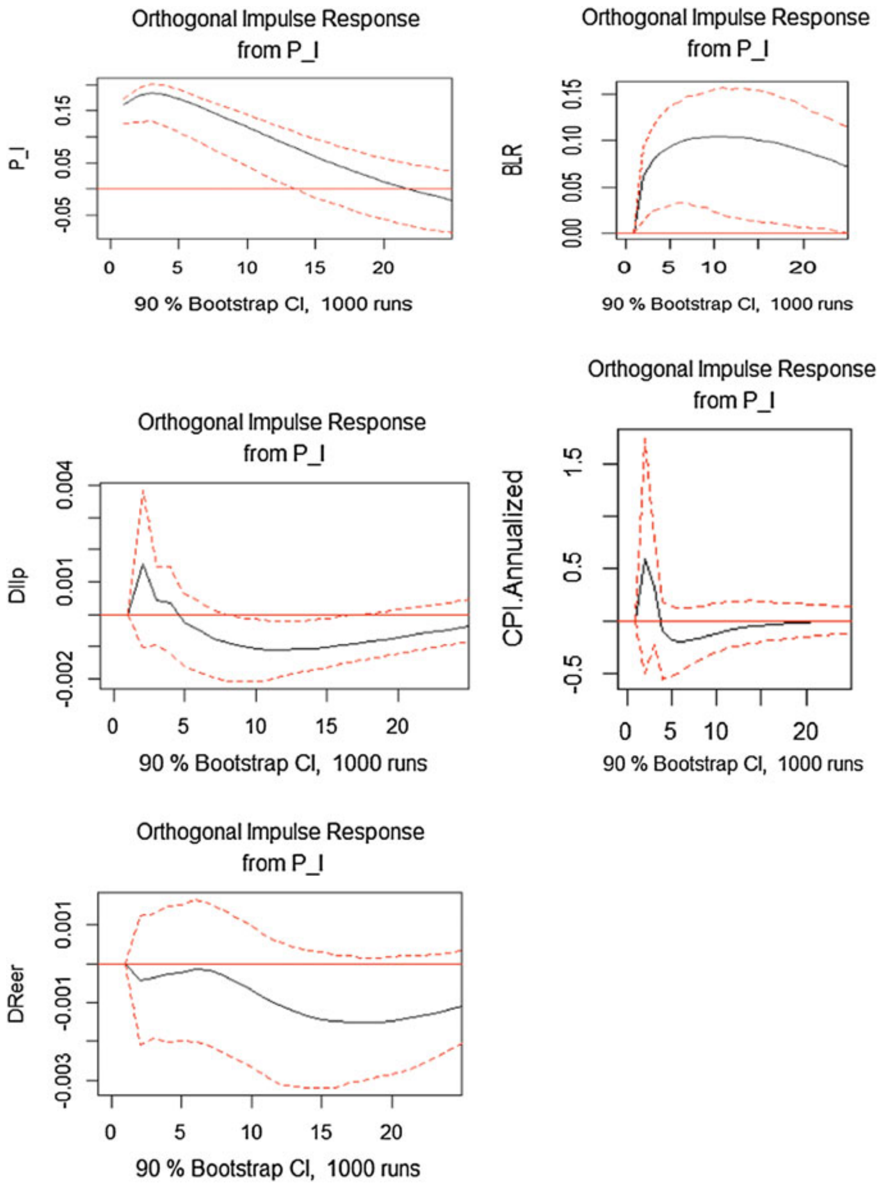

Fig. 16 Response to Cholesky one S.D. innovations ± 1 S.E: average of repo and reverse repo rates (Ordered Last)

RBI intervention in the foreign exchange market to smooth the rupee–dollar rate—has tended to make for a very weak—possibly nonexistent—exchange rate channel. Finally, the small size of the formal financial sector in India, together with the

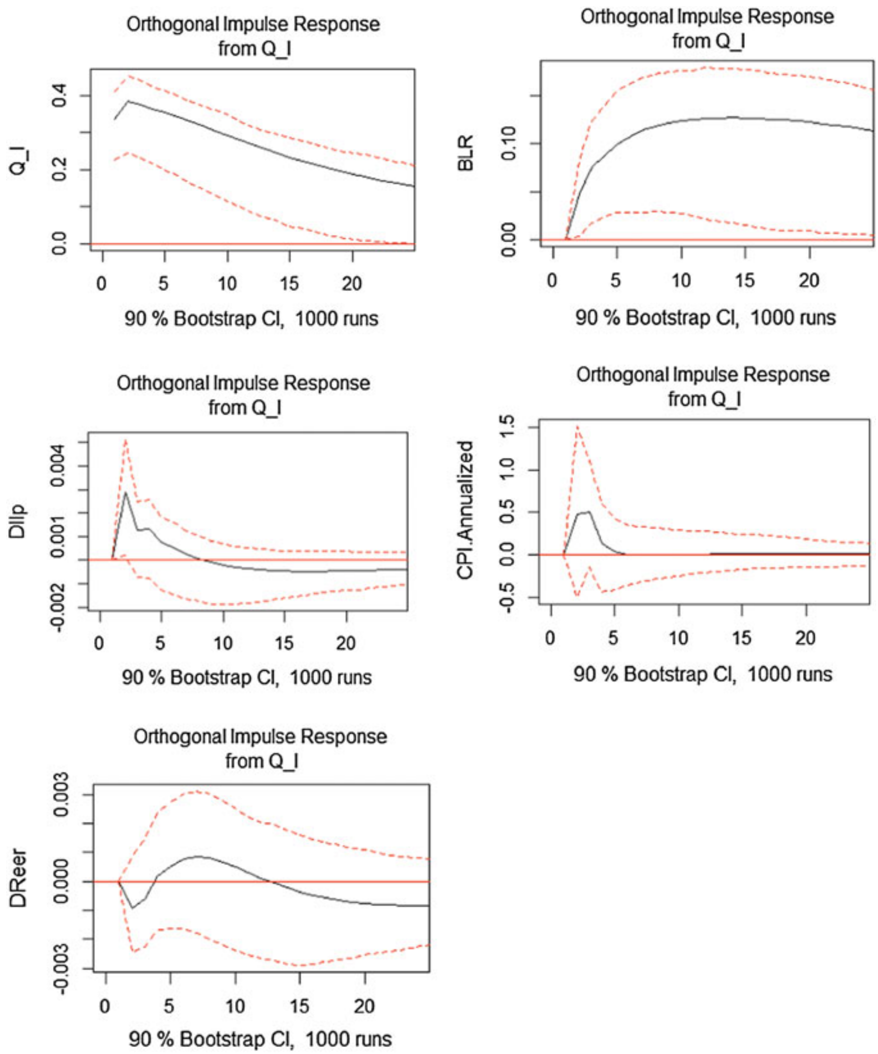

Fig. 17 Response to Cholesky one S.D. innovations ± 1 S.E: sum of CRR and SLR (Ordered Last)

absence of an exchange rate channel and a muted effect of policy rates on bank lending rates, has implied very weak effects of monetary policy on aggregate demand. In short, consistent with what is suggested by the descriptive evidence for India on the potential roles of both the macroeconomic and microeconomic factors

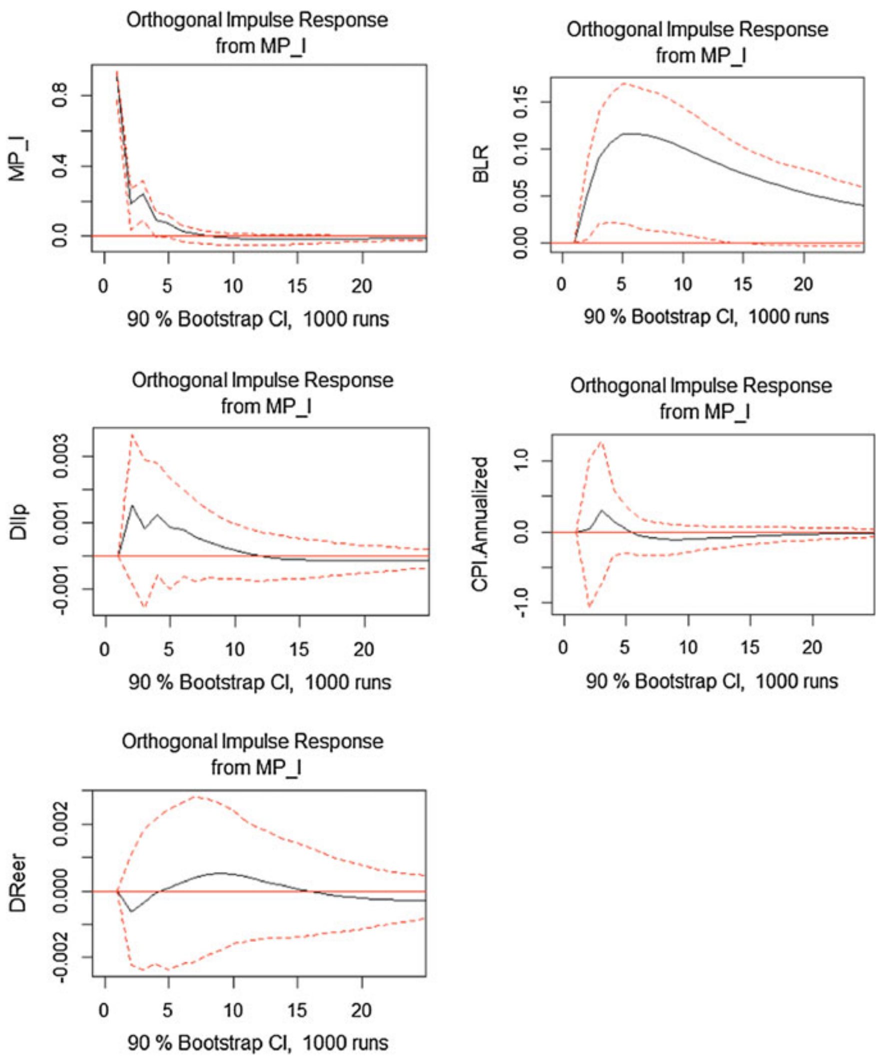

Fig. 18 Response to Cholesky one S.D. innovations ± 1 S.E: composite monetary policy stance (Ordered Last)

that are suggested by theory as influencing the strength of monetary transmission, our central results do not provide evidence of effective monetary transmission to aggregate demand in India.

5.2 Robustness Checks

In this section, we examine the robustness of the previous results to alternative specifications. First, we repeat the estimations by dropping the exogenous variables—world food and energy price inflation. The impulse response functions (not shown) are effectively the same as before.

Second, we tried a variant of the second identification scheme presented in Figs. 15, 16, 17, and 18, where the RBI can respond to macro variables—output

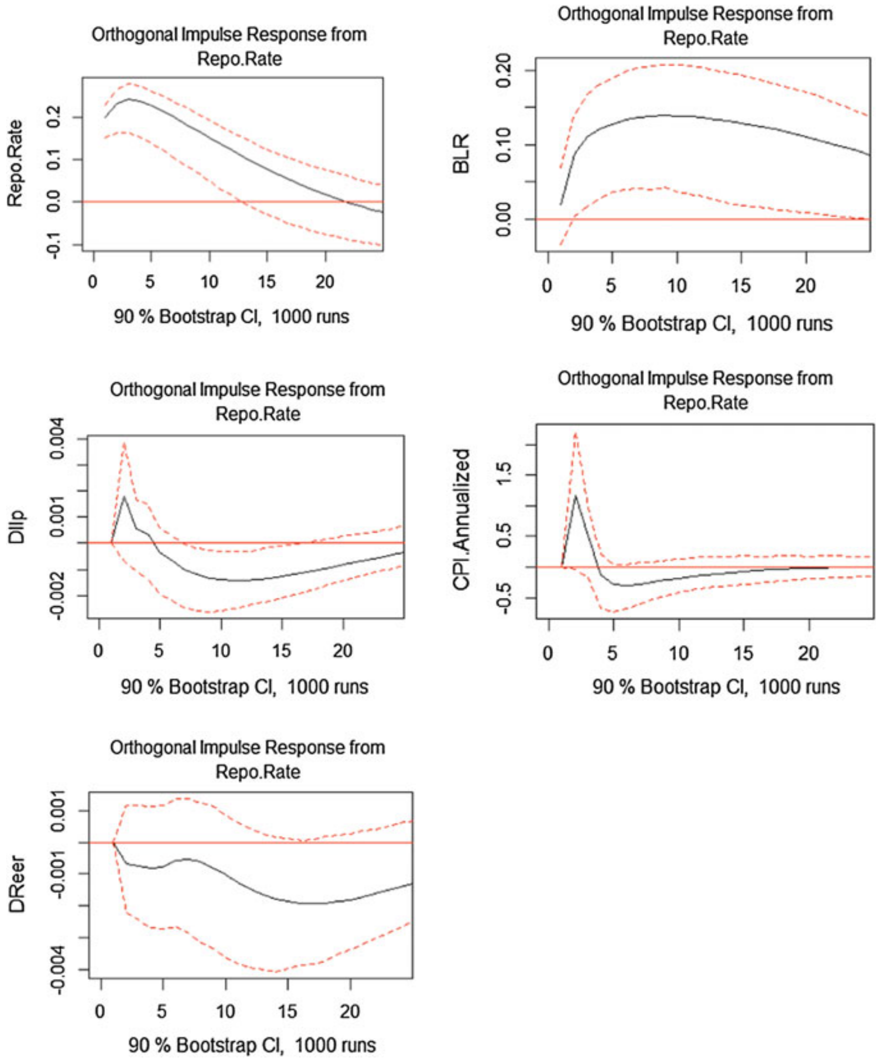

Fig. 19 Response to Cholesky one S.D. innovations ± 1 S.E: average of repo and reverse repo rates (Bank Lending Rate Ordered Last)

gap, inflation, and REER gap—within the month, but those variables in turn can respond to monetary policy only with a lag. RBI, however, does not observe (or does not react to) bank lending rate within the month, but the bank lending rate is potentially affected by monetary policy shocks contemporaneously (monetary policy variable ordered before the bank lending rate). The model has exogenous variables ordered first, as in the impulse responses shown in the previous subsection. The impulse responses for this alternative identification scheme are shown in the Appendix Figs. 19, 20, 21, and 22. The results are qualitatively similar. A tightening of monetary policy is associated with an increase in bank lending

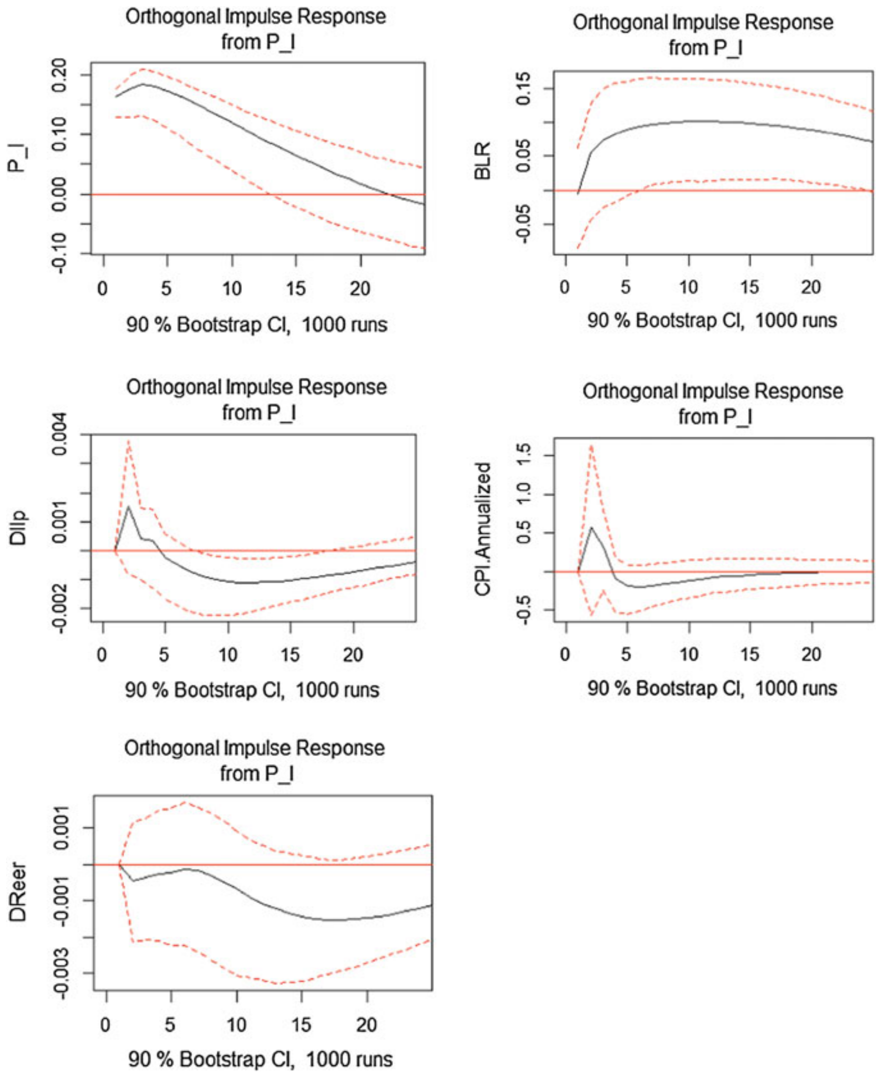

Fig. 20 Response to Cholesky one S.D. innovations ± 1 S.E: average of repo and reverse repo rates (Bank Lending Rate Ordered Last)

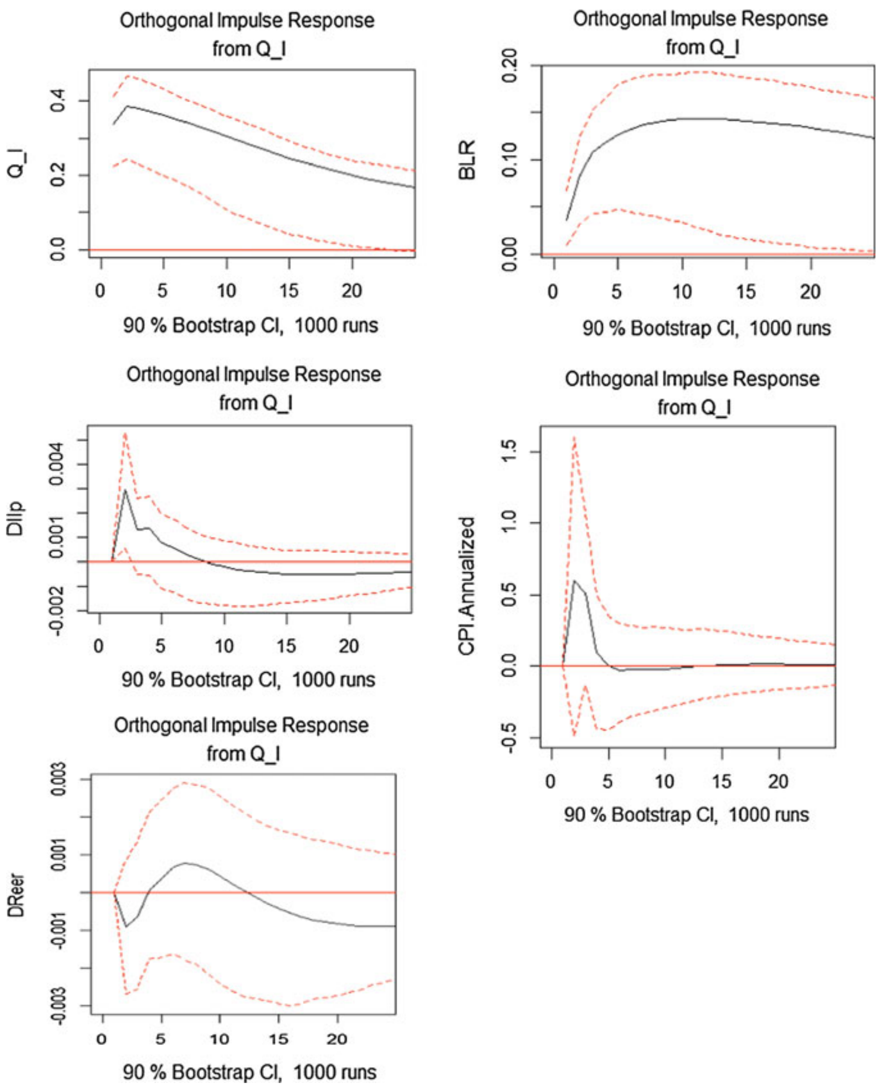

Fig. 21 Response to Cholesky one S.D. innovations ± 1 S.E: sum of CRR and SLR (Bank Lending Rate Ordered Last)

rates. The pass-through from the policy rate to bank lending rates is in the right (theoretically expected) direction, but the pass-through is incomplete. Our results provide no support for any effect of monetary policy shocks on aggregate demand as recorded either in the IIP gap or the inflation rate.

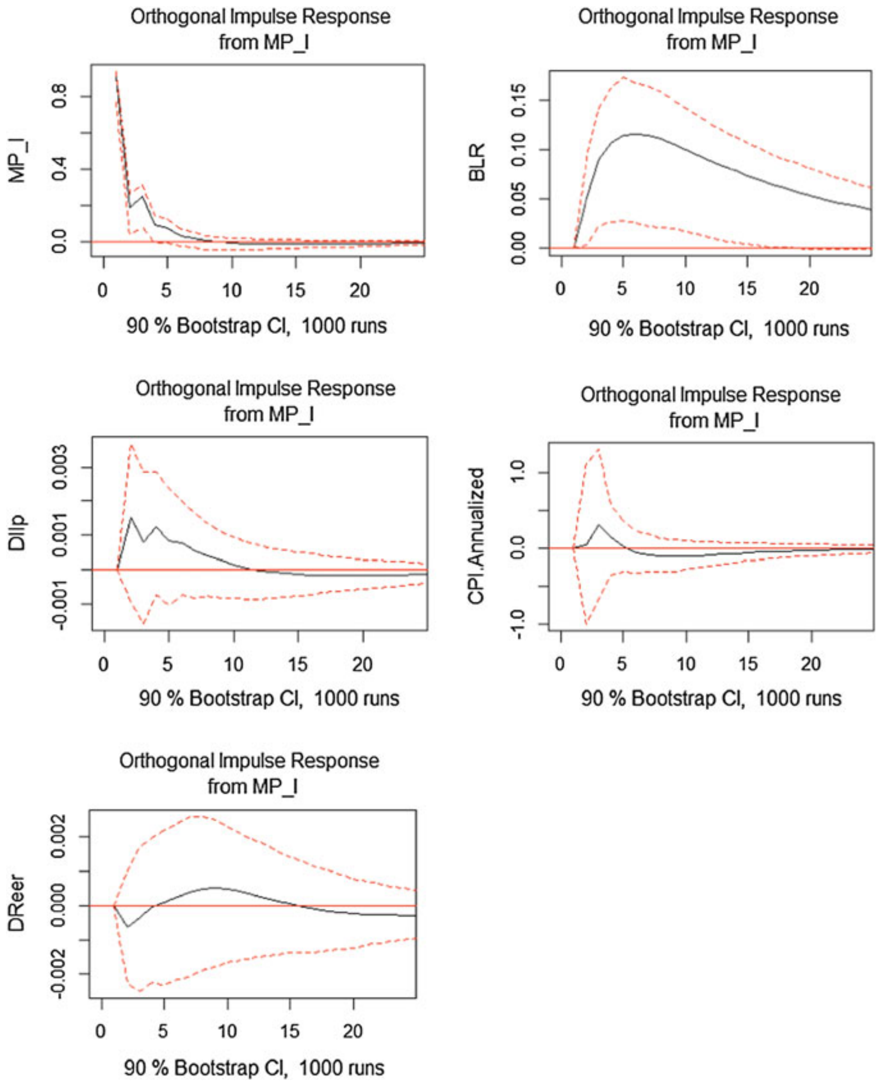

Fig. 22 Response to Cholesky one S.D. innovations ± 1 S.E: composite monetary policy stance (Bank Lending Rate Ordered Last)

6 Conclusions

This paper explores the bank lending channel of monetary transmission in the Indian context, using a structural VAR methodology that has commonly been applied to investigate monetary policy effectiveness not only in advanced and emerging economies, but also in many low-income ones. If we think of monetary transmission through the bank lending channel in two steps—from policy rates to bank lending rates and from bank lending rates to aggregate demand—there is some evidence that the first step is operative in India, unlike in many other developing countries (see Mishra et al. 2014). While pass-through from policy rates to bank lending rates is incomplete, there is some evidence that such pass-through exists. Our results, however, provide no support for the second step of monetary transmission, or any effect of monetary policy shocks on aggregate demand, as recorded either in the IIP gap or the inflation rate.[15]

A second channel of transmission that one might be expect to be important in India, given its floating exchange rate regime—the exchange rate channel—also does not receive much support from our results. The response of the exchange rate to monetary policy shocks is in right direction but the magnitude is very small. The implication is that any effects of monetary policy on aggregate demand in India are more likely to operate through the trade balance than through interest-sensitive components of aggregate of aggregate demand, but any such effects are likely to be weak. There are at least two possible reasons. One is that India remained characterized by a low degree of de facto capital mobility during the sample period, at least when compared to other emerging markets. This may explain a weak exchange rate response. A second possibility is that the RBI's intervention in the foreign exchange market has tended to mute the exchange rate response to monetary policy.

The question is how to interpret these results. As suggested by Égert and Macdonald (2009) (for the case of transition economies in central and Eastern Europe), it is likely to reflect some combination of the facts on the ground and shortcomings in the empirical methods that have been applied to this issue. For the reasons we indicated in the introduction, it is vitally important to determine the contributions of each of these factors. There is no doubt that shortcomings in both data and methodology are many. For example, IIP is only a partial indicator of overall economic activity. Importantly, the identification assumptions for the VAR are nontestable. Based on the descriptive evidence on the characteristics of the Indian economy that are likely to influence the effectiveness of monetary transmission, however, we suspect that "facts on the ground" may also be an important part of the story. For example, India's relatively low degree of financial integration, possibly abetted by RBI intervention in the foreign exchange market to smooth the rupee–dollar rate, would tend to make for a very weak, possibly nonexistent, exchange rate channel. On the other hand the small size of the formal financial sector in India would tend to undermine the effects on bank lending rates on aggregate demand. Since these are the two main channels through which, ex ante, we would expect monetary policy to affect aggregate demand in India, it may not be surprising that such effects are hard to detect in the data.

[15]Our results therefore do not provide a basis, for example, for assessing the optimal relative weights on inflation and the output gap in a monetary policy rule such as specified in (6) in the case of India.

Appendix: Brief Review of the Literature on Monetary Transmission in India

See (Figs. 19, 20, 21, and 22).

Paper details and time period	Method, variables used and related details	Results and summary
Das (2015) "Monetary Policy in India: Transmission to Bank Interest Rates" IMF WP End-March 2002 to end-October 2014 Each observation is a two week period	Bank Lending Channel, through lending and deposit rates Stepwise estimation of VECM models Estimates the pass-through from monetary policy changes to bank interest rates in two steps (i) from the monetary policy rate to the interbank market rate (that is the operating target of the framework) (ii) from the target rate to bank interest rates (deposit and lending rates) Daily data on interest rates and LAF transactions are averaged over 2 week periods, and the bank balance sheet data is available on a bi-weekly basis The monetary policy rates considered are the reverse repo rate and the repo rate Market interest rate targeted by the monetary policy framework is the weighted average call money rate and the two main bank interest rates considered are the rate on 3-month certificates of deposits and the prime lending rate (the average of five major banks) Although banks now price loans from the base rate, they still report PLRs. In practice, the prime lending rate and base rate of banks move together	Significant, albeit slow, pass-through of policy rate changes to bank interest rates in India. The extent of pass-through to the deposit rate is larger than that to the lending rate, and the deposit rate adjusts more quickly to changes in the policy rate Evidence of asymmetric adjustment to monetary policy: the lending rate adjusts more quickly to monetary tightening than to loosening. Deposit rates do not adjust upwards in response to monetary tightening, but do adjust downwards to loosening The speed of adjustment of both deposit and lending rates to changes in the policy rate has increased in recent years
Sen Gupta and Sengupta (2014) "Changes in Transmission Channels of Monetary Policy in India," Economic and Political Weekly	VAR Introduction of LAF as an operating procedure for monetary policy in the post-reform period is a landmark event for monetary	Finds a structural break in transmission corresponding to the introduction of LAF in 2000 Bank lending channel remains an important means of

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Paper details and time period	Method, variables used and related details	Results and summary
Monthly data April 1993 to March 2012	policy. This paper looks for a structural break in the post-reform period corresponding to the introduction of LAF in 2000 Assesses the changing importance of various transmission channels of monetary policy in the pre-LAF and post-LAF periods Divides sample into two periods—pre-LAF (before 2000) and post-LAF (post 2000) and sees whether the transmission has changed in the transition	transmission of monetary policy in India, but it has weakened in the post-LAF period The interest rate and asset price channels have become stronger and the exchange rate channel, although weak, shows a mild improvement in the post-LAF period
Khundrakpam and Jain (2012) "Monetary transmission mechanism in India: A Quarterly Model" RBI DEPR WP Quarterly data 1996–97Q1 to 2011–12Q2	Four channels of monetary transmission: interest rate channel, credit channel, asset price channel and exchange rate channel Structural VAR model with external vars as exogenous vars **Endogenous vars**: Real GDP growth, WPI inflation, Call money market rate (policy rate) in that order and then the channel specific variable **Exogenous vars**: OECD GDP and gross portfolio inflows **Transmission channel specific vars** Interest rate channel—CMR Credit channel—nonfood credit and total credit Asset price channel—BSE SENSEX Exchange rate channel—REER & NEER SVAR estimates in first difference (except interest rate variables), owing to presence of unit root (cointegration check not mentioned) Do not have confidence interval bands around IRFs	Two baseline estimates- with and without external vars **Interest rate channel—**Hike in policy rate leads to a decline in GDP growth on impact (magnitude: 0 to –0.0015) that dissipates slowly showing a V-shaped response whereas WPI inflation on impact goes up (0–0.0008), declines in about two quarters (to –0.0018) and its peak impact is felt with a lag of one quarter from the corresponding peak impact on GDP growth **Credit channel**—Shock to interest rate leads to decline in credit growth from 2nd quarter; GDP growth also declines on impact and negative impact on inflation (which goes up on impact) occurs one qrtr after the GDP decline **Asset price channel**—Equity price index goes up on impact and declines in second qrtr, GDP growth declines on impact and peaks in second quarter, and impact on inflation (goes up on impact) is more muted relative to other two channels **Exchange rate channel**—Immediate REER appreciation

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(continued)

Paper details and time period	Method, variables used and related details	Results and summary
		followed by depreciation; GDP response is very little and inflation shows a negative impact **Summary**: Inclusion of external variables prolongs the impact of MP shocks on GDP growth and inflation. Interest rate, asset price and credit channel are important while exchange rate channel is weak. Interest rate channel accounts for about half of the total impact of monetary shock to GDP growth and about one third of total impact on inflation, indicating it is the most important channel in India
Mohanty (2012) "Evidence on interest rate channel of monetary policy transmission in India," paper presented at the Second International Research Conference at the Reserve Bank of India Quarterly data (Paper not found)	Structural VAR Interest rate channel Studies policy rate changes through to their effects on output and inflation	Provides evidence that policy rate increases have a negative effect on output growth with a lag of two quarters and a moderating impact on inflation with a lag of three quarters, with both effects persisting for eight to ten quarters Results underline the importance of interest rate as a potent monetary policy tool
Khundrakpam (2011) "Credit channel of monetary transmission in India—how effective and long is the lag?" RBI DEPR WP Monthly data 2001:3 to 2011:3	Examines the operation of credit channel of monetary policy transmission in India through change in policy rate Two reduced-form equations, one with nominal bank credit as the dep. var. and the other with real bank credit, are estimated Estimates the regressions for the two models in first difference or growth form Monetary policy variable: Weighted call money rate (Because in India the effective policy rate had alternated between repo and reverse repo rate depending upon the deficit or surplus liquidity conditions) Other variables	Credit channel of monetary transmission is significant and robust in the post-LAF period The transmission of policy rate to nominal or real bank credit growth takes about 7 months over the full sample period as well as across various subsample periods Over the full sample period, 100 basis points increase in policy rate was found to reduce the annualized growth in nominal and real bank credit by 2.78 and 2.17 %, respectively However, a decline in the magnitude of the impact of policy interest rate on bank credit has been observed

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Paper details and time period	Method, variables used and related details	Results and summary
	IIP, WPI, NEER, REER Nominal bank credit: the total nonfood credit of scheduled commercial banks Real bank credit: real deposit and real money supply—the corresponding nominal series deflated by WPI. All variables in log	during the post global financial crisis period
Pandit and Vashisht (2011) "Monetary Policy and Credit Demand in India and Some EMEs" ICRIER WP Monthly data January 2001 to August 2010; (Not a good paper)	Examining the impact of changes in policy rates on lending rates and deposit rates of commercial banks Panel framework of seven EMEs including India Examined the transmission of policy rate viz., repo rate from the perspective of demand for bank credit in India. Monetary Policy Variable: Repo rate	Change in policy interest rate is an important determinant of firm's demand for bank credit (Not giving more details as this is more focused on a specific pass-through rather than complete transmission to real variables)
Singh (2011) "How Asymmetric is the Monetary Policy Transmission to Financial Markets in India" RBI Occasional Papers March 2001 to June 2012	VAR model Estimates pass-through from the policy rate to a variety of short and long-term market interest rates	Significant contemporaneous pass-through under deficit liquidity conditions from policy rates to call money rate as well as significant lagged effects There is also considerable asymmetry evident in the transmission of monetary policy to financial markets depending on the tight or easy cycles of monetary policy
Aleem (2010) "Transmission mechanism of monetary policy in India" Journal of Asian Economies; Quarterly seasonally adjusted data 1996Q4 to 2007Q4	Three channels of monetary transmission: bank lending channel, asset price channel and exchange rate channel VAR model to estimate dynamic responses of GDP, prices and interest rates to an unanticipated monetary policy tightening **Endogenous vars** Log GDP, Log WPI, Overnight call money market rate Channel specific vars Bank Lending channel—Prime lending rate, Bank loans (bank	**Results from Model 1** An increase in call money rate leads to a decline in GDP which bottoms out in third quarter and shows a V-shaped response. Prices also decline in response to a positive overnight call money rate shock and recovers after third quarter. Prices start declining after the fall in GDP (same as previous study). This effect disappears when exogenous variables are added. And monetary policy shock has temporary effects on the call

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(continued)

Paper details and time period	Method, variables used and related details	Results and summary
	credit to the commercial sector) Asset price channel—BSE's SENSEX-30 as an index of stock exchange Exchange rate channel—REER **Ordering Rationale**: They argue that RBI takes into account current stage of GDP and prices. Thus, overnight call money rate responds contemporaneously to shocks to GDP and prices. However, GDP and prices do not respond contemporaneously to overnight call money rate shocks. Likewise GDP, prices and overnight call money rate do not respond contemporaneously to a shock to the transmission channel specific variable but the reverse holds. So variables ordering –GDP –Prices –Interest rate –Channel specific var **Exogenous vars**: World commodity price index, Federal funds rate and US GDP Although some variables appear to be nonstationary, they estimate the VAR model in levels Model 1: First estimates benchmark VAR model with no channel specific variable Model 2: Then introduces latter at the end and Model 3: Then exogenizes latter using its lags as exogenous variables and compared (2) and (3) IRFs. (Mostly looking at GDP response) Do not have confidence interval bands around IRFs. They do these as robustness	money rate. Results from Model 2 **Bank Lending channel**—Prime lending rate responds immediately to a call money rate shock. A positive shock creates an initial increase in PLR to 0.24 %. After the second quarter, it converges toward the baseline. With bank loans, quantity of bank loans to the commercial sector decreases initially in response to a monetary policy tightening and then recovers after third quarter. Prices and GDP show a similar decline, bottoming out in third quarter **Asset price channel**—A monetary tightening creates a decline in GDP-bottoms out in fourth quarter, whereas prices initially fall and then pick up. **Exchange rate channel**: REER initially appreciates and shows a short-lived reaction to a positive overnight call money rate shock. GDP response is also very weak. Prices decline and show a V-shaped response. **Summary** Imposed restrictions on contemporaneous effects of endogenous variables to have an exact identification of benchmark VAR model 1. The results of the benchmark VAR model suggest that a monetary policy shock has transitory effects on call money rate. The price-puzzle vanished after inclusion of vector of exogenous foreign variables. Prices and GDP decline after a positive call money rate shock. Moreover, prices start declining after a decline in GDP 2. Results support the importance of bank lending

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Paper details and time period	Method, variables used and related details	Results and summary
	checks, estimating ±2S.E confidence intervals after blocking off each channel by exogenizing it	channel in transmission of monetary policy shocks to real sector 3. Neither asset price nor exchange rate channels are important. (Massive interventions by RBI in foreign exchange market to stabilize the exchange rate weaken the exchange rate channel) 4. Inclusion of foreign exogenous vars reveals that Indian monetary policy is constrained by US Fed's monetary policy. Hence, an analysis of Indian monetary policy requires inclusion of the federal funds rate in the information set of RBI 5. A proper comprehension of monetary transmission mechanism in India requires analysis not only of response of GDP, but also of response of exchange rate to monetary policy shock 6. Banks play an important role in financial intermediation in the Indian economy, and their strong representation reflects the lack of alternative sources of funding for the private sector
Bhattacharya et al. (2011) "Monetary Policy Transmission in an emerging market setting" IMF WP Monthly data 1997 to 2009	Unified treatment of exchange rate pass-through and the monetary policy transmission —assessment of the effectiveness of two alternative paths through which changes in the short rate impact upon the economy Structural VECM model **Ordering rationale** Assume that the exchange rate bears the first impact of external, exogenous shocks such as a change in foreign prices or interest rates. Any shock to the exchange rate contemporaneously affects all other variables, but other	Orthogonalized IRFs for 24 months with 95 % CI bands for both interest rate and exchange rate shocks Interest rate hike has no direct impact on output Exchange rate however appreciates on impact whereas WPI on impact goes up and then declines in 2–3 months bottoming out around month 6–7 Exchange rate shock associated with a rise in prices, no output response and a rise in interest rate **Summary**

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Paper details and time period	Method, variables used and related details	Results and summary
	variables do not affect it instantaneously This is followed by the interest rate affecting output and thereby the domestic demand and price but not the exchange rate. Similarly, the next variable, output, affects only the domestic price index contemporaneously while the domestic price index does not affect any variable instantaneously The exchange rate can also have an immediate effect on prices via import prices. Thus, domestic prices are ordered last in the model, which contemporaneously respond to all shocks in the system **Endogenous vars** IIP, WPI, NER, 91-day TBill rate **Exogenous vars** US PPI, 3-month TBill rate of US Fed All the variables, except the interest rate, are in logs. Interest rate is nonstationary and one cointegrating relation at 1 % significance level	Monetary policy transmission mechanism in India, an emerging economy, is weak Changes in interest rates do not affect aggregate demand implying the absence of inflation-output trade-off. Evidence of incomplete, but statistically significant, exchange rate pass though
Bhaumik et al. (2011) "Implications of bank ownership for the credit channel of monetary policy transmission: evidence from India" Bank level annual data; 2000 to 2007	Question looked at How bank ownership plays a role in the credit channel of monetary policy transmission; whether the reaction of different types of banks (i.e., private, state and foreign) to monetary policy changes is different in easy and tight policy regimes Estimates the change in loans in response to changes in PLR at the bank level Regression framework with dependent variable as bank loans and independent variable: Prime lending rate (lagged) Data on 58 banks	Bank lending channel to be working much more effectively in a tight money period than in an easy money period in India, i.e., banks decrease loan supply in response to increases in PLR in tight money periods Considerable differences in the reactions to monetary policy initiatives of various banks differentiated by ownership pattern These reactions are also influenced by the surplus or deficit liquidity conditions, with bank lending channel of monetary policy transmission being more effective under

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Paper details and time period	Method, variables used and related details	Results and summary
		deficit condition than under surplus condition. (Not giving much details since it is a different research design) Since the authors use the prime lending rate of banks themselves as the indicator of monetary policy, however, they implicitly assume complete and quick pass-through of changes in monetary policy to bank lending rates, thus missing a potential price response by banks to monetary policy and looking only for a quantity response
Mallick (2009) "Macroeconomic Shocks, Monetary Policy, and Implicit Exchange Rate Targeting in India," Quarterly, 1996:2 to 2009:1	Structural VAR	A contractionary monetary policy shock is associated with a statistically significant reduction in real output, but monetary policy shocks accounted for a small part of the forecast error variance in real output (Not giving details as not a conventional MP transmission paper)
Singh and Kalirajan (2007) "Monetary transmission in post-reform India: An evaluation" (Paper could not be accessed; found summary from lit review of other papers)		Highlights the significance of interest rate as the major policy variable for conducting monetary policy in post-reform India
Pandit et al. (2006) "Transmission of monetary policy and the bank lending channel: Analysis and evidence for India" RBI DRG Study Monthly data April 1993 to April 2002. (Poorly analyzed and written paper)	Bank Lending Channel (not clear how they incorporate this channel) Structural VAR Model. Panel data analysis of scheduled commercial banks (excluding regional rural banks and foreign banks)—46 banks in total afer data cleaning **Endogenous vars** log IIP, log WPI, log M3, CPR (Commercial Paper Rate) and the chosen policy instrument. Two policy instruments considered are CRR and change in Bank Rate (because their medium-term impact on	**Shock to CRR** With an increase in CRR, money supply (LM3) decreases, the market-determined interest rate (CPR) rises and increases for 5 months before the onset of a decline in its growth rate With a rise in CRR, the price variable initially increases in the first month but starts declining after the second month forming a hump-shaped figure As a result of increasing CRR, output (LIIP) declines **Shock to Bank Rate**

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Paper details and time period	Method, variables used and related details	Results and summary
	bank lending can be expected to be direct and fairly quick). Bank balance sheet data: Loans advanced by commercial banks, funds (defined as the aggregate of deposits and borrowings) with commercial banks and commercial banks' investments in government securities—all in logs	The money supply decreases and the price variable, after registering an initial drop, increases till the tenth month. There is inconsistency in the behavior of output and market-determined interest rate. IIP shows practically no effect They also see the effect of monetary tightening (using both CRR and bank rate) on log NEER, net FII inflows, FX reserves, Trade Balance, and BSE market cap A fall in CRR is accompanied by a rise in bank credit. There is a shift upwards in the economic activity parameter immediately given by log IIP **Summary** 1. On the basis of variance decompositions, there is not much difference as between CRR and bank rate as alternative policy instruments. However, on the basis of plausibility of relationships as given by the impulse response functions, CRR seems to perform relatively better *vis-à-vis* the Bank Rate 2. The response of advances to a change in the policy variable turns out to be significant at conventional levels, irrespective of whether the price variable (Bank Rate) or the quantity variable (CRR) is considered i.e., banks tend to cut back lending and adjust their funds in response to a policy action 3. Primarily the public sector banks are more reactive to the policy shocks
Al-Mashat (2003) "Monetary policy transmission in India: Selected issues and statistical appendix." IMF Country Report	Structural VECM Used the overnight call money rate to capture monetary policy stance in order to examine	Interest rate and exchange rate channels strengthen transmission of monetary policy while little evidence of working of bank lending

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Paper details and time period	Method, variables used and related details	Results and summary
Quarterly data 1980Q1 to 2002Q4 (Paper could not be accessed; found summary from lit review of other papers)	monetary transmission in the post-reform period	channel due to presence of directed lending to priority sectors The impact of a monetary policy shock on macroeconomic variables is larger after including the exchange rate in the model

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Financial Intermediation and Monetary Policy Transmission in EMEs: What has Changed Since the 2008 Crisis?

M.S. Mohanty and Kumar Rishabh

1 Introduction

The purpose of this chapter is to review what has changed to the monetary transmission mechanisms in emerging market economies (EMEs) since a similar review on this subject appeared in BIS (2008) and Mohanty and Turner (2008). A key finding then was that the introduction of inflation targeting by many EMEs in the 1990s, together with reforms to abolish interest rate controls, strengthen central bank credibility, and develop local bond markets, marked a major turning point for monetary policy in many countries. These reforms not only helped to reduce the earlier constraints on monetary policy stemming from a high degree of fiscal dominance and liability dollarization but also increased the role of interest rate and exchange rate in monetary policy transmission, leading to an environment of low and stable inflation.

However, the past decade has seen major changes to financial intermediation in EMEs, accompanied by rapid changes in external monetary environment following the global financial crisis in 2008. How have these developments affected the monetary transmission mechanisms in EMEs? Has the earlier assessment changed?

Views expressed in this paper are those of the authors and not necessarily the views of the Bank for International Settlements, University of Basel or the Reserve Bank of India.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_4

And how have central banks confronted many recent changes to the external environment? Our objective here is to explore some of these questions in a fairly selective manner, drawing on a large, though still developing, post-crisis literature on monetary policy in EMEs.

Understanding how central banks' instruments work has major implications for the stance of monetary policy. For the past several decades, this understanding has been greatly shaped by the New Keynesian literature, leading to what Clarida et al. (1999) call the "science of monetary policy." In this framework, the policy interest rate set by the central bank and its commitment to vary that rate consistently with its objectives play a critical role in determining the effects of monetary policy.

The precise channel through which monetary policy influences the economy has been a debatable issue. In typical transmission models, given assumptions of frictionless financial markets, perfect asset substitutability and rational expectations, the overnight rate set by the central bank determines the long-term interest rate, the exchange rate, and other asset prices which, in turn, determine the path of aggregate spending and inflation (Taylor 1995; Woodford 2003; Boivin et al. 2010). Term and risk premia—central to the analysis of imperfect asset substitutability by Tobin (1969) and Modigliani and Sutch (1967)—therefore play no role in the transmission mechanism. In addition, these models assume that size of the central bank balance sheets has no independent influence on aggregate demand so that bank reserves are provided perfectly elastically at the policy rate. Another assumption underlying these monetary transmission models is that in globally integrated economies, a central bank's ability to control interest rate is a function of the degree of exchange rate flexibility (the so-called trilemma doctrine). Hence, a fully floating exchange rate is able to insulate domestic monetary policy from external shocks (see Clarida et al. 2001; Gali and Monacelli 2005; Woodford 2009).

The New Keynesian models, particularly those incorporating features such as asymmetric information and credit market imperfections, appeared to describe fairly well the working of monetary policy before the 2008 financial crisis. For instance, the "financial accelerator" literature (e.g., Bernanke et al. 1999; Bernanke and Gertler 1995) highlighted the role of "external finance premium" in the transmission mechanism. A key point stressed by these papers was that the external finance premium paid by the borrowers varies with the interest rate, depending on the quality of their balance sheet. Because collateral is central to households and firms' ability to access credit, asset prices play a major role in the amplification of monetary shocks (see Kiyotaki and Moore 1997). In contrast, the "credit view" literature stressed the importance of lenders' capital and financing constraints which affect their ability to supply credit (Kashyap and Stein 2000; Bean et al. 2002). Given imperfect substitutability between reservable deposits and other liabilities, monetary policy generates credit supply effects because some banks are less able than others to replace deposit funding with outside finance.

However, the developments since the 2008 crisis have led to a major reassessment of the mainstream monetary transmission models. While integrating real-world financial frictions into monetary policy models continues to be a tough challenge for economists, recent research has pointed to, at least, four directions where the changes have been very significant. First, the crisis has demonstrated that central banks can use both quantity and price instruments simultaneously to achieve their goals. This has been most visible in the use of balance sheet policies by major advanced economy central banks to control monetary conditions after the short-term interest rate hit the zero lower bound. As Friedman and Kuttner (2011) note "the ability (of the central bank) to choose the level of the policy interest rate and the size of its balance sheets independently, over time horizons long enough to matter for macroeconomic purposes…represents a fundamental departure from decades of thinking about the scope of central bank action." In contrast to the efficient market models underlying the term structure hypothesis, there is now explicit recognition that term and risk premia play a crucial role in the determination of the cost of credit even in financially mature economies. The recent analysis by Gertler and Karadi (2013) has reinforced this view.

Second, in contrast to what the conventional monetary transmission models assumes, there is now increasing evidence that long-term interest rates are influenced more by global factors than local factors such as domestic business cycle or monetary policy (Obstfeld 2015; Turner 2014, 2015; Miyajima et al. 2015). While the tendency of the long-term interest rate to move together across economies is nothing new, what is special is that the correlation of bond yields has increased significantly after the 2008 financial crisis for emerging markets. Such a shift in bond market correlation assumes importance because it can reduce the role of the policy rate in the transmission mechanism and contribute to unwarranted fluctuations in credit, creating risks to monetary and financial stability.

Third, there has been a clear shift in the perception about the role of the exchange rate in the transmission mechanism. Not only have the responses of trade variables to exchange rate changes been smaller than assumed earlier, but exchange rates have also become far more volatile than can be predicated by measures of interest rate differentials. A further dimension has been that the growth of currency mismatches associated with the expansion of unhedged dollar borrowing by EMEs means that currency depreciation can be contractionary (Bruno and Shin 2014).

Finally, a key missing link in the earlier literature, as recently documented by Gertler and Kiyotaki (2011), was that it largely focused on the financing constraints on the nonfinancial borrowers and treated the financial intermediaries as a veil, thus ignoring the numerous agency problems and nonlinear asset price dynamics confronting the financial system. Indeed, as shown by Adrian and Shin (2010a, 2010b), capital and value-at-risk constraints facing financial intermediaries matter for their lending behavior. Because monetary policy affects asset prices and bank profitability, it can alter these constraints, causing shifts in credit supply. The interaction between the short-term interest rate, lenders' risk perception, and their attitude toward lending has been increasingly referred to as the "risk–taking channel" of monetary policy (Borio and Zhu 2012; Bakaert et al. 2013).

In what follows, in Sect. 2 we first start with a brief review of financial intermediation in EMEs to highlight the fact that many of the recent developments in the monetary transmission mechanisms can be traced to changes in the size and the nature of financing in EMEs as well as the external monetary environment facing them.

In Sect. 3, we discuss a few implications of these changes for the role of the interest rate, exchange rate, and credit channels in EMEs. One key finding of this section is that domestic monetary policy has to contend with increased globalization of debt markets and long-lasting shifts in global long-term interest rates and investor risk appetite that have the potential to make monetary conditions very volatile.

In Sect. 4, using a structural VAR model, we consider some empirical applications to India and note that the relative closed character of India's domestic bond markets has probably helped to limit the impact of external monetary shocks on the economy, particularly through the bond price and exchange rate channel. However, both equity price and credit channels continue to remain quite active.

In Sect. 5, we turn to a reduced from monetary transmission model to demonstrate a few policy challenges for the central bank when domestic bond markets are closely linked to the international bond markets. A key implication is that, with globalization of debt markets, the conduct of monetary policy through short-term interest rate has become a much more complicated affair, raising issues about the appropriate instruments for stabilizing inflation and output. In Sect. 6 we present conclusions.

2 Recent Changes in Financial Intermediation in EMEs

Historically, banks have been at the center of financial intermediation in EMEs. In addition, in the earlier decades, even though the financial systems of EMEs were open to international portfolio flows, the scale of these flows remained relatively limited in many cases, which meant that domestic interest rates were, to a large extent, tightly linked to the key monetary policy instruments of the central bank. Hence, monetary policy effects were largely determined by developments in the banking system. However, the environment in which monetary policy is conducted in EMEs has undergone major changes over the past decade. In this section we focus on three such changes: (a) the relative role of banks versus debt markets, (b) globalization of debt markets, and (c) the evolution of global long-term interest rates.

2.1 The Relative Role of Banks and Bond Markets

Table 1 shows total credit extended to the nonfinancial private sector in major emerging Asian economies as a percentage of GDP before and after the 2008 financial crisis as well as in mid-2000s. The data covers credit from all sources, including banks and bond markets from domestic and foreign sources. For comparison, the table also provides averages for other regions. As can be seen from the table, the ratio of total credit to GDP has increased rapidly in most countries

Table 1 Private sector credit and domestic bank lending in EMEs[a]

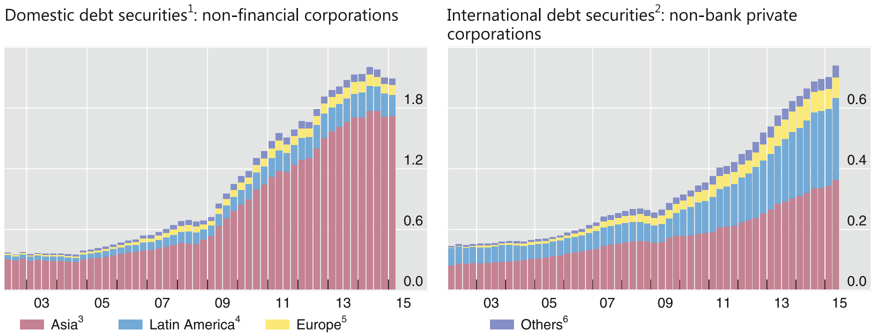
	Total credit to nonfinancial private sector (as a share of nominal GDP)[b]			Bank credit to nonfinancial private sector (as a share of total credit to nonfinancial private sector)		
	2004	2007	2013	2004	2007	2013
Emerging Asia	97	98	129	85	83	81
China	124	118	181	96	91	75
Hong Kong SAR	164	183	261	90	83	81
India	38	50	59	96	93	92
Indonesia	27	26	39	87	93	89
Korea	139	160	185	74	76	67
Malaysia	131	114	135	96	96	100
The Philippines	41	34	41			
Singapore	101	97	137	91	84	87
Thailand	109	97	127	97	98	97
Memo:						
Latin America[c]	*33*	*39*	*54*	*51*	*57*	*62*
Central and eastern Europe[d]	*62*	*79*	*96*	*49*	*56*	*53*
Other EMEs[e]	*49*	*62*	*62*	*82*	*85*	*89*

[a]For aggregates, simple average. [b]BIS calculations of total credit to private non–financial sector. [c]Argentina, Brazil, Chile, Colombia, Mexico and Peru. [d]The Czech Republic, Hungary and Poland. [e]Algeria, Israel, Russia, Saudi Arabia, South Africa, Turkey and United Arab Emirates
Sources IMF, *International Financial Statistics*; national data; BIS international banking statistics; BIS securities statistics

between 2004 and 2013. The trend started earlier but accelerated following the 2008 financial crisis.

It is important to note that credit has grown much faster in economies that are more open to capital flows and/or maintain some form of exchange rate link with currencies of major advanced economies than those that are less so financially open or have adopted a flexible exchange rate regime. This is particularly true in Hong Kong SAR, with its linked exchange rate system and highly open capital account as well as its role as an international financial centre, but also China even with its relatively closed capital markets. Notwithstanding their relatively independent monetary policy regimes, Korea, Malaysia, and Singapore have all seen rapid increases in their total credit to GDP ratios since the crisis.

Another fact emerging from Table 1 is that the share of credit from the banking system in total nonfinancial private credit has fallen in a number of countries. Even though banks continue to be important in credit allocation in EMEs, their role has declined over the past decade, especially in Asia. China is a major example where the share of bank credit in total credit has fallen by 21 percentage points between 2004 and 2013. Many other Asian economies have also seen significant declines in the share of bank credit.



[1] By residence. For the Czech Republic, Hong Kong SAR and Poland, calculated as the difference between total debt securities by residence and international debt securities by residence. [2] By residence. [3] For Asia, sum of China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. [4] For Latin America, sum of Argentina, Brazil, Chile, Colombia, Mexico and Peru. [5] For Europe, sum of the Czech Republic, Hungary, Poland, Russia and Turkey. [6] For others, sum of Israel, Saudi Arabia and South Africa.

Sources: BIS securities statistics; BIS calculations.

Graph. 1 Domestic and international debt securities. Amounts outstanding, in trillions of USD

A mirror image of the declining share of banks in credit is the growing importance of the bond market. Graph 1 shows two main dimensions of debt securities issuance by EME nonfinancial corporations—domestic and international issuance. There is evidence that financial intermediation through bond markets has increased, and a large part of that intermediation has moved offshore.[1] What is striking is that EME nonfinancial corporations have sharply increased their international debt issuance, which registered more than threefold growth between 2008 and 2013. Again, Asia seems to be leading the EMEs.

2.2 *Globalization of Debt Markets*

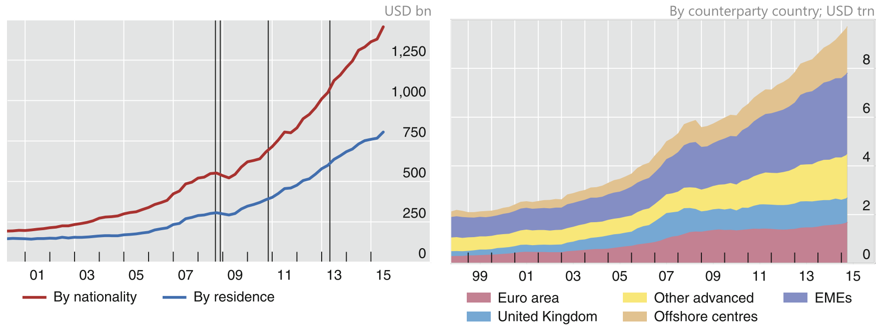
In addition to changes in the financing structure, the markets for debt securities have become increasingly global. There are several dimensions to the recent globalization of debt markets. They relate to the diminishing importance of national borders in the determination of capital flows, the use of currency in the denomination of debt transactions, and the structure of EME local currency debt markets.

In the traditional definition of capital flows, reported by the IMF, the concept of residency of the borrower plays a central role in the determination of economic area of a country and hence the magnitude of flows into and out of that country. However, as pointed out by Bruno and Shin (2014); Avdjiev et al. (2015), with capital flows straddling national borders, residency as a concept for measuring capital flows has become increasingly irrelevant. Take, for instance, a subsidiary of a Brazilian firm located in London issuing a dollar bond in London. This will not be

[1]See Hattori and Takats (2015) for a recent review on bond market financing in EMEs.

International debt securities issued by non-bank private corporations[1]

US dollar credit to non-banks outside the United States[2]



Vertical lines indicate bankruptcy of Lehman Brothers on 15 September 2008, Federal Reserve announcements of quantitative easing on 25 November 2008 and 3 November 2010 and FOMC hint on tapering on 1 May 2013.

[1] Amount outstanding of international debt securities issued by the non-bank private corporations in all maturities. Aggregate of Algeria, Argentina, Brazil, Chile, China, Colombia, the Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, the Philippines, Poland, Russia, Saudi Arabia, Singapore, South Africa, Thailand, Turkey, the United Arab Emirates and Venezuela. [2] For more information, see R. McCauley, P McGuire and V. Sushko, "Global dollar credit: links to US monetary policy and leverage", *BIS Working Papers No 483*, January 2015.

Sources: IMF, *IFS*; Datastream; BIS international debt statistics and locational banking statistics by residence; BIS calculations.

Graph. 2 Global debt markets and US dollar credit

reckoned as capital flow in the balance of payment statistics even though the funds may be ultimately used by the parent firm in Brazil. Avdjiev et al. (2014) discuss several channels through which the funds mobilized by the subsidiaries could appear as disguised capital flows. These funds could either be lent directly to the parent company as within-company loan or be extended as credit to another company in the same country or be simply parked as cross-border deposit in the domestic banking system.

The *red line* in left-hand panel of Graph 2 shows the scale of outstanding debt issuance by EMEs by nationality of borrowers. These numbers therefore capture international debt issuance by all nonfinancial corporations of a country residing anywhere in the world and are thus different from those based on the residency in Graph 1 (or shown by the *blue line* in Graph 2). On this definition, debt issuance by EMEs nonfinancial firms has not only grown rapidly since 2009, but they are now twice as large as those based on the residency of borrowers.

The second dimension of globalization of debt markets concerns the use of national currencies. An implicit assumption in the traditional monetary transmission models is that national balance sheets are denominated in national currency so that changes in monetary policy have implications for the flow of funds within the economy.[2] However, as the experience of widespread dollarization in the 1980s and 1990s demonstrated, the influence of national monetary policy is limited when a

[2]Avdjiev et al. (2015) point out that the traditional international finance is the outcome of a "triple coincidence." Besides its obsession with residency and currency, it places more emphasis on aggregate flows than on their sectoral composition.

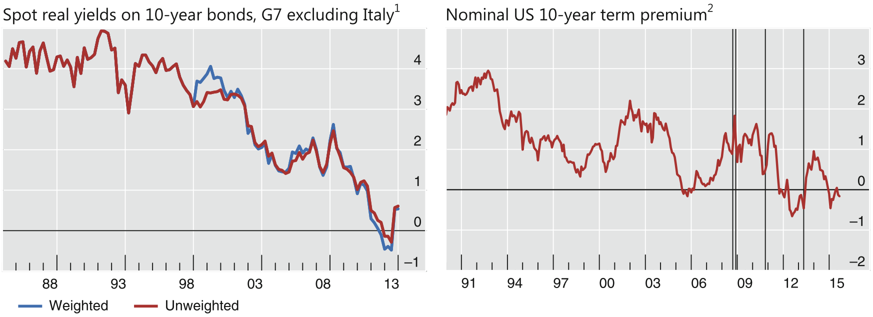
large part of domestic liabilities and assets are denominated in foreign currency (e.g., Kamin et al. 1998; Mohanty and Turner 2008).

While the degree of dollarization of the EME banking system has fallen considerably over the past decade that of the nonbank sector has increased. This is a global phenomenon but with a large EME component. McCauley et al. (2015) estimate the outstanding dollar debt of nonbank borrowers outside the United States. In other words, these are not dollar borrowing by US residents that are naturally affected by the dollar interest rate but by nonbank borrowers in the rest of world that have chosen to denominate their debt in dollar. As can be seen from the right-hand panel of Graph 2, total dollar credit outstanding against the nonbank, non-US borrowers expanded by more than fourfold between 2000 and 2015, from less than $2.2 trillion to $9.7 trillion. Dollar credit to EME non-bank borrowers has recorded the fastest increase, constituting the single largest component of total by 2015.

Reinforcing this trend is the third dimension of globalization of debt markets linked to internationalization of EME bond markets. During the 1980s and the 1990s, the EME local currency bond markets were not only underdeveloped but remained largely inaccessible to foreign investors. This, however, started to change in the beginning of the 2000s, as local bond markets started to develop in many EMEs and foreign investors preferred to invest in these markets, reducing barriers to international arbitrage. Estimates by the World Bank suggest that the share of nonresident holding of EME local currency bonds in total stock has more than doubled between 2008 and 2013 (from 13 % to 30 %). According to a BIS survey conducted in 2012, in a number of major EMEs these shares varied from 30 to 50 % (Mohanty 2014). Indeed, as argued by Shin and Turner (2015), growing nonresident investment in EME local currency bonds and the rapid expansion of international debt issuance by EME corporations represent two defining elements of the new financial landscape in EMEs.

2.3 Global Long-Term Interest Rates

Finally, another major factor shaping monetary conditions across the world has been the behavior of the global long-term interest rate. The left panel of Graph 3 plots King and Low's (2014) estimate of global real long-term interest rate which is an average of real 10-year spot yields of G7 economies (nominal yield minus expected inflation). The *red* and *blue lines* show the unweighted and GDP-weighted averages, respectively. Whereas the world real long-term interest rate was range bound during 1980s and early 1990s, it started to decline steadily in the beginning of the 2000s. The trend accelerated after the 2008 financial crisis, particularly following the introduction of large-scale asset purchase programs by the Federal Reserve and other advanced economy central banks. GDP-weighted real long-term interest rate tells a similar story, although data are available for a relatively short period.



Vertical lines indicate bankruptcy of Lehman Brothers on 15 September 2008, Federal Reserve announcements of quantitative easing on 25 November 2008 and 3 November 2010 and FOMC hint on tapering on 1 May 2013.

[1] Quarterly data calculated by M King and D Low in "Measuring the "World" Real Interest Rate", *NBER Working Paper*, no 19887. [2] Sum of inflation and real yield risk premia. These are calculated using the BIS term structure model.

Sources: BIS calculations. The left-hand panel was reproduced from "Measuring the "World" Real Interest Rate", *NBER Working Paper*, no 19887, February 2014, by M King and D Low.

Graph. 3 World real long-term interest rates. In per cent

Evidence reported in a recent report by the Executive Office of the President (2015) suggests that the US long-term yields tend to revert to a mean over time, but that reversion can be slow and not necessarily to a constant mean (Hamilton et al. 2015). Economic theory suggests that real interest rates are likely to be bounded because the underlying variables such as saving and investment respond to changes in interest rates—so bringing them back to their steady-state levels. However, the fact that the world real long-term interest rate has been declining over much of the past two decades confirms the hypothesis that the changes in either direction can be quite persistent. This can cause major shifts in resource allocation, international capital flows, and spending across countries.

To understand the sources of this variation, the right-hand panel of Graph 3 shows an estimate of US 10-year term premium taken from Hordahl and Tristani (2014). There are, of course, other components of the long-term interest rate, viz., market expectations of the short-term interest rate and inflation expectations, which are not reported here. The graph, nevertheless, shows that a significant part of the recent decline in the long-term interest rate reflected movements in the US term premium, which, after trending down during much of the past two decades, has fallen to very low or negative levels.[3]

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[3]Understanding the behavior of the long-term interest rate remains one of the most challenging issues in economics. There are several competing hypotheses offering alternative views about the underlying drivers of low long-term risk-free yields. Prominent among these are the "global saving glut" hypothesis by Bernanke (2005), the "global banking glut" hypothesis by Shin (2012), the "excess financial system elasticity" view by Borio and Disayatat (2011), and the "safe asset shortage" view by Caballero et al. (2008).

3 Monetary Transmission Mechanisms Post-2008 Crisis

How have these changes affected transmission of monetary policy in EMEs? In this section, we consider three main channels—the interest rate, the exchange rate, and the credit channel—to review the potential effects of recent changes in financial intermediation on the transmission mechanism.

3.1 The Interest Rate Channel

Interest rate often plays a key role in the transmission of monetary policy shocks. A rise in the policy rate by the central bank to dampen incipient inflation pressure leads to a rise in the short-term market interest rate and therefore most borrowing and lending rates in the economy. For this, the real interest rate is important: a rise in the nominal rate that reflects higher inflation expectations—so that real rate remains constant—will not change the perceived marginal costs of borrowing. Furthermore, since monetary policy operates most effectively by influencing the demand for durable goods, what matters is the extent to which changes in the policy rate affect funding costs for long-term projects. Following Mishkin (2007) and Boivin et al. (2010), this relationship can be formalized by a user cost of capital equation, which, in a closed economy, can be expressed as follows:

$$U_t^c = P_t^c[E\{\left(i_t^m - \pi_t\right) - (\pi_t^c - \pi_t)\} + \delta]$$

which can be equivalently written as

$$U_t^c = P_t^c[E\{i_t^m - \pi_t^c\} + \delta] \quad (1)$$

where P_t^c is the relative price of new capital, i_t^m is the domestic short-term interest rate, π_t is the inflation rate, π_t^c is asset price inflation, δ is the rate of depreciation, and E is the expectation operator. We are abstracting away from tax considerations, which nevertheless may be important sometimes, for example, when thinking of deductibility of the interest rate by adjusting the nominal interest rate by the marginal tax rate. The user cost equation shows that spending decisions of the agents depend on the expected real interest rate and real price appreciation of the asset over its entire life time. Assuming sticky prices, monetary policy affects demand for long-lived assets to the extent that it can change the expected future path of the real interest rate and the value of the asset. It is therefore obvious that the long-term interest rate plays a key role in the transmission mechanism of monetary policy.

Housing investment is a clear example of how the user cost channel works. A tighter monetary policy increases the cost of capital for the prospective home buyers both by increasing the long-term financing costs and weakening the expected future house price appreciation, causing a slowdown in the construction activity and aggregate demand. This direct effect is magnified by the fact that developments in the housing market affect the wealth position and creditworthiness of borrowers. For instance, in the United States, residential investment is found to be highly sensitive to the user cost of capital, even though the estimates of elasticity vary widely, from −0.2 to −1.0 (Mishkin 2007).[4]

The above user cost framework assumes that long-term interest rates and asset prices move in tandem with the expected future path of the short-term interest rate. However, to the extent that the term premium may move independently—as the events following the 2008 global financial crisis demonstrated—long-term funding costs can deviate substantially from the stance of monetary policy. In addition, Eq. 1 was written in the context of a closed economy, but, as the previous section highlighted, this assumption is increasingly unrealistic with the growing global integration of EMEs' debt markets.

One way to account for these factors is to bring them explicitly into the user cost equation. Let us denote the long-term sovereign bond yield in the domestic and international markets as LT^d and LT^{US}, respectively, and noting that international arbitrage implies that the expected rate of depreciation of exchange rate should be equal to the sum of yield differentials and currency risk premium $\boldsymbol{\rho}$, we have:

$$LT^d - LT^{us} = E[\Delta e] + \boldsymbol{\rho} \tag{2}$$

Decomposing the long-term yields into expected interest rate and term premium such that $LT^d = E\left[i_t^m\right] + q^d$ and $LT^{US} = E[i_t^{us}] + q^{us}$ and substituting in Eq. (1), we have:

$$U_t^c = P_t^c[E\{i_t^{us} + \Delta e - \boldsymbol{\pi}_t^c\} + (q^{us} - q^d) + \boldsymbol{\rho} + \boldsymbol{\delta}] \tag{3}$$

According to this equation, the user cost of capital in an open economy depends on three main elements: the first is the degree of correlation between the risk-free domestic and international yields, which could stem from the correlation of the excepted future EM short-term interest rates with the expected future fed funds rate (assuming that the US interest rate is the base rate for all EMEs). In a world with prefect capital mobility, the domestic risk-free long-term interest rate equals the US risk-free long-term interest rate, and monetary policy primarily works through the exchange rate. The second element is the degree of correlation between EME term and currency risk premia with the US term premium. Again, under perfect capital mobility, it is the US term premium that matters for the EME long-term interest rate, plus a country bond risk premium and a currency risk premium. The third element is the asset price change associated with capital flows, which also affects

[4]Leamer (2007) has argued that housing is special in some sense. Because house prices tend to be less flexible than other prices, changes in housing demand lead to smaller price movements but larger volume adjustments. This close association between housing and business cycles means that monetary policy can have a significant influence on economic activity through interest rates.

the user cost of capital. Note that Eq. (3) is an expression linking the cost of credit with the interest rate from the perspective of the borrower, and hence does not reflect the factors that may affect the supply of credit.

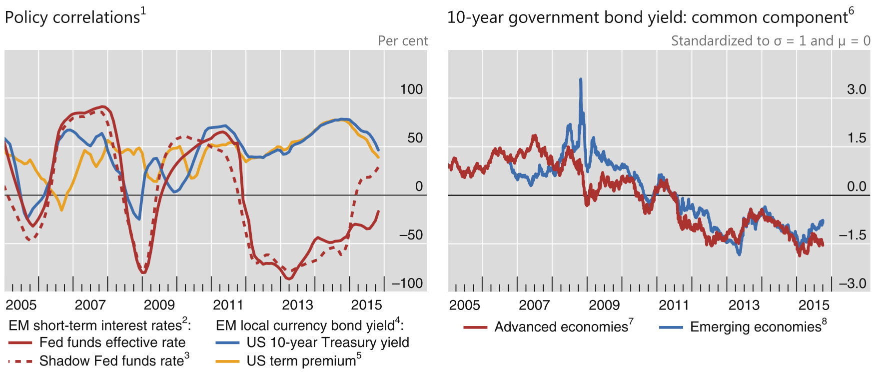
3.1.1 Correlation of Bond Yields

A key empirical issue is how domestic funding costs actually respond to a change in central bank's policy rate. To the extent that EME firms have unrestricted access to international debt markets, the pass-through of the policy rate to domestic borrowing costs could be reduced because the user cost of capital is likely to move closely with foreign interest rates. In this case the impact of domestic monetary policy depends on the degree of substitutability between domestic currency assets and dollar assets. Assuming limited exchange rate changes, a policy-induced rise in interest rate would prompt borrowers to switch to dollar debt and savers to domestic currency assets, leading to a partial loss of control of monetary conditions. At the same time, monetary authorities must consider the adverse implications of interest rate changes for the exchange rate and financial stability (see Rossini and Vegas 2008).

Ideally, the user cost of capital should not change if firms borrowing in dollars hedge their exposure to the expected future depreciation of the domestic currency against the dollar. In practice, however, such hedging is unlikely to be complete, and firms may be attracted to minimize funding costs in the short run by leaving a large part of their dollar borrowing unhedged.

In partially dollarized economies, much depends on how domestic yield curves behave in response to domestic and foreign interest rate shocks. As a first pass, in the left-hand panel of Graph 4 we report the coefficient of rolling correlation of EME interest rates with the US interest rate and US term premium. The correlations are computed using monthly data over a fixed window of 3 years for a group of major EMEs but excluding those that have a fixed exchange rate regime (e.g., Hong Kong SAR). The *solid red line* shows that the correlation of average EME policy rate with the fed funds rate has fluctuated over time, with a mean close to zero for the period shown. In the postcrisis period, this correlation has been actually negative. Because the fed funds rate has been close to zero since 2009, we recomputed the correlation using an estimate of the shadow fed funds rate, taken from Lombardi and Zhu (2014). As the *dotted red line* shows, the results are broadly similar, although the correlation has recently turned positive.

In contrast, as the *blue line* shows, with a few exceptions, the correlation of EME long-term interest rates with US long-term rate has not only been positive in the past decade, but it also increased steadily following the 2008 crisis. What is striking is that this correlation appears to stem mostly from the comovement of EME long-term rates with the US term premium (*yellow line*). The right-hand panel of Graph 4 throws further light on this by reporting the first principal component of EME and advanced economy long-term interest rates, this time including a larger pool of countries than just the United States. The common component of the two



[1] Coefficient of linear correlation calculated on a three year moving window. [2] Simple average of countries with flexible exchange rate regime: Algeria, Argentina, Brazil, Chile, China, Colombia, the Czech Republic, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, the Philippines, Poland, Russia, Singapore, South Africa, Thailand and Turkey. [3] Based on Lombardi and Zhu (2014). [4] JPMorgan Government Bond Index – Emerging Markets (GBI-EM), 7–10 years. [5] Decomposition of the 10-year nominal yield according to an estimated joint macroeconomic and term structure model; see P Hördahl and O Tristani, "Inflation risk premia in the euro area and the United States", *International Journal of Central Banking*, September 2014. Yields are expressed monthly in zero coupon terms. [6] The common component is the first principal component across each group of economies, and ignores country-specific factors. [7] Across the euro area, Japan, the United Kingdom and the United States. [8] Across Brazil, Chile, China, the Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, the Philippines, Poland, Singapore, South Africa and Thailand.

Sources: Bloomberg; Datastream; JPMorgan Chase; national data; BIS calculations.

Graph. 4 Correlation of interest rates

series moved in the opposite direction to each other before the crisis but started to comove very tightly after the crisis. It also broadly confirms King and Low (2014) estimates that the global long-term rate has declined to very low levels in the past decade.

Since interest rate levels are likely to be correlated because of several factors unrelated to monetary policy, a formal test must consider these correlations at first differences and allow for other determinants. A familiar test proposed by Sambaugh (2004); Klein and Sambaugh (2013) is as follows:

$$\Delta i_{jt} = \propto + \beta \Delta i_{bt} + \gamma' x_{jt} + u_{jt} \tag{4}$$

where i is either a short-term or long-term interest rate, the subscript "j" refers to home country and "b" to a base country, x is a vector of domestic variables determining the home interest rates, and u represents the difference in risk characteristic of home and base country assets. In a fully credible peg regime, the home country interest rate equals the base country interest rate; hence, $\beta = 1$ and $\gamma = 0$. Conversely, a fully independent monetary policy implies that $\beta = 0$ and $\gamma = 1$. For any intermediate values of β and γ the pass-through of the base country interest rate to home country rate will be partial.

Recent studies investigating Eq. (4) have generally converged to the conclusion that β is significantly positive for long-term interest rates but insignificant or only weakly positive for the short-term interest rates[5]. Miyajima et al. (2015), using data for a panel of 11 well-developed EME local currency bond markets, found that the response of EME 10-year bond yields to US 10 Treasury yields increased sharply to 53 basis points (due to 100 basis points increase in US treasury yield) after the 2008 crisis from 31 basis points for the entire sample starting January 2000. During periods of adverse market dynamics (such as the May–June 2013 "taper tantrum"), this response rises to slightly over 100 basis points. Using quarterly data for the most recent periods and a larger set of EMEs, Sobrun and Turner (2015) report similar results: whereas EME bond yields were weakly correlated with US yields during 2000–2004 that response became strong and statistically significant after 2005.

A litmus test for many studies is how to control for the unobserved common shocks that could lead to spurious correlations of interest rates. Obstfeld (2015) addresses this issue by considering different base country rates for different countries (such as the dollar interest rate for Mexico, the euro interest rate for Poland, and so on) so as to minimize the common time effects in the panel regression. His results suggest that while the coefficient of the short interest rate in Eq. (4) is small and insignificant, that of the long-term yields is highly significant at 1 % level. Even after changing the base country rates, the response of EME long-term rates to advanced economy long-term rates continues to be 40–50 basis points.

Kharroubi and Zampolli (2015) use a cross-section mean group estimator, as suggested by Pesaran (2006), to control for unobserved common shocks. Their results suggest that short-term interest rates in the flexible exchange rate regimes neither respond to the base country interest rate nor to global risk cycles. However, they find statistically significant effect for the domestic long-term interest rates, which rises by 60 basis points in response to 100 basis points rise in the base country long-term rates. In addition, their estimates suggest that the response of domestic long-term interest rates to domestic short-term rates is relatively small (around 20 basis points in both the pre- and post-crisis period).

In sum the evidence is quite solid that long-term interest rates of EMEs have been highly correlated with global long-term rates, consistent with our open economy user cost of capital framework. In addition, some studies have shown that this correlation could be due more to the US term premium than market expectations of the US short-term interest rate (Miyajima et al. 2014). A shock to the US term premium is qualitatively different because it has the potential to generate more severe repricing of EME assets.[6]

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[5]See, for instance, Turner (2015), Obstfled (2015), Kahrroubi and Zampolli (2015). For detailed country-wise estimates of response of EME bond yields to US bond yields, see Takats and Vela (2014) and BIS (2014).

[6]Using the post-2008 crisis data, Miyajima et al. (2014) report that 100-basis points rise in the US 10-year term premium is associated with 60 basis points increase in the Asian long-term interest rates following 2 months of the shock. Moreover, the effect of a term premium shock is twice as large as that from a shock to the US long-term interest rate.

3.1.2 Pass-Through to Bank Lending Rates

Is the interest rate channel still relevant? The answer depends, of course, on the structure of the financial system of a country. While the ratio of bond financing in total credit has increased across EMEs, there is significant difference across countries. Yet, a high degree of bank financing does not necessarily insulate domestic monetary policy from external shocks because banks are both issuers and investors in the bond market and compete with the bond market for their clients.

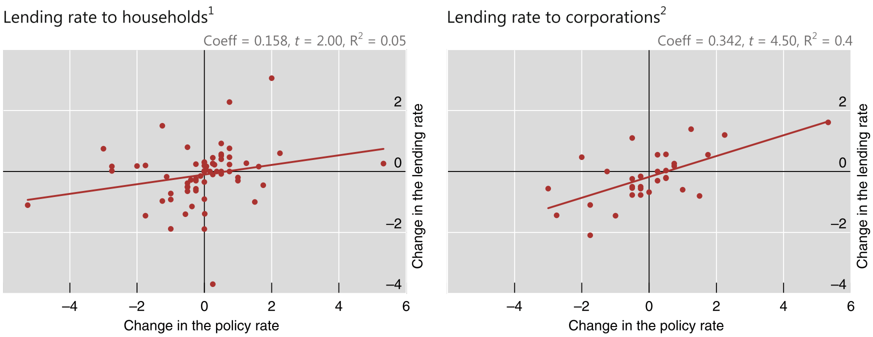
The degree of response of bank lending rates to the central bank policy rate will be conditioned by several factors. The first is the degree of competition within the banking system as well as with the bond market. In general, the higher is the degree of competition among banks in the loan market, the lower the probability that the bank intermediation spreads would fluctuate to offset the impact of policy rate change.[7] Introduction of more players in the credit market through bond markets can reduce the oligopolistic structure of the banking system, leading to stronger transmission of monetary policy to the banking system. On the other hand, the greater importance of capital markets in financial intermediation may accentuate information asymmetry problems between borrowers and lenders, leading to higher risk premia and a weaker monetary transmission mechanism, more generally.

A second factor is the funding structure of the banking system. Bank lending rates reflect expected short-term rates over the full maturity of loan, so include a maturity risk premium that can vary with the health of banks' balance sheets. In addition, banks have a more varied liability structure than just reservable deposits which suggests that their average funding costs may change only slowly in response to a change in the central bank policy rate.[8] This factor assumes particular importance, given that banks in many EMEs have accessed non-deposit funding sources, including the bond market, to finance a significant part of their asset growth. A recent BIS survey indicated that average contribution of non-deposit liabilities in total bank liabilities in a group of 20 EMEs was about 28 % during 2004–2013 (Ehlers and Villar 2015). In countries where financial markets are more developed (e.g., Hong Kong SAR, Korea, and Mexico) such non-core liabilities accounted for a much larger share of total bank liabilities.

A third factor is the nature of deposit and loan contracts. A high share of short-term liabilities in the total bank liabilities and short-term loans in total bank assets increases the pass-through of a given change in the policy rate to average funding costs of banks and, ultimately, to those of their borrowers. That said, the reliance on short-term liabilities also makes banks more vulnerable to shocks to

[7]On the role of structural factors in the transmission of monetary policy to bank lending rates, see, Cottarelli and Kourelis (1994), BIS (1995), Borio and Fritz (1995).

[8]See Berlin and Mester (1999) and Illes, Lombardi and Mizen (2015) for a formal loan pricing model.



[1] China, Hong Kong SAR, India, Indonesia, Korea, Malaysia and Singapore. [2] India, Indonesia and Korea.

Sources: Datastream; national data.

Graph. 5 Lending rates and policy rates. Annual changes, in percentage points

money markets and capital flows, reducing their ability to transform maturity and sustain credit supply. This implies that banks in countries with an underdeveloped bond market are likely to face a trade-off while optimizing their asset and liability structure to minimize funding and interest rate risks.

This factor is likely to be particularly important in EMEs where contractual maturity of bank liabilities tends to be quite short, with a median of just about 4 months for a group of 11 economies at the end of 2013 (Ehlers and Villar 2015). In addition, a high proportion of bank deposits in EMEs bears variable rates contracts (50–70 %), which means that deposit rates in many cases are effectively indexed to the policy rate. Although information is more limited for bank lending contracts, the picture is somewhat different across regions. For instance, while variable residential mortgage contracts accounted for 70–99 % of total residential mortgages in Asia in 2013, fixed rate contracts dominated mortgage markets in Latin America, with a ratio close to 100 % in Brazil and 70–96 % in Argentina, Chile, Colombia, and Mexico.

A rough indication of how bank lending rates behave in response to policy rate changes is given by the scatter plots in Graph 5 summarizing data for seven Asian economies over the past decade. The preference for four-quarter change to single-quarter change in interest rate was guided by the consideration that bank lending rates exhibit short-run stickiness due to the existence of fixed adjustment costs. The positive slope of the trend line in Graph 5 suggests that the response of the lending rate to monetary policy is quite different from that of the long-term bond yield. That being said, the average response of the household lending rate (16 basis points) is just about half of the response of the business lending rate (34 basis points). In addition, the explanatory power of regression is not very high for household lending rates.

A similar exercise exploring the relationship between bank lending rate and the US long-term rates did not yield meaningful results.[9] While more systematic analysis is needed to reach reasonable conclusions, these preliminary evidences nevertheless suggest that the interest rate channel of monetary policy may not have been completely eroded by the recent rapid growth of dollar borrowing by EME firms.

3.2 The Exchange Rate Channel

Another important transmission channel is the exchange rate which mainly operates in economies with a flexible exchange rate. As interest rate falls due to expansionary monetary policy, domestic interest-bearing assets become relatively less attractive, triggering capital outflows, and exchange rate depreciation. However, currency depreciation may have several opposing impacts and the net effect on output may turn out to be either positive or negative. While depreciation may boost exports and hence overall aggregate demand, on the one hand, it may also mean erosion in net worth for the borrowers with foreign currency debt and thus a decline in aggregate spending, on the other. A depreciating currency can also lead to higher inflation depending on the degree of pass-through of import prices into domestic prices.

A good example of how the exchange rate channel works is Singapore—an open economy par excellence. Given a high import content of domestic consumption (around 40 %), the exchange rate has a direct impact on domestic inflation (Loh 2014). And, since exchange rate has predictable effects on the demand for exports and factor inputs, it also has an indirect effect on inflation. In addition, the country has a large net international investment position vis-à-vis the rest of the world, and the daily exchange rate movement of the Singapore dollar is managed by the Monetary Authority of Singapore. With trade effects reinforcing balance sheet effects—currency depreciation improving rather than worsening net wealth position—the exchange rate plays an important counter-cyclical role in the economy.

However, in economies with significant currency mismatches, the role of the exchange rate can be very different. For instance, consider the following aggregate demand equation:

[9] The results from a panel regression for the household lending rate (HLR) and corporate lending rate (CLR) including both the policy rate (POL) and US-10 Treasury yields (US 10) are the following:

$$\begin{array}{l} \mathrm{HLR} = -0.132 + 0.160\ \mathrm{POL} - 0.161\ \mathrm{US10} \quad R^2 = 0.09 \\ \qquad (1.247) \quad (2.042) \qquad (-1.515) \\ \mathrm{CLR} = -0.233 + 0.315\ \mathrm{POL} - 0.277\ \mathrm{US10} \quad R^2 = 0.51 \\ \qquad (-2.158) \quad (4.490) \qquad (-2.575). \end{array}$$

$$y_t - y^* = \gamma(y_{t-1} - y^*) - \beta(r_t - r^*) - \lambda \Delta e_t + \epsilon_t \tag{5}$$

where y is the actual output, y^* is the potential output, r is the real interest rate, r^* is a normal or equilibrium real interest rate, e is the real exchange rate, and ϵ is a disturbance term. Output gap in this model is negatively related to the real interest rate gap as well as the exchange rate. A negative coefficient on λ assumes that currency depreciation is associated with improved trade balances and easier financing conditions. In practice, however, λ could take any plausible value depending on the structure of the economy. One form of contractionary devaluation, highlighted by the early literature, is exchange rate-induced rise in import costs, which turns λ positive, particularly in economies heavily dependent on commodity imports (Frankel 2011). It is also possible that exchange rate elasticities are considerably small in economies that rely heavily on imported inputs for export production. The second type of contractionary devaluation that received much attention during the 1990s EME currency crises is the case of liability dollarization where currency depreciation is associated with widespread deterioration of balance sheets of borrowers, causing tighter financing conditions.[10]

Eichengreen (2002) points out that the impact of the exchange rate in economies with large currency mismatches is likely to be nonlinear—while small currency depreciations are likely to satisfy the conditions for λ being negative, large depreciations can cause severe financial distress because "they confront banks and firms with asset prices for which they are unprepared, while doing little to enhance competitiveness effects because of the speed with which they are passed through into inflation."

However, scepticisms about the role of the exchange rate changed considerably in the aftermath of the 1994–1995 Mexican crisis and the 1997–1998 Asian financial crises, which not only heralded a new era of independent monetary policy in EMEs—led in many cases by the introduction of inflation targeting—but led to concerted efforts by the EM authorities to reduce the degree of currency mismatches (see BIS 2008). At the same time, a significant reduction in the degree of exchange rate pass-through into inflation meant that the exchange rate improved the growth and inflation trade-off facing the central bank.

3.2.1 Post-Crisis Changes

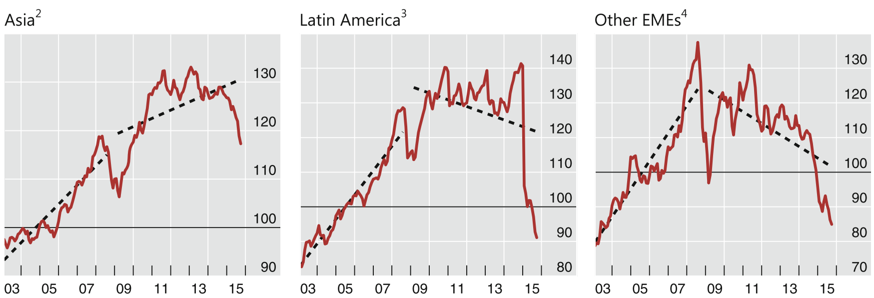
Since 2010, however currency mismatches in many EMEs have increased notably because of a substantial increase in foreign currency borrowing by emerging market non-financial companies (Chui et al. 2016). The exchange rate therefore has come back to the center of monetary policy debate post-2008 crisis. As shown in Graph 6,

[10] For evidence on contractionary balance sheet devaluation, see Cavallo et al. (2004), Bebczuk et al. (2006). For the analytical literature on balance sheet effects of the exchange rate, see Caballero and Krishnamurthy (2002), Cespedes et al. (2004), Chang and Velasco (2000).

real exchange rates have exhibited protracted cycles with upswings of currency appreciation followed by downswings of depreciation. Latin America is a case in point. While average real exchange rate in the region at end-October 2015 has been roughly at its level in 2005, the intervening period has seen rapid movements on both the strong and weak sides. In Brazil, exchange rate cycles have been associated with large changes in the financial and economic conditions. A similar, though less protracted, trend in the real exchange rate has been visible in several parts of Asia (e.g., India and Indonesia) and central and eastern Europe (e.g., Turkey and Hungary).

A key contributing factor has been the behavior of commodity prices (BIS 2014). In many oil-exporting countries, exchange rate swings have been associated with protracted shifts in the terms of trade. At the same time, the correlation between EM exchange rates with indicators of global risk aversion (such as the VIX) increased considerably in the aftermath of the 2008 global crisis (see, Rajan 2014); Miranda-Agrippino and Rey (2013) and Rey (2013) have argued that shifts in global investors' risk appetite have led to an unusual convergence of exchange rate and asset price cycles across the globe.

One effect of such currency movements in the face of large accumulated foreign currency debt has been that the EME credit cycles now tend to comove more closely with the dollar exchange rate. Bruno and Shin (2014) have used the expression "the risk taking channel of the currency appreciation." In Bruno and Shin model, global banks play a key role in the transmission of external shocks because they channel liquidity from the US money market to the local EME banking system. Since dollar depreciation improves balance sheets of bank borrowers with dollar debt, it reduces the effective credit risk facing banks, leading to expansion of lending. Conversely, the periods of large dollar appreciations are followed by contractions in global banks' balance sheets and widespread dollar shortages. In terms of Eq. (5), this means that the value of λ is just not a static function of the degree of currency mismatches but varies depending on the force of the amplification mechanism at work.



Dashed-black lines represent trends for the periods January 2003 to July 2008 and February 2009 to June 2015, respectively.

[1] Real exchange rate vis-à-vis the USD, deflated by CPI. Simple average of real exchange rate indices (2005 = 100) of the region. An increase denotes an appreciation. [2] China, Hong Kong, India Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand. [3] Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela. [4] Czech Republic, Hungary, Poland, Russia, South Africa, Turkey.
Source: National data.

Graph. 6 Real exchange rate in emerging markets[1]

There is also increasing evidence that the exchange rate can affect financing conditions even without such financial imbalances. One such mechanism is the amplification of market volatility stemming from growing interaction between the foreign exchange market and the bond market that can, at times, be triggered by speculative investor positioning and pro-cyclical investment strategy pursued by some investors such as professional asset managers (Feroli et al. 2014). Turner (2012) shows that the hedged and unhedged returns on EM local currency bonds have consistently diverged, suggesting that the exchange rate played a crucial role in the bond market dynamics. The failure of the uncovered interest parity means that foreign investors have affected the risk premium, causing large fluctuations in domestic monetary conditions.[11] When the exchange rate appreciates investors may take speculative carry positions in bond markets to gain from the expected future appreciation, which drives down EM risk premium and bond yields to very low levels. During the periods of market stress, however, as currency depreciates and uncertainty about the future exchange rate rises, foreign investors rush to exit, causing higher bond yields and tighter financing conditions.[12]

Such currency carry trades may not be restricted only to nonresident investors. EME residents could also make use of dollar debt issuance to undertake similar investment strategies, leading to volatile capital and credit flows. For instance, a recent study has found that nonfinancial companies had used US dollar bond issuance to take on financial exposure that shared attributes of dollar carry trades (Bruno and Shin 2015). The proceeds of such bond issuance were invested in high-yielding bank deposits as well as in shadow banking products and commercial papers.

3.3 The Credit Channel

The credit channel of monetary policy operates through the balance sheets of the lenders and the borrowers, depending on the degree of financial imperfections in an economy.[13] A key question raised by the 2008 crisis, in the light of the recent rapid increase in bank leverage in many advanced economies, is the extent to which the behavior of financial intermediaries can contribute to magnifying monetary policy effects on credit supply. Gertler and Kiyotaki (2011) introduce financing constraints facing banks into the original financial accelerator models proposed by Bernanke et al. (1999). To the extent that banks' own balance sheet conditions constrain their

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[11]See also Chinn and Frankel (1994), Longstaff et al. (2011), Gonzalez-Rodzada and Levy-Yeyati (2008), Du and Schreger (2013), Miyajima et al. (2014) on the role of risk premium in EME debt markets.

[12]Gadanecz et al. (2014) estimate a bond yield model for EMEs allowing for a currency risk premium proxied by the 3-month implied exchange rate volatility from options price. Their results suggest that a one percentage point increase in the implied exchange rate volatility is associated with five basis points increase in EME local currency bond yields over 2005–2013.

[13]See Brunnermeier et al. (2012) for a review on the role of financial frictions in macroeconomics.

ability to access deposit funding and they are vulnerable to idiosyncratic liquidity shocks, dysfunction in either market leads to jumps in the external finance premium, as experienced by many countries during the 2008 financial crisis.

An important aspect of credit channel that has received much attention post-2008 crisis is the link between monetary policy and risk taking by financial intermediaries. Adrian and Shin (2010b) consider the behavior of financial intermediaries that typically mark a significant part of their assets to market (shadow banks such as interdealed broker or banks that invest heavily on securitized products). In their model, individual bank managers face value at a risk limit and are risk neutral. An easier monetary policy, boosting asset prices and profitability, reduces banks' capital, and value-at-risk constraints, encouraging them to take on more risk. In the equilibrium, the market price of risk becomes endogenous, amplifying the impact of monetary policy on credit.

Acharya and Naqvi (2012) discuss a similar risk taking channel where the incentive structure facing bank mangers rather than financing constraints of banks plays a key role in the propagation of credit and asset price cycles. Since bank managers' compensations are linked to the volume of loans, excessive liquidity is associated with systematic mispricing of downside risk, causing credit, and asset price bubbles. Nicolo et al. (2010) discuss several other mechanisms that may be at work in strengthening the link between monetary policy and risk taking by financial intermediaries.

Given a high degree of imperfection in their financial systems, the credit channel may be of particular relevance to the EMEs. Several recent studies based on the pre-crisis EME data suggest that monetary policy has a stronger effect on the banking systems that are less well-capitalized and competitive than others,[14] and monetary policy may have particularly large effect on smaller banks whose access to outside finance may be very limited. Agenor and Montiel (2008) discuss monetary policy effects in economies where weak lenders' protection right and high default probability cause banks to over-collateralise loans. Under such conditions, an easy monetary policy lowers lending constraints of large firms but squeezes small and marginal borrowers who have little to gain from higher asset values. A segmented credit market with a large informal sector thus makes EMEs simultaneously vulnerable to pro-cyclical credit market dynamics and active credit rationing. Agenor and Pereira de Silva (2013) cite the example of Brazil where bank lending spreads have been inversely correlated with fluctuations in economic activity, providing evidence on the pro-cyclical credit dynamics.

While it is difficult to determine the precise effects of the changes in financial intermediation on credit supply in EMEs, recent research does seem to provide useful guides. One key finding emerging from this literature is that globalization of banking may weaken the link between domestic monetary policy and credit

[14]For a recent review on credit channel, see Beck et al. (2014). For evidence in the context of EMEs, see Khwaja and Mian (2008), Firth et al. (2009), Olivero, Li and Jeon (2011), Kohlscheen and Miyajima (2015).

variables (Cettorelli and Goldberg 2012). Because global banks use their own internal capital market to channel funds across borders, they could potentially offset the impact of changes in domestic interest rates on credit variables. This also implies that EME credit conditions may become more vulnerable, particularly, to US monetary policy shocks. The results reported by Cettorelli and Goldberg (2012) suggest that a 100-basis point increase in the fed funds rate reduces foreign lending of US large commercial banks by as much as 2.2 %, implying a significant contractionary effect on EMEs.

Second, the expansion of dollar debt in EMEs implies that their domestic credit conditions are now very closely connected to the availability of dollar liquidity. This was, for instance, vividly demonstrated following the collapse of Lehman Brothers in 2008, which spread shock waves across the globe, causing large-scale dollar shortages and huge deleveraging pressures on EMEs (McGuire and von Peter 2009). As the shock transmitted to the FX swap markets, the cost of dollar funding escalated to very high levels, precipitating a broadly based tightening of credit conditions across EMEs.[15] More generally, as argued by Borio et al. (2011), the sharp rise in dollar liabilities of EMEs over the past decade has meant that EME credit cycles have become more synchronized with the cycles in cross-border financing. In typical boom periods, cross-border credit tends to grow faster than growth in overall credit, with banks resorting to wholesale dollar funding markets to finance new asset growth.[16] The process reverses itself with higher US interest rates, leading to large-scale unwinding of dollar borrowings and widespread credit slowdown in EMEs.[17]

Finally, to the extent that risk taking activities dominate, the credit channel is likely to become an important financial stability concern for many EMEs. Unfortunately, compared to the voluminous literature that exist on the bank lending channel, there is very little empirical work on the risk taking channel in EMEs, owing largely to the lack of detailed historical data on individual lenders and borrowers. That said, evidence based on aggregate credit data provides some useful guidance. For instance, using a cross-country panel model, Kohlscheen and Rungcharoenkitkul (2015) found that external factors such as the US dollar exchange rate and the implied US stock market volatility (VIX) have become more significant drivers of credit growth in EMEs after the 2008 crisis than they were before the crisis. Consistent with the risk taking channel of the exchange rate, their results suggest that a 10 % appreciation of EM currencies against the dollar is associated with about 85 basis points increase in credit growth in EMEs in the short run and 135 basis points increase in the long run.

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[15]See Baba and Packer (2009).

[16]See Avdejiv and Takats (2014) for further evidence on the role of cross-border credit in bank lending to EMEs.

[17]See McCaully et al. (2015) who note that since 2009 this role has been taken over by the international bond market following sharp decline in US term premia. Shin (2014) has termed the recent growth of international bond issuance as “the second phase of liquidity,” the first being rapid expansion of cross-border bank lending following policy rate cuts by advanced economies in 2008.

4 Monetary Policy Transmission in India: An Empirical Assessment

In this section, we try to find out which of the channels of monetary policy are important in India. In addition to the three specific channels discussed in the previous section, we would also consider the asset price channel operating through equity prices. There have been some studies already examining the monetary policy transmission in India. For example, Al-Mashat (2003), using a quarterly structural vector error correction model (VECM) for the period of 1980–2002, found that interest rate and exchange rate channels were important, while due to the presence of directed lending regulations, evidence on the working of bank lending channel was weak. However, Pandit et al. (2006) found the existence of bank lending channel with small banks being more responsive to a policy shock. Singh and Kalirajan (2007) contended that the significance of policy interest rate substantially increased in India in the post 1990s reform period.[18]

In our analysis, we also try to answer the question whether US-specific shocks have an impact on Indian monetary conditions. That is, in addition to testing for the traditional channels of transmission we check whether US shocks directly transmit to India's long-term bond yields and whether such shocks are met with policy reaction by the central bank, much similar to the enquiry by Miyajima et al. (2014).

4.1 Data and Methodology

We use a structural vector autoregressive (SVAR) framework and examine one channel at a time, like Khundrakpam and Jain (2012), keeping in mind that only a limited number of variables should be considered in order not to lose too many degrees of freedom. Therefore, we first estimate a baseline SVAR model and then augment the model by other channels. A way in which we differ with the previous studies on India is by taking US monetary policy shocks explicitly into consideration.

All data are quarterly, seasonally adjusted, and converted into logs (except the rate variables). Most of the variables were found to be integrated of order one and hence were first differenced to make them stationary.

We first run a baseline SVAR model without any of the above transmission channel variable. We use the following variables: 10-year US term premium (us_gov10_premia), real non-agricultural non-government GDP (ind_rgdp_nang) for output, wholesale price index (WPI, ind_wpi) for prices, and weighted average call rate (ind_call_rate) as policy rate. 10-year US term premium is used as a proxy for foreign monetary influence. Non-agricultural, non-government GDP is defined

[18]Other recent studies on Indian monetary transmission mechanisms are Aleem (2010), Patra and Kapur (2010), and Khundrakpam and Jain (2012).

as total GDP excluding agriculture and allied activities, and "community, social and personal services." We use this variant of GDP as it is expected to be more responsive to interest rate changes.

As for structural restrictions, of our domestic variables, weighted call rate responds contemporaneously to real GDP and WPI but not vice versa. Further, WPI is modeled as depending contemporaneously on real GDP. Finally, the US specific variables are exogenous to all domestic variables in the system. Therefore, the variables in the baseline model are ordered as {us_gov10_premia, ind_rgdp_nang, ind_wpi, ind_call_rate}. The baseline model thus gives us an idea of how the domestic interest rate channel works in terms of influencing output and inflation. Further, we can also check if US monetary policy has played any role in the evolution of Indian macroeconomic variables and policy interest rate setting.

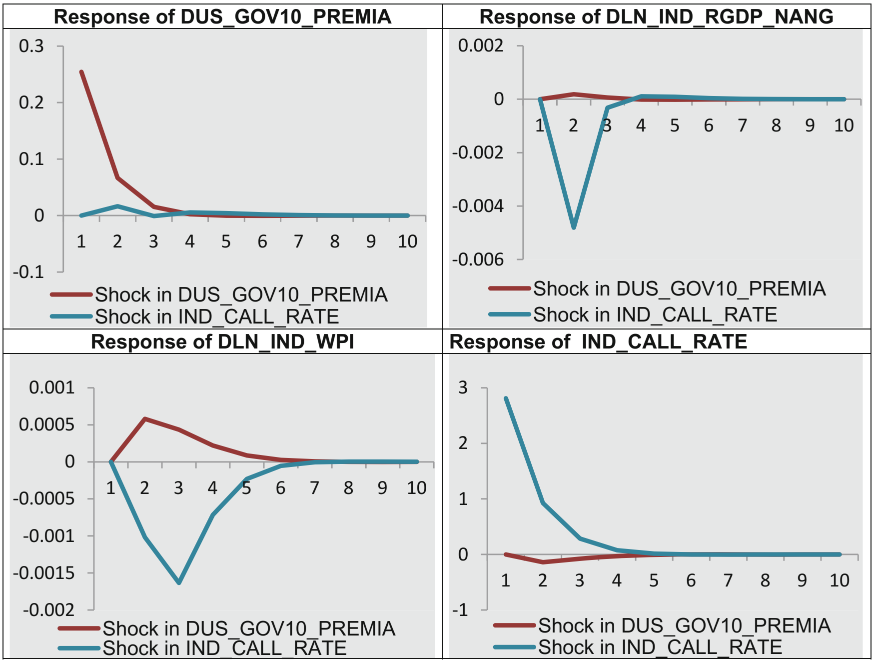
Turning to augmenting our model with other transmission channels, we keep the baseline restrictions same and assume that the additional channel is contemporaneously affected by all the other variables included in the baseline model. Thus, the variables in the augmented model are ordered as {us_gov10_premia, ind_rgdp_-nang, ind_wpi, ind_call_rate, "channel variable"}. The channel variables are non-food credit (ind_nbfoodcr) for the credit channel, BSE Sensex (ind_bsesensex) for the asset price channel, the real effective exchange rate (REER, ind_reer), and the nominal effective exchange rate (NEER, ind_neer) for the exchange rate channel and 10-year government bond yield (YLD_IND_10) for the bond price channel.

Additionally, in both the set of models, we use gross portfolio inflows as an exogenous variable to account for other global influences. We also include a dummy variable that takes value 1 in the peak crisis period (2008 Q1–2009 Q1) and zero otherwise. The analysis is done for the data from 1996 Q2–2014 Q4.

4.2 Results: The Baseline Model

We present the impulse responses from the baseline model in Graph 7 which shows the dynamic responses of output and inflation to one standard deviation shock in the call rate. Both output and inflation respond negatively to positive shocks in the call rate—as should be expected in models with sticky prices. We can further notice that in response to a call rate shock, the decline in GDP growth precedes the negative impact on inflation and the peak impact on inflation is also felt with a lag of one-quarter from the peak impact on GDP.

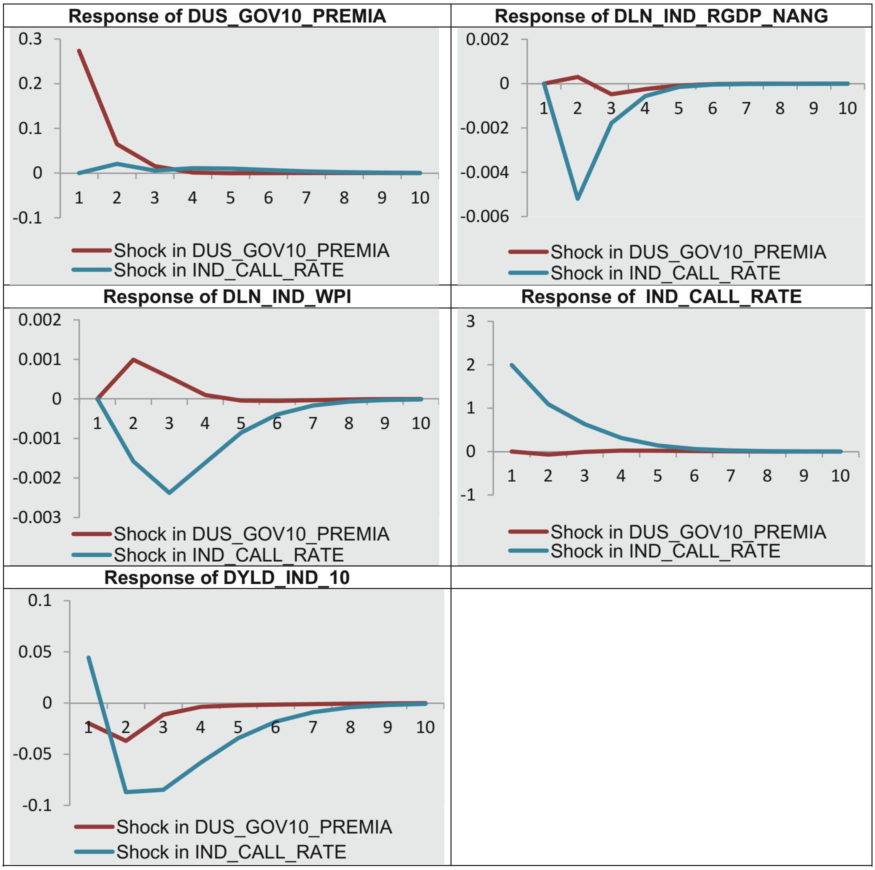
The remarkable negative response of output to shocks in the call rate may partly be due to the fact that we use the nonagricultural, nongovernment GDP as a measure of output, therefore, by definition, excluding less interest rate sensitive portion of GDP. However, this result is robust to using the aggregate real GDP, where the responses are still negative and significant, albeit smaller. Further, we also checked if these results are influenced by our identification strategy, causing



Graph. 7 Impulse responses from the baseline model

contemporaneous correlation between output and the call rate. We, therefore, run the model without the restriction that the call rate responds contemporaneously to output (keeping all other restrictions the same as before) and we reach the same conclusion about the dynamic response of output to call rate shocks. In short, our results confirm the findings of others such as Aleem (2010), Khundrakpam and Jain (2012) that shocks to the call rate do have predictable effects on the economy.

For the US term premium, we do not find any evidence of it affecting the output or the call rate. Thus, over the period of the study, US monetary policy does not seem to have had any major influence on Indian monetary policy setting. To check for the importance of a direct long-term interest rate channel, we augmented the benchmark model with a bond price variable, represented by the yield on 10-year Government of India bond. Miyajima et al. (2014) in a very similar model specification found that the US long-term interest rate has remarkable influence on the long-term interest rates in the East Asian economies. We do not expect such dramatic results in the case of India for the reasons we discussed above, viz., relative insulation of Indian debt markets from international participation. The impulse responses for this model are presented in Graph 8. As expected, the 10-year Indian bond yields show no significant response to US term premium shock. Further, all the baseline results still hold.



Graph. 8 Impulse responses from the augmented model with Indian bond yield

Our results are consistent with the findings of Ghosh et al. (2017) in this volume that India has been able to keep its monetary policy independence from external forces intact due to its more cautious approach to bond market liberalization. Although India has progressively relaxed limits on foreign inflows into its domestic bond market in the recent years, the share of foreign ownership in the government bond market still remains very low. Another reason for incomplete arbitrage is limited capital account convertibility, which restricts borrowings by resident firms and households in the international debt markets. Our results complement Ghosh et al.'s analysis in another direction. They examine the impact of US monetary policy on capital flows to India and conclude that equity flows are more sensitive to global risk aversion but debt flows react more strongly to US interest rates. We investigate the same question by focussing on the price channel of transmission of US unconventional monetary policy, which is influenced by but does not necessarily depend on the quantity of capital flows (interest rates can move even without underlying changes in quantities of flows).

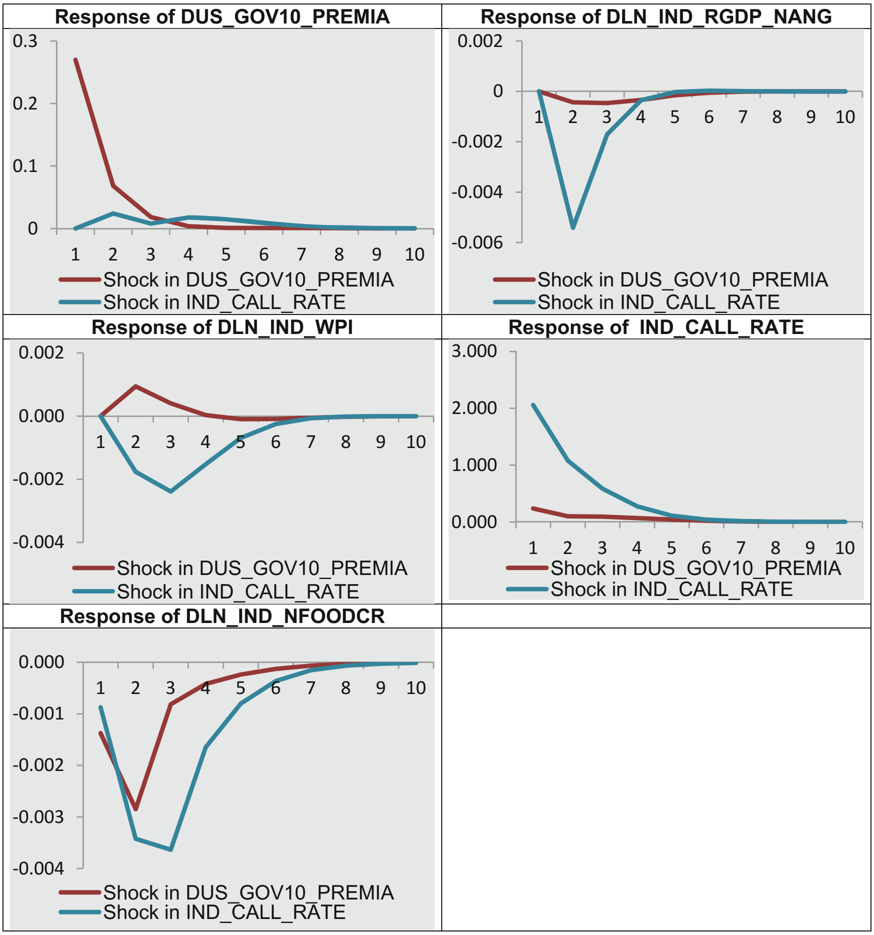
4.3 Results: Augmented Model with Additional Transmission Channels

Through the augmented models we want to test whether and how short-term policy rate and US term premium shocks transmit to other channels of monetary transmission.

The impulse responses for models including transmission variables are presented in Graphs 9, 10, 11. The first is the credit channel which is expected to work on top of the direct interest rate channel. The efficacy of this channel obviously depends upon whether a significant number of borrowers are dependent on banks. Further, a higher US term premium can reduce credit growth by weakening the banks' balance sheets (due to the expected higher non-performing loan ratio) and making them more risk averse. Graph 9 shows the relevant impulse responses. While results from the baseline model hold we find that a positive shock to the call rate leads to a decline in non-food credit. By contrast, the response of nonfood credit to US term premium shock is not significant.

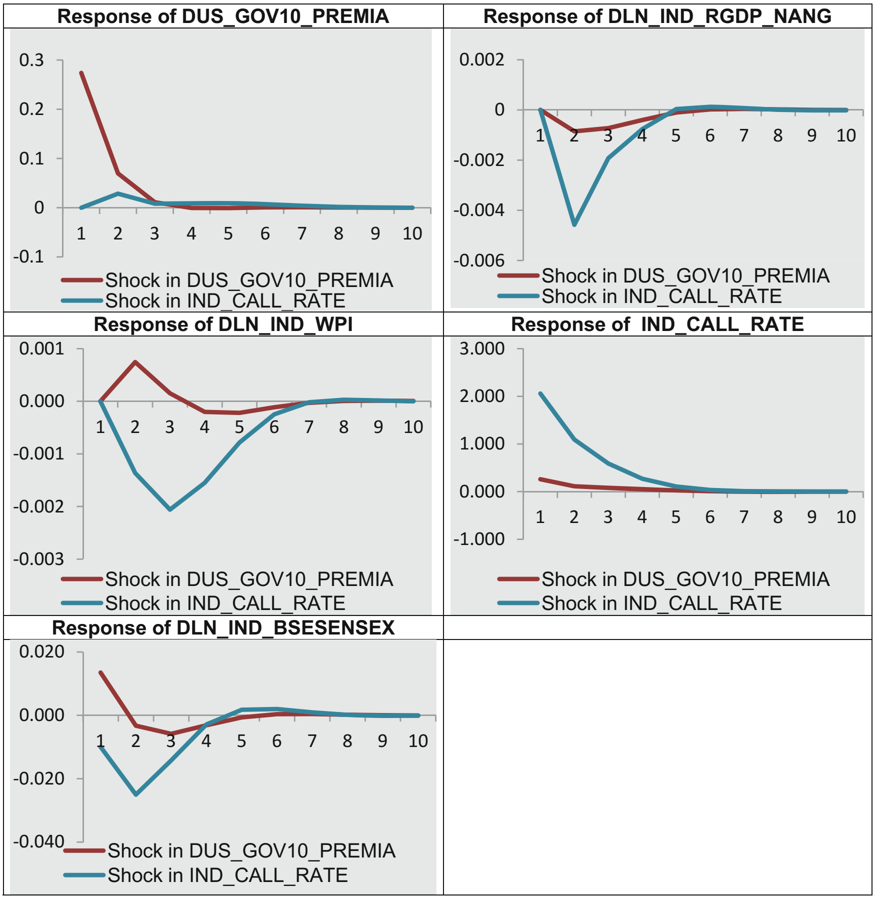
Next, we turn to assessing the asset price channel. A tightening of monetary policy is expected to make equity, as an asset, less attractive compared with other alternative assets, such as bonds, leading to a fall in equity prices, and this may, through Tobin's q, reduce investment. Also, a decline in the equity prices may reduce consumption demand through a net wealth effect on households. Similarly, a US term premium rise is expected to push asset prices down, for example, by leading to capital outflows. As a proxy for the asset price channel in India, we use the BSE SENSEX—the most popular index of Indian equity prices. The relevant impulse responses are shown in Graph 10. We find again that the results of the baseline model hold. Also clearly, a positive shock to the policy rate leads to a decline in equity prices, which peaks after two quarters following the shock. However, we do not see the US term premium shock having any significant effect on asset prices.

Finally, we look at the exchange rate channel. We consider both the REER and the NEER for the exchange rate channel. Graph 11 presents relevant impulse responses when REER is taken as the transmission channel. Here we find a result that is contrary to what we expect. While the baseline results hold true again, we find a positive shock to the policy rate that leads to a real exchange rate depreciation. Khundrakpam and Jain (2012) explain this diversion from the UIP by contending that interest rate differentials do not play an important role in the exchange



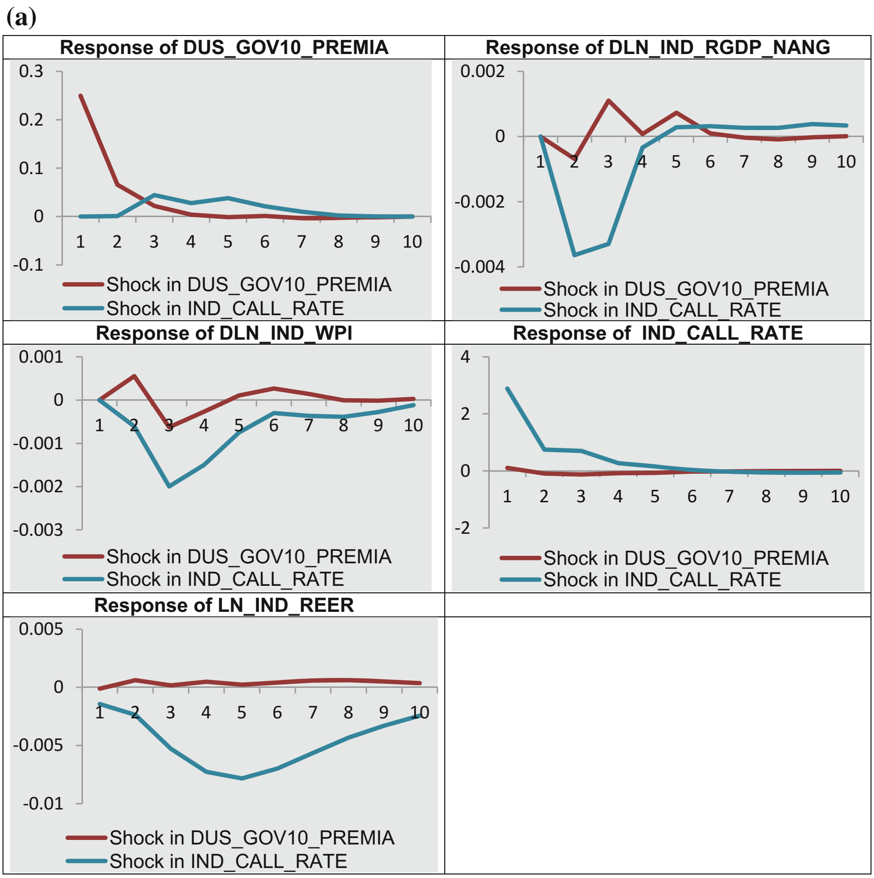
Graph. 9 Impulse responses from the augmented model with credit channel

rate determination in India. As discussed before, a part of the explanation is that the most interest sensitive part of capital flows, i.e., the debt component, is restricted in India, reducing the currency appreciation effect of a higher interest rate. Another could be that a tighter monetary policy may actually reduce equity flows by weakening growth prospects. Thus, it is possible that, on a net basis, a policy rate shock leads to a decline in net capital inflows and a currency depreciation. We find a similar result when we take the NEER as a transmission channel. In case of a US term premium shock, we find that it has no significant effect on the REER or NEER for the reasons mentioned above.



Graph. 10 Impulse responses from the augmented model with asset price channel

To sum up, we find that the interest rate is an important channel of monetary policy transmission in India as it has significant effect on output and inflation. Among, the other channels, both the asset price channel and credit channel are active while the bond price and exchange rate channels in India do not work in the expected way mainly due to its capital account policies. Keeping Miyajima et al. (2014) results in mind, thus provide indirect evidence that external monetary policy shocks are transmitted to the domestic financial systems through globally integrated debt markets which reduces barriers to international arbitrage and equalizes long-term rates across economies. In other words, the “impossibility trinity” holds, i.e., an open debt market limits the sphere of influence of domestic monetary policy



Graph. 11 **a** Impulse responses from the augmented model with exchange rate channel (REER). **b** Impulse Responses from the Augmented Model with Exchange Rate Channel (NEER)

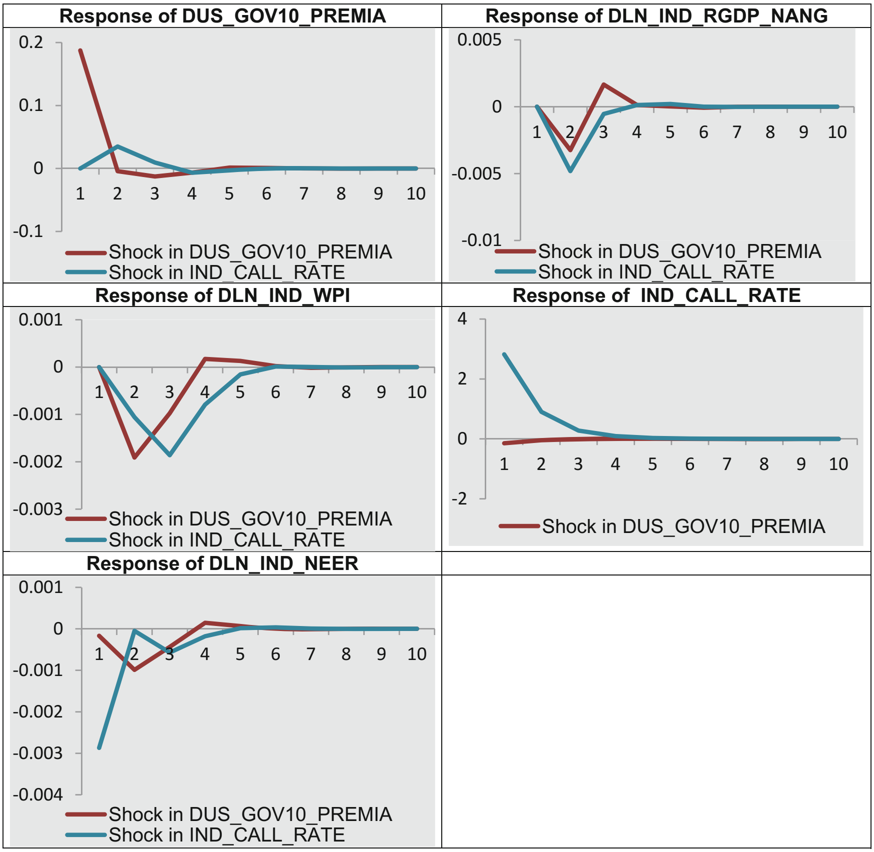
on the economy. In what follows we use a simple reduced form model to demonstrate the challenges facing the monetary authority.

5 Interest Rate Setting in Globalized Debt Markets

5.1 The Closed Economy Case

In this section, we present a simple monetary model to illustrate how a globalized debt market might complicate central bank's response. Following Genberg (2008), the analytical model comprises four equations. These equations are written in the simplest form and the lagged values are suppressed but they may nevertheless be

(b)



Graph. 11 (continued)

important. We also assume a frictionless economy, so imbalances such as currency mismatches and credit market imperfections do not play a role. We first start with a closed economy model

$$\pi_t = \alpha\, Y\, gap_t + \varepsilon_t^{\pi} \tag{6}$$

$$Ygap_t = \beta_1 \left[i_t^m - \pi_t\right] + \beta_2 U_t^c + \varepsilon_t^{Ygap} \tag{7}$$

$$U_t^c = P_t^c [E\{i_t^m - \pi_t^c\} + \delta] \tag{8}$$

Equation 6 is a simple version of the Phillip curve where inflation (π_t) depends on output gap $(Ygap_t)$. The error term $\boldsymbol{\varepsilon_t^\pi}$ captures the omitted factors and a white noise component. Equation 7 defines the IS relation with output gap being dependent on the short-term nominal market interest rate $(\mathbf{i_t^m})$ net of inflation $(\boldsymbol{\pi_t})$ and the expected user cost of capital $(\mathbf{U_t^c})$. The last term again is the error and has the usual interpretation as above. Equation 8 is the user cost of capital equation, hence identical to Eq. (1).

By substituting the expected user cost expression in the IS equation specified above, we have

$$Ygap_t = \beta_1 \left[i_t^m - \pi_t\right] + \beta_2 P_t^c \left[E\ \left\{i_t^m - \pi_t^c\right\} + \delta\right] + \varepsilon_t^{Ygap} \tag{9}$$

Next we define the central bank reaction function in Eq. (10), which links the policy rate (i_t^p) to the output gap and deviation of actual inflation (π_t) from the target (π^T):

$$i_t^p = \gamma_0 + \gamma_1 \left[\pi_t - \pi^T\right] + \gamma_2\ Ygap_t + \varepsilon_t^{i^p} \tag{10}$$

This is basically a form of the Taylor rule (Taylor 2003). Note, however, that we have an additional term (γ_0) in the interest rate rule usually assume to be a constant to capture other factors that have become important for central banks in EMEs.

Our discussion in the previous sections suggests that the size and the form of financial intermediation are crucial for transmission of monetary policy shocks. Most notably, firms have been able to access bond markets to finance investment. In a closed economy framework, this could, for instance, mean that the market borrowing rate (i_t^m) is now more tightly linked to the policy interest rate (i_t^p).

We, therefore, need a relationship between (i_t^p) and (i_t^m) that takes into account several institutional factors that create a wedge between the policy interest rate and the market interest rate which we denote by X_t. It may also include the effects of pricing power of banks and structural impediments to interest rate setting in the banking system. It can also be thought to be capturing general level of risk aversion or perceived credit risk in the economy:

$$i_t^m = \theta_1 i_t^p + \theta_2 X_t + \varepsilon_t^{i^m} \tag{11}$$

In order to characterize the static equilibrium market interest rate $(i_t^{m^*})$ and equilibrium policy rate $(i_t^{p^*})$, we solve for the market interest rate and policy interest rate in Eqs. (9) and (10) when output gap and inflation gaps are zero. We therefore have

$$i_t^{m^*} = \pi^T - \frac{\beta_2}{\beta_1} P_t^c \left[E\left\{i_t^m - \pi_t^c\right\} + \delta\right] + \frac{1}{\beta_1} \varepsilon_t^{Ygap} \tag{12}$$

$$i_t^{p^*} = \gamma_0 + \varepsilon_t^{i^p} \tag{13}$$

Note, again the error terms have the usual meaning as discussed above. Now, we are ready to find an expression for γ_0 and using that we augment the traditional Taylor rule. Thus, by substituting Eqs. (12) and (13) in Eq. (10), we have

$$\gamma_0 = \frac{1}{\theta_1}\left(\pi^{T} - \frac{\beta_2}{\beta_1}P_t^c\left[E\left\{i_t^m - \pi_t^c\right\} + \delta\right]\right) - \frac{\theta_2}{\theta_1}X_t + \frac{1}{\theta_1}\frac{1}{\beta_1}\varepsilon_t^{Ygap} - \frac{1}{\theta_1}\varepsilon_t^{i^m} - \varepsilon_t^{i^p}$$

where $\frac{1}{\theta_1}\frac{1}{\beta_1}\varepsilon_t^{Ygap} - \frac{1}{\theta_1}\varepsilon_t^{i^m} - \varepsilon_t^{i^p}$ are a bunch of errors which we denote by φ_t.

Finally, our simplistic but augmented monetary policy reaction function can be written as

$$i_t^{\mathbf{p}} = \frac{1}{\theta_1}\left(\pi^{\mathbf{T}} - \frac{\beta_2}{\beta_1}P_t^c\left[E\left\{i_t^m - \pi_t^c\right\} + \delta\right] - \theta_2 X_t\right) + \gamma_1\left[\pi_t - \pi^T\right] + \gamma_2\,\text{Ygapt} + \varphi_t + \varepsilon_t^{i^p} \tag{14}$$

Ignoring the two error terms, the last two terms are the usual Taylor rule arguments. The first term explicitly brings into the policy rule, the expected user cost, and financial intermediation factors. This relation will be used as baseline when we open up the economy to international bond flows.

Two main implications of the closed economy augmented Taylor rule are worth noting. First, as discussed by Genberg (2008), it predicts how financial intermediation can affect the "neutral interest rate" to stabilize the economy. One example, discussed in Sect. 3, is the case of increased bond financing leading to lower intermediation spreads. This is akin to monetary easing and thus to maintain neutral monetary stance, the central bank must respond by increasing the policy rate. In contrast, an increase in perceived credit risk, unrelated to fundamentals of the economy, or higher intermediation spreads resulting from attenuation of asymmetric information problem through the bond market, will mean monetary conditions have tightened, thus requiring a lower policy rate.

Second, our augmented central bank reaction function also illustrates how market expectations of the interest rate and asset prices play an important role in the design of appropriate interest rate response, particularly when they deviate from those desired by the central bank. This is likely to affect the size and the speed of the response of aggregate demand to changes in the interest rate as well as other shocks driving these expectations. For instance, a cut in the policy rate may be accompanied by unexpected buoyancy in house prices, leading to faster than expected transmission of policy shocks to the housing market, which may not be welcome by the central bank from the view point of financial stability. The same phenomenon could also be driven by house price inflation completely unrelated to monetary policy (demographic shocks), which increases the perceived pay-off to home buyers from housing investment, driving spending and inflation away from target.

The main point to note is that the conventional Taylor rule still serves a useful purpose in stabilizing the economy. To the extent that changes in domestic financial intermediation are gradual, central banks can prevent major risks to monetary and financial stability by appropriately adjusting their policy response. Precisely for this reason, in many countries, monetary authorities regularly monitor a wide range of real and financial market indicators to detect and address some of these risks.

5.2 The Open Economy Case

Using the above framework we can also bring in the open economy considerations into the picture. Consider the expected user cost equation in an open economy which is identical to Eq. (3):

$$U_t^c = P_t^c[E\{i_t^{us} + \Delta e - \pi_t^c\} + (q^{us} - q^d) + \rho + \delta]$$

We want to arrive at the open economy interest rate rule as we did in case of the closed economy. Equation (15) provides such an expression:

$$\begin{aligned} i_t^p = \frac{1}{\theta_1}(\pi^T - \frac{\beta_2}{\beta_1}P_t^c[E\{i_t^{us} + \Delta e - \pi_t^c\} + (q^{us} - q^d) \\ + \rho + \delta] - \theta_2 X_t) + \gamma_1\left[\pi_t - \pi^T\right] + \gamma_2\, \text{Ygapt} + \varphi + \varepsilon_t^{ip} \end{aligned} \tag{15}$$

The open economy interest rate rule clearly demonstrates how foreign factors may have a bearing on monetary policy setting. According to Eq. (15), the neutral policy interest rate, in a globalized environment, will have to be set taking into account domestic and US term premia, currency risk premia and expected exchange rate movements. We can now think of several scenarios where policy rate has to be maneuvred independent of core domestic objectives. Take, for instance, the case of a lower US term premium that results from policy actions such as large-scale quantitative easing by the fed. This leads to rapid exchange rate appreciation, which reduces the cost of credit in the shortrun. Note that this leads to an easing of domestic monetary conditions, requiring a higher domestic interest rate to stabilize inflation. Such a strategy is especially problematic when the domestic fundamentals require an opposite action, and would be unsustainable if higher interest rates encouraged more capital inflows. A reverse scenario may quickly develop if the US term premium starts to rise, for instance, that happened during the "taper tantrum" episode, leading to a sudden tightening of monetary conditions.

Equation (15) also predicts the neutral rate in more direct cases of the US Federal Reserve's forward guidance such as its intention to maintain a zero fed funds rate into the future. Such guidance directly changes the expected path of future US short-term rates and hence credit costs facing EME borrowers. Again, it is difficult to envisage the central bank playing by Eq. (15). In practice, the dilemma could be more complicated because exchange rate may appreciate too fast and too soon and that such appreciation may trigger an unwelcome credit boom, raising risks to financial stability.

In short, with globalization of debt markets, monetary policy conduct through the short-term interest rate becomes a much more complicated affair. A simple Taylor rule is unlikely to be sufficient in stabilizing the economy against external monetary shocks, requiring monetary authorities to depend on multiple instruments to balance domestic and external objectives (e.g., Obstfeld (2015). India's approach has suggested that the degree of capital account flexibility—and therefore the choice of monetary policy regime—plays an important role in determining the impact of external shocks.

6 Conclusion

The objective of this paper was to review changes in the monetary transmission mechanism in EMEs following several major changes to financial intermediation over the past decade. It is by now fairly obvious that the globalization of debt markets, together with a sharp decline in global long-term interest rate and accumulation of large dollar debt by EME nonfinancial corporations, have complicated the transmission mechanism of monetary policy in many economies. One well-known consequence of reduced barriers to international arbitrage is that domestic asset prices cannot deviate too much from international asset prices. The analysis in this paper suggested that these changes have affected all three major channels of monetary policy creating new tensions for monetary and financial stability policies. However, as pointed out by Ghosh et al. (2017) in this volume, India has well-navigated recent large global shocks because of its cautious approach to bond market liberalization. Our results suggested that monetary policy continues to play a significant role in the macroeconomic evolution of the Indian economy.

A key question is the extent to which the recent changes to the transmission mechanism affect interest rate setting, especially in small open economies. Our results suggest that the traditional Taylor rule can still be a reasonable guide to monetary policy in relatively closed economies subject to gradual changes in financial intermediation. In this case, the neutral interest rate could be adjusted to prevent major inflation risk due to potential changes in the response of aggregate demand to interest rate. The challenges are more complicated in globally integrated debt markets. As discussed by Obstfeld (2015), Agenor and Pereira de Silva (2013), a single interest rate instrument is unlikely to be a satisfactory solution in most cases, requiring the central bank to use other instruments (such as foreign exchange intervention and macro-prudential tools) to reduce risks to price and financial stability.

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Monetary Policy Transmission in the Presence of Product and Labor Market Frictions: The Case of India

Rahul Anand, Sonali Das and Purva Khera

1 Introduction

Monetary policy has evolved over the past few decades, with a consensus forming among policymakers and academics on having price stability as the main objective. Numerous countries in both advanced economies and emerging market economies have adopted inflation targeting since the end of the 1980s, many after unsatisfactory experiences with setting intermediate money targets or with maintaining a fixed exchange rate. In India, several high-level committees have argued for a move to inflation targeting since the mid-2000s. After years of low growth and high inflation, a committee was constituted in 2013 to consider what is needed to revise and strengthen the monetary policy framework, and its report was finalized in January 2014.[1] The Committee laid out the rationale for adopting flexible inflation

[1]Reserve Bank of India (2014b), "Report to the Expert Committee to Revise and Strengthen the Monetary Policy Framework," available at http://www.rbi.in/scripts/PublicationReportDetails.aspx?UrlPage=&ID=743. Also known as the Patel Committee Report, as it was led by Dr. Urjit Patel, Deputy Governor of the RBI.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_5

targeting (FIT[2]) in India and recommended that inflation should be the nominal anchor for the monetary policy framework.[3] The RBI acted in a manner consistent with FIT from that point, and officially adopted the framework in February 2015.

In addition to discussing the advantages of inflation targeting, the Patel Committee report noted that one of its disadvantages is that it is a medium-term framework because of the long and variable lags in monetary policy transmission. In India in particular, this is a relevant concern as monetary policy transmission has been found to be partial and asymmetric in addition to being slow (Das 2015). The RBI has expressed concern over a lack of policy rate pass-through to lending rates and deposit rates, with recent RBI monetary policy statements mentioning pass-through of past policy rate cuts to lending rates as a prerequisite for further monetary easing and discussing lending rate sensitivity to the policy rate.[4] Concerns about transmission are not unique to India, as the strength of monetary policy transmission in developing countries as a whole has come into question (see Mishra and Montiel 2012; and Mishra et al. 2014).

This paper studies the environment for monetary policy transmission in India, focusing on the extent to which it is affected by frictions in goods and labor markets. These often discussed frictions—barriers to entry and competition as well as cumbersome processes necessary to fire employees, which make firms reluctant to expand—have contributed to the development of a large informal economy in India. The Indian economy stands out in its degree of informality[5]: about half of GDP comes from informal sector activities, and around 90 % of employment is informal. Kanbur (2014) analyzes the causes of informality in India, including higher costs of registration and higher private costs of regulation. Chapter 4 of the Patel Committee Report (RBI 2014a) discusses likely impediments to monetary transmission in India and groups them into three broad categories: (i) fiscal dominance, (ii) the large informal sector, and (iii) financial and credit market frictions.

Using the framework of Anand and Khera (2016), we study how reforms aimed at reducing frictions in the goods and labor markets in India would affect monetary policy transmission. The model is a small open-economy dynamic stochastic

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[2]Under which the inflation target is to be achieved on average over the business cycle, while accommodating growth concerns in the short run (Ito 2013).

[3]It also recommended that this nominal anchor should be set by the RBI as its predominant objective of monetary policy and that, subject to the establishment and achievement of the nominal anchor, monetary policy conduct should be consistent with a sustainable growth trajectory and financial stability.

[4]The March 4, 2015 and April 7, 2015 monetary policy statements, respectively.

[5]The *informal economy* is made up of the informal sector and its workers plus the informal workers in the formal sector. The *informal sector* is defined as "…all unincorporated private enterprises owned by individuals or households engaged in the sale and production of goods and services operated on a proprietary or partnership basis and with less than ten total workers." *Informal workers/employment* are "…those working in the informal sector or households, excluding regular workers with social security benefits provided by the employers and including the workers in the formal sector without any employment and social security benefits provided by the employers." (National Commission on Employment in the Unorganized Sector 2009).

general equilibrium (DSGE) model with formal and informal sectors, endogenous firm entry, and monopolistic competition and price and wage stickiness in the formal sector. Product market regulation affects firm entry costs and the degree of competition, and labor market regulation affects hiring costs. We use headline inflation targeting as the monetary policy rule, as is done in practice. Anand et al. (2015) show that headline inflation targeting improves welfare outcomes in economies where a large proportion of households are credit constrained and the share of food expenditures in total consumption expenditure is high, as is the case in India. We find monetary policy to be less effective in the high-friction environment corresponding to tight regulations. Monetary policy has a smaller effect on inflation, compared to a situation with lower hiring costs and, to a lesser extent, lower entry costs. In addition, when both hiring costs and entry costs are lower, the trade-off between prices and output improves, as there is a lower decline in output for the same decrease in inflation following a monetary policy tightening.

2 Related Literature

2.1 Monetary Policy Transmission in India

There is a vast literature studying the effects of monetary policy, which advances as improvements are made in the methods used to identify exogenous monetary policy shocks and is also updated as the implementation of monetary policy changes over time. Christiano et al. (2000) provides a comprehensive review of the literature on monetary policy transmission. Several recent studies try to account for the possibility that the link between monetary policy instruments and aggregate demand—the monetary transmission mechanism—may be weaker in low-income countries than it is in advanced and emerging economies. Mishra and Montiel (2012) review the reasons why the credit (bank lending) channel is likely to be the dominant one for developing countries and survey the evidence on the effectiveness of monetary transmission in developing countries. They conclude that, despite methodological issues present in the literature, monetary transmission appears to be weak in developing countries. Mishra et al. (2014) find large variation in the response of bank lending rates to monetary policy shocks across countries, with weaker transmission in developing countries.

Mohan (2008) comprehensively surveys monetary policy in India, including the evolution of the operating framework, instruments used for liquidity management, and reforms. Sengupta (2014) uses a vector autoregression (VAR) to study the various channels of monetary transmission in India from 1993 to 2012. She finds a structural break in transmission corresponding to the introduction of the Liquidity Adjustment Facility (LAF) in 2000, with the bank lending channel remaining important since the introduction of the LAF but the interest rate and asset price channels becoming stronger. Singh (2011) uses a VAR model from March 2001 to

June 2012 to estimate pass-through from the policy rate to a variety of short- and long-term market interest rates. He finds significant contemporaneous pass-through under deficit liquidity conditions as well as significant lagged effects. Mohanty (2012) also narrows in on the interest rate channel, studying policy rate changes through to their effects on output and inflation. Estimating a quarterly structural VAR model, he finds that policy rate increases have a negative effect on output growth with a lag of two quarters and a moderating impact on inflation with a lag of three quarters, with both effects persisting for eight to ten quarters. Using vector error correction models, Das (2015) finds partial and slow pass-through of policy rate changes to bank interest rates, and evidence of asymmetric adjustment to monetary policy where the lending rate adjusts more quickly to monetary tightening than to loosening.

2.2 Monetary Policy in the Presence of Market Frictions

The literature which introduces labor market frictions into the New Keynesian model with nominal rigidities used to analyze monetary policy is relatively new. The combination of labor market frictions and wage rigidities leads to inefficient unemployment fluctuations, and introducing these features in a model with nominal rigidities makes room for monetary policy to reduce these inefficiencies, although the latter has to be traded-off with the desire to stabilize inflation (Gali 2008). Blanchard and Gali (2006) model how the trade-off between inflation and unemployment stabilization depends on labor market characteristics, and draw the implications for optimal monetary policy. While not focused on monetary policy, Bilbiie et al. (2012) bring endogenous producer entry and creation of new products into a DSGE to understand their role in propagating business cycle fluctuations.

2.3 Product and Labor Market Reforms, and Their Interaction

Blanchard and Giavazzi (2003) study the macroeconomic effects of deregulation in goods and labor markets using a two period (short run and long run) general equilibrium model with monopolistic competition, wage bargaining, and regulation. Product market deregulation is modeled as a fall in firm entry costs, and labor market deregulation is modeled as a fall in workers' bargaining power. They show that, in the long run, output and employment increases with both product and labor market deregulation. Subsequent studies have built on this framework. In their stylized model, Blanchard and Giavazzi (2003) discuss the political economy of product and labor market deregulation. Currently, employed workers may oppose deregulation because it decreases wages in the short run, although leaving them

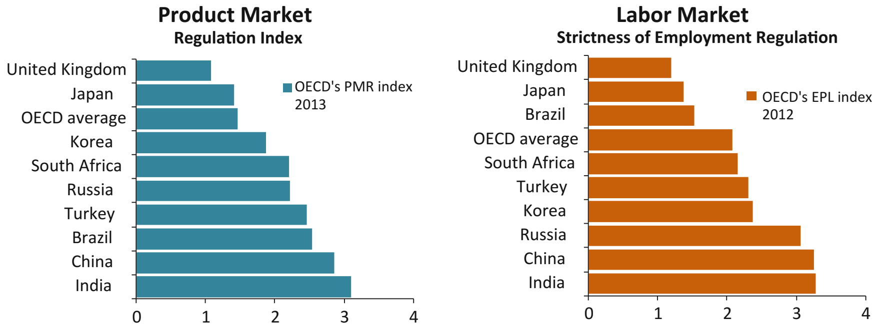

Fig. 1 Product and labor market regulation

unchanged in the long run, and may decrease employment at incumbent firms, although increasing employment overall. For product market deregulation, on the other hand, the effects are favorable in both the short and long run, with an increase in real wages and a decrease in unemployment. They suggest that product market deregulation may help to implement labor market deregulation. In their model, however, the whole of the economy is subject to regulation and the adjustment to deregulation occurs through new firm entry. This is different from the Indian case, where a deregulation of the formal sector would, in the first instance, affect the size (and thus formality) of existing informal sector firms, and also potentially lead to new firm creation. Anand and Khera (2016), in their model tailored to the Indian economy with its large informal sector, find that simultaneous reforms are beneficial, and higher gains are experienced the higher the informality in the economy before reforms.

3 Product and Labor Market Regulations in India

This section documents the above-mentioned goods and labor market frictions present in India. Despite some progress made through reforms, product and labor markets remain tightly regulated in India. In the OECD's index of product market regulation (PMR), India ranks higher than the other BRICS and well over the OECD average (Fig. 1). The PMR index measures the incidence of regulatory barriers to competition via state control of business operations and the protection of incumbents, as well as through various legal and administrative barriers to start-ups or to foreign trade and investment. Specifically, the indicators[6] aim at capturing aspects of regulation which: (i) limit the number of suppliers of a particular product or service; (ii) limit the ability of suppliers to compete, (iii) reduce the incentives of

[6]The OECD builds three PMR indices focused on state control, barriers to entrepreneurship, and barriers to trade and investment. We present the overall PMR index in Fig. 1.

suppliers to compete, or (iv) limit the choices and information available to customer (OECD 2014). According to this Index, a high level of state control indicates relatively pervasive public-sector involvement in India's product markets, and existence of prohibitive administrative burdens on business start-ups and other regulatory hurdles to dynamic business environment leads to several barriers to entrepreneurship in the formal sector. The difficult environment for firms in India is also captured in the World Bank's Ease of Doing Business rankings (World Bank 2016), where India ranks 130th out of 189 countries. This is a slight improvement from the 2015 ranking, when India placed 134th, with the increase in the ranking being due to an increase in the ease and speed of acquiring an electricity connection, and a decrease in redundant inspections. Compared to other emerging markets, India falls behind in dealing with construction permits, enforcing contracts, and resolving insolvency.

India also ranks high on the OECD's employment protection legislation (EPL) index, indicating a lack of flexibility in the labor market. The EPL index measures the procedures and costs involved in dismissing individuals or groups of workers and those involved in hiring workers on a fixed-term or temporary basis. In India, for example, the index would take into account features of key pieces of labor market regulation—such as the Industrial Disputes Act (IDA) , the Factories Act, the Shops Act, and the Contract Labor Act—as well as the ease of complying with these regulations. Chapter 5 of the IDA requires firms employing 100 or more workers to obtain government permission for layoffs, retrenchments, and closures (as of 1984). There are some differences in labor regulations across Indian states, as several states have made amendments to the IDA, commonly by allowing an increase in threshold size of the firm to which it applies from 100 to 300 workers, and also by allowing other exemptions. Studies have noted the lack of medium-sized enterprises in India, and have found rigidities in labor markets across states to affect firm hiring decisions, growth, and productivity outcomes (Achyuta et al. 2013; and Dougherty 2009).

4 Model

The model used in this chapter is the same as in Anand and Khera (2016). It is a small open-economy DSGE model with monopolistic competition and sticky prices and wages, formal and informal sectors, and frictions in the labor market following Blanchard and Gali (2006), as well as frictions in the product market following Bilbiie et al. (2012). Anand and Khera (2016) study the impacts of product and labor market deregulation on output, unemployment and formality, focusing on reform interactions, and short run and long run differences in impacts. Among other results, they find that, in the long run, deregulation leads to an increase in output and formality, along with a decrease in unemployment.

In this section, we provide a brief description of the model and highlight the aspects of the model that are most relevant to the policy experiment at hand.[7] The model is made up of the following agents: a representative household, capital producers, wholesale firms (both formal and informal), retail firms (both formal and informal), the government, the monetary authority, and the rest of the world. There are three consumption goods: formal tradable goods (F, produced by formal retailers and sold domestically and to the rest of the world), informal nontradable goods (I, produced by informal retailers), and imported goods (f^*, produced in the foreign economy and sold domestically by import retailers in the formal sector).

In each sector, wholesale firms combine labor supplied by households and capital supplied by capital producers, to produce intermediate goods using a constant return to scale technology. Unemployment exists as wholesalers in each sector pay a hiring cost when hiring new labor, which is an increasing function of the labor market tightness. Wages in each sector are determined through Nash bargaining between workers and firms.

Formal and informal retailers purchase wholesale goods from wholesalers in their respective sectors, differentiate these into different varieties, and set the retail price for each individual variety in an environment of monopolistic competition and price adjustment costs *a la* Rotemberg (1982). The number of retailers operating in each sector is determined endogenously by a sunk entry cost that retailers pay when starting a new business, where the price elasticity of demand for each individual variety of retail good, is positively related to the number of competitors in each sector. Formal retailers sell the final formal tradable good to households, capital producers, and government in the domestic economy, while also exporting it to the foreign economy. Informal retailers on the other hand, sell the informal final good to domestic households only.

Profitability of firm entry depends on the costs of hiring workers and wage bargaining power of workers, while barriers to firm entry, in turn, affect the evolution of employment by determining the size and number of producers in each sector. Thus, firm and employment dynamics in each sector is determined by the interaction between the product and labor market regulations, which together determine the extent of informality in the economy.

The representative, infinitely living household maximizes its expected discounted lifetime utility of consumption, C_t, which is a composite basket of domestic consumption, $C_{D,t}$, and imported good consumption, $C_{f^*,t}$. The household earns labor income from working in the formal sector $(L_{F,t})$ or in the informal sector $(L_{I,t})$. Entry of new firms in both sectors is financed by the household and it receives profits from the ownership of wholesale firms (W) and retailer firms (R).

[7]For details of the model and derivation of equilibrium conditions, see Anand and Khera (2016).

Domestic consumption $C_{D,t}$ is a composite of goods produced in the formal sector $C_{F,t}$ and in the informal sector $C_{I,t}$.[8]

A group of competitive capital producers combine formal goods and imported goods to produce investment goods, which is then combined with the used capital goods rented from wholesalers to produce new capital. Government consumes an exogenous stream of final goods consisting of domestically produced formal goods and imported goods, and provide unemployment benefits to unemployed workers, which is financed by taxing wage income in the formal sector. They also set the nominal interest rate on domestic bonds using a Taylor-type rule.

Several key differences between firms in the formal and informal sectors are modeled, to match the facts of Indian firms. Formal firms have higher capital intensity, are more productive, and have a lower chance of bankruptcy. Only formal wage income is taxed as wage income earned in the informal sector is hidden from the government. The government only purchases formal sector goods, only formal sector goods are traded abroad, and only capital production comes from the formal sector. As discussed in greater detail below, formal sector firms face greater regulation and thus are thought to have a higher entry cost.

4.1 Labor Market Frictions—Hiring Costs Faced by Wholesale Firms

Using a standard Cobb-Douglas production function, formal and informal firms hire workers supplied by domestic households, and rent capital from domestic capital producers ($K_{F,t-1}$ and $K_{I,t-1}$), to produce formal and informal wholesale goods, respectively:

$$Y_{F,t}^{W} = \theta_{F,t}(K_{F,t-1})^{\psi_F}(L_{F,t})^{1-\psi_F}$$
$$Y_{I,t}^{W} = \theta_{I,t}(K_{I,t-1})^{\psi_I}(L_{I,t})^{1-\psi_I}$$

$\theta_{F,t}$ and $\theta_{I,t}$ are productivity shocks, and ψ_F and ψ_I are capital intensities related to capital income shares. They sell these to retailers in their respective sectors at a price of $P_{F,t}^{W}$ and $P_{I,t}^{W}$ in a competitive manner.

The stock of employed labor in each sector varies because of the endogenous variation in hiring, and an exogenous probability of getting fired, $\sigma_{F,t}$ and $\sigma_{I,t}$, every period. After firing and hiring take place, the labor employed at the end of period t is given by as follows:

[8]These can be described with a Dixit-Stiglitz (1977) CES function, separately in the formal and in the informal sectors. As firm entry is endogenous allowing the number of firms in each sector change over time, the aggregation conditions include the number of firms.

$$L_{F,t} = (1-\sigma_{F,t})L_{F,t-1} + H_{F,t}$$
$$L_{I,t} = (1-\sigma_{I,t})L_{I,t-1} + H_{I,t}$$

Hiring ($H_{F,t}$ and $H_{I,t}$) is costly, resulting in equilibrium unemployment (U_t) in the model. Wholesale firms in both the formal and informal sectors face a per-worker cost of hiring. Following Blanchard-Gali (2006), the hiring cost per hire is:

$$\mathrm{HC}_{F,t} = \beta_{\mathrm{HCF},t}(x_{F,t})^{\alpha_{\mathrm{HCF}}}$$
$$\mathrm{HC}_{I,t} = \beta_{\mathrm{HCI},t}(x_{I,t})^{\alpha_{\mathrm{HCI}}}$$

where $\beta_{\mathrm{HCF},t}$ and $\beta_{\mathrm{HCI},t}$ are positive constants, and $x_{F,t}$ and $x_{I,t}$ are indices of labor market tightness. That is, in each sector, x represents the ratio of aggregate hires to the available labor force. It is also the probability of being hired in period t, i.e., the job finding rate. While the hiring cost is taken as given by each firm, it is an increasing function of labor market tightness, where α_{HCF} and α_{HCI} are elasticities of hiring costs with respect to hiring probabilities. Labor market deregulation corresponds to a fall in the hiring cost in the formal sector. That is, a decrease in the exogenous term β_{HCF}.

Capital and labor demand in each sector is derived from maximizing wholesalers' expected discounted value of future profits:

$$R_t^K = \psi_F \frac{P_{F,t}^W}{P_t} \frac{Y_{F,t}^W}{K_{F,t-1}}$$
$$R_t^K = \psi_I \frac{P_{I,t}^W}{P_t} \frac{Y_{I,t}^W}{K_{I,t-1}}$$
$$(1-\psi_F)\frac{P_{F,t}^W}{P_t}\frac{Y_{F,t}^W}{L_{F,t}} = W_{F,t} + \mathrm{HC}_{F,t} - E_t\left[\rho_{t,t+1}\mathrm{HC}_{F,t+1}(1-\sigma_{F,t+1})\right]$$
$$(1-\psi_I)\frac{P_{I,t}^W}{P_t}\frac{Y_{I,t}^W}{L_{I,t}} = W_{I,t} + \mathrm{HC}_{I,t} - E_t\left[\rho_{t,t+1}\mathrm{HC}_{I,t+1}(1-\sigma_{I,t+1})\right]$$

The equation for capital demand in each sector is standard in the literature, where the marginal product of capital is equal to its cost, R_t^K. The labor demand, on the other hand, is now determined by equating its marginal product to the cost of employing labor, which includes the real wage plus the cost of hiring.

Wages in each sector, $W_{F,t}$ and $W_{I,t}$, are determined through Nash bargaining between workers and wholesalers, where exogenously determined wage bargaining power of the worker in the two sectors is given by $\lambda_{F,t} \in (0,1)$ and $\lambda_{I,t} \in (0,1)$, respectively. This captures the level of unionization in each sector, and a fall in the bargaining power of formal sector workers, where λ_F is the other labor market deregulation reform. The evolution of formal and informal wages derived in Anand and Khera (2016) suggests that wages in the informal (formal) sector not only depend upon the rigidities in the informal (formal) labor market, but also in the formal (informal) labor market.

4.2 Product Market Regulation—Entry Cost Faced by Retail Firms

There are a continuum of monopolistically competitive formal and informal retailers, who buy wholesale goods to produce different final good varieties, $Y_{F,t}(j_F)$ and $Y_{I,t}(j_I)$, and sell these at different prices, $P_{F,t}(j_F)$ and $P_{I,t}(j_I)$, respectively. The demand function facing each retailer is

$$Y_{F,t}(j_F) = \left(\frac{P_{F,t}(j_F)}{P_{F,t}}\right)^{-\varepsilon_{F,t}}$$
$$Y_{I,t}(j_I) = \left(\frac{P_{I,t}(j_I)}{P_{I,t}}\right)^{-\varepsilon_{I,t}}$$

The elasticity of substitution between goods in the formal sector is denoted by $\varepsilon_{F,t}$, and the elasticity of substitution between goods in the informal sector is denoted by $\varepsilon_{I,t}$. The markup in each sector depends on the relevant elasticity of substitution, and also on the number of firms. The markup is decreasing in the number of firms. Formal sector firms have greater market power than informal sector firms.

Product market regulation affects the entry cost of retail firms. Following Bilbiie et al. (2012), firm entry is endogenous with firms entering the formal and the informal retail markets in every period. Firm exit is exogenous and given by the bankruptcy rates δ_F and δ_I. In both the formal and informal sectors, new firms enter the market, $N^E_{F,t}$ and $N^E_{I,t}$, until the expected discounted value of future profits covers the sunk entry cost f:

$$E_t \sum_{s=t}^{\infty} \rho_{s,s+1}(1-\delta_F)^s \Pi^R_{F,s} = f_{F,t}$$
$$E_t \sum_{s=t}^{\infty} \rho_{s,s+1}(1-\delta_I)^s \Pi^R_{I,s} = f_{I,t}$$

where ρ is the stochastic discount rate, and Π^R is the retail firm's profit. These entry conditions determine the number of firms in each sector, $N_{F,t}$ and $N_{I,t}$, in the long run. The number of firms operating each period is given by:[9]

[9]Here Anand and Khera (2016) assume that the firms which enter in period t, only start to produce goods in period $t + 1$, i.e., this is the standard time-to-build assumption.

$$N_{F,t} = (1 - \delta_F)(N_{F,t-1} + N^E_{F,t-1})$$
$$N_{I,t} = (1 - \delta_I)(N_{I,t-1} + N^E_{I,t-1})$$

Product market deregulation corresponds to a fall in the entry cost in the formal sector. That is, a decrease in the exogenous term $f_{F,t}$.

4.3 Monetary Authority

The monetary authority sets the interest rate following a Taylor-type monetary policy rule:

$$i_t = (1 - \rho_i)\bar{\imath} + \alpha_i i_{t-1} + \alpha_\pi(\pi_t - \bar{\pi}) + \alpha_Y(Y_t - \bar{Y}) + \varepsilon_{i,t}$$

where α_i captures interest rate smoothing, and the central bank responds to current inflation and output deviations from steady state. α_π and α_Y are the weights on inflation and output stabilization, respectively. $\varepsilon_{i,t}$ is the monetary policy shock which captures unanticipated shocks to the nominal interest rate.

4.4 Data and Estimation

A combination of calibrated and estimated parameters is used to employ the model for policy analysis. The calibrated parameters in the model are set to match the available literature for India as well as the data (Table 1). The parameters relating to labor and goods market rigidities (i.e., $\beta_{\text{HCF}}, \beta_{\text{HCI}}, \lambda_F, \lambda_I, f_F$, and f_I[10]) are all calibrated to be higher in the formal sector, corresponding to the regulations in this sector as opposed to the unregulated informal sector. Because of scarce empirical evidence regarding the value of these parameters, the calibration strategy aims to match, as accurately as possible, the empirical evidence, and available data on key statistics relating to the formal and informal labor market in India. For instance, setting them at the values described in Table 1 gives the informal employment share at 82 % in the steady state.

Bayesian estimation is used to estimate the remaining parameters. The data used are nine key macroeconomic variables for India: GDP, private consumption expenditure, investment, government consumption expenditure, exports, imports (all expressed in constant prices), the real exchange rate, inflation, and the nominal interest rate.

[10]Steady-state values of the hiring cost parameters β_{HCF} and β_{HCI} are obtained by calibrating the hiring cost to wage ratio in both the formal and informal sector using data published by the World Economic Forum (The Global Competitiveness Report 2014).

Table 1 Calibration of Benchmark Model for India

Description		Value
Discount rate		0.994
Capital depreciation rate		0.025
Share of domestic goods in aggregate consumption		0.8
Substitutability between domestic and foreign goods		1.15
Gross inflation (percentage annually)		4.5
Gross foreign inflation (percentage annually)		2.5
Government spending-to-GDP ratio		0.11
Social spending-to-GDP ratio		0.014
Export-to-GDP ratio		0.19
Import-to-GDP ratio		0.21
Price elasticity of exports		4.5
Substitutability between formal and informal goods		1.5
Share of formal goods in consumption		0.5
Capital share in production function	Formal	0.34
	Informal	0.34
Elasticity of substitution among retail goods	Formal	7
	Informal	12
Productivity	Formal	1.5
	Informal	1
Share of hiring costs in wages	Formal	3
	Informal	0.5
Worker bargaining power	Formal	0.8
	Informal	0.1
Hiring cost elasticity to job-finding rate	Formal	0.5
	Informal	0.5
Worker firing rate	Formal	0.1
	Informal	0.75
Firm entry cost-to-output ratio	Formal	0.5
	Informal	0.15

The three-month Treasury bill rate is used as a proxy for the nominal interest rate, and the real effective exchange rate (REER) is used as a proxy for the real exchange rate. The sample runs from 1996Q1 to 2012Q1, which gives us 65 observations for each of the time series. The Hodrick-Prescott (HP) filter is used to remove a time trend in the data and obtain the stationary series, and measure these in terms of the percent deviation from the steady state. The data is also seasonally adjusted (except the real exchange rate and the nominal interest rate). All data is taken from the CEIC database. See Anand and Khera (2016) for more details.

To sum up, Anand and Khera (2016) draw the following conclusions from the posterior estimates. First, the persistence of formal sector shocks is higher relative to informal sector shocks. Also, in absolute terms, the shocks in the formal sector have considerably high persistence. Second, shocks in the informal sector are more volatile than the corresponding shocks in the formal sector. Third, estimates of the Taylor rule imply a strong preference to smooth inflation ($\alpha_\pi = 2.89$) and interest rate fluctuations ($\alpha_i = 0.83$), and significantly lesser to output deviations ($\alpha_Y = 1.07$).

5 Results

5.1 *Benchmark Results*

We first present the effects of a monetary policy shock in an economy in which there is no deregulation, to establish the benchmark for comparison. Figure 2 shows the impulse responses to a monetary policy shock—a tightening of 50 basis points. As expected, output and inflation decline. The real exchange rate appreciates because of the fall in local prices compared with foreign prices. The appreciation in the real exchange rate causes a fall in export demand for formal goods which leads to a larger decline in labor demand and wages in the formal relative to the informal sector.

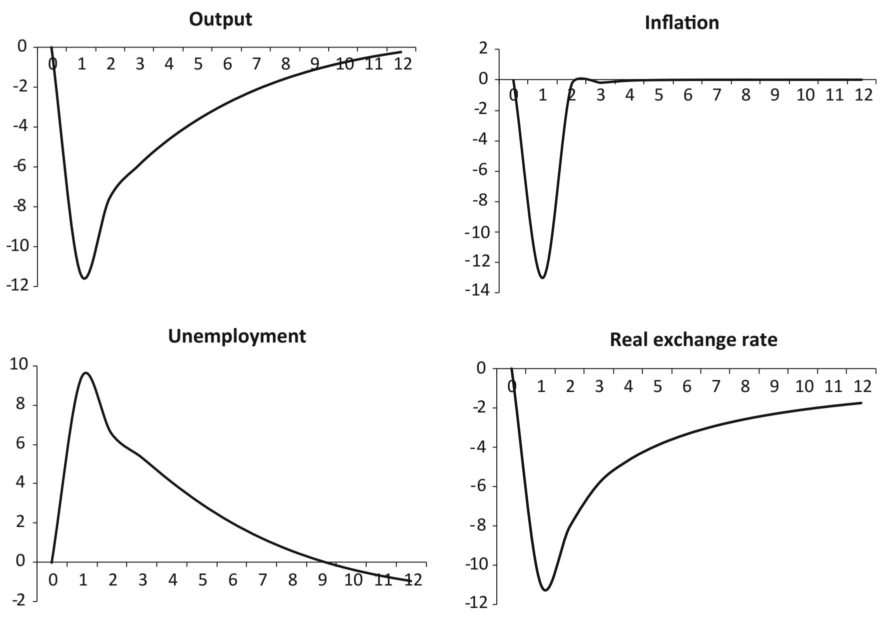

Fig. 2 Impulse Responses to a Monetary Policy Shock—Benchmark Model. *Note* The impulse responses shown above are to a 50 basis point positive shock to the interest rate. Each variable's response is expressed as the percent deviation from its original steady-state value

5.2 Main Deregulation Scenarios

We next consider three deregulation scenarios: (i) the case of a decline in hiring costs; (ii) the case of a decline in entry costs; and (iii) the case of a decline in both hiring costs and entry costs, which represents how a combined package of reforms would be expected to affect monetary transmission. In terms of the model, the three deregulation cases are represented as follows:

(1) Labor market deregulation: 50 % decline in $\beta_{\mathrm{HCF},t}$; and $\beta_{\mathrm{HCI},t}$, $f_{F,t}$ and $f_{I,t}$ as given.
(2) Product market deregulation: 50 % decline in $f_{F,t}$; and $f_{I,t}$, $\beta_{\mathrm{HCF},t}$ and $\beta_{\mathrm{HCI},t}$ as given.
(3) Product market and labor market deregulation: 50 % decline in both $f_{F,t}$ and $\beta_{\mathrm{HCF},t}$; and $f_{I,t}$ and $\beta_{\mathrm{HCI},t}$ as given.

In order to better understand the magnitude of the changes in these parameters, Table 2 shows the impact of lowering labor and product market regulations on the size of the formal labor market in India. For instance, a 50 % decline in $\beta_{\mathrm{HCF},t}$, leads to an increase of formal sector labor share by 3.5 % in the first 3 years, and by 10 % in 10 years.[11] On the other hand, a decline in firm entry costs in the formal sector, $f_{F,t}$, leads to a short-run fall in the formal labor share. This is the short-run adjustment cost as described by Anand and Khera (2016), which is due to the slow reallocation of resources between the two sectors. Product market deregulation leads to an increase in both formal and informal employment, where higher (unchanged) rigidities in the formal labor market leads to a faster and larger increase in L_I relative to L_F, leading to a fall in formal labor share for up to 3 years, after which it starts to increase (refer to Anand and Khera (2016) for a more elaborate discussion).

Figure 3 presents the impulse responses to a monetary policy tightening corresponding to each deregulation scenario, as well as the impulse responses from the benchmark no-deregulation case for comparison. The responses are presented as a deviation from the initial (steady-state) value of the particular outcome variable, in percent. This is to account for the fact that a deregulated economy will have a different (steady-state) value of output, unemployment, inflation, and so on. In this way, we can see the extent to which a change in monetary policy affects economic variables, proportional to the starting point.

In the first case, that of a decrease in hiring costs, we see that inflation declines by a greater amount in response to the monetary policy shock than in the benchmark case. Output also falls by more than in the benchmark case, and the decline is more persistent. Unemployment does not rise as much in response to the monetary

[11] A smaller decline in the formal sector hiring cost, of 20 % for example, would lead to an increase in the formal sector labor share of 2.5 % in 4 years and of 4.5 % in the long run. And a larger decline in the formal sector hiring cost, of 80 %, would lead to an increase in the formal sector labor share of 6 % in 4 years and 11 % in the long run.

Table 2 Deregulation and formality

Parameter	Magnitude (% decline)	Change in formal sector labor share in employment (%)	
		After 12 quarters	After 40 quarters
Formal sector labor hiring cost ($\beta_{\mathrm{HCF},t}$)	50	3.5	10
Formal sector labor hiring cost and formal sector worker bargaining power ($\beta_{\mathrm{HCF},t}$ and $\lambda_{F,t}$)	50	10	17
Formal sector firm entry cost ($f_{F,t}$)	50	−1.5	0.4

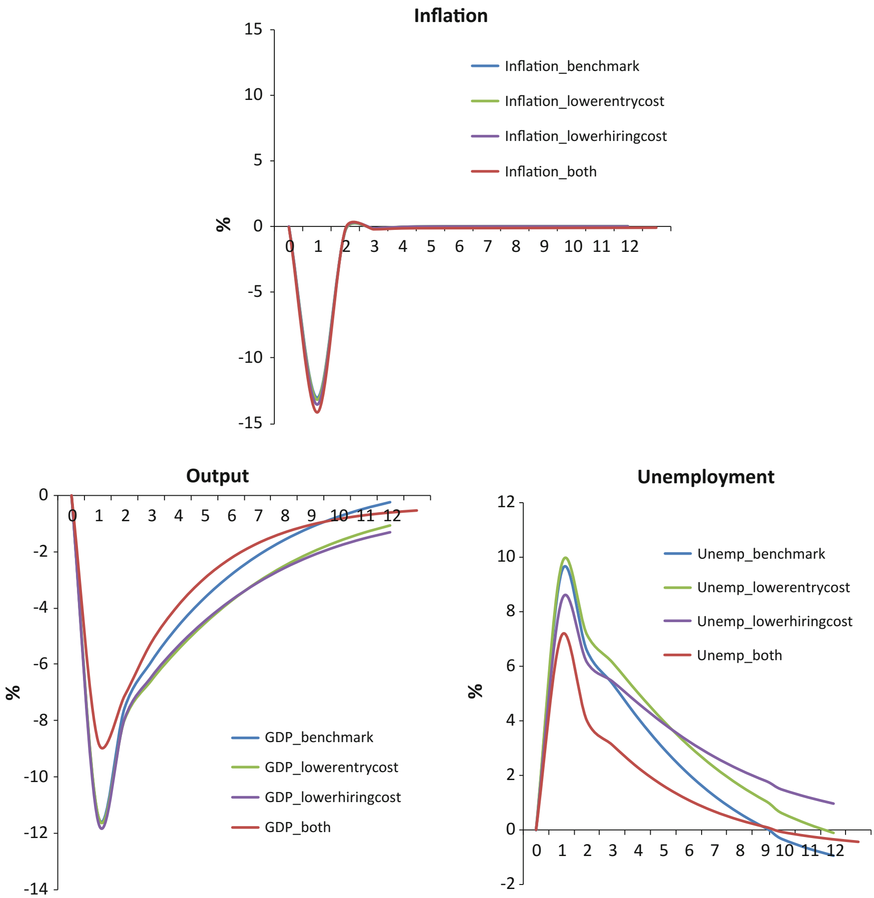

Fig. 3 Deregulation—Impulse Responses to a Monetary Policy Shock. *Note* The impulse responses shown above are to a 50 basis point positive shock to the interest rate. Each variable's response is expressed as the percent deviation from its original steady-state value

tightening, compared to the benchmark case, suggesting a better trade-off between output and unemployment in the situation where hiring costs are lower. In the second case, that of a decrease in entry costs, we see that the responses of inflation, output, and unemployment are small relative to the benchmark scenario responses. That is, since lowering entry barriers eases firm entry, its main effect is in the long run, where entry occurs, output increases, and formal sector employment increases.

Next, in the case where both hiring costs and entry costs are lower, we see a larger decline in inflation compared to the benchmark case. The larger decline in inflation occurs while output declines considerably less and unemployment increases considerably less than in the benchmark case. We see that, when both hiring costs and entry costs are lower, the intended price response to monetary policy can be gained with less of a cost in terms of output and unemployment. With a more flexible economy, the trade-off between prices and economic activity improves.

5.3 Intuition

Looking at Fig. 2 provides some insights into how product and labor market regulations affect the transmission mechanism of a standard New Keynesian framework. We find that the presence of both types of regulations leaves the baseline transmission mechanism of a New Keynesian setting qualitatively unaffected. All the variables respond to shocks in the same way that they would in an economy without product and labor market regulations, i.e., there is a fall in inflation and output and an increase in unemployment following a monetary policy tightening.

However, product and labor market regulation do affect the magnitude of the responses, as we see in Fig. 3. This is driven by the impact of formal sector regulations on the size of the formal versus the informal sector in the economy. Table 2 shows that the share of the formal economy is higher when regulations are lower. Overall, there are two opposing effects at play in the economy's response to shocks. On the one hand, the informal sector plays a shock absorbing role due to the terms of trade effect between the formal and the informal sector. Hence, the larger the informal sector, the lower the impact of shocks in the economy. On the other hand, lower regulation in the formal sector results in greater flexibility and adjustment to macroeconomic shocks in the economy. Thus, deregulation increases the impact of shocks in the economy. In terms of the impact of a monetary policy shock on output and unemployment, we find that the former effect dominates, whereas the latter effect dominates in terms of its impact on economy-wide inflation. For instance, when labor market regulations are lower (i.e., a decrease in formal sector hiring cost), an increase in the interest rate has a larger impact on the real output, as formal firms have higher flexibility. However, the formal sector wages and the expected costs of hiring also fall by more, leading to a lower increase in unemployment compared to an economy with higher regulations where the hiring costs and wages are less sensitive to disturbances. Both—the larger impact on output and wages—results in a higher decrease in inflation. Hence, with a more flexible economy, the trade-off between prices and economic activity improves.

5.4 Labor Markets—Further Flexibility

In this section, we analyze further how an increase in labor market flexibility affects monetary policy transmission. In addition to the previous section, where we considered lower formal sector hiring costs, we add the case of lower bargaining power in the formal sector. That is, the scenario being considered is

(4) Labor market deregulation: 50 % decline in $\beta_{\mathrm{HCF},t}$ and 50 % decline in $\lambda_{F,t}$; and $\beta_{\mathrm{HCI},t}$, $f_{F,t}$, and $f_{I,t}$ as given.

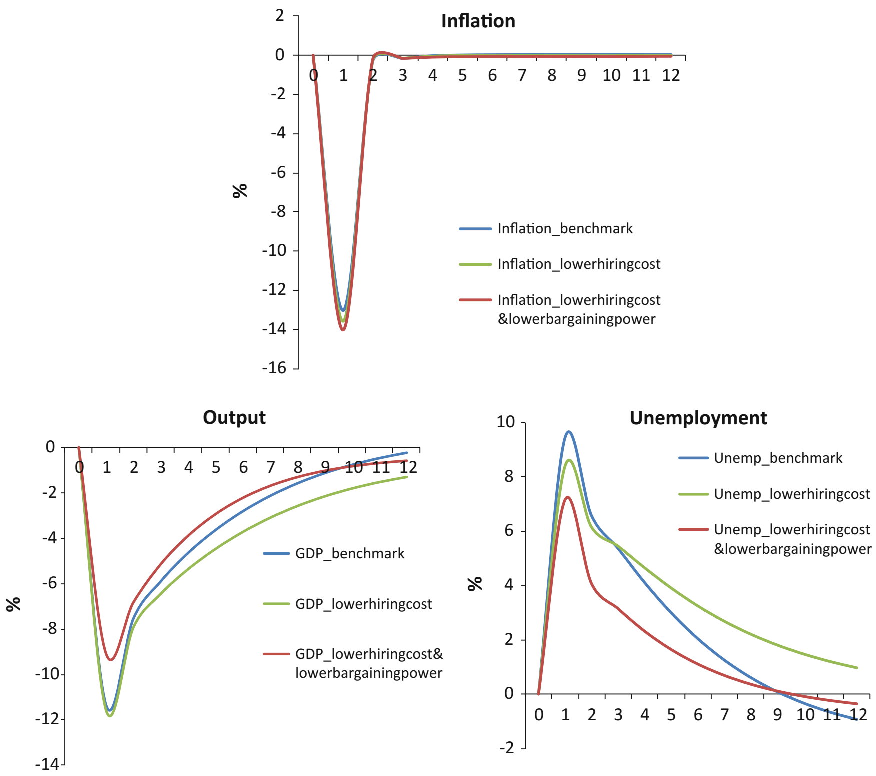

Fig. 4 Labor Market Flexibility—Hiring Costs and Bargaining Power. *Note* The impulse responses shown above are to a 50 basis point positive shock to the interest rate. Each variable's response is expressed as the percent deviation from its original steady-state value

The results are shown in Fig. 4. With this added dimension of labor market flexibility: (i) the inflation response to the monetary policy shock is even greater than with just lower hiring costs; and (ii) the output decline associated with the monetary tightening is lower.

6 Conclusion

Using the framework of Anand and Khera (2016), we study how reforms aimed at reducing frictions in the goods and labor markets would affect monetary policy transmission in India. Comparing the impulse responses of economic variables to a monetary policy tightening shock in several deregulation scenarios—an economy with lower hiring costs; an economy with lower entry costs; an economy with both lower hiring and entry costs; and an economy with both lower hiring costs and reduced bargaining power of workers—we find that monetary policy is more effective in a low friction environment. When labor markets are more flexible or, to a lesser extent, entry costs for firms are lower, monetary policy has a greater effect on inflation, compared to the benchmark economy. In addition, when labor market and product market deregulation are combined, the trade-off between prices and output improves, as there is a lower decline in output for the same decrease in inflation following a monetary policy tightening.

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Part III
Liquidity Management and Financial Structure of the Indian Economy

Financial Markets and Investment Finance in India: Implications for Monetary Transmission

Rajesh Chakrabarti

> *"We will take steps to improve the transmission mechanism… The question is where we should be as a country. Ideally, a lot of rates should be priced at a market rate… In most countries, you don't have a situation in which banks decide what rate that should be; it is a market-based rate. We need to move towards that. The corporate sector does not care from where the money is coming as long as it is cheap. So, if banks are not willing to cut rates, the borrower will go to the commercial paper market."*
>
> —Raghuram Rajan, April 2015 in an interview to Business Standard

1 Introduction: Overview and Context-Setting

The financial market–monetary policy nexus is an important area in central banking. However, usually the discussion is about how the latter affects the former. This chapter will, on the contrary, seek to examine the effect of financial markets—and the reforms therein—on the efficacy of monetary policy in the country. It will attempt to review the literature on how financial market reforms affect the grip with which the gears of monetary policy engage with the real economy at least in the short run—the "transmission mechanism"—and how that has evolved with financial reforms in India in the recent past.

The question has been an important one in the monetary policy literature particularly in the context of emerging market economies which have their own economic peculiarities. The aggregate demand channel is usually rather weak there; and the exchange rate often works through a cost-push mechanism. Motivating their survey of the literature on the effectiveness of monetary policy transmission in low-income countries around the world, Mishra and Montiel (2013) argue that

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_6

given their common and significant differences in financial structures from developed economies, there is no reason to expect the efficacy of monetary transmission observed in developed economies to carry over to low-income economy. In fact, given the much higher level of informality of financial markets in low-income countries, they posit a much weaker and less reliable transmission mechanism in low-income countries. In the absence of systematic multicountry comparative studies, they use Acosta-Ormaechea and Coble (2011)'s four-country study to surmise that the sophistication of financial system indeed appears to be correlated with stronger and predictable monetary transmission.

The case for India is even more curious. India's level of sophistication of financial institutions is higher than most low-income countries in the region, (and around much of the world). And yet, in the single paper on India included in the survey (Mallick 2009), spanning the period 1996–2009 of significant financial market development, India's price level response to monetary policy on average is insignificant and counterintuitive.

In order to understand the linkages between financial structure and monetary transmission, it is perhaps useful to understand the connections and differences between the two alternative channels of financial intermediation—banks and markets. Financial markets and banking or financial institutions are similar in their broad goal and deliverable: intermediation between the surplus generator (savers, mostly households) and decision makers of levels of real capital (investors, mostly firms and governments). In that sense they are parallel and alternative arteries of the financial system which, in turn, is analogous to the circulatory system in the economy, ceaselessly moving the surplus from savers to investors and bringing back the returns to the providers of savings. But the nature of the intermediation and their methods of achieving the intermediation are quite different. Markets are arm's length, transactional while banks are relationship based. The nature of risk transformations and level of transparency are significantly different from the two as well. Finally, the payment systems are linked to banks and hence even markets need to depend on banks for their functioning. Therefore, the two channels are also complementary and interconnected. And both are sensitive to monetary policy moves.

As a vehicle of monetary policy, in general financial markets have always been and continue to be a distant second to credit institutions, or simply, banks. Increasingly, though the bank-market dichotomy has become less clear, both the world over as well as in India. As banks embrace market dependent operations while providing the essential connect to financial markets to the payment system itself, the borders between financial products and realms of operation have become increasingly fuzzy. Nevertheless, broadly speaking bilaterally negotiated institutional credit and securities trading in a faceless market do remain two distinct realms. In that sense, as the quote at the beginning of the chapter indicates, the market sensitivity of lending rates in India has a long way to go. And indeed the efficacy or "bite" of monetary policy is primarily determined by the sensitivity of the lending rate to policy rates. However, given that there is a separate chapter exploring the relationship between banks and monetary policy, this chapter will restrict itself exclusively to markets for tradeable securities and how changes in the rules of the game in these markets have altered, and have affected transmission mechanism.

A rather stylized and introductory characterization of the linkage between monetary policy rates and asset markets can run along the following lines: investors broadly have three competing buckets to put their funds in—bank accounts, fixed income securities or bonds, and risky securities, for simplicity say equities, in increasing order of riskiness. Starting from an equilibrium situation as the central bank raises interest rates, bank rates increase making bank accounts more attractive than before luring away some investors from the bond markets, which, experiencing selling pressure witnesses a decline in bond prices and a consequent rise in yields, which in turn attracts some equity investors away reducing equity prices. The key component in this story, obviously is the first step where the bank rates are assumed to respond to policy rates—a rather heroic assumption in many contexts including contemporary India. However, that apart, the almost equally important element of the story is the bond market that reacts competitively to the change in bank lending. Deep, liquid, and active bond markets have proven to be the Achilles' heel for many an emerging market economy and India is no exception. To the extent financial reforms can improve the efficiency of the markets, they can therefore contribute to the efficacy of the transmission mechanism as well.

Given the importance of the topic both from the research as well as policy perspective, the paucity of literature here is more than a little surprising; it is most likely a "no-man's land" phenomenon falling between monetary economists who concentrate on the more important credit channel and finance scholars who invest their energies in understanding internal mechanics and inefficiencies of asset markets. Nevertheless some literature does exist. In a cross-country analysis of the relationship between financial development and monetary policy, Krause and Rioja (2006) documents a significant correlation between developed financial markets and efficient monetary policy implementation. Singh et al. (2008) find a stronger interest rate pass-through in countries with competitive banking industry but also in those for broad and deep equity/bond markets. The relationship, however, is complex with impact on other channels as well. Woodford (2002) underlines the concern that development of financial markets can actually complicate the work of central banks as markets replace banks as the primary channel of financial intermediation reducing the central bank's ability to generate real effects by allowing agents to subvert the bank rate effects by working through markets, exactly what Governor Rajan meant in the opening quote to this chapter.

The market value of traded financial assets is another important area. Mishkin (2001) and Bernanke and Gertler (2000) popularized the view that central banks had no direct role in ensuring asset prices stayed "in whack" with the fundamentals; that, in line with the conventional central banking role of maintaining price stability, monetary policy should target inflation and interfere with asset prices only in so far it happens incidentally in the course of inflation targeting. This view moved on the premise that central bankers are unlikely to have the expertise to determine a “price bubble” from an asset price spike that is driven by fundamentals. However, this view has been widely questioned in the aftermath of financial crisis (Pattanaik and Singh 2010) implying that financial markets ought to be seen not only as a channel of monetary transmission but also providing an objective of policy. Gali (2014), however, has brought the discussion full circle by pointing out that at least for “rational” bubbles, monetary policy aimed at deflating it may possibly end up with exactly the opposite effect. In other words, central bankers need to be careful in considering asset prices in determining policy rates.

These relationships are likely to be as important in emerging market countries like India as in developed countries, but their strength may depend upon the level of development in financial markets, making an understanding of financial markets—their current state and structure as well as the legal and institutional structure behind their development and the regulatory set-up and its changes—critical for appreciation of the conduct of monetary policy in India. The Indian financial system, particularly financial markets, has indeed come a long way since liberalization started in 1991, though studies of the effects of this development on monetary policy transmission remain hard to find. Nevertheless, it is fair to say that India still remains a bank-dominated financial system (see Allen et al. 2012; Sahoo 2013) though the markets have gained significant ground in recent years. The persistent under development of wholesale debt markets, for instance (see Chaudhuri et al. 2014), and the excessive reliance of small and medium enterprises on banking credit (rather than capital markets) to fund their capital expenditure (see IFC 2012) as well as the stickiness in prices for small loans are among factors that affect the efficacy of the monetary transmission channel.

The goal of the present chapter is to review the extant literature to summarize and outline the broad contours of the work around monetary transmission channels in India as well as shed light on some of the key features and changes in the Indian financial system with an attempt to broadly link the two. The chapter is structured as follows. Section 2 will delve a little deeper on the key channels of monetary transmission and briefly summarize the literature in the Indian context. Section 3 will present a “bird’s eye view” of the financial structure in India today dwelling upon a few selected features and changes like the financing realities of Indian corporates and SMEs as well as major changes in the financial system such as the FSLRC. Section 4 will discuss how some of the features and changes in the financial system are likely to impact the transmission mechanism. Section 5 will conclude with pointers to future research.

2 Channels of Monetary Transmission and the Relevance of Financial Markets

The literature on monetary policy transmission has identified the four broad channels of transmission of monetary policy to generating real effects—the text-book interest rate channel, the credit channel, the asset price channel, and the exchange rate channel. To this, Mohan (2008) has suggested the addition of a fifth channel, the expectation channel.

The transmission of monetary policy through the interest rate mechanism is well known. It impacts cost of capital that, in turn, affects spending decisions both of businesses and households (Singh et al. 2008). In an expansionary monetary policy universe, the cost of capital reduces and as such demand (from households) and investment (of firms) increases with the resultant increase in output. In recent years, Taylor (1995) has argued that interest rate channel is a key conduit. There is empirical evidence for this channel in many areas of world: Smets and Wouters (2002) and Angeloni et al. (2003) for Euro area countries, and for Asian countries, Amarasekara (2008) for Sri Lanka, and Disyatat and Yongsinsirikul (2002) for Thailand.

Banks intermediate retail (on demand and short term) deposits into (long term) projects and investments and perform an important maturity and liquidity transformation role in a financial system. Information asymmetry and incentive incompatibility between financial market intermediaries and investors coupled with deposit insurance mean that banks acquire retail deposits with relative ease, especially in emerging market economies like India. In an expansionary monetary policy, the net worth of borrowers increases (flowing from lower cost of capital and higher equity and collateral prices). Banks respond to this by lending more to high net worth borrowers, thereby increasing investments and furthering demand. On the other hand, in a contractionary monetary policy setting, borrowers' net worth decreases and banks respond by reducing their lending thus depressing investments and demand. This is also called the balance sheet channel of credit in the literature. The other dimension of the credit channel is bank lending. Bank lending channel relies on two premises—resource constraints of banks and the imapct of monetary tightening on their supply of credit to the markets. The other is that some firms (like small and medium enterprises for example) are bank-dependent as they do not have effective access to capital markets.

Bernanke and Gertler (1995) were among the first to argue that a credit channel of monetary transmission exists that can supplement or even overshadow the interest rate channel. However, Edwards and Mishkin (1995) questioned its effectiveness pointing out that financial innovations reduces the relevance of banks to credit markets. There is some evidence of it working in emerging markets (see, for instance, Angeloni et al. (2003) for Euro countries and Bayangos (2010) for Philippines).

The asset price channel of monetary transmission operates through Tobin's q (market value of firm divided by replacement cost of capital). As the interest rate declines, the replacement cost of capital declines making it easier for firms to issue equity and therefore fund investments. A reverse effect is witnessed when the interest rate increases. The investors demand a higher "hurdle rate" for investing in the firm and as such, we witness a drop in investments. Another effect related to asset price channel is the effect of wealth on consumption—consumer spending is determined by the amount of resources the consumer has. These resources are real, financial, and human capital that the consumer possesses. As the interest rate declines and translates into higher equity and real estate prices, the consumer becomes "richer" with the resultant increase in ability to consume and invest, translating positively on to real economy. (Dan 2013).

Finally, there is the exchange rate channel of monetary policy transmission. When domestic interest rates fall, domestic (currency) deposits lose their attraction vis-a-vis foreign currency deposits. This results in a depreciation of the domestic currency and rise in net exports with the corollary rise of output. (Mishkin 1996).

Broadly speaking, the aggregate demand (interest rate) channel is often weak in emerging market economies. However, this may change as with rising income levels people increase their consumption of interest rate sensitive goods. Also for import-dependent countries, the exchange rate cannel can often work through cost-push mechanisms, and not necessarily through the import substituting aggregate demand side.

The Indian reality about relative strength of the various transmission channels has been the subject of several inquiries, not all of them providing the same results. Ray, Joshi, and Saggar (1998) argue that liberalization has fundamentally altered the transmission mechanism environment in Indian monetary policy and infer that the exchange rate channel played an important role. Al-Mashat (2003) presents evidence that the interest rates and the exchange rates are the most important channels for monetary transmission. Pandit and Vashisht (2011) find evidence of the credit channel for India. Apart from this, RBI (2005), Mohan (2008), Mohanty and Turner (2008) Patra and Kapur (2010), Mohanty (2012), Khundrakpam and Jain (2012), Khundrakpam (2011), Kapur and Behera (2012) and Singh (2012) have all studied the effect of various transmission mechanisms in India using different econometric techniques. Keltzer (2012) surveys the literature till 2012 and connects it to financial sector development. More recently, the Urjit Patel Committee report (RBI, 2015) sums up the "broad consensus" that monetary shocks affect output with a lag of 2–3 quarters and headline WPI inflation with a lag of 3–4 quarters, with the interest rate channel being the most effective one. There is some evidence of the bank lending channel being impactful as well, but the exchange rate channel and the asset price channel appear to be very feeble in India. Separately, Bhatt and Kishore (2013) find evidence of the impactfulness of the bank lending channel on real output, underlining the continuing bank-centrality of the Indian financial system.

As both Kletzer (2012) and RBI (2015) emphasize, financial market development plays a critical role in determining the efficacy of all these channels. Prominent among the financial factors, RBI (2015) identifies as impediments to the transmission mechanism are the pre-emption of funds through SLR; small savings scheme with sticky interest rates; various subventions and the large informal sector in the country's financial sector. In the following sections, we take stock of India's financial markets and provide a review of the evidence provided by the admittedly scanty work in exploring these connections.

3 Investment Financing and Financial Markets in India—A Few Selected Features

According to the last Financial Development Report released by the World Economic Forum in 2012, India ranks 40th among 62 countries covered in the *Financial Development Index*. However, among the seven pillars that went into making the rankings, India's rank varied substantially from 9th (in nonbanking financial services) to 56 (in Institutional environment) (see Table 1). In the area of Financial Markets, however, India received a reasonably good rank of 28, signifying that in terms of market infrastructure and delivery and settlement processes, the Indian financial markets do not fare too badly, particularly among emerging

Table 1 Sources of funds for nonfinancial firms (*Percentage* of total funding; 2001–2005)

	Large Enterprises (LEs)				Small and Medium Enterprises (SMEs)				All firms
	All LEs	Listed LEs[a]	LE-M	LE-S	All SMEs	Listed SMEs[a]	SME-M	SME-S	
Internal sources	46.6	58.3	47.8	43.9	15.11	39.49	11.3	21.4	45.29
Equity (Private + Public)	16.8	12.4	15.6	19.5	31.59	34.82	35.7	28.7	18.32
Capital Market-Debt	2.5	22	1.9	3.8	7.0	3.41	12.0	2.8	3.56
Debt: Banks and FI's	16.9	12.3	16.3	18.4	21.62	10.44	25.1	17.0	17.16
Debt: Group Co's/Promoters	1.9	−0.2	22	1.2	3.4	8.98	4.4	2.0	1.0
Trade credits	11.2	12.0	11.7	10.0	15.83	6.89	14.7	18.5	10.78
Others	4.1	28	4.4	3.3	5.5	−4.03	−3.3	9.6	3.93
Number of observations	4760	1001	3899	861	9014	400	6122	2893	12343

This table provides evidence on the sources of (new) funds for nonfinancial Indian firms during the 5-year period of 2001–2005, based on the *Prowess* database of CMIE. The table shows the breakdown between firms in the small and medium enterprises (SME) sector and large enterprises, as well as between manufacturing and services sectors. The numbers in the table are *flow* variables. For a given category of firms, the numbers reported in the table are obtained by first calculating the total *new* funds from each funding source during 2001–2005, expressed as the *percentage* of the total funds from all sources during the same period

[a]Listed at the BSE or LSE

Source The source of the data is *Prowess* database compiled by the Center for Monitoring Indian Economy (CMIE)

Source Allen et al. (2012)

market countries. This seems to suggest that in terms of market development India does not fare too poorly in a relative sense though it seems to lag quite a bit in the area of financial inclusion, a priority area of financial policy. Chakrabarti (2014) summarizes the key characteristics of the Indian financial system as follows: it is marked by low Financial Penetration/Inclusion; a stable, very fragmented, public-sector-dominated banking system; poor but developing credit infrastructure in terms of credit information; vibrant financial markets, particularly in the equity and derivatives segments with a robust and efficient settlement system but also several illiquid listed firms; an anemic corporate bond market that has so far resisted a decade-long effort by the government to kick-start it; a business group dominated corporate sector with a large employment-driving SME and microenterprise sector. In terms of regulation India has a rule-based, fragmented (multiple-agency) regulatory structure that is widely held to be outdated leading to a move toward a gradual transition toward a more integrated and principle-based regulatory system. The financial system has been virtually reinvented in the last quarter century of reforms, with the extent of changes comparable to those in aviation and telecom. The financial sector is now undergoing second-generation reforms and these reforms will continue to evolve. In the post-reform phase, for instance, the sector has become globalized through international flows and has witnessed massive growth in intermediary segments like mutual funds and insurance.

With this rather sweeping characterization of the financial sector in mind, we shall focus on selected parts of the markets and issues therein in the remainder of this section.

3.1 Financing Pattern of Firms

It is important to point out that in the standard IS-LM framework of monetary policy, the policy action actually engages with the real variables (admittedly in the short-run) by affecting the cost of capital of investors. As nominal rates are raised, textbook monetary models inform us, the investors witness an increase in his cost of capital and shelves investment plans leading to reduced aggregate demand. This mechanism, however, works only if the investing firm's cost of capital is strongly determined by policy rates operating through the financial system—banks as well as markets. As such a clearer understanding of the investment finance and firm financing reality of India is imperative to develop an understanding of the sensitivity of the firm investment on policy rate changes, in other words, the efficacy of the transmission mechanism.

Table 1 from Allen et al. (2012) reproduced below gives a sense of the relative importance of various sources of financing for the different types of firms in India. The time period of the study ends in 2005 but since this data comes from a research study rather than a regular publication, similar data for later periods are not available. However, the data reported in the more recent IFC study of the MSME sector (IFC 2012) that covers the entire MSME sector seem to suggest the situation has not changed significantly.

Notwithstanding the developments in the capital markets, they seem to fill only a small part of the direct investment financing in India. For the four categories of firms in their sample (LE-M, SME-M, LE-S, SME-S), Table 1 indicates the average proportion of funds obtained from different sources, namely:

- *Internal sources*: net income after dividends + depreciation + provisions or funds set aside,
- *External financing through markets and banks*: equity and debt raised from capital markets and debt/bank loans from financial institutions;
- *Alternative sources of external financing*: equity and debt raised from *private* sources including group companies and promoters or founders, trade credits, and other liabilities.

Table 1 first indicates that large Indian firms obtain about 37 % of their total funding from capital markets and financial institutions; for 13 % of their funding needs they rely on alternative sources of external financing, and the rest comes from internal sources.[1] For the SMEs, markets and banks are somewhat more important, providing for as much as 60 % of the total needs. However, though private and public equity together account for over 31 % of funds for the SME's, they conclude that the greater part, if not most of it, is private equity from friends, family, and business associates. In fact, the proportion of equity financing is not much less for unlisted SMEs (vast majority of SMEs) as compared to the listed SMEs. Trade credits constitute the third most important source of financing for SMEs. Coming in at over 15 % for all SMEs this is significantly larger than for any other category. By contrast, the listed SMEs have the least reliance on trade credits.

For large firms in both manufacturing and service sectors, the most important funding channel is internal finance, accounting for nearly 48 and 44 % of all funds, respectively. The second most important source of funds for large manufacturing firms is equity, accounting for about 16 and 20 % respectively of all funds, while debt raised from institutions accounts for over 16 and 18 % respectively. As noted above, the financing pattern for SMEs is strikingly different. Trade credit follows equity (including that from family and friends) and institutional credit as the third most important source of funds. On the other hand, as compared to large firms, internal sources constitute a far less important funding source for SMEs (except for the listed SMEs).

Overall, the results shown in Table 1 are largely consistent with the findings in the *Reserve Bank of India* (2005) based on financial reports of around 2,000 *public* companies; similar financing patterns of SMEs in the Prowess sample are also found in our own surveys of SME firms. The importance of alternative financing

[1]The numbers in the table are *flow* variables. For a given category of firms, the numbers reported in the table are obtained by first calculating the total *new* funds from each funding source during 2001–2004, expressed as percentage of the total funds from all sources during the same period.

sources for corporate sectors in India, such as trade credits, is confirmed in all the studies using different databases and methodologies.

The considerably greater importance of trade credits as a source of funds for smaller firms in India vis-à-vis larger firms stands in sharp contrast to the findings in developed countries. For example, Petersen and Rajan (1997) find that the ratios of accounts payable and accounts receivables to sales are significantly higher for large firms than for small businesses in the US. Since, trade credits are usually more costly than institutional credits, this may be interpreted as evidence that small Indian firms face bank credit constraints (following the same line of reasoning as Petersen and Rajan 1994). Lower levels of bank debt for small companies are consistent with this interpretation.

3.2 Developments in the Equity and Bond Markets

In its report in late 2008, when the Planning Commission's High Powered Committee on Financial Reforms chaired by Raghuram Rajan (Planning Commission 2009), categorized the levels of liquidity in various financial markets in India as depicted in Fig. 1. While Indian markets have seen a lot happening in the less than four years following that report, the basic liquidity levels have probably not changed drastically from that assessment.

Though financial markets in India cherish a long history in India they were completely revamped during the liberalization starting in the early 1990s. The dominant equity exchange, NSE, was established in 1994 and the regulator SEBI empowered in 1992. Trading in commodity forwards, halted in the mid-1960s, resumed and equity derivatives—that now account for a much greater trading

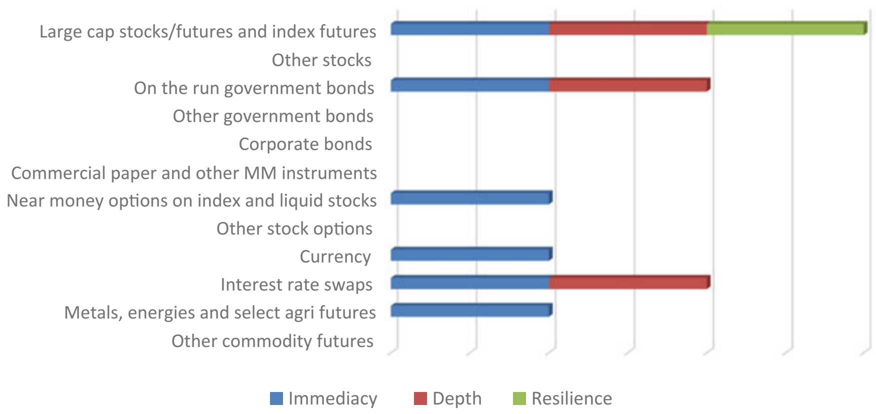

Fig. 1 Liquidity in various financial markets (*Source* based on planning commission 2009)

volume than equities themselves—made their appearance in 2001. Intermediary industries like mutual funds and insurance were opened up in the late 1990s and early 2000s and both sectors have exhibited unprecedented growth in the period that followed. Currency markets have also boomed with India's share of world currency transactions—itself a raising amount—growing ninefold between 2004 and 2011. Currency futures have been introduced in 2008 and more recently currency options have begun trading on exchanges as well.

As in many other countries, the financial markets arranged in terms of turnover in India would provide the following ordering—foreign exchange, money market, equity derivatives, equities, government securities, corporate debt. Together with a widening of the range of tradable assets, Indian markets have also witnessed a revolution of sorts in trading technology and transparency. T + 2 settlements meaning all trading being settled in two working days, standard in India now, is among the best in the world. Online brokerage accounts and dematerialized trading in equity shares have taken equity trading a long distance away from the dark days of BSE-dominated trading in the preliberalization period.

The first decade of the new century has witnessed explosive growth in the activity of collective investment industry and insurance industry, an important participant in markets. As the mutual funds industry gradually evolved from a government monopoly to a competitive industry with foreign participation, the assets under management have risen from less than Rs. 80,000 crores in March 2003 to over Rs. 5,92,000 crores in March 2011, a rise of well over seven times. Similarly, the insurance industry has grown at an annual rate exceeding 30 % for the life sector and close to 16 % for the nonlife sector between 2000 and 2010. Finally, foreign institutional investment (FII) flows, allowed since 1993, had reached a cumulative figure below Rs. 40,000 crores in March 2000. By November 2011, the cumulative figure exceeded Rs. 5,43,000 crores (more than thirteen times) despite significant pull-back during the global crisis as well as the Euro crisis.[2] Since March 2000, the Sensex value has risen roughly six times in a decade and a half – from slightly below 4,000 to above 26,000 albeit with significant gyrations during the period. On the whole then, the first few years of the current century have proved to be a period of explosive growth for Indian markets, notwithstanding global crises.

The exception to this across-the-board growth story has been the corporate bonds sector. Despite close top-level policy attention to this segment starting at least with the Patil Committee recommendations in 2005, number of listings as well as trading volume have remained stubbornly low in this area that is becoming particularly critical with the growing need of infrastructure financing. In the absence of corporate bonds, which should have been the natural instrument to finance long-term infrastructure projects, much of the funding has come from bank lending which implies significant asset-liability duration mismatch for banks (since bank liabilities are of much shorter maturity it leaves the banks more exposed to interest

[2]IRDA Annual Reports (various years).

risks on the asset side compared to the liability side). The reasons commonly cited for the poor performance of the sector include the charging of stamp duty, market microstructure issues as well as restrictions on financial institutions—the primary buyers of corporate bonds—to holding debt securities of only AAA ratings.

Despite close top-level policy attention to this segment, the number of listings and trading volumes have remained low. The bond market has stagnated repeatedly in the 3–4 % range. Despite considerable attention in the bond market development, the corporate bond market accounted for less than 4 % of the source of funds for large Indian companies. (Banerji et al. 2011). This is particularly problematic for infrastructure where long-term low-cost debt financing aligns well with the cash flows of the project (Chakrabarti 2014). In the absence of well functioning corporate debt markets, infrastructure projects have been hitherto financed substantially by the banking sector (and within that, majorly by public sector banks). However, given the liquidity transformation and maturity transformation that occurs when banks intermediate term and demand deposits to investments, they cannot make long-tenure loans even as concession period stretches to as long as 30 years. Furthermore, to the extent, there are any bond markets at all, secured bonds have dominated unsecured bonds regardless of the size of the borrower (Banerji et al. 2011). This suggests that the suppliers of debt capital lack the means to assess the borrower as such.

Indian bourses, the BSE and the NSE now figure in the top ten of the world's capital markets in terms of market capitalization but in terms of liquidity they still leave a lot to be desired. The NSE has a turnover velocity (annual turnover value divided by market capitalization) of just over 57 % while for BSE that boasts of maximum listed stocks anywhere in the world, the figure is merely 18 %. The Nasdaq by contrast has a turnover velocity of 340 %. It is fair to say that the lower 50 % of BSE stocks hardly see any movement. In terms of market participants, about half of all trading happens between roughly 450 participants, roughly a third of whom are proprietary traders. Trading has become more concentrated over the years and participation in equity markets ranges from 2–5 % of the population by various estimates—and 5–10 % if one adds the mutual fund investment. Such revelations—this was made in response to a question in Parliament—are often picked up by sections of the media as indicative of price-manipulation through cartelization and cheating of the common investor. Such concerns, however, are likely misplaced since advanced markets also exhibit similar traits (Chakrabarti 2010).

With market-capitalization over two-thirds of its GDP, India does not fare too poorly relative to other emerging markets, but it is dwarfed by the same ratio in developed economies like the United States (399 % of the GDP) and the United Kingdom (539 % of the GDP). (Chakrabarti 2014). Since the global financial crisis, the equity capital markets have suffered periodically from lethargy and significant-size initial public offerings ("IPO") have been few. This is likely because the IPO process in India is fairly time consuming. The timeline and the disclosures required of a company typically result in higher time and transaction costs on the Indian company. Transaction costs related to making primary market offerings is believed to be a key reason behind this (BCG 2012).

The lack of retail participation in the equity capital markets, either directly or through mutual funds is another area that demands attention. India has one of the largest domestic savings rate in the world. However, a recent SEBI-sponsored survey revealed that only 11 % of Indian households invest in the capital markets. This is compounded by geographical disparities. A total of 74 % of the assets under management (AUM) in the equity segment are concentrated in the top five cities. Lack of awareness is often revealed as the principal reasons for households not investing in capital markets (BCG 2012; Chakrabarti 2014).

Empirical research on the asset price channel in India has found asset price channel to be insignificant (Aleem 2010). Making the markets accessible for issuers and increasing the depth of capital markets by bringing in more retail investors will strengthen the asset price channel of monetary transmission by making more of the retail investor wealth “locked in” in the capital markets.

Concentrated shareholding (low free float) and trading in only few select stocks are likely to be the other reasons (Economic Times 2013). The relative lack of depth and low liquidity has first-order implications on the strength of monetary policy transmission through the financial markets. As discussed, development of financial markets has been found to result in stronger pass-through of monetary policy impulses through the interest rate channel (Singh et al. 2008).

3.3 Regulatory Changes

Regulatory regimes around the world can be characterized on two dimensions – rules versus principles in deciding on regulations and unified versus fragmented or sectoral in the structure of its regulators. The financial regulatory environment in India is heavily fragmented and exceedingly rule-based.

Before the recent shifting of the Forward Markets Commission into SEBI (proposed for long but done only in the aftermath of a crisis) as many as six different federal ministries were involved in regulating parts of the financial system. Among the apex regulators, RBI controls all banking and nonbank financial companies, currency related transactions as well as bond markets, while SEBI is in charge of exchanges and actors therein, and IRDA insurance. The current setup suffers heavily from regulatory gaps and overlaps and is, at times, marked with possibility of regulatory capture and arbitrage. Another crisis spurred by the ULIP controversy had the government constitute a Financial Stability and Development Council (FSDC) chaired by the Finance Minister to coordinate among apex regulators.

Changing technology and business models continue to blur the dividing line between banking and markets as well. A problem of the fragmented, silo-based regulatory system is the potential mismeasurement of overall risks associated with diversified financial conglomerates—the SBI and ICICI groups for instance—that span several segments of the financial sector from banking to insurance to capital markets. However, in the wake of the global financial crisis and the worldwide emphasis on monitoring large financial institutions, the RBI has started producing an annual Financial Stability Report that attempts to fill this void by taking a more comprehensive view of the financial sector.

Winds of change, however, are blowing in the Indian financial sector and very slowly but surely, the system and regulatory structure is being nudged to move into the opposite corner of the rules-versus-discretion and unified-versus-fragmented spectrums. An important step in that direction has been the recent Financial Sector Legislative Reforms Commission (FSLRC) revising the financial sector-related laws (see Box 1 for a brief summary of the FSLRC and its key recommendations). The implications of these changes for monetary policy are in the areas of financial stability as well as measures that enhance the efficient functioning of the financial system and uniformity of incentives across markets. It is likely that these measures will improve the quality of intermediation.

Box 1: The FSLRC-Roadmap for the future or an impossible dream?
The Financial Sector Legislative Reforms Commission ("**FSLRC**") was constituted by the Ministry of Finance in March 2011 under the chairmanship of Justice B.N. Srikrishna. The setting of the Commission was a result of a felt need that the legal and institutional structures of financial sector in India need to be recast in tune with the contemporary requirements of the sector.[3] The regulatory architecture governing the Indian financial system has hitherto evolved in a piece-meal fashion with law and policymakers creating the infrastructure responding to the need of the hour. Furthermore, the regulatory approach is "entity-based" with RBI regulating banks and nonbanks, SEBI regulating capital market intermediaries,[4] the IRDA[5] regulating insurance companies and the PFRDA[6] regulating pension funds. The unintended consequence of this "silo-based" approach is regulatory gaps, overlaps, and arbitrage.

Alive to these concerns that underlie the financial regulatory architecture, the FSLRC took a revolutionary approach and proposed several broad-based reforms impacting inter alia, consumer protection, microprudential regulation, monetary policy, legal microstructure and regulatory accountability, systemic risk and resolution of failed firms. Saliently, it proposed the following:

- A nonsectoral microprudential law/regulator that would ensure similar reasoning about risk is applied across the financial system.[7] At present, sectoral regulators also lay down the prudential guidelines for an entity.

[3]Report of the Financial Sector Legislative Reforms Commission, p. xiii.

[4]The Finance Act 2015, proposes a merger of SEBI and the Forward Market Commission ("FMC") that presently regulates commodities market.

[5]Insurance and Regulatory Development Authority, established under the Act of 1999.

[6]Pension Fund Regulatory Development Authority, established under the Act of 2013.

[7]Supra note 23, at p. xv.

This structure generates incentives for regulatory arbitrage as entities (conglomerates especially) have the incentive to push the riskiest business activities in the subsidiary that is required to hold lower capital per unit risk and giving rise to systemic risk as a corollary. A plenary microprudential regulator appears to be better suited as it can have access to the entire balance sheet of the entity. Further, a plenary (as against sectoral) regulator is also less suspect to regulatory capture.

- A shift of regulatory discourse from rule-based to the principles-based approach. Rules are specific in nature and their prescriptive nature renders clarity to the law *ex ante* (Kaplow 1992). At the same time, rule-based regulations suffer the risk of obsolescence on the flip side.[8] Since financial markets develop products and processes quickly, the specificity of law is a drawback and in effect means, the regulators are always chasing the market actors. The FSLRC's proposal of adopting a principles-based approach to legal microstructure is animated at reducing obsolescence. Furthermore, rule-based approach is susceptible to gaming by strategic actors that know the content of the law ex ante. Principles-based law is robust to gaming concerns. (Fon and Parisi 2007).
- A plenary judicial authority, the Financial Sector Appellate Authority ("**FSAT**") to supervise the regulators across the financial sectors and hold them accountable. As discussed above, to the extent regulators are risk-averse and impede development and innovation in financial markets through instruments like product-bans, establishment of FSAT should promote sectoral development and innovation.
- A formal Monetary Policy Committee ("**MPC**") to determine the policy interest rate[9] (that is the principal instrument of monetary policy action presently). The minutes of the MPC will be disclosed with a 3 week lag to the meeting. Regardless of the MPC, however, the head (Governor) of the central bank will be solely responsible for delivering on the monetary policy objectives and inflation targets the former has agreed to maintain with the central government.
- Separation of public debt management function from the RBI into an independent public debt agency. Management of public debt entails being the investment banker to the government and retain subscriptions to its debt securities, at the lowest yield available. As the RBI is also the central bank obligated to maintain monetary stability, the management of public debt creates a potential conflict of interest in that it may be incentivized to keep the interest rates low (to keep the yield down) when its obligations toward monetary stability dictate otherwise.

[8]Ibid.

[9]Supra note 23 at 106.

- Establishment of a Resolution Corporation to systematically wind up failed financial firms. At present, the RBI uses its powers under Banking Regulation Act to merge a failed bank into another bank (preferably a public sector bank) protecting all the depositors and unsecured creditors in the process. However, this policy appears susceptible to two criticisms; first, orchestrating such mergers induces moral hazard among the managers, shareholders, and other creditors and mitigates the incentive for imposing market discipline. Second, such mergers are likely to have anticompetitive implications in that the receiving bank increases in size relative to other banks in the geographies it operates and as such may attract depositors at a cheaper rate relative to other smaller banks. A Resolution Corporation essentially acts as a signal that banks and financial institutions may be allowed to fail consistent with free market principles and as such ex ante, subject its managers, shareholders, and external creditors to market discipline.

The FSLRC proposals, if implemented, would produce a very different, regulatory structure from what currently exists. They, especially the proposals to adopt principles-based regulation, establish FSAT, and establish the MPC and an independent public debt management agency will potentially catalyze financial market development and innovation and as such are likely to have attendant implications for monetary policy transmission.

4 Effects of Financial Developments on Monetary Transmission

The preceding section has only sketched a few of the persistent features and far-reaching changes that have marked the Indian financial system in the quarter century, since liberalization began. In the next few paragraphs, we speculate on the impact that these features and changes may have had and continue to have on the monetary transmission process. The mapping on individual steps in the financial reforms to the transmission system and its corollary effects on monetary policy design constitutes a much needed and intellectually fascinating research agenda. Unfortunately, it is also an extremely challenging project methodologically. It involves identifying and measuring the impact of individual measures of several near-simultaneous changes—a veritable econometric challenge in itself. To make things worse the impact occurs on a set of variables that become observable with any degree of statistical precision only over multiyear periods. Unsurprisingly, the supply of empirical papers investigating the connection has been scanty to nil.

In the absence of empirical documentation of effects of individual reforms to monetary transmission in India, a listing of broad trends and major features and a speculation of how they may have affected the transmission mechanism are the only (very poor) substitutes available to us.

As secular features it is clear that: (i) Indian financial markets have experienced significant deepening as the proportion of market capitalization to GDP has risen markedly over the years; (ii) derivatives have emerged as key elements of the financial system; (iii) the vulnerability of the exchange rate and the asset markets to the ebb and flow of international capital has increased and will continue to stay high; (iii) changes in financial regulatory architecture will progress steadily most likely moving toward a greater principles-based, unified regulatory structure. As these changes happen, the Indian financial system will, at least in the foreseeable future, continue to be marked by (i) a high degree (though decreasing) of informality and noninstitutional nature of small business funding; (ii) lack of liquidity in several key markets including the corporate bond market.

The expected effects of these changes and features are, of course, varied. Deepening of financial markets should obviously help to strengthen the transmission channel, but the question remains whether the deepening is an artifact of rising asset values in a market with participation of a minuscule fraction of the population —direct equity market participation for the Indian population is below 5 % and even after taking into account indirect participation through mutual funds, remains well below the 15 % mark. The rural–urban divide is extremely strong as well, with the 5 metros accounting for almost three-quarters of the entire asset under management for the mutual fund industry. This is why informality may very well sit with increasing deepening as asset price increases in the formal sector can co-exist with informality in the last mile for the majority of savers and businesses. The rise of derivatives, in general, is also a positive development for strengthening monetary transmission as derivatives help to complete markets and aid arbitrage, therefore possibly circumventing institutional delays or reluctance on the part of banks in transmitting policy rate changes to alterations in effective lending rates. There are, of course, the concomitant fears of derivatives leading to hyper leveraging and overconcentration of risks to a few entities with possible destabilizing effects of the financial system itself, but with the highly conservative regulatory stance of the Indian financial system as well as the post-global-financial-crisis institution of stability report, this risk seems to be a remote one. The extent to which the strengthening of transmission has actually been happening in India is something that only future research can say, however.

For a committee focused on financial legislation, the FSLRC has quite a bit to say on monetary policy matters including about the policy setting body itself. However, its impact on monetary transmission is likely to come from a far more indirect angle. Several of the existing problems and gaps in the financial system in India stem from regulatory gaps and overlaps as well as the application of "one-size-fits-all" regulation in a highly heterogonous financial system. The long-term effect of FSLRC implementation is believed to strengthen financial markets and integrate asset markets making it easier for new financial products to come into being and for credit markets to get more strongly connected with markets for traded securities. By strengthening markets and making them more efficient, the recommendations are likely to strengthen the transmission mechanism as well. The net effect is expected to give rise to a more competitive financial system with less room for individual decisions (as compared to now, for instance, for major banks).

5 Conclusion

This chapter has sought to provide a broad overview of the Indian financial markets and link it to the literature on monetary transmission from the point of view of conducting monetary policy efficiently. The quest is timely and critical as it is challenging. While the link between financial markets and monetary transmission is well recognized over the world, actual research work linking the two areas is thin in the context of emerging markets. The reason for this is not hard to find: it is extremely difficult, if not impossible, to isolate and identify the effect of individual financial sector changes on the monetary transmission process. Separating out the channels of the transmission process and measuring their relative strength is an econometric challenge in itself. To econometrically connect near simultaneous changes in the financial sector on these individual channels or even the overall transmission process is perhaps too much to ask for.

However, it is almost the silver jubilee of the beginning of liberalization in India and the financial sector, together with the external sector, has been the primary ground for reforms. In that sense, therefore, a parallel understanding of the progress and remaining challenges of financial reforms and the concomitant changes in the transmission process can still add to an understanding of the effects that may be of practical value to policymakers if not completely satisfactory for the discerning academic. This is what the chapter has attempted to do.

The picture that emerges from the foregoing discussion is that notwithstanding the very impressive progress made since liberalization began in 1991, Indian financial markets still have a distance to cover in becoming the dominant intermediary. India remains primarily a bank-based system and the liquidity and efficiency parameters of Indian markets as well as their inclusiveness are still away from reaching optimum levels. Banks have understandably hogged the limelight in monetary policy research and financial markets appear to have received scant attention.

Markets have come a long way since 1991 and yet have a long way to go to become the key mechanism to affect monetary policy as they do in some countries. As the opening quote from the RBI governor indicates, that is indeed a desirable state of affairs. The fact that the effectiveness of monetary policy today hinges on the willingness of banks to co-opt the policy thrust, instead of their hands being tied by efficient market forces is not the best situation from a monetary policy effectiveness point of view. However, that is exactly how things are going to stay unless both banking and markets become more competitive than they presently are.

Nevertheless change is afoot and policy action coupled with technological innovation is likely to bring considerable improvements in Indian markets in the short to medium run. Regulatory changes like those advocated by the FSLRC can bring about significant rise in market competition and efficiency and hopefully breathe life the country's anemic bond market. It stands to reason that such changes will likely add more muscle to the transmission process as well.

Acknowledgement The author would like to acknowledge excellent research assistance by Mandar Kagade on an earlier draft of this chapter and extremely valuable comments from the editors and an anonymous referee.

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State Intervention in Banking: The Relative Health of Indian Public Sector and Private Sector Banks

Viral Acharya and Krishnamurthy V. Subramanian

The health of Indian public sector banks has come under intense spotlight in recent times. In this chapter, we undertake a critical analysis of public sector banks by comparing them with new private sector banks. Our analysis raises several concerns about the health of Indian public sector banks and thereby the efficacy of the Indian banking system going forward. First, unless Indian public sector banks raise significant capital in the next 5 years, their balance sheets would have to shrink alarmingly for their capital to remain over the levels mandated by Basel 3 requirements. Second, Indian public sector banks pose significantly greater systemic risk to the Indian banking system when compared to private sector banks. The greater systemic risk of public sector banks affects their operating performance adversely, which in turn exacerbates their systemic risk. Finally, the higher vulnerability of public sector banks stems from the combination of significant distress combined with thin capital; and, asset growth funded with high leverage in the form of volatile wholesale liabilities.

Acharya is grateful to Michael Robles of V-LAB for help with NYU Stern Systemic Risk Rankings calculations for Indian financial firms. Krishnamurthy Subramanian would like to thank Venkatesh Ramamoorthy for excellent research assistance.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_7

1 Introduction

The blowup of United Bank of India and the subsequent resignation by its chairman, which is unprecedented in the history of public sector banks (PSBs), has turned the spotlight on the health of PSBs. Though the distress of the PSBs has aggravated significantly over the last couple of years, the inherent competitiveness of PSBs has been a cause of concern for some time now. Even when the PSBs were relatively healthier in 2008, the Rajan committee report had opined "those who argue that PSBs are in good health simply do not understand that they are condemning them to oblivion. Indeed, it seems to me that there are interest groups that want PSBs to remain the way they are only because they can continue to be a cash cow, to be milked dry" (*The Economic Times*, Feb 26, 2014, page 16). The key question that arises therefore in the context of the Indian banking sector is whether state intervention in banking has worked.

To study this question, in this chapter, we undertake a critical analysis of PSBs. As part of this exercise, we use private sector banks—especially the new private sector banks—to serve as a useful benchmark for comparison. To focus attention on the perilous state of Indian PSBs, we provide evidence based on a wide-ranging set of data that examine (1) the capital position of public sector banks vis-à-vis private sector banks, especially given the upcoming adoption of Basel 3 capital standards; (2) the systemic risk posed by PSBs vis-à-vis private sector banks and how this risk is related to their operating performance; and, finally, (3) their relative profitability.

We then discuss the likely causes relating to the divergent measures of capital, systemic risk, and profitability between PSBs and private sector banks, focusing on asset growth and funding risk from liabilities.

We conclude the chapter with some policy conclusions based on our analysis.

2 Capital Position of PSBs Vis-a-Vis Private Sector Banks

Transition arrangements to meet the capital adequacy norms stipulated by Basel 3 have been kick-started by the Reserve bank of India (RBI). Therefore, it is important to understand the current capital position of PSBs vis-a-vis the regulatory mandated levels. Table 1 shows the capital adequacy position of the public sector and private sector banks as on March 2014. As Table 2 shows, as at end-March 2014, RBI required a minimum Tier 1 capital as a proportion of risk assets of at least 6.5 % and requires a higher 7.0 % as at end-March 2015. As seen in column 1 of Table 1, as of March 2014, all PSBs were in compliance with the Tier 1 capital requirements. However, the capital position for PSBs is likely to be overstated because of the regulatory forbearance which RBI provides on restructured assets. Without forbearance these assets would be categorized as non-performing assets (NPAs), the restructuring being a response to likely imminent default. As a consequence, provisioning would rise and Tier 1 capital would fall. To examine the

Table 1 Capital position of public sector and private sector banks

Bank name	Tier 1 CAR	Impaired Tier 1 CAR (Scenario 1)	Impaired Tier 1 CAR (Scenario 2)	Impaired Tier 1 CAR (Scenario 3)
Public sector banks				
State Bank of India	9.72	4.09	7.36	9.10
Allahabad Bank	7.51	0.32	4.31	5.86
Andhra Bank	8.09	(0.10)	4.49	6.18
Bank of Baroda	9.28	4.72	7.87	8.90
Bank of India	7.24	3.79	5.70	6.52
Bank of Maharashtra	7.44	3.54	6.35	7.30
Canara Bank	7.68	2.46	5.63	6.44
Central Bank of India	7.37	(3.15)	2.73	4.57
Corporation Bank	8.14	0.90	5.02	6.32
Dena Bank	7.43	2.09	5.54	6.54
IDBI Bank Limited	7.79	4.05	6.40	7.36
Indian Bank	10.24	4.59	7.87	8.97
Indian Overseas Bank	7.47	1.86	4.87	6.10
Oriental Bank of Commerce	8.86	0.10	5.25	6.66
Punjab and Sind Bank	7.62	(0.29)	4.20	5.56
Punjab National Bank	8.87	2.00	6.16	7.64
Syndicate Bank	8.68	3.08	6.83	8.00
UCO Bank	8.71	2.71	6.87	8.44
Union Bank of India	7.54	2.66	5.55	6.71
United Bank of India	6.54	(1.46)	2.16	4.39
Vijaya Bank	8.12	4.14	6.69	7.57
Private sector banks				
Axis Bank	12.62	12.60	13.86	14.22
DCB Bank Limited	12.86	14.21	14.55	14.55
HDFC Bank	11.77	14.01	14.07	14.07
ICICI Bank	12.78	12.75	13.83	14.34
Indusind Bank	12.71	14.58	14.69	14.69
Kotak Mahindra Bank Ltd	17.77	19.48	19.56	19.88
Yes Bank Ltd	9.80	12.00	12.03	12.03

Table 2 Basel 3 capital requirements—transitional arrangements for Indian banks

Minimum capital ratios	31-Mar-14 (%)	31-Mar-15 (%)	31-Mar-16 (%)	31-Mar-17 (%)	31-Mar-18 (%)	31-Mar-19 (%)
Minimum common equity Tier 1 (CET1)	5.000	5.500	5.500	5.500	5.500	5.500
Capital conservation buffer (CCB)	–	–	0.625	1.250	1.875	2.500
Minimum CET1 + CCB	5.000	5.500	6.125	6.750	7.375	8.000
Minimum Tier 1 capital (Min. CET1 + Additional Tier 1)	6.500	7.000	7.000	7.000	7.000	7.000
Minimum total capital (Tier 1 + Tier 2)	9.000	9.000	9.000	9.000	9.000	9.000
Minimum total capital + CCB	9.000	9.000	9.625	10.250	10.875	11.500

Tier 1 capital ratios if the regulatory forbearance were not provided, we follow the methodology adopted by the P J Nayak committee on governance of bank boards and examine the impaired capital ratios under three different scenarios. These scenarios are as follows:

Scenario 1: No regulatory forbearance on restructured assets is available and a 70 % provision cover is required. This is an extremely prudent scenario.
Scenario 2: Regulatory forbearance is available in terms of RBI's present norms for restructured assets, together with the need to maintain a 70 % provision cover. Further, a 4.25 % provision cover is maintained for restructured assets. We also project in this scenario that 30 % of outstanding restructured assets would convert each year into NPAs. This scenario is less prudent than Scenario 1.
Scenario 3: Regulatory forbearance is available as before, and the provision cover is lowered to 50 %. As in Scenario 2, a 4.25 % provision cover is maintained for restructured assets and 30 % of restructured assets are projected to be converted into NPAs. This is a weaker discipline imposed on banks.

As Table 1 shows, in Scenario 1, the Tier 1 capital ratios of all PSBs would be significantly lower than the regulatory mandated levels of 6.5 % with four public sector banks (Andhra bank, Central bank of India, Punjab and Sind bank, United bank of India) becoming insolvent. In the less prudent scenario 2, 70 % (= 15 of the 21) of the public sector banks would have Tier 1 capital ratios that are lower than the regulatory mandated levels of 6.5 %. Even in the least prudent scenario 3, about 40 % (= 8 of the 21) of the public sector banks would have Tier 1 capital ratios that are lower than the regulatory mandated levels of 6.5 %. In contrast, all the private sector banks would have Tier 1 capital ratios that are significantly higher than the regulatory mandated levels of 6.5 % even in the most prudent Scenario 1.

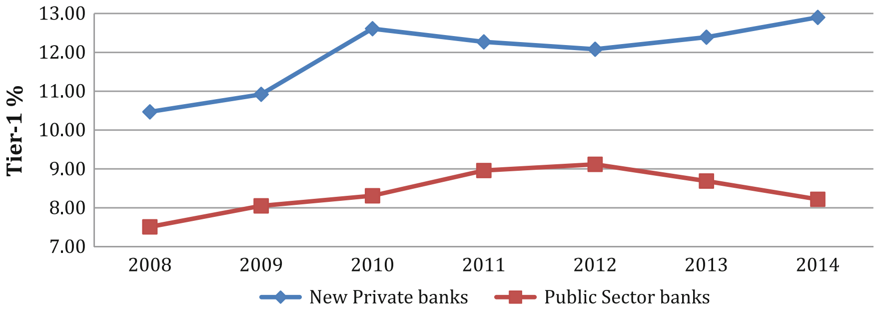

Fig. 1 Average Tier 1 capital ratios for public and new private sector banks

Figure 1 below shows that on an average, over the past 6 years, new private banks have 3.5 % points more Tier 1 capital than PSBs.

As Table 2 shows, the capital requirements mandated by Basel 3 ramp-up significantly in the forthcoming years with the minimum total capital plus the capital conservation buffer increasing from 9 % as of March 2014 to 11.5 % by March 2019. As we saw in Table 1, devoid of the cushion provided by regulatory forbearance, a significant number of PSBs are already weakly capitalized. Therefore, given the significant increase in regulatory capital requirements in the forthcoming years, it is quite useful to estimate the expected capital requirements for both PSBs and new private banks in the forthcoming years.

We estimate the capital requirements from March 2014–2019. For this purpose, we assume that the risk-weighted assets of banks to grow at a nominal growth rate of 16 %. Given the recent deterioration in the quality of assets, we assume that the ratio of gross NPAs to risk-weighted assets, the ratio of restructured assets to risk weighted assets, and the ratio of provisions to risk-weighted assets in the period up to March 2019 would equal their averages over the 1 year ended at March 2014. These growth rates are computed separately for PSBs and new private banks to reflect their distinct rate of growth. We also assume that the return on equity and the payout ratios would equal their historical averages estimated over the last 5 and 3 years, respectively. Further, we assume that 30 % of outstanding restructured assets would convert into NPAs every year. Finally, we provide for a 4.25 % for FY 2014–2015, and a 5 % cover for restructured assets thereafter. As seen in Table 3, the total capital required by PSBs equals Rs. 9,97,400 crores under the extremely prudent Scenario 1, Rs. 6,53,300 crores under the less prudent Scenario 2, and Rs. 5,12,300 crores under the least prudent Scenario 3. These amounts translate into 2.6, 1.7, and 1.3 times the aggregate market capitalizations of PSBs as of May 7, 2015.

A similar exercise conducted for the new private sector banks reveals that capital required equals Rs. 9,540 crores under Scenario 1, Rs. 4,980 crores under Scenario 2, and Rs. 1,350 crores under Scenario 3 (see Table 4). Clearly, the new private sector banks are much more comfortably capitalized, and the variance between the three scenarios is very low. Moreover, only two banks among the seven require capital

Table 3 Capital shortfall estimates of public sector banks

	Capital shortfall ('000 crores)			Capital shortfall as a multiple of total equity market capitalization (as of May 7, 2015)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Allahabad	28.3	18.4	14.4	5.0	3.3	2.5
Andhra	17.5	10.8	8.0	4.1	2.5	1.9
BoB	57.3	32.9	22.9	1.7	1.0	0.7
BoI	83.4	57.4	46.8	6.2	4.3	3.5
BoMH	21.8	15.5	13.0	5.7	4.1	3.4
Canara	78.0	53.7	43.8	4.6	3.2	2.6
CBoI	45.7	32.3	26.8	2.5	1.8	1.5
Corporation	21.3	13.5	10.3	4.6	2.9	2.2
Dena	18.2	12.1	9.7	6.7	4.5	3.6
IDBI	63.2	44.1	36.3	5.8	4.0	3.3
Indian	20.9	12.4	8.9	3.0	1.8	1.3
IOB	47.2	33.6	28.0	9.3	6.6	5.5
OBC	28.8	19.3	15.4	5.1	3.4	2.7
Punjab and Sind	13.5	9.4	7.7	7.1	4.9	4.0
PNB	59.9	34.4	24.0	2.1	1.2	0.8
SBI	264.2	166.8	126.9	1.3	0.8	0.6
Syndicate	23.4	14.8	11.3	3.6	2.3	1.7
UCO	22.2	14.1	10.8	3.5	2.2	1.7
Union	47.0	31.6	25.3	5.6	3.8	3.0
United	21.5	16.4	14.3	9.3	7.1	6.2
Vijaya	14.2	9.6	7.7	3.7	2.5	2.0
Total	997.4	653.3	512.3	2.6	1.7	1.3
Min	13.5	9.4	7.7	1.3	0.8	0.6
Max	264.2	166.8	126.9	9.3	7.1	6.2
Average	47.5	31.1	24.4	4.8	3.2	2.6

infusion while others are not required to raise capital for their capital adequacy under these scenarios.

In the light of the above scenario, the Government of India has explicitly stated that it would not be able to provide significant amounts to recapitalize the PSBs.[1] During post-budget interview in March 2015, the Secretary of Department of Financial Services in the Ministry of Finance stated that the Government cannot afford to invest in the equity of banks whose value is getting eroded and the amount of capital infused will be strictly rationed and subject to performance of banks. Also, the Government on its part will not take the dividends from banks which can

[1]http://www.livemint.com/Politics/QVSJN8z29MA4SJAYhjyOlO/Hasmukh-Adhia–Dividends-to-govt-will-be-returned-to-PSU-ba.html.

Table 4 Capital shortfall estimates of private sector banks

	Capital shortfall ('000 crores)			Capital shortfall as a multiple of total equity market capitalization (as of May 7, 2015)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Axis Bank	0.0	0.0	0.0	0.0	0.0	0.0
DCB Bank	0.5	0.4	0.4	0.1	0.1	0.1
HDFC Bank	0.0	0.0	0.0	0.0	0.0	0.0
ICICI Bank	9.0	4.6	1.0	0.1	0.0	0.0
Indusind Bank	0.0	0.0	0.0	0.0	0.0	0.0
Kotak Mahindra Bank	0.0	0.0	0.0	0.0	0.0	0.0
Yes Bank	0.0	0.0	0.0	0.0	0.0	0.0
Total	9.5	5.0	1.3	0.0	0.0	0.0
Min	0.0	0.0	0.0	0.0	0.0	0.0
Max	9.0	4.6	1.0	0.1	0.1	0.1
Average	1.4	0.7	0.2	0.0	0.0	0.0

be further utilized for internal capital infusion. So, the Government will decide the quantum of capital taking into account the dividends retained by the banks as it happened last year. In the next financial year 2015–2016, it plans to infuse Rs. 7,940 crores while Rs. 8,000 crores dividend will be retained by the banks.

Also, the Government is open to stake sale by PSBs, provided they retain 52 % ownership of PSBs. We use this scenario to observe how much capital will be raised by PSBs in case they went for stake sale with a threshold of 52 %. Table 5 below shows that the proceeds from the stake of PSBs may fetch only Rs. 42,000 crores.

This situation has to be viewed from the background of low valuations of PSBs in the market. Though they are supposed to have a minimum of industry average market valuation (in the form of market-to-book ratio) mainly due to their implicit sovereign guarantee, they are trading well below their counterparts in the market. This reflects poorly in their market capitalization which in turn does not help to raise capital from the market. As we can see from Fig. 2 below, over the past 10 years, the average market-to-book ratio of new private banks has been three times more than that of PSBs indicating their weak market position.

Reflecting the unattractiveness of PSBs to investors, State Bank of India—the bellwether for PSBs—could not raise the intended Rs. 9,600 crores via share sale to institutional investors in January 2014. It could raise only 80 % of that amount equating to Rs. 8,032 crores; even that 80 % transpired only because 41.3 % of the issue was bought by the state-owned Life Insurance Corporation of India as foreign investors largely stayed away from the offering. If investors' confidence in the State Bank of India is feeble, then their conference in other PSBs can only be fragile, which raises significant concerns about PSBs' ability to raise capital from the external markets.

Table 5 Maximum proceeds from stake sales of public sector banks

	Govt stake (%)	Mkt Cap (May 7) in '000 crores	Max stake sale (%)	Proceeds from stake sale based on mkt cap on May 7 in '000 crores
Allahabad Bank	58.9	5.7	6.9	0.4
Andhra Bank	60.1	4.3	8.1	0.3
Bank of Baroda	56.3	34.0	4.3	1.5
Bank of India	66.7	13.4	14.7	2.0
Bank of Maharashtra	85.2	3.8	33.2	1.3
Canara Bank	69.0	16.9	17.0	2.9
Central Bank of India	88.6	18.1	36.6	6.6
Corporation Bank	63.3	4.7	11.3	0.5
Dena Bank	58.0	2.7	6.0	0.2
IDBI	76.5	10.9	24.5	2.7
Indian Bank	81.5	6.9	29.5	2.0
Indian Overseas Bank	73.8	5.1	21.8	1.1
Oriental Bank of Commerce	59.1	5.7	7.1	0.4
Punjab National Bank	58.9	29.0	6.9	2.0
Punjab and Sind Bank	81.4	1.9	29.4	0.6
SBI	58.6	197.7	6.6	13.0
Syndicate Bank	67.4	6.5	15.4	1.0
UCO bank	77.2	6.3	25.2	1.6
Union Bank of India	60.1	8.4	8.1	0.7
United Bank of India	88.0	2.3	36.0	0.8
Vijaya Bank	74.1	3.8	22.1	0.8
Total				42.4

Indian banks have over the period of 2009–2014 raised equity of Rs. 61,734 crores, of which Life Insurance Corporation (LIC) has contributed significantly. As of September 2014, the average share of LIC in PSBs has been 9.60 % which is a marginal increase compared to that of 9.07 % in September 2013. The share of LIC (Life Insurance Corporation of India) ranges from a maximum of 22.54 % in Corporation bank to a minimum of State Bank of Mysore of 1.47 %. Thus, we can observe that due to lower valuations of PSBs and the subsequent underpricing, another public sector enterprise namely, the LIC has to bear the investments. Though it may appear to be a case of round-tripping of funds in an imprudent way,

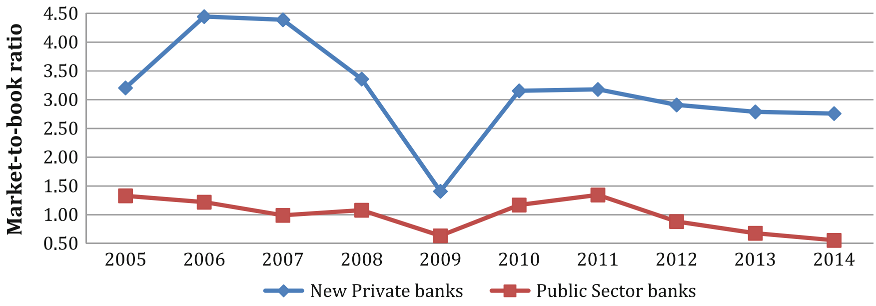

Fig. 2 Market-to-book ratios of public and new private sector banks

Table 6 Holding of LIC in PSBs (%)

Bank name	Sep-13	Sep-14
Corporation Bank	24.69	22.54
Indian Overseas Bank	8.91	14.23
United Bank	4.60	14.19
SBI	13.43	13.50
Bank of Maharashtra	7.82	13.41
Dena Bank	5.92	13.12
Bank of India	12.67	11.81
Punjab National Bank	13.15	11.78
Bank of Baroda	12.01	10.57
Punjab and Sind Bank	4.56	10.49
Central Bank	7.03	10.04
Allahabad Bank	10.76	9.94
Union Bank	10.85	8.78
Oriental Bank	10.61	8.22
Syndicate Bank	11.03	8.18
UCO Bank	10.20	7.91
IDBI Bank	8.63	7.00
Andhra Bank	7.98	6.74
Canara Bank	5.48	6.04
Vijaya Bank	12.09	6.00
Indian Bank	2.42	2.60
State Bank of Bikaner	2.22	2.02
State Bank of Mysore	1.47	1.47

it also leads to potential financial stability concerns in the market where a systemically important financial institution (LIC) holds substantial shares of major banks in the market. Table 6 below shows the shareholding of LIC in PSBs and their subsequent increase as of September 2014.

Table 7 Projected growth rates of risk-weighted assets of PSBs without any capital infusion

Projected growth rates of risk-weighted assets without any capital infusion			
	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)
Allahabad	−2.0	2.0	5.0
Andhra	0.0	5.0	7.0
BoB	2.0	7.0	9.0
Bol	−5.0	−1.0	1.0
BoMH	−9.0	−4.0	−2.0
Canara	−6.0	−1.0	1.0
CBol	−7.5	−3.0	−1.0
Corporation	−0.9	3.6	5.9
Dena	−3.4	1.0	3.2
IDBI	−6.6	−2.3	−0.2
Indian	1.4	6.0	8.3
IOB	−8.3	−4.2	−2.1
OBC	−3.6	0.8	3.0
Punjab & Sind	−6.2	−1.9	0.3
PNB	2.2	6.9	9.2
SBI	−0.7	3.8	6.1
Syndicate	−0.8	3.7	6.0
UCO	−1.0	3.5	5.8
Union	−3.9	0.5	2.7
United	−19.9	−16.3	−14.5
Vijaya	−4.4	0.0	2.2
Min	−19.9	−16.3	−14.5
Max	2.2	7.0	9.2
Average	−4.0	0.5	2.7

Now considering the above, wherein we do not expect capital infusion from Government and PSBs cannot raise capital in the market themselves, we predict a deceleration in their growth. PSBs may have to shrink their balance sheets in order to maintain their capital over the regulatory mandated levels by 2019 as stipulated by Reserve Bank of India. We estimate the growth rate of risk-weighted assets of PSBs in a scenario where there would not be any capital infusion. From Table 7 below, we can observe that the majority of PSBs may have to shrink their balance sheet in case of no external assistance in order to meet the minimum Tier 1 capital requirements by 2019.

3 Systemic Risks Faced by Indian Public Sector Banks

Market-based data can help to assess the preparedness of Indian banks to deal with future losses. At NYU Stern V-LAB (vlab.stern.nyu.edu/welcome/risk), the capital needs of banks in future stress conditions are estimated relative to a prudential requirement once stress losses are written down against bank equity. In particular, the V-LAB estimates use market data to assess the downside risk of banks and assess their "gearing" in a stress scenario by comparing their book liabilities to market value of equity after taking account of the downside market risk. The resulting measure of *expected capital shortfall* of each financial firm is called *SRISK* and it can be aggregated across financial firms in a country or types of banks to get an estimate of the aggregate or group-wide *SRISK,* respectively. We describe this measure in detail before using it to assess the systemic risks for Indian banks.

3.1 The Conceptualization and Implementation of Systemic Risk

Acharya (2009) and Acharya et al. (2010a, b, c) argue that systemic risk should not be described in terms of a financial firm's failure per se but in the context of a firm's overall contribution to system-wide failure. The intuition is that when *only* an individual financial firm gets distressed, i.e., its equity capital becomes low relative to its promised debt- or debt-like liabilities, there are minimal economic consequences because healthier financial firms can fill in for the failed firm's void in intermediation services. When capital is low in the aggregate, however, it is not possible for other financial firms to step into the breach. This breakdown in aggregate financial intermediation is the reason where there are severe consequences for the broader economy such as credit crunch and fire sales of assets.

Acharya et al. (2012) implement this intuition by proposing a measure of systemic risk contribution of a financial firm, called *SRISK* and measured as the expected capital shortfall of a firm in a crisis. In particular, *SRISK*, of firm *i* at time *t* is defined as the capital that the firm is expected to need (conditional on available information up to time *t-1*) to operate "normally", i.e., not face a "run" of its creditors, if we have another financial crisis. Symbolically it can be defined as

$$SRISK_{i,t} = E_{t-1}(Capital\ Shortfall_i | Crisis) \tag{1}$$

Brownlees and Engle (2011) (see also Engle 2011) provides the econometrics of estimating *SRISK* by modeling the bivariate daily time series model of equity returns on firm *i* and on a broad market index using publicly available data. To calculate *SRISK*, we first need to evaluate the losses that an equity holder would face if there is a future crisis. To do this, volatilities and correlations of individual financial firm's equity return and the global market-wide return are allowed to change over time and simulated for 6 months into the future many times. Whenever the broad index falls by 40 % over the next 6 months, a rather pessimistic scenario that captures the kind of market collapse witnessed during the Great Depression in 1930s and the Great Recession 2007-2009, this is viewed as a crisis. For these scenarios, the expected loss of equity value of firm *i* is called the Long Run Marginal Expected Shortfall or *LRMES*. This is just the average of the fractional returns of the firm's equity in the crisis scenarios.[2]

The capital shortfall can be directly calculated by recognizing that the book value of debt will be relatively unchanged during this 6-month period while equity values fall by *LRMES*. Assume a prudential capital ratio is considered to be *k* which we take as 8 % (and 5.5 % for Europe to adjust for the differences between the European IFRS and US GAAP accounting standards in the treatment of netting of derivatives). Then we can define *SRISK*, of firm *i* at time *t* as:

$$\begin{aligned} SRISK_{i,t} &= E_{t-1}((k(Debt + Equity) - Equity)|Crisis) \\ &= k(Debt_{i,t}) - (1-k)(1 - LRMES_{i,t})Equity_{i,t} \end{aligned} \tag{2}$$

where $Equity_{i,t}$ is the market value of equity today, $Debt_{i,t}$ is the notional value of nonequity liabilities today, and $LRMES_{i,t}$ is the long run marginal expected shortfall of equity return estimated using available information today. This measure of the expected capital shortfall captures many of the characteristics considered important for systemic risk such as size and leverage. These characteristics tend to increase a firm's capital shortfall when there are widespread losses in the financial sector. But a firm's expected capital shortfall also provides an important addition, most notably the *co-movement* of the financial firm's assets with the aggregate market in a crisis.[3]

Before we employ estimates of *SRISK* to provide a comparative analysis of the global financial sector health, few points are in order.

First, *SRISK* can be considered as the capital shortfall estimate for a financial firm based on a market-data-based "stress test." Stress tests have now become a standard device used by regulators to determine the capital that an institution will

[2]In versions of the model where the simulation is not yet implemented on V-LAB, LRMES is approximated as 1−exp(−18*MES) where MES is the 1-day loss expected if market returns are less than −2 %. MES in related to other standard measures of financial risk also reported on V-LAB, such as Corr, which is the correlation between a stock's return and the aggregate market, and VOL, which is the annualized volatility of a stock's return. Note that V-LAB also reports the Beta of a stock which is the %change in a stock's price for a %change in the aggregate market price; however, Beta is symmetric and does not give the %change in a stock's price for a downward movement in aggregate market.

[3]In this sense, SRISK is based on a notion of systemic risk in which a "tsunami"-type shock hits the global economy rather than a "contagion"-type shock in which an individual financial firm's interconnectedness causes losses elsewhere in the financial system. The latter would, however, also be statistically picked up in a co-movement of a financial firm's assets with the aggregate market providing that the contagion does have market-wide impact.

Fig. 3 SRISK for the Indian Financial Sector

need to raise if there is a macroeconomic shock.[4] Regulatory stress tests employ book value of equity capital, estimate losses using models that map macroeconomic stress into asset losses, and require book values of capital to be sufficiently high based on regulatory *risk-weighted assets*.[5] In contrast to regulatory stress tests, *SRISK* is based on the market value of equity capital, estimates losses using market-data-based estimate of downside risk of market equity or its vulnerability to a crisis, and requires market values of capital to be sufficiently high relative to *quasi-market value of assets* (measured as market value of equity plus the book value of nonequity liabilities). As a result, while the regulatory notion of leverage corresponds to risk-weighted assets divided by a measure of book value of equity of a financial firm, the notion of leverage captured in *SRISK* is *quasi-market leverage,* which is quasi-market value of assets divided by the market value of equity.

Second, as argued by Calomiris and Herring (2013) (see their Figs. 3 and 4, in particular), an important advantage of using the market value of equity and its exposure to a crisis or aggregate downturn is that market-based signals of financial

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[4]Acharya et al. (2014) summarize the adoption of stress tests by regulators in the United States and the Europe: "An annual supervisory stress test of the financial sector in the United States has become a requirement with the implementation of Dodd-Frank Wall Street Reform and Consumer Protection Act (Pub.L. 111–203, H.R. 4173) of 2010. Macroprudential stress tests have also been used by U.S. and European regulators to restore market confidence in financial sectors during an economic crisis. As a response to the recent financial crisis, the 2009 U.S. stress test led to a substantial recapitalization of the financial sector in the U.S. In Europe, the 2011 stress test also served as a crisis management tool during the European sovereign debt crisis. The European exercise lacked credibility in this role, however, due largely to the absence of a clear recapitalization plan for banks failing the stress test.".

[5]Again quoting Acharya et al. (2014): "The current approach to assessing capital requirements is strongly dependent on the regulatory capital ratios defined under Basel Accords. The capital ratio of a bank is usually defined as the ratio of a measure of its equity to a measure of its assets. A regulatory capital ratio usually employs book value of equity and risk-weighted assets, where individual asset holdings are multiplied by corresponding regulatory 'risk weights'. The regulatory capital ratios in stress tests help regulators determine which banks fail the test under the stress scenario and what supervisory or recapitalization actions should be undertaken to address this failure.".

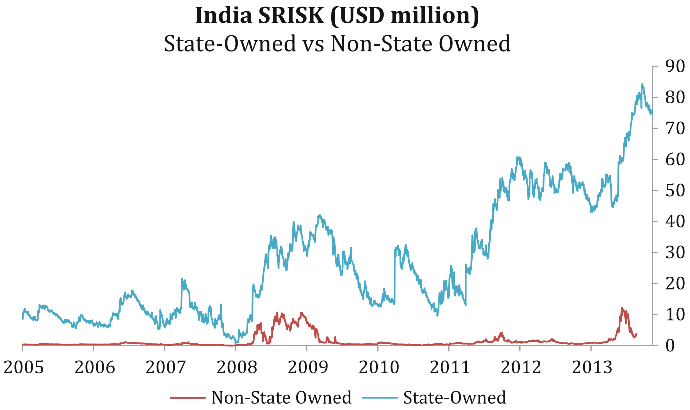

Fig. 4 SRISK for the Public Sector and Private Sector Indian Banks

sector distress have been found to be much better as early warning signals than regulatory measures of financial sector risk (risk-weighted assets to total assets) and book values of equity.

Third, and related to the second point, regulatory risk weights for asset classes are inherently static in nature whereas the true economic risk of asset classes fluctuates over time. Indeed, combined with shifts in financial leverage, the "change that risk will change" can be considered an essential cause of financial crises. Acharya et al. (2014) demonstrate that market-based risk assessments of financial firm balance sheets, in particular, using the *SRISK* measure and its components, captured better the actual stress of financial firms in Europe during 2011, relative to the regulatory risk assessments, which relied on static risk weights, notably zero risk weights for risky sovereign bonds of countries in the southern European periphery.

Fourth, since it is based on market data, one limitation of *SRISK* is that it can be computed only for financial firms whose equity is publicly traded. In other words, it cannot be computed readily for privately held financial firms. Hence, all assessment of global financial sector health and comparative analysis across countries that follows is subject to this important caveat.

Finally, given the simple formulaic structure for *SRISK*, we can also understand changes in *SRISK* over time as coming from changes in its components, the book value of nonequity liabilities, the market value of equity, and the market value of equity times the *LRMES*, as follows:

$$\begin{aligned}
\Delta SRISK_i &= SRISK_{i,t} - SRISK_{i,t-1} \\
&= \Delta Debt_i + \Delta Equity_i + \Delta Risk_i, \ \textit{where} \\
\Delta Debt_i &= k(Debt_{i,t} - Debt_{i,t-1}), \\
\Delta Equity_i &= -(1-k)(Equity_{i,t} - Equity_{i,t-1}), \ \textit{and} \\
\Delta Risk_i &= (1-k)(LRMES_{i,t}Equity_{i,t} - LRMES_{i,t-1}Equity_{i,t-1})
\end{aligned} \tag{3}$$

where the changes in *Debt, Equity,* and *Risk* are measured over the period from *t-1* to *t,* and together with the appropriate weights from the *SRISK* formula in (2), these changes combine to explain the change in *SRISK* over the period from *t-1* to *t.*

This decomposition highlights that increases in nonequity liabilities and expected losses in a crisis increase *SRISK* over time whereas increases in market value of equity decrease *SRISK* over time.

3.2 SRISK Measures for the Indian Financial Sector

V-LAB estimates of aggregate *SRISK* for the Indian financial sector are shown in Fig. 3. The estimates suggest that as of May 2015, in the event of a −40 % correction to the global market over a 6-month period (as seen in the Great Depression and the Great Recession), the Indian banking sector would require about $55 billion in market value of equity to maintain a 8 % capital ratio (of market equity to market equity plus book value of nonequity liabilities). As Fig. 3 also shows, the estimated *SRISK* was also around this level in the Fall of 2008 and 1Q of 2009, reaching a peak of over $90 billion following the Federal Reserve "taper" announcement in May 2013. Overall, the estimates highlight that the vulnerability of the Indian financial sector to a global downturn has increased since 2008–2009, even though it has reduced somewhat since its peak in 2013.

To put this number in perspective, let us benchmark it. The required capital need as of May 2015 would be over 3 % of India's current GDP and over 25 % of the market value of equity of these firms, the numbers in May 2013 being 6 % and 60 %, respectively. As another benchmark, the *SRISK* for China is about $300 billion, so 5 % of Chinese GDP, but only about 15 % of the market value of equity of the financial sector.

While a −40 % correction to the global market is arguably a rather stressed scenario, these numbers suggest that the Indian financial sector's capacity to recapitalize itself in future stress is worth a careful scrutiny.

Figure 4 shows how much of the *SRISK* for India comes from PSBs versus private banks. Not surprisingly, both have given their large share of Indian banking as well as poorer quality of assets, most of the Indian *SRISK* is composed of the capital needs of PSBs, close to $50 billion of the estimated total of $55 billion coming from these banks. Indeed, this has historically been the case too, though the share of private sector banks to overall *SRISK* rose somewhat during the "taper" episode.

What is further disturbing is the concentration of this capital need within the public sector banks. Table 8 shows that close to $40 billion of the estimated capital need as of May 2015 comes from ten large PSBs. In contrast, the four largest private sector banks (represented by the line at the bottom in Fig. 4) have negative SRISK of total of $45 billion, i.e., they are substantially capital surplus. Note that if the private sector banks were expected to be able to move in readily to acquire assets, branches, and franchises of PSBs, then it would be reasonable from an

Table 8 *SRISK, SRISK* ranking (RNK), and *SRISK% (SRISK* of a firm divided by total *SRISK* across positive *SRISK* firms) using bank by bank estimates for the Indian financial sector (other reported variables are explained in footnote 4), May 2015

Institution	SRISK %	RNK ▲	SRISK ($ m)	MES	Beta	Cor	Vol	Lvg
State Bank of India	13.85	1	8,095	2.06	0.81	0.22	32.8	12.01
Bank of India	10.84	2	6,334	2.18	0.86	0.16	52.0	47.32
Bank of Baroda	8.37	3	4,890	2.68	1.05	0.18	43.5	18.96
Canara Bank	7.28	4	4,257	2.21	0.87	0.14	40.4	27.94
Punjab National Bank	6.58	5	3,848	1.84	0.73	0.16	35.9	20.04
Union Bank of India	6.07	6	3,546	1.93	0.77	0.19	38.6	34.81
IDBI Bank Ltd	4.75	7	2,778	2.42	0.95	0.21	45.2	27.84
Indian Overseas Bank	4.66	8	2,726	1.83	0.72	0.17	34.1	50.05
Corp Bank	4.02	9	2,350	1.98	0.78	0.22	36.7	48.41
Syndicate Bank	3.92	10	2,292	2.18	0.88	0.21	40.7	32.48
UCO Bank	3.78	11	2,211	2.12	0.83	0.19	47.9	34.58
Allahabad Bank	3.49	12	2,041	2.05	0.80	0.18	38.3	35.69
Oriental Bank of Commerce	3.48	13	2,032	2.51	0.99	0.17	43.6	33.57
Andhra Bank	2.64	14	1,546	1.95	0.77	0.18	37.8	34.66
Indian Bank	2.35	15	1,373	1.87	0.75	0.18	33.3	22.90
Vijaya Bank	2.28	16	1,331	1.71	0.67	0.18	31.0	36.13
Bank of Maharashtra	2.24	17	1,307	2.04	0.80	0.20	35.6	34.08
Dena Bank	2.07	18	1,208	1.90	0.75	0.16	33.8	44.66
Punjab and Sind Bank	1.69	19	988	1.74	0.66	0.16	30.3	52.03
State Bank of Travancore	1.57	20	917	1.36	0.54	0.16	25.7	33.33
State Bank of Bikaner and Jaipur	1.13	21	658	1.58	0.62	0.18	30.9	23.05
State Bank of Mysore	1.09	22	637	1.68	0.66	0.21	30.9	31.90
Jammu & Kashmir Bank Ltd/The	0.57	23	333	1.34	0.54	0.15	30.2	15.14
South Indian Bank Ltd/The	0.51	24	295	1.62	0.64	0.18	30.4	16.70
Karnataka Bank Ltd/The	0.50	25	293	2.07	0.82	0.17	45.9	17.70
Dhanlaxmi Bank Ltd	0.19	26	112	1.79	0.71	0.16	54.4	23.67
Lakshmi Vilas Bank Ltd/The	0.09	27	51	1.52	0.60	0.17	31.1	12.01
Karur Vysya Bank Ltd/The	0.00	28	−45	1.16	0.46	0.11	23.5	9.69
DCB Bank Ltd	0.00	31	−213	2.24	0.87	0.24	36.3	4.17
Federal Bank Ltd	0.00	32	−392	1.91	0.75	0.20	34.7	6.60
City Union Bank Ltd	0.00	33	−436	1.08	0.42	0.13	32.7	4.79
Yes Bank Ltd	0.00	47	−2,130	2.48	0.97	0.20	35.3	3.75

(continued)

Table 8 (continued)

Institution	SRISK %	RNK ▲	SRISK ($ m)	MES	Beta	Cor	Vol	Lvg
IndusInd Bank Ltd	0.00	48	−3,209	2.47	1.01	0.23	33.2	2.74
ICICI Bank Ltd	0.00	49	−5,680	3.44	1.40	0.21	39.9	4.71
Axis Bank Ltd	0.00	50	−7,138	2.94	1.22	0.23	39.2	3.58
Kotak Mahindra Bank Ltd	0.00	51	−11,836	1.85	0.75	0.15	35.6	1.82
HDFC Bank Ltd	0.00	52	−17,293	2.37	0.94	0.31	25.5	3.16

economic standpoint to offset the positive SRISK of PSBs with the negative SRISK of private sector banks. However, the Indian PSBs were created during nationalization in the 1960s and 1970s as an act of law with the State bank of India Act and the Bank nationalization Act governing these entities. In other words, unlike other Indian corporations that are governed by the companies act, the PSBs remain outside the ambit of the companies act. As a result, acquisition of PSBs by private sector banks presents significant hurdles. Given these hurdles, mobility of assets, branches or franchises of PSBs remains a big question mark. Hence, the aggregate SRISK numbers for India shown in Figs. 3 and 4 only add up the positive SRISK estimates for Indian financial firms.

It is also interesting to ask the question how the *SRISK* of Indian banks has evolved over the past 5 years and what has contributed to this evolution (changes in liabilities, changes in market values of equity, or changes in downside risk, as explained formally above).

Table 9 provides such an evolution as well as its decomposition. As the figure shows, barring a few exceptions, the estimated capital needs have risen over the past 5 years for Indian PSBs, with the primary contributor to this rise being the increase in debt liabilities that have far outpaced any improvements in market value of equity (with downside risk having also risen in many cases). In contrast, for private sector banks, the estimated capital needs have substantially declined, with any growth in debt liabilities more than offset by the gains in market values of equity (with downside risk having declined in most cases).

Overall, the V-LAB estimates of capital needs of Indian banking sector in case of aggregate stress suggest that the Indian PSBs are substantially undercapitalized relative to private sector banks, and the gap has widened substantially too over the recent past. This is consistent with the other estimates we have shown so far based on calculations for estimated capital needs to meet Basel III norms. The rest of the chapter explores the various reasons that have contributed to this rising gap with the goal of understanding possible remedies.

Table 9 Changes in *SRISK* estimates bank by bank for the Indian financial sector (other reported variables are explained in Eq. (3) in the Appendix), between May 2010 (t-1) and May 2015 (t)

Institution	SRISK (t) ▼	SRISK (t-1)	Δ SRISK	Δ(DEBT)	Δ(EQUITY)	Δ(RISK)
State Bank of India	8,094.5	2,713.2	5,381.4	4,749.9	−14.6	646.1
Bank of India	6,333.8	2,049.6	4,284.2	2,944.3	1,474.3	−134.3
Bank of Baroda	4,889.5	1,398.0	3,491.5	3,310.4	31.4	149.7
Canara Bank	4,257.5	2,132.6	2,124.8	1,494.5	725.2	−94.9
Punjab National Bank	3,848.4	−153.4	4,001.8	1,729.2	2,000.5	272.1
Union Bank of India	3,546.4	−500.7	4,047.1	2,875.1	1,178.5	−6.5
IDBI Bank Ltd	2,777.9	2,821.6	−43.8	−174.6	158.4	−27.6
Indian Overseas Bank	2,726.1	1,521.6	1,204.5	1,080.0	212.4	−87.8
Corp Bank	2,350.3	767.7	1,582.6	946.5	647.1	−11.0
Syndicate Bank	2,291.8	1,679.2	612.5	667.3	−69.2	14.5
UCO Bank	2,211.2	1,794.8	416.4	534.9	−138.9	20.4
Allahabad Bank	2,041.2	1,010.3	1,030.9	601.1	443.4	−13.6
Oriental Bank of Commerce	2,032.4	980.5	1,051.9	322.5	617.8	111.6
Andhra Bank	1,545.9	665.8	880.1	506.1	430.2	−56.2
Indian Bank	1,372.7	474.1	898.7	539.5	557.2	−198.1
Vijaya Bank	1,330.7	179.0	1,151.8	1,243.8	−64.7	−27.4
Bank of Maharashtra	1,307.4	877.0	430.3	508.7	−71.5	−6.8
Dena Bank	1,207.7	617.4	590.2	506.8	95.1	−11.6
State Bank of Travancore	917.1	517.7	399.4	263.1	162.4	−26.1
State Bank of Bikaner & Jaipur	658.4	530.1	128.3	163.3	−45.2	10.2
State Bank of Mysore	636.6	386.4	250.2	117.2	127.3	5.8
Jammu and Kashmir Bank Ltd/The	333.3	163.9	169.3	220.2	6.7	−57.6
South Indian Bank Ltd/The	295.3	138.2	157.1	225.0	−49.9	−18.0
Karnataka Bank Ltd/The	293.1	174.5	118.6	109.1	−0.5	10.0
Dhanlaxmi Bank Ltd	111.6	−29.7	141.3	40.3	87.7	13.4
Lakshmi Vilas Bank Ltd/The	50.7	53.9	−3.2	73.9	−68.0	−9.1
Karur Vysya Bank Ltd/The	−44.8	−53.3	8.5	249.5	−208.5	−32.5
DCB Bank Ltd	−212.6	−13.4	−199.3	50.6	−225.6	−24.3
Federal Bank Ltd	−391.8	−64.7	−327.1	165.4	−524.3	31.8
City Union Bank Ltd	−436.2	−39.0	−397.2	100.1	−497.4	0.1
Yes Bank Ltd	−2,129.7	−601.7	−1,528.0	678.3	−2,035.7	−170.6
IndusInd Bank Ltd	−3,208.8	−586.5	−2,622.3	400.4	−3,304.4	281.7
ICICI Bank Ltd	−5,680.3	−5,051.7	−628.5	726.1	−2,429.0	1,074.4
Axis Bank Ltd	−7,138.3	−2,984.4	−4,154.0	1,458.4	−5,077.5	−534.9
Kotak Mahindra Bank Ltd	−11,835.7	−2,662.8	−9,172.9	466.7	−8,922.1	−717.5
HDFC Bank Ltd	−17,293.1	−7,365.9	−9,927.2	3,399.9	−11,187.8	−2,139.4

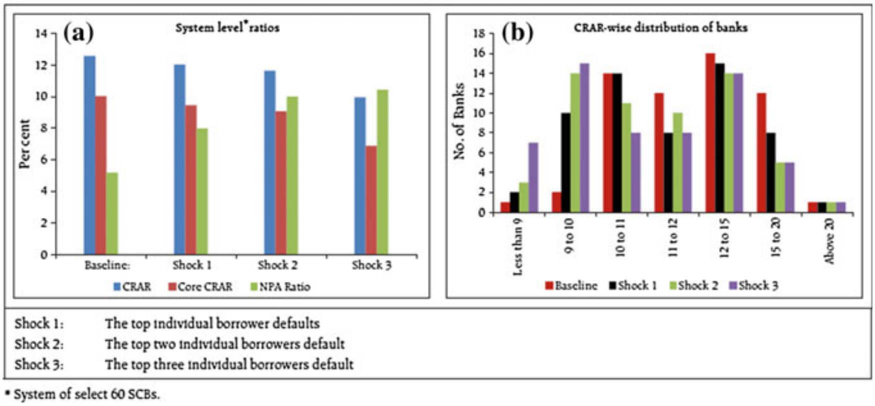

Fig. 5 Credit concentration risk: Individual borrowers

3.3 *Credit Concentration of Indian Banks*

Another kind of systemic risk that affects the banking industry is the credit concentration risk. Credit concentration risk is exacerbated when banks are exposed to a few borrowers with huge exposures. When such a borrower defaults, banks run the risk of significant capital erosion due to their high exposures to them. RBI conducts biannual stress tests on the banking system based on their credit concentration in their Financial Stability Report (2015). For the data as of September 2015 obtained from this report, three stress scenarios were assumed with top one, two, and three individual borrowers defaulting, respectively, in each case. As shown in Fig. 5, inferences from the financial stability report suggest that of the select sixty scheduled commercial banks, seven banks fail to maintain the mandated 9 % CRAR (capital to risk-weighted assets ratio) under these three stress scenarios. Also, at the level of the banking system, the impact on CRAR for the above three scenarios are 54, 94, and 262 basis points. Similarly, there will be a loss of 41, 71, and 112 % on profit before tax for the three scenarios on the banking system as a whole.

With the impact of group borrowers being high on the banking system, the financial stability report also considered different scenarios of default by group borrowers. As Table 10 suggests, 27 banks fail to maintain 9 % CRAR when top ten group borrowers default.

Apart from borrower level credit concentration, the financial stability report also looks at sectorwise credit concentration that can give rise to stress scenarios. The report considered the industrial sector as it constituted a large portion of advances in the banking system. Various stress scenarios such as increase in the share of restructured advances and NPAs were considered. As Table 11 demonstrates, the results of the analysis revealed that Iron and steel sector, the micro, small and

Table 10 Credit concentration risk: Group borrowers

Shocks		System level				Bank level	
		CRAR	Core CRAR	NPA ratio	Losses as % of capital	Impacted banks (CRAR < 9 %)	
Baseline case		12.6	10.0	5.2	–	No. of banks	% share in total assets of banking system
Shock 1	Top 1 group borrower defaults	11.9	9.3	8.6	6	1	0.1
Shock 2	Top 2 group borrowers defaults	11.4	8.8	11.1	10	5	4.8
Shock 3	Top 3 group borrowers defaults	11.1	8.4	13.0	14	8	10.4
Shock 4	Top 4 group borrowers defaults	10.7	8.1	14.7	17	13	16.9
Shock 5	Top 5 group borrowers defaults	10.4	7.8	16.2	19	15	34.2
Shock 6	Top 6 group borrowers defaults	10.1	7.5	17.6	22	20	43.3
Shock 7	Top 7 group borrowers defaults	9.9	7.2	18.9	24	22	46.2
Shock 8	Top 8 group borrowers defaults	9.6	7.0	20.1	26	26	50.7
Shock 9	Top 9 group borrowers defaults	9.4	6.7	21.3	28	26	50.7
Shock 10	Top 10 group borrowers defaults	9.1	6.5	22.4	30	27	52.0

medium enterprises sector, and the textile sector pose the greatest credit concentration risks to the banking system.

Another important segment for concentrated lending is the infrastructure sector, which accounts for almost 16 % of all the advances in the banking system. Among them, as Table 12 shows, power and transport segments have the most impact accounting for almost 50 % loss in profit at the banking system level in the worst case scenario.

Table 11 Sectoral profile: Industry

Sector	Industry	(a) of which: MSME	(b) of which: Textile	(c) of which: Iron and steel
Share in total advances	40.78	7.91	3.18	4.67
Share in restructured standard assets	82.42	4.74	6.18	14.01
Share in total NPAs	54.05	9.32	7.05	6.88
Sectoral restructured standard advances ratio	13.20	3.92	12.67	19.58
Banking system's restructured standard advances ratio	6.53	6.53	6.53	6.53

Table 12 Sectoral profile: Infrastructure

Sector	Infrastructure	(a) of which: power	(b) of which: transport	(c) of which: telecom
Share in total advances	15.49	9.24	3.24	1.54
Share in restructured standard assets	45.66	29.31	14.64	1.71
Share in total NPAs	12.69	4.99	3.78	1.76
Sectoral restructured standard advances ratio	19.25	20.71	29.50	7.24
Banking system's restructured standard advances ratio	6.53	6.53	6.53	6.53

Credit concentration risk can prove to be potentially debilitating to the banking system when considered in the context of the weak position of PSBs as explained in Sect. 2 earlier. Therefore, we now examine the impact of systemic risk of banks on their performance measures and vice versa.

4 Systemic Risk and Performance—an Empirical Analysis

Compared to the studies on the origin, impact and mitigation of systemic risk, its impact on bank performance and vice versa remains largely unexplored. Though market-based measures have been widely employed as leading indicators of systemic risk, accounting measures have been largely neglected. However, taken in entirety, we believe these measures can provide some valuable inputs in the run up to their contribution toward systemic risk.

For this purpose, we use the daily values of the ratio of SRISK to market capitalization for each bank and average the same over each quarter to analyze its effect on bank performance as proxied using accounting measures such as earnings per share, NPA ratios, net interest margin, return-on-assets, and provisions coverage ratio. We undertake regressions of the following form:

$$Performance_{it} = \alpha_0 + \beta_1 * (SRISK/MCap)_{it-1} + \beta_2 * Public_i * SRISK_{it-1} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{4}$$

where $(SRISK/MCap)_{it-1}$ denotes the ratio of SRISK to market capitalization for bank i average over quarter t-1, $Public_i$ also denotes a dummy to capture the bank i is a PSB or not introduce a dummy and the interaction term captures the differential impact of systemic risk on the performance of PSBs vis-a-vis the private sector banks:

$$\beta_2 = \left| \frac{\partial Performance}{\partial (SRISK/MCap)} \right|_{Public\ Sector\ Banks} - \left| \frac{\partial Performance}{\partial (SRISK/MCap)} \right|_{Private\ Sector\ Banks} \tag{5}$$

α_i and α_t denote bank and your fixed effects, respectively. The bank fixed effects enable us to control the effects of any observed or unobserved factors that affect bank performance on average. In contrast, the year fixed effects control for average effects observed across all the banks in a particular year. Therefore, the year fixed effects enable us to control for any secular time trends that may influence the correlation between SRISK and bank performance.

Table 13 presents the results of the above analysis, where we use quarterly ratios of 39 Indian banks from 2000–2015. Given the bank fixed effects employed in these regressions, the coefficient for the PSB dummy is not identified separately from the

Table 13 Multivariate analysis of the difference between public sector and private sector banks in the impact of performance on systemic risk using SRISK as the dependent variable

Performance measure as the independent variable	Public sector bank dummy interacted with lagged performance measure	Public sector bank dummy	Lagged performance measure	Number of observations	R-squared	Bank fixed effects and year fixed effects
EPS	**0.030*****	1.395***	−0.048***	1,618	0.783	Yes
Return on Assets	**9.032**	1.387***	−26.025***	1,618	0.783	Yes
Net Interest Margin	**15.494*****	1.274***	−13.061***	1,618	0.783	Yes
Provisions coverage ratio	**0.607*****	1.301***	−0.356***	1,618	0.780	Yes
Gross NPA	**−3.200**	1.677***	−0.568	1,618	0.778	Yes
Net NPA	**0.240**	1.528***	0.614	1,618	0.777	Yes

coefficients on the fixed effects. Therefore, we use the coefficients of these bank fixed effects to estimate the average for the PSBs and the average for the private sector banks. The coefficient of the PSB dummy thus reports the difference between these two averages.

The correlation of the lagged performance measure with systemic risk is along expected lines for each of the performance measure. On average, for the Indian financial system, systemic risk appears to be lower for a bank with higher EPS, high return-on-assets, high net interest margin, high provisions coverage ratio.

Crucially, however, there are two important findings in the context of PSBs. First, the systemic risk of PSBs is systematically higher than that of the private sector banks as seen in the positive and statistically significant coefficient for the PSB dummy. Economically, the PSBs face SRISK that is greater than that for the private sector banks by about 1.2–1.7 times their market capitalization.

Second, the correlation of live performance measures with systemic risk seems to be significantly higher for the PSBs than for the private sector banks as seen in the positive and statistically significant coefficients for the interaction of the PSB dummy with EPS, net interest margin, and the provisions to coverage ratio.

We now examine how systemic risk contributes to bank performance and how this effect varies between PSBs and private sector banks. For this purpose, we undertake regressions of the following form:

$$(SRISK/MCap)_{it} = \alpha_0 + \beta_1 {*} Performance_{it-1} + \beta_2 {*} Public_i {*} Performance_{it-1} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{6}$$

where $(SRISK/MCap)_{it-1}$ denotes the ratio of SRISK to market capitalization for bank i average over quarter t-1, $Public_i$ also denotes a dummy to capture the bank i is a PSB or not introduce a dummy and the interaction term captures the differential impact of systemic risk on the performance of PSBs vis-a-vis the private sector banks:

$$\beta_2 = \left|\frac{\partial(SRISK/MCap)}{\partial Performance}\right|_{Public\ Sector\ Banks} - \left|\frac{\partial(SRISK/MCap)}{\partial Performance}\right|_{Private\ Sector\ Banks} \tag{7}$$

α_i and α_t denote bank and your fixed effects, respectively. The bank fixed effects enable us to control for the effects of any observed or unobserved factors that affect bank performance on average. In contrast, the year fixed effects control for average effects observed across all the banks in a particular year. Therefore, the year fixed effects enable us to control for any secular time trends that may influence the correlation between bank performance and SRISK.

From Table 14, we observe that for the Indian banking system as a whole systemic risk correlates negatively with return-on-assets and gross NPA as seen in the negative and statistically significant coefficients of these variables. Crucially, however, we note that PSBs have systematically lower return-on-assets, low provision coverage ratio, higher gross NPA, and higher net NPA as seen in the statistically significant coefficients for these variables.

Table 14 Multivariate analysis for the difference between public sector and private sector banks in the Impact of systemic risk on bank performance using various performance measures as the dependent variables and SRISK and its interaction with the dummy for public sector banks as the primary explanatory variables

Performance measure as the dependent variable	Public sector bank dummy interacted with lagged SRISK-to-Marketcap	Public sector bank dummy	Lagged SRISK-to-Marketcap	Number of observations	R-squared	Bank fixed effects and year fixed effects
EPS	**−1.471*****	1.815	0.256	1,618	0.486	Yes
Return-on-assets	**0.0001***	−0.003**	−0.001***	1,618	0.473	Yes
Net interest margin	**0.0001**	0.001	−0.000	1,618	0.715	Yes
Provision coverage ratio	**0.007**	−0.076*	−0.006	1,618	0.728	Yes
Gross NPA	**0.004*****	0.033***	−0.003***	1,618	0.483	Yes
Net NPA	**0.001****	0.013***	0.000	1,618	0.399	Yes

Most importantly though, we note that higher systematic risk lowers the earnings per share ratios of PSBs disproportionately more than that of the private sector banks. As well, higher systematic risk of the PSBs manifests in disproportionately higher gross NPA for the PSBs than for the private sector banks. Thus, the analysis presented in Table 14 suggests that the higher systematic risk of PSBs affects their performance disproportionately more than that of the private sector banks.

Note that the analysis in Tables 13 and 14 cannot be undertaken in the vector auto regression (VAR) framework. Our objective has been to examine in Table 13 the effect of each of the performance variables—return-on-assets, net interest margin, gross NPA, net NPA, etc.—on systematic risk and in Table 14 the effect of systemic risk on performance. In contrast, in a VAR framework, we would simultaneously explain each variable using all the other variables in a lead–lag setup, which is not our objective.

5 Profitability

Profitability is another parameter which must be studied in order to study the health of an organization. If PSBs are in a bad shape leading to their weak capital position, then their profitability cannot be far behind. However, in order to confirm our judgment, we observe the profitability measures of PSBs vis-à-vis new private banks.

We examine the performance of the banking sector over the past decades by plotting the average return-on-assets for the two categories of banks during the period of 2005–2014. A couple of inferences stand out when one observes Fig. 6 below.

First, since 2007, a scissor-like movement is observed in the return-on-assets of the new private sector banks when compared to the PSBs. In particular, while the return-on-assets for the PSBs other than the State Bank group had remained almost constant at 0.9 % from 2008–2011, since 2011, the return-on-assets has fallen drastically to 0.4 % as of FY March 2014. Also, the State Bank groups' return-on-assets has been experiencing decline since 2009. The new private sector

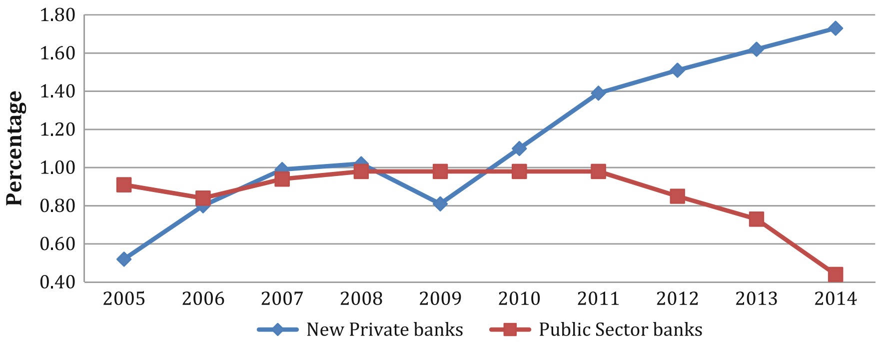

Fig. 6 Return-on-assets of public and new private sector banks

banks on the other hand, have managed to maintain a high return-on-assets consistently since 2007 with the exception in 2009 (due to DCB bank). Moreover, the gap between the new private sector banks and the PSBs has been widening since 2007 with the difference being approximately 1.30 % points as of March 2014. Moreover, while return-on-assets for old private sector banks has been varying as it has been higher than their public sector counterparts since 2008.

Second, there has been a secular decline in the return-on-assets across all bank categories in December 2013 when compared to March 2013. This suggests that the slowing down of the economy is starting to affect the profitability of banks across all categories. In fact the inflection point in the return-on-assets starting in March 2013 suggests that the decline in profitability across all bank categories may continue into the near future. Because the profitability of PSBs is in general low, this declining trend is likely to create significantly more distress in the PSBs than in their private sector counterparts. During the same period, however, new private banks register an increase displaying a positive deviation from the macroeconomic conditions.

As our second measure of profitability, we examine the net interest margin for the various categories of banks (see Fig. 7). Three inferences are noteworthy in this context. First, we notice that the difference in the net interest margin between the new private sector banks and the other PSBs is significant. Moreover, this difference has been widening since 2008. As of March 2014, the gap in the net interest margin of the new private sector banks vis-à-vis the other PSBs is significant differing by 1 % point. Second, while the State Bank group has experienced a decline in the net interest margin since 2011 (from an average of 2.95–2.73 % in 2014), it has performed better than other PSBs whose average net interest margin has slumped from 2.74 % in 2011 to 2.33 % in 2014. Third, the net interest margin for the other PSBs has also been falling since March 2011, which again brings into the spotlight the distress in other PSBs.

As our third measure of the performance of the Indian banking sector, we examine the market-to-book ratios of banks. We contrast the market-to-book ratios of the PSBs with those of the private sector banks. Here again, we notice that the

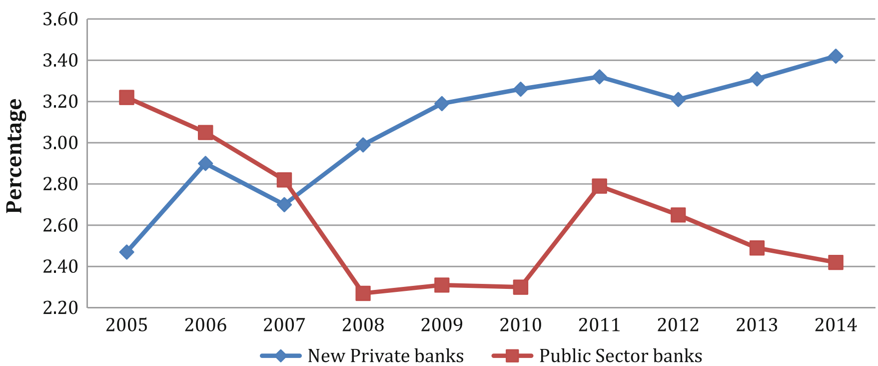

Fig. 7 Net interest margins of public and new private sector banks

market-to-book ratios of the private sector banks are substantially greater than that of the PSBs. As of March 2014 while the average market-to-book ratio of the new private sector banks equals 2.76, the average market-to-book ratio of the PSBs equals 0.56. Since stock market values factor in future profitability as well as current profitability, the significantly lower market-to-book ratios for the PSBs indicates the bleak view of the PSBs in the eyes of the stock market participants. All these measures further buttress the claim that PSBs have been underperforming and are creating less value than private banks. Importantly, the lower market-to-book of these PSBs would also affect detrimentally the PSBs ability to raise capital in the equity markets, accentuated by low probability of Government capital infusion (discussed above in Sect. 2, Fig. 2).

Overall, PSBs low and declining return-on-assets, low and declining net interest margin, low productivity is reflected in the significantly lower market-to-book ratio. Taken together, it is hard to escape the conclusion that PSBs remain a drain on taxpayers' resources apart from being highly susceptible to future shocks.

The majority owner of PSBs, the Government is also not benefitting from them as evident from Fig. 8. After being constant at around 18 % from 2008–2011, the average return on equity has fallen to approximately 7 % in 2014. At the same time, the private banks have recovered from the fall in 2009 at 10 % to a healthy average of 17 % in 2014. The major reason for the fall for PSBs are the Nationalized banks whose return on equity has fallen from 18 % in 2010 to 6 % in 2014 with SBI group faring better at an average of 9.67 % in 2014. Thus, PSBs create a dent on the Government's fiscal prudence and deny opportunity for other profitable investment options with its low returns.

Most of the ills of the PSBs can be singularly traced back to its asset quality, as they are forced to lend at nonoptimal conditions for various nonviable private projects, welfare schemes, and also to other public enterprises. Figures 9 and 10 below shows that PSBs and new private banks started off from the same position in 2005 with a declining trend while after the crisis, new private banks have strengthened their credit portfolio and reduced NPAs, while PSBs have showed a

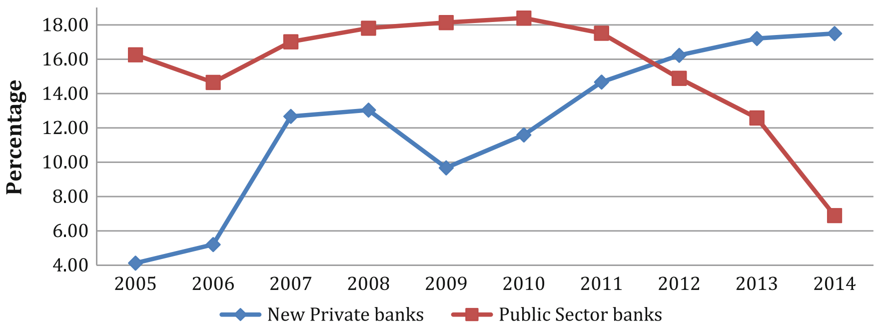

Fig. 8 Return on equity of public and new private sector banks

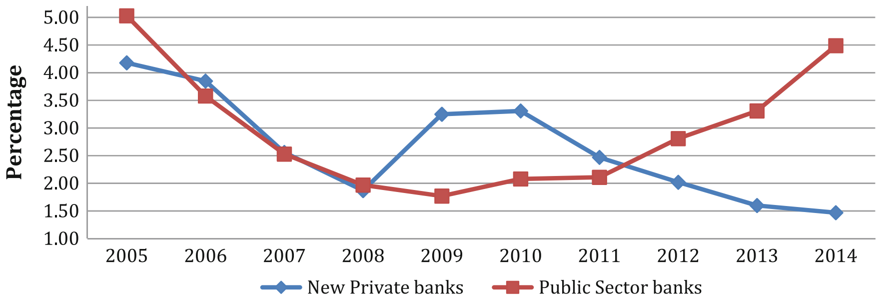

Fig. 9 Gross NPA ratios of public and new private sector banks

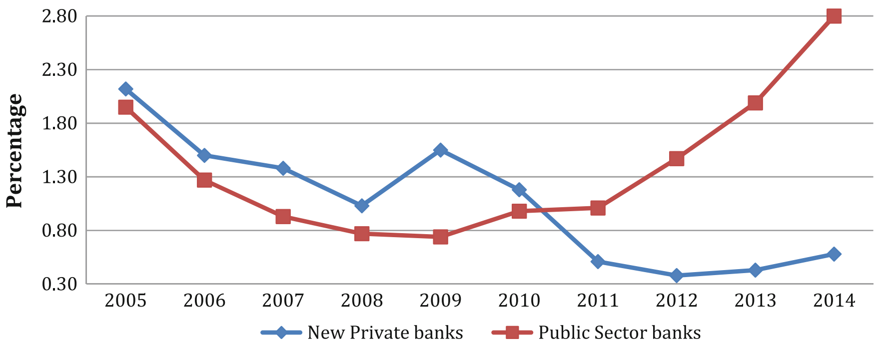

Fig. 10 Net NPA ratios of public and new private sector banks

huge increase in NPAs (Non-Performing Assets). It clearly shows that PSBs have no control over their NPAs in spite of the growing Gross NPA ratio from 2009–2014 (from an average of 1.77–4.49 %). SBI group on the other hand too had not fared well with its Gross NPA ratio soaring from a modest 2.56 % in 2009 to 4.96 % in 2014. At the same time, the reverse of the above is observed in case of new private banks. The same scenario for PSBs and new private banks can be observed in Net NPA ratio also.

The growth of provisions also corresponds with the growth of NPAs among both the PSBs and new private banks. We can also observe that there is an increasing trend in the Net NPA ratio of new private banks from 2012 indicating an increase in provisions which is evident in Fig. 11 also. Thus, new private banks are also better equipped to face NPAs in future scenarios given their low NPA ratios.

Apart from NPAs, one more important factor that we need to consider to study asset quality is the extent of restructured assets. Restructured assets indicate stress in the credit portfolio which can turn potentially bad in the future. It also camouflages the current asset quality by intertemporally shifting the credit risk, though it

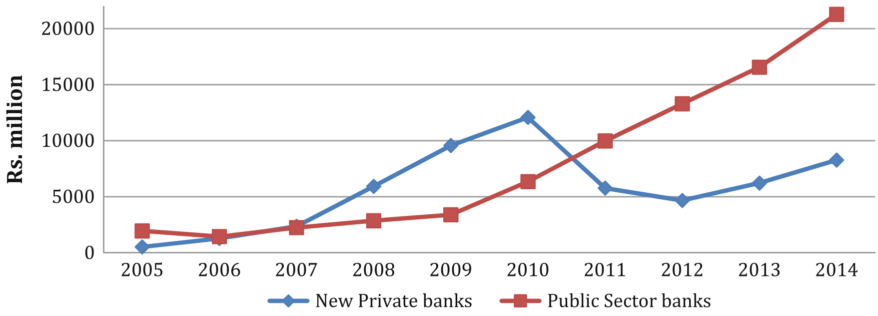

Fig. 11 Level of provisions for stressed assets for public and new private sector banks

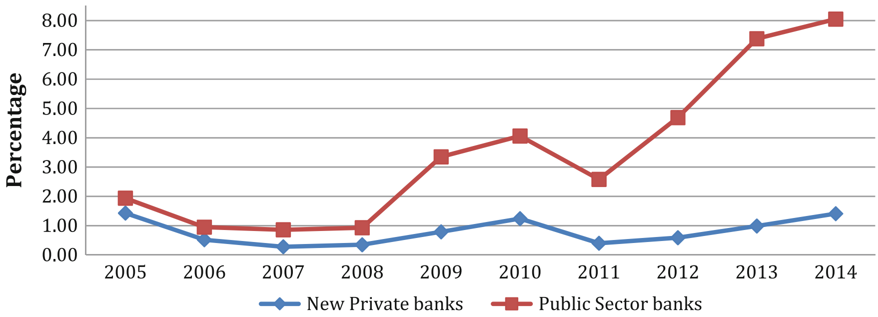

Fig. 12 Ratio of Restructured assets to Gross advances of public and new private sector banks

gives a genuine opportunity to mitigate the risk, if done prudently. We can observe that for both PSBs and new private banks the ratio shows an increasing trend indicating an economic slowdown/macroeconomic impact. However, PSBs show much higher proportion of restructured assets than new private banks indicating deteriorating nature of their assets posing a huge problem in future. As on March 2014, an average PSBs have accumulated almost 8 times more restructured assets to total assets compared to new private banks (Fig. 12).

The total stressed assets ratio (combining both NPA and restructured assets) confirms again the issues mentioned above with respect to PSBs and new private banks. Both seems to have undergone same trend (with new private banks significantly lower stressed ratio than PSBs) while PSBs showing a steep spike post-2011 (Fig. 13). This again shows that the PSBs have no control over the asset quality posing potential future problems in managing bad assets.

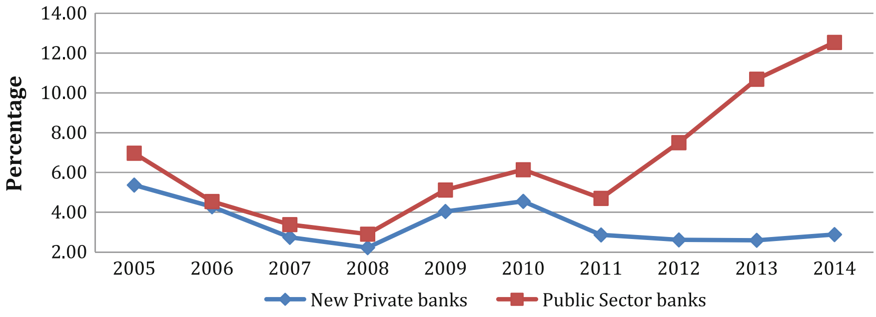

Fig. 13 Ratio of stressed assets to Gross advances of public and new private sector banks

6 A Diagnosis of the Problems Affecting Indian PSBs: High Asset Growth Combined with Volatile Liabilities

Figure 14 below shows the trend in the assets of public and new private banks. Public sector banks evidently started with huge assets have grown much bigger compared to their private counterparts.

Since it may be unfair to compare the large number of PSBs to few new private banks, we study the growth rate of assets. The growth rate of the assets of new private banks show a marked slump during the crisis while PSBs show only some moderation. In the last 3 years, we can observe a converging trend with both public and new private banks averaging at around 15 % (Fig. 15). Though, both categories of banks may be growing at almost same rate, the sheer size of PSBs is a cause of concern as it poses a systemic threat to the financial system.

We now examine liquidity risks in the banking system with leverage ratio, calculated as ratio of total assets of a bank to its equity (capital and reserves). It is higher for PSBs (averaging 18.8 %) when compared to new private sector banks (averaging 12 %) (see Fig. 16). This shows that any macroeconomic shock that

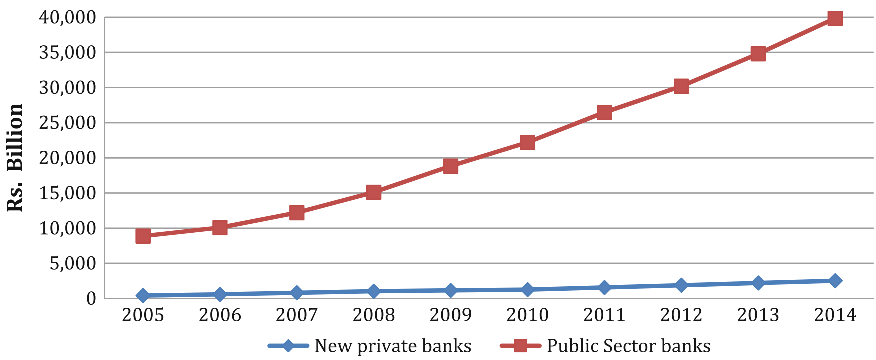

Fig. 14 Asset level of public and new private sector banks

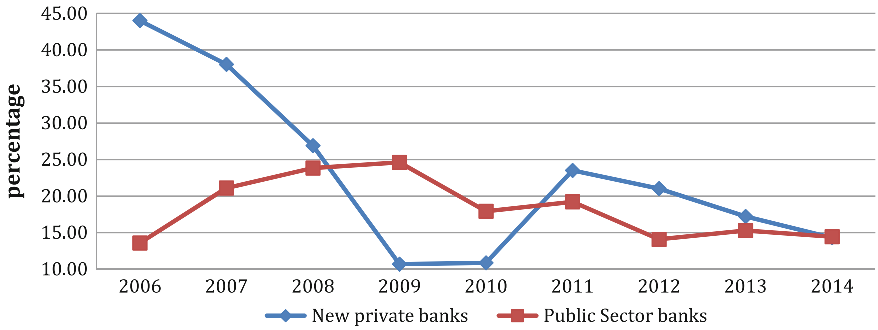

Fig. 15 Asset growth of public and new private sector banks

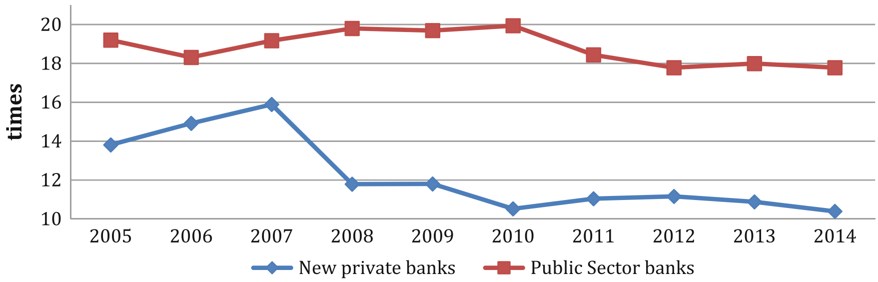

Fig. 16 Total assets to equity (leverage ratio) of public and new private sector banks

leads to reduction in value of assets will affect PSBs to a greater extent than the private sector banks.

Apart from PSBs being more highly levered, the structure of liabilities of PSBs deserves attention as well. PSBs are funded significantly more with volatile wholesale liabilities when compared to the private sector banks. While private sector banks have reduced their reliance on the volatile wholesale liabilities, PSBs have increased theirs from 30 % in 2008 to approximately 37 % in 2013 (Fig. 17). For many of the large nationalized banks, close to 50 % of liabilities is funded with wholesale liabilities. This increases vulnerability of these banks when we take into account the high asset growth in these banks.

Hahm et al. (2013) investigate the role of noncore bank liabilities (components of funding other than retail deposits) in signaling financial vulnerability. They formulate a credit supply model where a bank maximizes profit subject to a Value-at-Risk (VAR) constraint. Banks are able to expand lending without violating the constraint when measured risks are low. However, when core deposits do not grow in line with credit supply, banks turn to other sources of funding to support its credit growth, typically from other banks operating as wholesale lenders in the capital market. An important link is established between currency crises and credit crises as the procyclical behavior that fuels credit boom is financed through capital

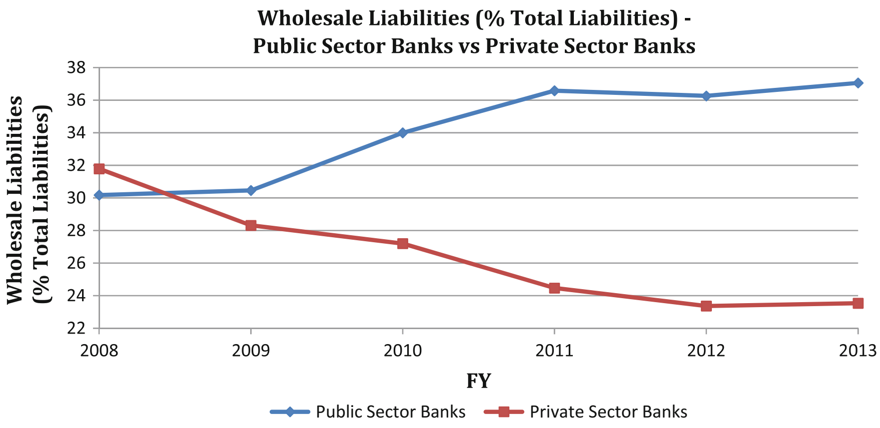

Fig. 17 Wholesale liabilities of public and private sector banks

inflows via the banking sector. Empirically, authors find support for this hypothesis. Measures of noncore liabilities, and especially the liabilities to the foreign sector, serve as a good indicator of the vulnerability to a crisis, both of a collapse in the value of the currency as well as a credit crisis where lending rates rise sharply.

This suggests that at least in emerging and developing economies, noncore bank liabilities may be usefully monitored as a complementary measure to the credit to GDP ratio in gauging the stage of financial cycles and the buildup of financial risk. Demirgüç-Kunt and Huizinga (2010) examine the implications of a bank's activity mix (represented by the share of noninterest income in the form of fees, commissions and trading income in total operating income) and funding strategy (deposits versus other nondeposit short-term funding) for its risk and return. Their analysis reveals a tradeoff that at low levels of noninterest income and nondeposit funding, there may be some risk diversification benefits of increasing these shares, although at higher levels of noninterest income and nondeposit funding shares, further increases result in higher bank risk. This suggests that traditional banks—with a heavy reliance on interest income generating and deposit funding—are safer than banks with strategies that rely prominently on generating noninterest income or attracting wholesale funding.

The growth rate of demand deposits and savings deposits also remain high for new private banks compared to PSBs. New private banks after the savings bank account deregulation have started to attract depositors by offering competitive interest rates. After a period of stickiness, this move has triggered the movement of deposits toward new private banks which are in the forefront of gaining of more depositors causing significant dent in the low cost funds of PSBs. The average growth rate of demand deposits of new private banks stood at 21 % while that of PSBs stood at 13 % during the period considered indicating the expanding share of new private banks. (see Fig. 18).

From Fig. 19 below showing the growth rate of savings deposits also new private banks average (31 %) was much higher than that of PSBs (17 %).

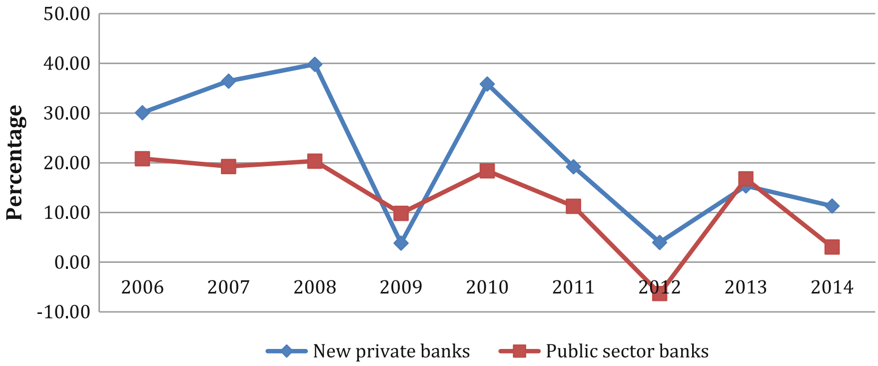

Fig. 18 Growth rate of demand deposits of public and new private sector banks

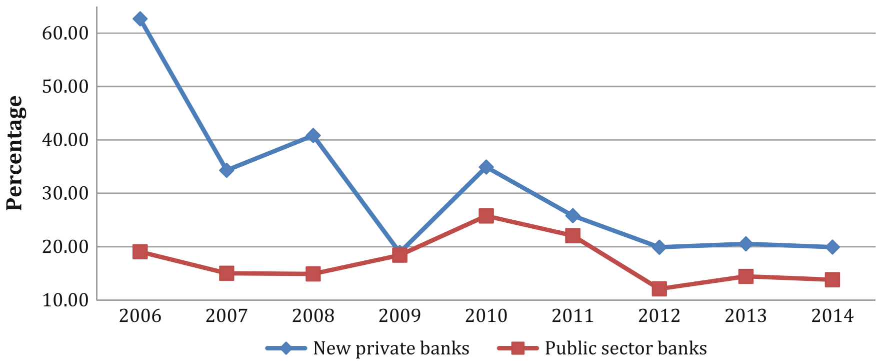

Fig. 19 Growth rate of savings deposits of public and new private sector banks

On the other hand, term deposits which are more sticky and prone to transaction lags than savings and demand deposits have also started to shift toward new private banks as evident from the convergence of their growth rates with that of PSBs. Their averages converged at around 20 % considering the slump for new private banks. (see Fig. 20).

When taken together, the savings and demand deposits, the new private banks clearly outperform the PSBs in gaining both in times of industry moderation and growth. All the above factors can be attributed to the fact that PSBs have gained organizational inertia owing to their implicit sovereign guarantee. This makes them difficult to make adjustments as demanded by market movements.[6] Process-oriented improvements, customer oriented decisions, and market-related adjustments are hard to implement in case of PSBs owing to their lethargic organizational culture and

[6]http://www.business-standard.com/article/finance/govt-banks-won-t-pay-more-on-savings-a-cs-111110600031_1.html.

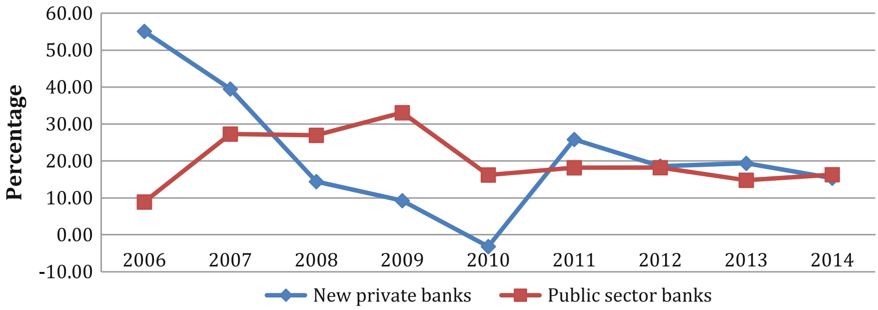

Fig. 20 Growth rate of term deposits of public and new private sector banks

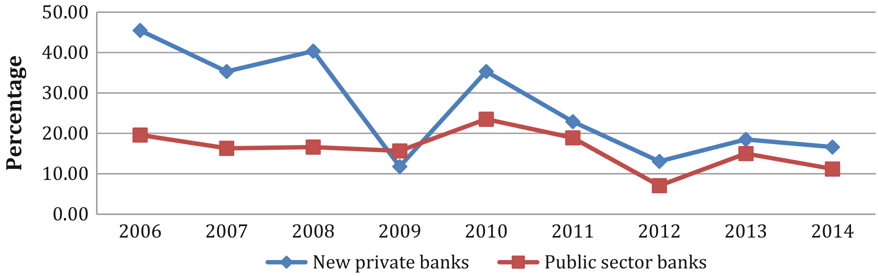

Fig. 21 Growth rate of CASA deposits of public and new private sector banks

work ethics. Though in short term they may have the privilege of retaining customers owing to their strong market presence but as the economy grows and customer becomes more aware, they may have to be nimble and lean in order to make swift decisions conducive to market movements. (see Fig. 21).

Considering the fact that PSBs have implicit guarantee of the sovereign, it must be able to raise funds in markets abroad where the investors will tend to be more risk averse considering market asymmetry. However, when it comes to borrowings raised abroad new private banks though smaller in number have on an average raised more than double of that of PSBs. (see Fig. 22).

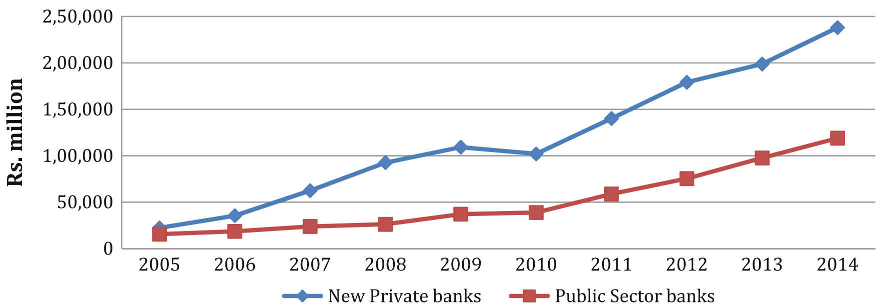

Fig. 22 Borrowings outside India of public and new private sector banks

7 Conclusions and Policy Implications

Our analysis of the Indian banking sector has highlighted the precarious condition of PSBs. Given the ills affecting the PSBs, the onus of remedying this situation through radical reform lies primarily with the Government. In the absence of such reform, or if reform is piecemeal and nonsubstantive, it is unlikely that there will be material improvement in their performance. This could impede the Government's objective of fiscal consolidation if the Government has to recapitalize the PSBs. On the other hand, if the Government decides not to spend taxpayer money in such recapitalization, then PSBs would have to significantly shrink their balance sheets in order to maintain adequate capital. Given the critical importance of PSBs in the financial intermediation needs of the Indian economy, such shrinkage would have significant dampening effects on economic growth. Either way, the cost of inadequate reform of PSBs will be steep. We suggest the following steps for correcting the state of PSBs.

First, some of the PSBs that have most gearing should be recapitalized now and their debts reduced, as they still have reasonable market values of equity. This could be achieved for instance through deep discount rights issues as a number of academics has suggested. This will put the burden of further losses on their shareholders rather than on taxpayers in due course. It is also likely to improve their incentives to restructure troubled assets promptly.

Second, many of the problems relating to the efficiency of PSBs, the quality of their human capital as well as their ability to adapt a rapidly changing technological landscape arise in large measure from the manner in which the PSBs are governed. As has been highlighted by the P J Nayak committee, the boards of most of these banks lack the necessary expertise as well as the required sense of purpose to steer the banks through their present difficult position. The boards are disempowered, and the selection process for directors is increasingly compromised. Board governance as well as overall governance is consequently weak. Governance difficulties in PSBs also arise from several externally imposed constraints. These include dual regulation, by the Finance Ministry in addition to RBI; board constitution, wherein it is difficult to categorize any director as independent; significant; and widening compensation differences with private sector banks, leading to the erosion of specialist skills. In order to improve governance of PSBs, the Government must distance itself from several bank governance functions that it presently discharges. For this purpose, the Bank Nationalization Acts of 1970 and 1980, together with the SBI Act and the SBI (Subsidiary Banks) Act must be repealed. All banks be incorporated as regular corporations under the Companies Act and must be mandated to satisfy the corporate governance norms prescribed by the Securities Exchange Board of India. The process of board appointments, including appointments of whole-time directors, needs to be professionalized.

Third, PSBs need to be slowly weaned off their funding advantage coming from government guarantees. In the short run, this could be achieved by requiring them to pay a deposit insurance premium that compensates for the guarantee they cash in on in stress times. They could also be subjected to *larger* capital buffers given their funding reliance on the state rather than the market.

Finally, in the long run, some of the PSBs can be privatized or their assets reallocated. Some of them could be acquired by the relatively well-capitalized private sector firms; the ones with worst asset quality could be wound down; and, greater entry of smaller and newer banks can be enabled to yet maintain healthy levels of competition.

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The Term Structure of Interest Rates in India

Rajnish Mehra and Arunima Sinha

1 Introduction

The financial sector plays a crucial dual role in any economy. It enables households to smooth consumption over their life cycle by insuring against idiosyncratic income shocks and channels savings to productive investments. Consequently, its role in economic development has received considerable attention in the literature on emerging markets. The consensus is that an efficient and transparent financial sector is a crucial concomitant of sustained economic growth.[1]

We thank Ravi Bansal, John Donaldson, an anonymous referee and the editors for their insightful comments and Neeru Mehra for editorial assistance. The usual caveat applies.

[1]While there is a considerable literature documenting the correlation between economic growth and financial development, Rajan and Zingales (1998) provide convincing evidence on causality.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_8

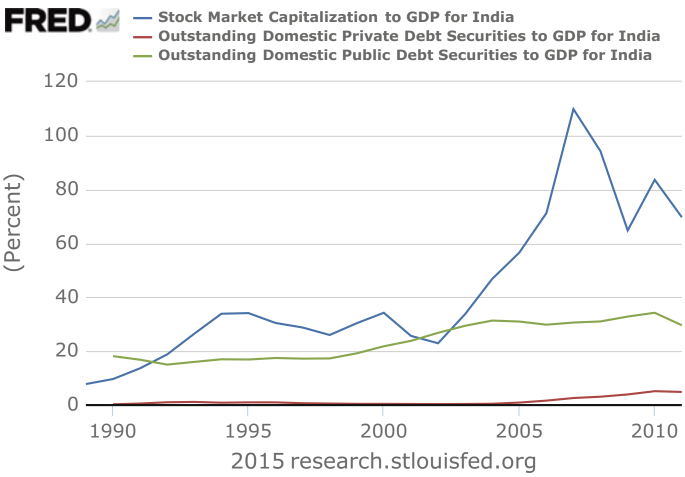

Fig. 1 Evolution of the financial sector in India: 1990–2011

The growth and development of the financial sector in India has been uneven. Indian equity markets have a long and colorful history.[2] They grew exponentially following economic reforms precipitated by the balance of payments crisis in 1991, and the Bombay Stock Exchange (BSE) is currently a "top ten" exchange in terms of market capitalization. Indian equity markets have also been the subject of considerable academic research: almost every study conducted on a major stock exchange has been replicated using Indian data sets.

In marked contrast, debt markets in India have languished. Prior to 1991 the corporate bond market was virtually nonexistent. The government debt market was illiquid, as a large part of the outstanding debt was held as mandated reserves by the banking sector. Consequently, there has been little academic work using Indian debt market data sets.

Figures 1 and 2 show the post-1990 evolution of these markets both in India and the US.

This chapter focuses on Indian debt markets for both government and corporate debt and, in particular, on the term structure of interest rates of government securities. We investigate whether the yield curve can be rationalized based on the 'expectations hypothesis'. To the best of our knowledge, the expectations hypothesis has not been tested in the Indian context. We also explore the information content in the term structure and its implications for monetary policy.

[2]Indian equity markets had their inception in the early 1830s. The first organized exchange—the Native Share and Stock Brokers' Association (the forerunner of the Bombay Stock Exchange) was established in 1887 making it the oldest in Asia. The market experienced its first crash in 1865. The run up in stock prices prior to the crash was a consequence of the increased demand for Indian cotton precipitated by the disruption of cotton supplies due to the American Civil War.

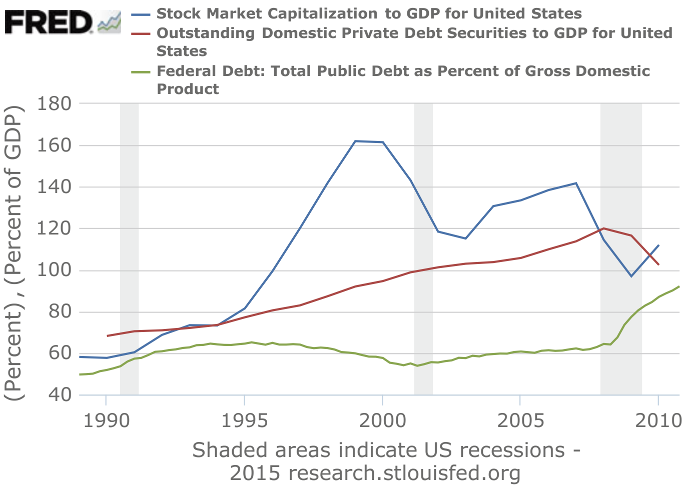

Fig. 2 Evolution of the financial sector in the US: 1990–2011

The chapter consists of six sections. Section 2 documents the evolution of Indian debt markets. Section 3 presents an overview of the literature on the term structure. In Sect. 4, we report and interpret results on tests of the expectations hypothesis and in Sect. 5 we discuss some possible reasons for our findings. Section 6 concludes the paper.

2 The Evolution of Debt Markets in India

The history of public debt in India dates back to the East India Company. After its inception in 1935, the Reserve Bank of India (RBI) was instrumental in managing public debt, issuing debt as needed to finance both fiscal deficits and infrastructure projects. By and large, Sovereign (GoI) debt was held by banks and life insurance companies to maturity and until 1990, there was essentially no secondary market where it was traded.

Corporate investment was almost exclusively financed by equity issues, private placement of bonds or by bank loans, a trend that continues to date.

2.1 The Government Securities Market

Until 1990, the Government securities (G-Secs) market in India was notably underdeveloped due to a variety of factors, including high statutory liquidity ratios (SLRs) governing commercial banks, and administered interest rates. Starting in 1992, a series of reforms were undertaken by the Reserve Bank of India (RBI) and the government to develop and deepen the market: the setting up of a system of Primary Dealers, a Treasury auction system, the introduction of 91-day Treasury

Table 1 Statistics for Government of India securities

Year	Total internal marketable debt	Gross Fiscal Deficit (GFD)	GFD financed through market borrowings
1990–91	26.27	7.61	17.92
1995–96	25.09	4.91	56.43
1999–00	35.30	5.17	59.28
2004–05	39.35	3.87	40.49
2009–10	36.07	6.46	94.23
2012–13	36.92	4.84	103.52

Figures in columns 2, 3, and 4 are expressed as percentages of GDP at market prices

Table 2 Ownership patterns of Government of India securities

Year	Commercial Banks	Insurance Companies	Foreign Institutional Investors Investors	Reserve Bank of India
2007	41.57	26.19	0.18	6.51
2008	42.51	24.78	0.52	4.78
2009	38.85	23.2	0.24	9.71
2010	38.03	22.16	0.59	11.76
2011	38.42	22.22	0.97	12.84
2012	36.28	21.08	0.88	14.41
2013	34.5	18.56	1.61	16.99

Figures in the columns are a fraction of the total

bills and zero-coupon bonds, the introduction of repos in G-Secs and other OTC instruments like Interest Rate Swaps. The Government Securities Act of 2006 modernized the legal infrastructure for this market. For a comprehensive summary of the reforms undertaken, the reader is referred to Annex 1 of Mohan and Ray (2009). Table 1 presents some statistics documenting the evolution of the market.

The outstanding stock of internal government debt as a percentage of GDP increased from 26.3 % to almost 37 % between 1990 and 2013. The percentage of Gross Fiscal Deficit financed by market borrowings increased from 18 % to over 90 % over the same period. As summarized in Table 2, the ownership pattern of these securities has also substantially changed. The fraction of Government of India securities owned by commercial banks and insurance companies declined from 67.7 to 53 %, while the holdings of the RBI rose from less than 7–17 %.

Another notable development is the declining role of the RBI in the primary G-Secs market, with the percentage of gross market auctions with devolvement on the RBI declining to almost zero by 2006–2007, compared to more than 13 % in 1996–1997.

Two other notable trends are (i) the progressive lengthening of the maturity of outstanding debt, with average maturity increasing from 5.7 years in 1995–1996 to 13.8 in 2005–2006 and (ii) a deepening of the secondary market for securities, as evidenced by a 50 % increase in the share of repos in the market transactions of G-Secs.

Table 3 Government and Corporate Bonds as a percentage of GDP, March 2013

Debt as a % of GDP	Government	Corporate	Total
China	33.1	13.0	46.2
Hong Kong	37.8	31.4	69.2
Indonesia	11.4	2.3	13.7
Korea	48.7	77.5	126.2
Malaysia	62.4	43.1	105.5
Philippines	32.2	4.9	37.1
Singapore	53.1	37.0	90.1
Thailand	58.6	15.9	74.4
Vietnam	19.8	0.7	20.5
India	49.1	5.4	54.5

From: R. Gandhi BIS 2015

2.2 *The Corporate Bond Market*

Post the 1990 reformative overhaul, the Government securities market has expanded to an extent that its size is on par with trends in other emerging economies (Table 3). The corporate debt market, however, is an outlier, languishing in the bottom third of its cohort.

This anomalous development has been extensively commented upon[3] and has been the subject of two "high powered" government commissions.[4] We do not revisit their conclusions or review the discussion on the reasons postulated for the under development of the corporate debt market. Suffice to say, they are largely regulatory and include the following:

a. Onerous and time-consuming disclosure regulations relative to those required for private placement.
b. "Prudent Investment" regulations that bias institutions towards holding G-Secs and AAA corporates.
c. Outdated bankruptcy laws and ineffective judicial enforcement.

As result of a heightened awareness that a well-functioning corporate bond market is a concomitant for continued capital formation and effective corporate control, and the implementation of policy initiatives to this end, the past decade has seen an uptick in this market (Fig. 3).

[3]See Wells and Schou-Zibell (2008), Mohan and Ray (2009) for an excellent overview.

[4]The Patil Committee report (2005) and the Rajan Committee report (2008).

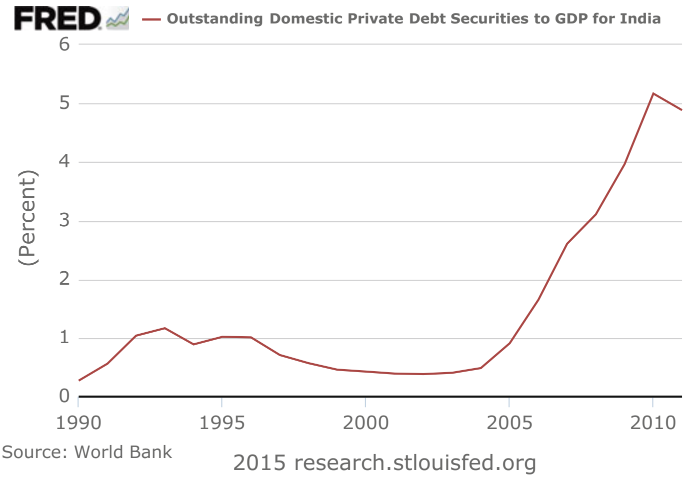

Fig. 3 The corporate debt market in India: 1990–2011

3 The Term Structure of Interest Rates

A major research initiative in finance focuses on the determinants of the cross-sectional and time series properties of asset returns.

An asset-pricing model is characterised by an operator that maps the sequence of future random payoffs of an asset to a scalar, the current price of the asset.[5] If the law of one price[6] holds in a securities market where trading occurs at discrete points in time, this operator $\Psi(.)$ can be represented as[7]

$$P_t = \Psi(\{y_{s+t}\}_{s=1}^{\infty}) = E\left[\sum_{s=1}^{\infty} m_{s+t,t} y_s | \Phi_t\right] \tag{1}$$

where P_t is the price at time t of an asset with stochastic payoffs $\{y_{s+t}\}_{s=1}^{\infty}$, $\{m_{s+t,t}\}_{s=1}^{\infty}$ a stochastic process,[8] Φ_t is the information available to households who trade assets at time t and E is the expectations operator defined over random variables that are measurable with respect to the sigma algebra generated by Φ_t. If

[5]Both the payoffs and the price are denominated in the numeraire consumption good.

[6]Assets that have identical payoffs have identical prices.

[7]See Ross (1976), Harrison and Kreps (1979), Hansen and Richards (1987) for the technical restrictions on the payoff process for Eq. (1) to hold.

[8]$m_{s+t,t} = \prod_{k=0}^{s-t-1} m_{t+k+1,t+k}$, where $m_{t+k+1,t+k}$ is a random variable such that $P_{t+k} = E[m_{t+k+1,t+k}\, y_{t+k+1} | \Phi_{t+k}]$.

the asset payoffs end T periods from now, we define the random variables $\{y_{s+t}\}_{s=T+1}^{\infty}$ to be zero. If the securities market is arbitrage-free,[9] then the process $\{m_{s+t,t}\}_{s=1}^{\infty}$ has strictly positive support (with probability one) and is unique if the market is complete.[10]

No arbitrage is a necessary condition for the existence of security market equilibrium in an economy where all agents have access to the same information set. If, however, there is an agent in the economy with preferences that can be represented by a *strictly increasing*, continuous utility function defined over security payoffs, then the no arbitrage condition is both necessary and sufficient for the existence of a security market equilibrium[11] (Dybvig and Ross 2008). In an economy characterized by such an agent and no arbitrage, *all* equilibrium asset-pricing models are simply versions of Eq. (1) for different stochastic processes $\{m_{s+t,t}\}_{s=1}^{\infty}$, often referred to as stochastic discount factors or pricing kernels.

An important subclass of asset-pricing models focuses on the pricing of default free zero-coupon bonds of varying maturities at a point in time. Since these bonds make only one deterministic payoff they are easy to price, as Eq. (1) simplifies to

$$P_{s,t} = \Psi(\{1_{s+t}\}) = E[m_{s+t,t}|\Phi_t] \tag{2}$$

where $P_{s,t}$ is the price of an s-period bond at time t. This bond has a unit payoff, 1_{s+t} at time $s + t$. Security prices in this setting are simply the expected value of the stochastic discount factors. For a one-period bond, maturing at time $t + 1$

$$P_{1,t} = E\left[m_{t+1,t}|\Phi_t\right]$$

$$P_{s,t} = E\left[m_{t+1,t}P_{s-1,t+1}|\Phi_t\right] \tag{3}$$

Hence, if the process on $m_{t+1,t}$ is known, in principle a bond of any maturity can be priced by chaining together the period discount factors (see footnote 8).

We next define some terms to be used later in this section and the following sections.[12]

The yield to maturity $Y_{s,t}$ of an s-period bond is defined by

$$P_{s,t} = (1 + Y_{s,t})^{-s} \tag{4}$$

[9]A securities market is arbitrage-free if no security is a "free lottery" and any portfolio of securities with a zero payoff has zero price.

[10]If markets are incomplete, there will, in general, be multiple processes $\{m_{s+t,t}\}_{s=1}^{\infty}$ such that (1) holds. Not all of them need have a strictly positive support.

[11]Households maximize utility given their endowments and security prices and supply equals demand at these security prices.

[12]Our definitions below draw on Campbell et al. (1997).

In the bond pricing literature it is common to use continuously compounded yields ($y_{s,t}$)

$$y_{s,t} = \ln(1 + Y_{s,t})$$

Hence,

$$y_{s,t} = -s^{-1} p_{s,t} \tag{5}$$

where $p_{s,t} = \ln P_{s,t}$. Henceforth, we will use lower case letters to denote log-transformed variables.

The (log) *yield spread* $\delta_{s,t}$ is the difference in yield between an s-period bond and a one-period bond.

$$\delta_{s,t} = y_{s,t} - y_{1,t} \tag{6}$$

The (log) *holding period return*, $h_{s,t+1}$, at time t, on an s-period bond is the return on holding the bond from time t till $t + 1$. It is a random variable at time t.

$$h_{s,t+1} = p_{s-1,t+1} - p_{s,t} \tag{7}$$

or using (5)

$$h_{s,t+1} = s y_{s,t} - (s-1) y_{s-1,t+1} \tag{8}$$

The (log) *s-period ahead forward rate* at time t is the rate on an investment in a one-period bond from time $s + t$ to $s + t + 1$ that is implicit in current bond prices. This future rate can be guaranteed at time t.

$$f_{s,t} = p_{s,t} - p_{s+1,t} \tag{9}$$

The *term structure of interest rates* at a point in time t refers to the (log) yields to maturity $y_{s,t}$ for a set of default-free zero-coupon bonds. *The yield curve* is a plot of these yields versus the time to maturity s. A time series plot of the yields on government bonds of different maturities for India and the US is shown in Figs. 4 and 5. Figures 6 and 7 plot the term structure on February 29, 2012 and June 1, 2015 for the two countries.

The discussion so far has focused on a real economy, with payoffs and prices denominated in the numeraire consumption good and "real" returns. In contrast, much of the term structure literature deals with the nominal term structure of interest rates, primarily because government bonds in most countries have nominal payoffs.[13] One approach to pricing nominal bonds is to deflate nominal prices by the price index and then use Eq. (3).

[13] In the US, Treasury Inflation Protected Securities (TIPS) debuted in 1997 and research on the real term structure is still in its infancy. See Pflueger and Viceira (2013). India briefly issued inflation indexed bonds in 1997 and again starting in 2013.

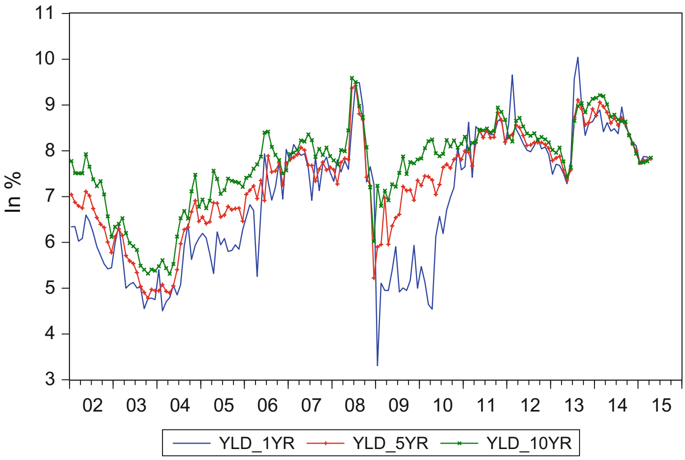

Fig. 4 Zero-coupon yields from January 2002 to April 2015 for India using the Nelson-Siegel methodology (detailed in Sect. 4)

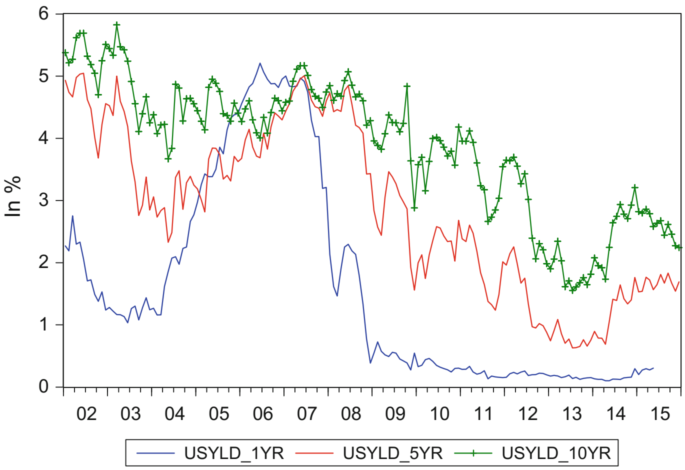

Fig. 5 Zero-coupon yields from January 2002 to April 2015 for USA using the Nelson-Siegel methodology

If I_t is the price index and P_t^n the nominal price of the bond at time t, we can rewrite (3) as

$$P^n_{s,t}/I_t = E\left[m_{t+1,t} P^n_{s-1,t+1}/I_{t+1} \middle| \Phi_t\right]$$

$$\text{or} \quad P^n_{s,t} = E[m_{t+1,t} P^n_{s-1,t+1}/\Pi_{t+1} | \Phi_t] \tag{10}$$

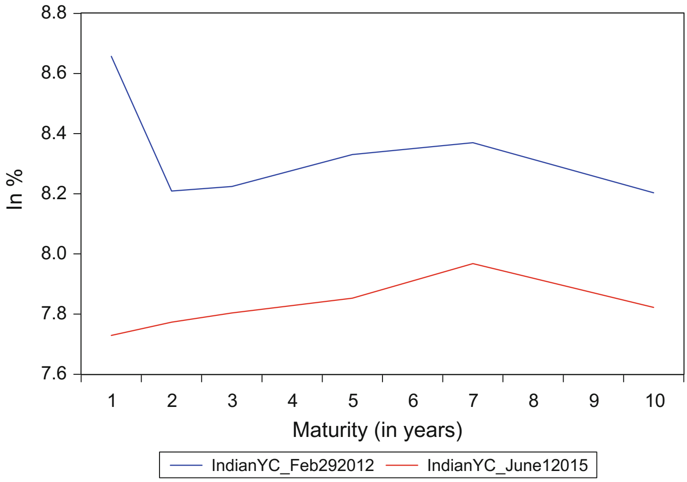

Fig. 6 Term structure for India on February 29, 2012 and June 1, 2015

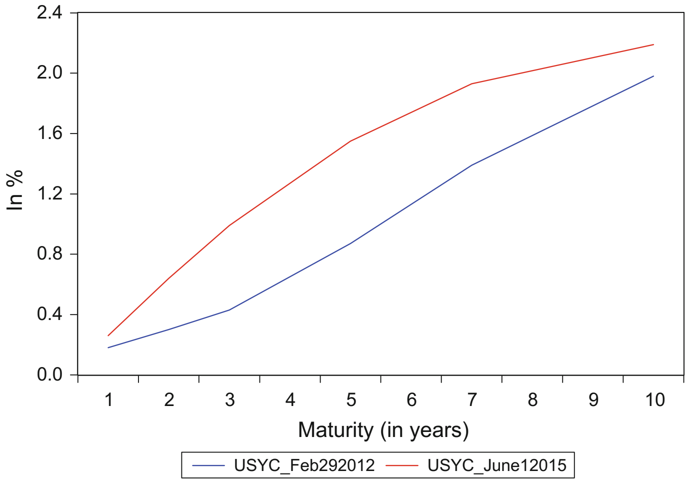

Fig. 7 Term structure for the US on February 29, 2012 and June 1, 2015

$$\text{or} \quad P^n_{s,t} = E\left[m^*_{t+1,t} P^n_{s-1,t+1} | \Phi_t\right] \tag{11}$$

where $\Pi_{t+1} = I_{t+1}/I_t$ is the gross inflation rate between time t and $t+1$ and $m^*_{t+1,t}$ is the *nominal stochastic discount factor*.

The various term structure models in the literature are different specifications of the process on $m_{t+1,t}$ and Π_t or the process $m^*_{t+1,t}$ may be modeled directly.[14] The process may be chosen in an ad hoc manner so as to match the empirically observed yield curve[15] or it may be endogenously determined in an equilibrium model. In consumption-based asset-pricing models, $m_{s+1,t}$ is usually expressed as a function of the marginal rate of substitution of consumption between time s and t of the agents who trade securities. For example, Donaldson et al. (1992) and Backus et al. (1989) model $m_{s+t,t}$ as $\beta^s u^{'}(c_{s+t})/u^{'}(c_t)$. Here c_t is the aggregate per capita consumption at time t, $u^{'}(c_t)$ is the marginal utility of consumption at time t and β is the rate of time preference. In the case of constant relative risk aversion (CRRA) preferences this specializes to $\beta^s(c_{s+t}/c_t)^{-\alpha}$, where α is the coefficient of relative risk aversion and simultaneously, the reciprocal of the elasticity of intertemporal substitution.

What is the information content in the yield curve? Do current short-term rates predict future short-term rates? If the current yield spread is high does it imply that future long rates will increase? That is, is there a mapping from short-term rates to long-term rates? Is this relationship stable over time? If it is stable, what fraction of the change in long rates will be a change in "real rates" as opposed to a compensation for changes in the price level? These questions are not of mere academic interest; they are of first-order importance for policymakers. Monetary policy acts on the short end of the yield curve, but it is the *real* long-term rate that is relevant for the investment decisions of firms that translate into economic growth. A stable mapping from short-term to *real* long-term rates is necessary if monetary policy is to be an effective tool for influencing real output. In fact, much of the debate on the effectiveness of monetary policy can be recast in terms of the stability of this mapping.

We plan to examine some of these questions through the lens of the *expectations hypothesis*. There are a number of versions of the expectations hypothesis, some of them mutually inconsistent (Cox et al. 1981). However, the difference in their implications is not *quantitatively*[16] significant. In this study, we use the version used by Campbell and Shiller (1991), as we use their methodology. Their interpretation emphasizes that the expected holding period returns on zero-coupon bonds of different maturities differ, at most, by a constant. This constant may depend on the time to maturity but it is *time invariant*. Equivalently, the hypothesis implies that the expected excess holding period returns of long bonds over short bonds—*the term premium*—is a constant. Any model where the product of the stochastic discount factor and bond price, $m^*_{t+1,t}P^n_{s-1,t+1}$ in Eq. 11 is log normally

[14]This is what is commonly done in practice.

[15]Backus et al. (1998) provide an excellent introduction to this literature.

[16]If bond returns are log normally distributed, it can be shown that the maximum "error" introduced by using one version instead of the other is bounded by $2\times(2^{-1}\sigma^2)$; since the standard deviation σ of bond returns is typically a few percentage points, the quantitative effect is small. Technically, the error arises due to Jensen's inequality ($E\ \ln(x)\neq \ln\ E(x)$ and $E(1/x)\neq 1/E(x)$).

distributed implies a constant term premium and is consistent with the expectations hypothesis as we have defined it. This condition is satisfied by numerous term structure models, including Vasicek (1977).

Using the notation developed earlier, this implies[17]

$$E(h_{s,t+1} - h_{1,t+1}) = E(h_{s,t+1}) - y_{1,t} = \theta_s \tag{12}$$

or equivalently, using (8)

$$E(sy_{s,t} - (s-1)y_{s-1,t+1}) - y_{1,t} = \theta_s$$

which can be rewritten as

$$E(y_{s-1,t+1}) - y_{s,t} = \theta_s/(s-1) + (y_{s,t} - y_{1,t})/(s-1) \tag{13}$$

where θ_s is a time invariant constant.

An implication of the expectations hypothesis that follows from (13) is that if the current yield spread $\delta_{s,t}$ is high, the future long yield is expected to be higher than the current long bond yield. Intuitively, if the s-period bond has a higher yield than the one-period bond, the expected yield on the s-period bond should rise over the next period to induce a capital loss if the expected holding period returns are to be the same for the s-period and one-period bonds.

Another implication of the expectations hypothesis is that the long rate is an average of expected future returns per period over the life of the bond. Using (5) and (7) we see that

$$y_{s,t} = \frac{1}{s}\sum_{i=0}^{s-1} h_{s-i,t+1+i}$$

This has implications for the relative volatility of short and long rates: long-term bonds should be less volatile than short-term bonds.

In the next section, we explore the implications of the expectations hypothesis using data sets on Indian government securities.

4 Tests of the Expectations Hypothesis

In order to examine the nominal yield curve, we need the zero-coupon yield curve of government securities. Although most traded government bonds, especially those with long maturities are not pure discount bonds, they can be used to construct the

[17] Campbell et al. (1997) introduce yet another variation on the expectations hypothesis, the "pure expectations hypothesis." This is simply Eq. (12) with $\theta_s = 0$. We do not use this interpretation here.

zero-coupon yield curve. A widely used technique to do this is based on the Nelson-Siegel-Svensson methodology, detailed below.

The yield on a s-period zero-coupon bond $y_{s,t}$ is approximated as

$$y_{s,t}=\beta_0+\beta_1\frac{1-\exp\left(\frac{-s}{\tau_1}\right)}{\frac{s}{\tau_1}}+\beta_2\left[\frac{1-\exp\left(\frac{-s}{\tau_1}\right)}{\frac{s}{\tau_1}}-\exp\left(\frac{-s}{\tau_1}\right)\right]+\beta_3\left[\frac{1-\exp\left(\frac{-s}{\tau_2}\right)}{\frac{s}{\tau_2}}-\exp\left(\frac{-s}{\tau_2}\right)\right] \tag{14}$$

where β_0 approximates the level of the yield curve, β_1 approximates its slope, β_2 the curvature, and β_3 the convexity of the curve. The convexity captures the hump in the yield curve at longer maturities (20 years or more). The specification in (14) is the Svensson (1994) extension[18] of the Nelson-Siegel (1987) formulation, which is a special case of (14) with $\beta_3=0$.

This technique of constructing nominal and real yield curves has been extensively used. Gürkaynak et al. (2007), for example, construct the zero-coupon nominal (and real) yield curve for the United States using this methodology.[19] The parameters β_0, β_1, β_2, β_3, τ_1, and τ_2 are estimated using maximum likelihood by minimizing the sum of squared deviations between actual Treasury security prices and predicted prices.[20] Other techniques for fitting the zero-coupon curve include McCulloch (1990), using cubic splines and the Fama and Bliss (1987) forward rate curve.[21]

The National Stock Exchange (NSE) uses the Nelson-Siegel (1987) methodology to estimate the zero-coupon yield curve for Indian government securities[22] using data on secondary market trades for government securities reported on the Wholesale Debt Market. This market constitutes approximately 70 % of the secondary market volume in the traded GoI securities. The methodology used is detailed in Darbha et al. (2000). A notable feature of the NSE methodology is that it uses prices for each individual trade, for each bond traded on a specific date, in contrast to the practice of using volume-weighted prices in deeper and more liquid markets.

In this study, we use the NSE data on the zero-coupon yields. Figure 4 shows a time series plot of this data for the period January 2005–April 2015. For purposes of comparison, the zero-coupon yields for the US over the same time period are shown in Fig. 5.

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[18]This extension makes the fitted yield curve more flexible.

[19]The estimates for this nominal curve are updated daily, and are available from January 1972 on the Federal Reserve Board website.

[20]The prices are weighted by the inverse of the duration of the securities. Underlying Treasury security prices in the Gürkaynak, Sack, and Wright estimation are obtained from CRSP (for prices from 1961–1987), and from the Federal Reserve Bank of New York after 1987.

[21]For an application of this methodology to other countries see, for example, Jondeau and Ricart (1999).

[22]The yield curve is updated daily.

For the Indian case, nominal yields across the maturity structure move in tandem for most of the sample period, except between 2008 and 2010: even though the 1-year yield had fallen to approximately 5 % on average, 5- and 10-year yields remained significantly higher. It is interesting to note that a similar (albeit, opposite) discrepancy between the short- and long-term yields was observed in the United States in 2004: as 1-year yields rose, longer term yields remained flat and briefly declined. A similar disconnect between short and long rates was observed in the Indian data in 2011 and 2013.

A major difference between the US and Indian yields emerged in the aftermath of the financial crisis and the subsequent "Quantitative Easing" in the US. While US. long-term yields declined, Indian long yields have remained steady (and risen), except for the period between mid 2011–2013. Finally, compared to the near zero yields seen in the US, the short-term rates in India have been relatively high.

4.1 Tests of the Expectations Hypothesis

There is a large extant literature on testing the expectations hypothesis. A popular approach is to test if the condition in Eq. (13) holds using the regression methodology in Campbell and Shiller (1991). The difference between the (s − *1*)-period yield expected next period, and the current s-period yield $y_{s,t}$ is regressed on the spread between the s and one-period yields:[23]

$$y_{s-1,t+1} - y_{s,t} = \alpha_s + \gamma_s \left(\frac{y_{s,t} - y_{1,t}}{s-1} \right) + \varepsilon_t. \tag{15}$$

The expectations hypothesis implies that the slope coefficient γ_s in the Campbell-Shiller regression[24] (15) should not be statistically different from one.[25]

While the Campbell-Shiller regression tests movements in long-term yields relative to the yield spread over short horizons, another strand of the literature tests long-term movements in short yields as predicted by the yield spread. Fama and Bliss (1987) construct a forward rate spread and test if this spread can predict the future spot rate. The authors find that the forecasting power of the term structure improves as the time horizon increases. In this chapter, we restrict our attention to the original Campbell and Shiller (1991) formulation.

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[23]Campbell and Shiller (1991) refer to the spread between the current s- and one-period yields as the "perfect foresight" spread.

[24]One of the concerns with the Campbell-Shiller regression is that the long yield $y_{s,t}$ appears on both sides of the regression. Thus, the negative sign may be a result of measurement error. To deal with this, Campbell and Shiller (1991) test the robustness of their results using instrument variables for the long yields.

[25]In addition, under the pure expectations hypothesis the intercept term should be zero.

Table 4 Campbell-Shiller slope coefficients for US nominal yields (γ^C are the slope coefficients of Eq. (15) reported by Campbell (1991) using estimated US monthly coupon yields for 1952–1987 from McCulloch (1990). γ^{DS} are the slope coefficients of Eq. (15) reported by Dai and Singleton (2002) using the Fama and Bliss (1987) dataset. The regressions are constructed using the 1-month yield as the one-period yield)

Coeffs	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
γ^C	−0.17	−1.38	−1.81	−2.23	−2.66	−3.09	na	−5.02
	(0.36)	(0.68)	(1.15)	(1.44)	(1.63)	(1.74)		(2.31)
γ^{DS}	−0.42	−1.42	−1.70	−1.19	−2.14	−2.43	−3.09	−4.17
	(0.48)	(0.82)	(1.12)	(1.29)	(1.41)	(1.51)	(1.70)	(1.98)

Numbers in parentheses are the corresponding standard errors

4.2 Campbell-Shiller Regression for US Data

The main finding for the US data sets is that the Campbell-Shiller slope coefficient is smaller than one, and becomes negative at longer maturities. This implies that when the yield spread in the regression in (15) is high, the yield on the long-term bond falls over the life of the short-term bond, instead of rising, as predicted by the hypothesis. The robustness of these findings on the slope coefficient, across sample periods, and combinations of yield maturities has been interpreted as a rejection of the expectations hypothesis in the data. Table 4 presents a summary of the results from two prominent analyses.

4.3 Campbell-Shiller Regression Using Indian Data Sets

> "Does the slope of the term structure-the yield spread between longer term and shorter-term interest rates-predict future changes in interest rates? And if so, is the predictive power of the yield spread in accordance with the expectations theory of the term structure? These questions are important, both for forecasting interest rates and for interpreting shifts in the yield curve."
>
> Campbell and Shiller (1991)

Given the central role of the expectations hypothesis in the term structure literature, we analyze this construct for the Indian case. To the best of our knowledge, the expectations hypothesis has not been tested in the Indian context.

We look at four specific time periods: January 2002–December 2007, January 2006–June 2009, and July 2009–April 2015 in addition to a complete data set from January 2002 to April 2015. The first sample data subset is the period marking the beginning of the worldwide financial crisis; the second period corresponds to a period of financial turmoil in the United States and the third period to the aftermath of the crisis. In our regressions, we use the 1-month Treasury bill rate as a proxy for the short rate.

Table 5 Campbell-Shiller coefficients for India nominal yields (The regression in (15) is constructed using the 1-month yield as the one-period yield) 2002:1–2015:4

	Yield maturity							
Coeffs	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
α	0.03	0.00	0.00	0.00	0.01	0.01	0.01	0.01
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
γ	4.00*	1.01	−0.32	−1.28*	−2.11*	−2.69*	−3.15*	−2.84*
	(0.97)	(1.41)	(1.51)	(1.40)	(1.35)	(1.22)	(1.90)	(2.50)

Numbers in parentheses are the corresponding HAC Newey-West standard errors. The asterisks denote coefficients statistically different from 1

Table 6 Campbell-Shiller coefficients for India nominal yields 2002:1–2007:12

	Yield maturity							
Coeffs	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
α	0.06	0.01	0.00	0.02	0.03	0.04	0.05	0.04
	(0.06)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)
γ	7.73*	2.77	−1.60	−4.74*	−6.69*	−7.68*	−8.02*	−7.32*
	(2.79)	(2.19)	(0.08)	(1.49)	(1.62)	(1.50)	(2.51)	(4.40)

Numbers in parentheses are the corresponding HAC Newey-West standard errors. The asterisks denote coefficients statistically different from 1

The slope coefficients of the Campbell-Shiller regression for the Indian nominal yield curve are reported in Tables 5, 6, 7 and 8.

Another implication of the expectations hypothesis is that when the yield spread is positive, short yields tend to rise to equate returns over the life of the long bond. To test this, we use the following regression, discussed in Campbell (1995):

$$\frac{\sum_{i=1}^{s-1} y_{1,t+i}}{s-1} - y_{1,t} = \alpha_s + \gamma_s \left(\frac{s-1}{s}\right)(y_{s,t} - y_{1,t}) + \varepsilon_t \tag{16}$$

Table 7 Campbell-Shiller coefficients for India nominal yields 2006:1–2009:6

	Yield maturity							
Coeffs	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
α	0.18	0.05	−0.01	−0.03	−0.02	−0.01	0.00	0.01
	(0.09)	(0.06)	(0.07)	(0.09)	(0.09)	(0.09)	(0.10)	(0.07)
γ	7.33*	4.74*	2.02	−1.15	−3.97*	−5.93*	−7.18*	−5.28
	(2.24)	(1.56)	(2.65)	(3.33)	(3.02)	(2.79)	(2.54)	(4.83)

Numbers in parentheses are the corresponding HAC Newey-West standard errors. The asterisks denote coefficients statistically different from 1

Table 8 Campbell-Shiller coefficients for India nominal yields 2009:7–2015:4

	Yield maturity							
Coeffs	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
α	0.03	0.04	0.04	0.03	0.02	0.01	0.01	0.00
	(0.06)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)
γ	2.32*	−1.19*	−1.70*	−1.25*	−0.91*	−0.73*	−0.63	−0.50
	(0.45)	(0.86)	(1.25)	(0.94)	(0.80)	(2.79)	(2.54)	(2.22)

Numbers in parentheses are the corresponding HAC Newey-West standard errors. The asterisks denote coefficients statistically different from 1

Table 9 Additional test of the expectations hypothesis for 2002:1–2015:4

	Yield maturity							
Coeffs	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
α	0.04	0.08	0.11	0.08	0.11	0.09	0.09	1.42
	(0.06)	(0.14)	(0.18)	(0.20)	(0.21)	(0.22)	(0.16)	(0.31)
γ	4.77*	1.33*	1.25*	1.20*	1.13*	1.08	0.95	−0.01*
	(0.86)	(0.15)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.30)

Numbers in parentheses are the corresponding HAC Newey-West standard errors. The asterisks denote coefficients statistically different from 1

This equation tests the relation between long-run changes in the short-term interest rate and the yield spread for the 2002–2015 period. As before, if the expectations hypothesis holds, the slope coefficient should not be statistically different from one. The results are presented in Table 9; we find that for yield maturities up to 4 years, slope coefficients are statistically larger than one. We interpret this to imply that the yield spread has significant predictive power for long-run changes in the short rates only up to the 4-year maturity. Campbell (1995) finds that in the US, the yield spread has predictive power for both the short and long end of the maturity structure, but not at the medium term. However, as in the US data, the results in Table 9 appear to contradict those of Table 5. Campbell (1995) suggests that this may not be the case. In accordance with his analysis, the size of the slope coefficients at the 5- and 7-year maturities in Table 9 suggests that Indian investors are better informed about future movements in short-term interest rates at medium-term horizons, rather than at the shorter end of the maturity structure.

Here the regression is tested on the full sample set. For shorter subsamples, the computation of long-run changes in the short rate leads to a large reduction in the length of the time series.

We also compute the term structure of variances for the Indian nominal yield curve, (shown in Table 10) and contrast these to the US data in Table 11.

Table 10 Variances across the term structure for India

	3 mo	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
2002:1:2015:4	2.59	1.99	1.61	1.39	1.26	1.16	1.02	0.86
2002:1:2007:12	1.37	1.05	0.92	0.88	0.86	0.85	0.84	0.82
2006:1:2009:6	1.95	1.51	1.20	0.97	0.81	0.68	0.53	0.43
2009:7:2015:4	2.73	1.63	0.93	0.59	0.41	0.32	0.24	0.20

Table 11 Variances across the term structure for US data

	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	7 yrs	10 yrs
1972:1:2015:5	12.49	11.90	11.20	10.52	9.90	8.88	7.84
1984:1:2007:12	5.24	5.20	5.07	4.92	4.78	4.50	4.15
2006:1:2009:6	3.17	2.58	2.01	1.52	1.13	0.62	0.29
2009:7:2015:4	0.01	0.05	0.13	0.23	0.31	0.45	0.55

4.4 Results

For the period 2002–2015 and the subperiods of interest our results provide strong support for the predictability of nominal yields and for the predictability of their difference in Indian bond data. As Table 5 (which spans the entire sample period) documents, the estimated slope coefficients γ are significantly different from zero for all bonds with duration 3 or more years, a pattern broadly repeated in Tables 6, 7 and 8. However, these coefficients are also significantly different from 1, which implies a rejection of the null hypothesis that the expectations hypothesis holds.

Our results for the entire sample period (Table 5) are surprisingly similar to those for the US documented in Table 4. As the yield to maturity rises, patterns seen in the Campbell-Shiller coefficients for US data are replicated: the slope coefficients are smaller than 1, and negative. This implies that as the short yields rise, the expected long yields fall, instead of rising as predicted. The subsample analyses are also informative: other than at the very short end of the term structure,[26] the slope coefficients for Indian data are quantitatively similar to those of the US Notably, in the second and third subsamples, the deviations from the expectations hypothesis at the long end of the yield curve are almost double the coefficients observed for the US and, in the most recent sample, the size of the slope coefficients are significantly smaller.

A naïve strategy of buying high yielding long-term bonds would have paid off handsomely over the past 15 years, contrary to the predictions of the expectations hypothesis. The negative slope coefficients (notably large in Tables 6 and 7) imply that in addition to high yields, investors in these bonds would have realized a

[26]For bonds with duration less than 2 years, in many instances we cannot reject the expectations hypothesis. This is in contrast to the observations in the US.

substantial capital gain. However, investors holding high yielding bonds with maturity less than 1-year would have realized capital losses.

Our results on the term structure of variances for the Indian nominal yield curve are consistent with the implications of the expectations hypothesis: the variance of the yields on longer duration bonds is smaller than the variance of bonds with a shorter duration. Over most time periods the variance of the 10-year yield is less than half of the variance of the 1-year yield.

Our observations are in contrast to those in the US. As Table 11 shows, in the most recent period, the long end of the curve is more volatile than the short end. During the Great Moderation period (1984–2007), the variance of the 10-year yield is approximately 80 % of the 1-year yield implying that long bonds were excessively volatile. This "volatility puzzle" is not observed in the Indian data.

5 Rationalizing the Rejections of the Expectations Hypothesis

The consistent rejections of the expectations hypothesis and the implied predictable variation in excess returns for long bonds[27] has been a "puzzle" as it suggests a trading strategy[28] with higher expected returns than implied by the constant term premium model. A number of explanations have been offered for this "predictability" in bond returns. These explanations can be broadly classified into three categories:

a. Failure to account for a time-varying risk premium
b. Bounded rationality and policy credibility of the central bank
c. The small sample properties of the test itself.

In the following discussion, we analyze these explanations in some detail.

Time-Varying Risk Premium: There is a strand of literature that argues that the "term premium" regression in (15) is time varying and the failure to account for this leads to a bias in the slope coefficient. A number of models that allow for a time-varying term premium can rationalize the deviation of the slope coefficients from one as a "risk premium."

Wachter (2006) introduces external habits in a consumption-based asset pricing model with a short interest rate that varies with surplus consumption. This endowment economy is successful in generating the negative Campbell-Shiller coefficients as a risk premium that is positive and varies in a countercyclical manner. Bansal and Shaliastovich (2012) show that the predictability in bond

[27]As evidenced by the slope coefficients of the Campbell-Shiller regression being different from 1.

[28]As noted by Campbell (1995), going long in bond holdings during periods in which the yield curve is steep, and shorting in periods of a flat yield curve is an investment strategy that has, historically, produced higher than average returns.

returns can arise due to a time-varying risk premia that increases with uncertainty about expected inflation and falls with uncertainty about expected growth.

While the literature has focused primarily on using the covariation or risk premia term to explain predictability in expected excess returns, there is increasing evidence to suggest that subjective expectations, which are different from those implied by the true probability distribution of the underlying process of returns, may be important.

Bounded Rationality and Credibility of Central Bank Policy: This explanation proposes that investors in financial market have irrational expectations. The regression in (15) is a joint test of the expectations hypothesis and the belief that investors have rational expectations. If the latter is not true, the regression error will no longer be orthogonal to the regressor and the slope coefficient will be biased. Kozicki and Tinsley (2001) and Fuhrer (1996) use shifts in agents' expectations about monetary policy to explain the rejection of the hypothesis in US data. In the first paper, the authors link changes in long-run forecasts of short yields to shifts in perceptions about the inflation target. Adaptive learning is used to model agents' behavior as they update their estimates of the long-run inflation target. These shifting endpoints in the short rates are incorporated into the determination of longer yields, and the expectations hypothesis is no longer rejected. Fuhrer (1996) models the short rate as being determined by the Federal Reserve, in response to output gap and inflation. He finds that the changes in the Federal Reserve's inflation target and response coefficients (to output gap and inflation) lead to variations in the long nominal rates of the magnitude that are observed in the data.[29] He concludes that if shifts in the expectation formation process of future short rates is accounted for, the hypothesis fares well relative to the data.

A rich literature has attempted to explain the findings on the Campbell-Shiller coefficients by allowing for a time-varying term premia and subjective expectations. It is also useful to interpret the negative bias with respect to 1 as the under-reaction of expected future yields of maturity $(s-1)$ to changes in the current short yield. In Froot's (1989) analysis, the test of the expectations hypothesis in (15) is decomposed into two slope coefficients, one corresponding to the error in expectations and the other a term premium. The first is found to be negative, that is, a portion of the deviation of γ from one can be attributed to errors in expectations. It is also found that at longer maturities, the slope coefficient corresponding to the term premium becomes quantitatively less important.

Mankiw and Summers (1984) also reject the hypothesis that expected future yields are excessively sensitive to changes in the contemporaneous short yield, along with the expectations hypothesis. They test if myopic expectations can justify the rejections of the expectations hypothesis, but the latter is rejected as well—that is, financial markets are "hyperopic," giving lesser weight to contemporaneous fundamentals than to future fundamentals.[30]

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[29]The long rates are derived using the expectations hypothesis.

[30]The authors use the term premia to explain the rejections of the expectations hypothesis.

Piazzesi et al. (2015), Sinha (2016) highlight the importance of subjective expectations. In the first paper, using survey data for professional forecasters in the US, the authors show that prior to 1980, when the level of yields was rising and the yield spread was small, survey forecasters predicted lower long yields than those that would be predicted by a statistical model. Since the forecasters update their information about high long yields slowly, they predict lower excess returns than were observed in the data. Thus, when the yield spread was low, and yield levels were high, survey forecasters predicted that long rates would fall, as seen in the empirical data. In Sinha (2016), the fact that optimizing agents misperceive the current increase in the short yield (due to a monetary policy shock) as an increase in yields for decisions they face over the infinite horizon results in a fall in the actual expected future yields. Therefore, in an endowment economy framework, the fact that the adaptive learners update their beliefs about yield processes slowly leads them to predict different paths of yields than under the true model. Nimark (2012) uses a model of trading to show that when traders have differential information, the non-nested information sets imply that individual traders can systematically exploit excess returns. They are able to take advantage of the forecasting errors of other traders in the model, even when no trader is better informed than the other. In Nimark's analysis, traders are rational, and the dispersion in their expectations about bond returns are caused by observing different signals. Under perfect information, the expectations hypothesis holds. However, when information sets are non-nested, and long bonds are traded frequently (and not necessarily held to maturity), the hypothesis no longer holds and excess returns are predictable.

Kozicki and Tinsley (2005) explore bounded rationality of agents and relate it to the credibility of monetary policy. Long-term yields have long horizon inflation expectations built into them. When the gap between long horizon inflation expectations and current inflation is large, the difference between long and short rates will also be large (this is the spread that appears in equation (15)). This may also be interpreted as low perceived credibility of policy. As policy credibility rises, long rates will fall. Thus, a large spread (reflecting low policy credibility) will precede falling long rates, as credibility improves.

Properties of the Campbell–Shiller Test: Finally, the expectations hypothesis may be rejected in the data because of the poor properties of the test itself, for finite sample data. This may be due to high persistence in variables or learning. Bekaert and Hodrick (2001) consider the Expectations Hypothesis in a vector autoregressive (VAR) framework. The VAR is estimated subject to the constraints of the expectations hypothesis, and the authors use this system to generate data and investigate the small sample properties of a variety of tests, such as the Wald test. They find that the rejections of the hypothesis may be explained, in part, by the poor properties of the Wald test in finite samples.

The rejections of the expectations hypothesis in the Indian context may arise due to a combination of the diverse factors detailed above. Additional research is required to disentangle and decompose the concomitants of predictability in expected returns.

6 Information in the Term Structure, Policy Implications and Concluding Comments

The joint term structures of real[31] and nominal interest rates encode critical information about risk free discount factors and expectations of future inflation. Both are crucial inputs for financing and investment decisions. Discount factors are a benchmark for the pricing of financial assets in the economy and for determining the cost of capital for capital budgeting, while expectations about future inflation impact the formulation and implementation of monetary policy.

Policymakers use the nominal term structure to infer expectations of inflation and real interest rates. As Haubrich et al. (2012) note, "Inflation expectations can gauge the credibility of a government's fiscal and monetary policies, whereas real rates measure the economic cost of financing investments and the tightness of monetary policy."

Changes in the level of nominal yields can be attributed to changes in the real interest rate, expected inflation or the inflation risk premium. Furthermore, the term structure of nominal expected returns can be decomposed into the real interest rate, the premium for holding a real long-term bond (the excess returns of holding nominal long-term bonds over real bonds), expected inflation and the inflation risk premium. An empirical identification of these different components, and their response to different inflation regimes, has been a rapidly expanding area of research for developed economies. Bansal and Shaliastovich (2012) use survey data on GDP growth and inflation for the US between 1969–2010 to identify the link between nominal bond premia and volatilities in expected growth and expected inflation. Uncertainty in real growth and inflation are found to have significant predictive power for excess bond returns. The authors also find that the nominal term premia decreases when real uncertainty declines, and increases with rising inflation uncertainty. Similar results are obtained for U.K. data. Ang et al. (2008) use a model with regime switches, inflation and time-varying prices of risk to identify whether changes in the nominal yields can be attributed to real interest rates, expected inflation or inflation risk premia. The authors document a negative correlation between the real short rate and expected as well as unexpected inflation.

Identifying the effects of expected inflation and inflation surprises on the real interest rates for the Indian case has been relatively unexplored so far. There is evidence to suggest, however, that there may be different inflation regimes in the Indian data. Hutchison et al. (2013) use a regime-switching model to investigate the monetary policy rule in the Indian context. The authors find that the Reserve Bank of India did not adopt inflation targeting; empirical estimates suggest that the RBI switched between two regimes, which are distinguished by their relative emphasis on output and price stability. This suggests that investigating the link between

[31] In the Indian context, however, the real term structure of interest rates is not available as inflation indexed bonds have only been recently introduced. Hence expectations about future inflation cannot be inferred from the term structure.

Table 12 Response of Zero-coupon yields to changes in the RBI policy repo rate

1-year	5-years	10-years
2002:1–2015:4		
0.86*	0.56*	0.32*
(0.37)	(0.20)	(0.16)
2002:1–2007:12		
0.29	0.35*	0.27*
(0.27)	(0.13)	(0.13)
2006:1–2009:7		
1.55*	0.84*	0.43
(0.34)	(0.32)	(0.30)
2009:7–2015:4		
−0.20	0.21	0.21*
(0.35)	(0.13)	(0.10)

Note This table reports the slope coefficients (β) from the regression in Eq. (17). The numbers in brackets are the heteroscedasticity adjusted standard errors. The starred coefficients are statistically different from zero

varying inflation volatility, nominal excess returns, and the real interest rate is an important avenue for future research in the Indian context, which we intend to explore in subsequent work.

While monetary policy clearly affects the short end of the yield curve it is the *real* long-term rate that is relevant for the investment decisions of firms that translate into economic growth. Much of the debate about the effectiveness of monetary policy can be recast in terms of the mapping from short-term to *real* long-term rates. There is, however, considerable disagreement in the literature about the effectiveness of monetary policy in affecting real economic activity.

Starting in May 2011 the RBI has used the repo rate as an instrument to implement monetary policy.[32] Lacking data on the real term structure, we explore whether nominal long-term zero-coupon yields at different maturities respond to changes in this policy rate. We consider the following regression:

$$\Delta y_{s,t} = \alpha + \beta(\Delta \text{repo}_t) + \varepsilon_t \tag{17}$$

Table 12 presents the response of the 1-, 5- and 10-year yields to the change in the repo rate.[33]

[32]Source: RBI's Handbook of Statistics on the Indian Economy.

[33]Since we are using monthly data, there are several qualifications to our exercise. As noted by Gürkaynak et al. (2005), this regression may be subject to the simultaneous equation or omitted variables bias. For example, the change in the RBI's policy rate may be a response of the rate to the change in asset prices that took place in the previous month. That is, the change in the policy rate is not a surprise. Analysis of the change in daily yields in response to surprise changes in the repo rate is a promising topic for future research.

While there is clear evidence of predictability in the data, we find that the mapping from short-term to *nominal* long-term rates over the period 2002–15 is not stable.[34] Our results imply that implementing monetary policy in India would prove to be a challenging exercise.

Appendix

Data Sources

Statistic	Source
Total Internal Marketable Debt	Outstanding central government debt from: Handbook of Statistics on Central Government Debt
Gross Fiscal Deficit and its Financing	Handbook of Statistics on the Indian Economy, 2013–14 (Table 105). RBI publication
GDP at Market Prices	Handbook of Statistics on the Indian Economy, various editions. RBI publication
Ownership patterns of GoI Securities	Handbook of Statistics on Central Government Debt

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[34]It is possible that the mapping from *real* short-term to *real* long-term rates is stable but the risk premium for inflation is time varying.

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Liquidity Management and Monetary Policy: From Corridor Play to Marksmanship

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1 Introduction

From January 2014, the Reserve Bank of India (RBI) initiated a regime change in the conduct of monetary policy. Drawing upon the intellectual edifice provided by the recommendations of an expert committee (RBI 2014) headed by its Deputy Governor,[1] this transformation began with the RBI adopting inflation measured by the headline consumer price index (CPI) as the nominal anchor for monetary policy, with numerical targets for January 2015 and January 2016. The institution of a

The views expressed in this paper are to be attributed to the authors and not necessarily to the institution to which they belong.

[1]Dr.Urjit Patel chaired the Expert Committee to Revise and Strengthen the Monetary Policy Framework. The case for inflation targeting in India had already been made by several committees in the past, notably the Percy Mistry Committee (GoI 2007), the Raghuram Rajan Committee (GoI 2009), and the B.N. Srikrishna Committee (GoI 2013). The Urjit Patel Committee was unique in setting out a complete operational "model" underpinning the regime, each element reinforcing the other in a mutually consistent manner. Reforms in liquidity management are an integral part of its recommended framework.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_9

bimonthly policy review cycle (April 2014) and biannual monetary policy reports or MPRs (starting from September 2014) followed, with upgrades and design adjustments in the operating framework (September 2014) to ensure transmission of monetary policy impulses. Executive legitimacy and a full institutional architecture was laid out in a monetary policy framework agreement (MPFA) between the RBI and the Government of India (GoI) that *inter alia* set a medium term inflation target of 4 ± 2 % with the mid-point of the band to be achieved by the end of 2017–2018, accountability mechanisms, and communication requirements (February 2015). Significant from the point of view of this paper is that the MPFA enjoined the RBI to set out in the public domain the operating procedure of monetary policy. The MPR (April 2015) fulfilled this requirement.

Efficient liquidity management is critical to the operationalization of monetary policy, the plumbing in its architecture. In the literature, monetary policy has been associated with "inside" lags—recognition, decision, and implementation—and outside lags—impact, and final (Perryman 2012). From an operational perspective, however, the crucial lags that monetary policy authorities have to deal with are: (i) from policy instrument to operating target or the variable that is directly controllable by monetary policy actions; (ii) from the operating target to the intermediate target, the latter being a variable having a stable and predictable relationship with final goals, which the central bank can hope to influence; and (iii) from intermediate target to the final objective(s). The main challenge before liquidity management is to minimize the first lag—ensure transmission of instrument changes to the operating target on a continuous basis, swiftly, and seamlessly. It calls for high skill in accurately assessing liquidity and market conditions on a forward-looking basis and deploying instruments, singly and/or in combinations, to modulate liquidity conditions in a manner that aligns the operating target with the policy stance. In turn, these operations ensure controllability of reserves and prevent disruptions in payment and settlement. In situations confronted with imperfect/missing markets, the use of developmental, regulatory, and macro-prudential instruments in concert with liquidity management adds an additional dimension of complexity. Statutory backing to all these developments has been provided by amendments to the Reserve Bank of India Act in 2016.

The RBI's liquidity management framework has come a long way since its inception in 1999. As recent efforts underscore, it is still evolving in response to changing macroeconomic and financial conditions, both domestic and global, and by learning by doing. Currently, the fixed overnight repurchase (repo) rate under the Liquidity Adjustment Facility (LAF) is the single monetary policy rate and the weighted average call money rate (WACR) is the operating target of monetary policy. The objective of liquidity management is to anchor the WACR around the policy rate. Against this backdrop, this chapter draws on select country practices and important contributions to the literature to evaluate the liquidity management framework in India by asking two questions: (I) what has been its performance in terms of securing the first leg of transmission—from the policy rate to the operating target? (II) what have been the collateral gains in terms of minimizing the volatility of the operating target, thereby strengthening the conditions for efficiency in the second leg of transmission? The rest of the chapter is organized into five sections. A review of the literature and country practices in the next two sections informs and sets up testable propositions for an assessment of the Indian experience in Sect. 4. An empirical appraisal of these hypotheses is the subject of Sect. 5. The final section concludes the chapter.

2 Survey of the Literature

There is a wide consensus in the literature that a sound and effective operating framework and active liquidity management are essential for fulfilling the goal of price stability (Bindseil and Nyborg 2008). There is also a consensus on the choice of the operational target: an interest rate over which the central bank has the most control since it can induce banks to borrow from it or place deposits with it (Henckel et al. 1999).[2] This is typically embodied in the level of the overnight market rate, which then guides the various short-term interest rates at which banks borrow and lend from each other and further out, the rates banks offer to customers on a risk-free basis (Borio 1997; Bindseil 2004; Ho 2008). The overnight rate thus becomes an anchor for the yield curve, with risk term spreads linking interest rates facing other economic agents. It has been argued that choosing a longer term interest rate as the operational target can lead to operating problems since the market is left to decide on the appropriate overnight interest rate, and this can lead to volatility in the short end of the market (Manna et al. 2001). Moreover, steering a longer term rate by the central banks is conceivable only when the policy rate is close to zero and the central bank commits to keeping it at or close to zero (McGough et al. 2005; Woodford 2005). The literature also emphasizes a commitment to mitigating volatility in the overnight rate so as to transmit monetary policy signals clearly, stabilize the price of liquidity and minimize the fluctuations in time varying premia (Allen et al. 2009; Linzert and Schmidt 2008; Cassola and Morana 2006).

2.1 *Instruments*

As regards the choice of instruments—open market operations (OMOs) including repurchases or repos, standing facilities, reserve requirements, counterparties, and collateral—there is a proliferating strand in the literature. Broadly, OMOs are associated with higher welfare than standing facilities although it has been shown that this holds only when inflation is low (Freeman 1996; Chapman and Martin 2007). Moreover, a central bank's OMOs may have no effect on the economy, because the private sector can neutralize the effects of the central bank's actions (Cúrdia and Woodford 2011). In practice, the distinction between open market operations and standing facilities is not clear as there is a spectrum of instruments containing elements of both (Bindseil and Wurtz 2007).

[2]The exchange rate predates the interest rate as an operating target of monetary policy. Although still in practice in small open economies such as Singapore, it faces diminishing practitioner appeal today as it entails a loss of independence of monetary policy and exposes the economy to external shocks (RBI 2014).

2.2 Corridors, Ceilings, and Floors

Monetary policy operating systems have been classified into three groups: (i) corridor systems without reserve requirements, (ii) reserve requirement systems with or without a corridor and (iii) floor and quota systems (Sveriges Riksbank 2014). Considerable interest has been drawn to the practice of central banks guiding their operational targets within corridors (Chart 1a) (Furfine 2000; Woodford 2000, 2001, 2003; Whitesell 2006; Martin and Monnet 2009: see Sveriges Riksbank 2014 for a comprehensive review). Briefly, a symmetrical corridor is advocated when the central bank has accurate liquidity forecasts and can ensure that the probability of the system's need to borrow is matched by that of its need to lend.

In the aftermath of the 2008–2009 financial crisis and in the face of persisting low inflation amidst protracted weakness of economic activity, a number of central banks in major advanced economies took their policy rates close to zero and have kept them at these exceptionally low levels, supported by massive liquidity injections through unconventional monetary policies. In some cases, policy rates or marginal deposit facility rates have turned negative. As a result, the corridor has yielded to a floor system, with the overnight rates anchored to the bottom (Chart 1b) (Bernhardsen and Kloster 2010). One advantage of the floor system is that the central bank can increase the supply of liquidity to the banking system without pushing short-term money market rates below the key rate, and thus it can have two independent tools—the interest rate and the amount of liquidity supplied. The disadvantage is that it can impair the working of the interbank market. The main difficulty associated with corridors/floors is the ability of the central bank to control the appropriate level of reserves supplied (Whitesell 2006). Even small errors in liquidity forecasts can detract from fine-tuning. Reducing the width of the corridor is suggested as a means to overcome this problem, since it lowers the sensitivity of the operating target to reserve changes.

An alternative to a corridor is a zero corridor with the central bank lending and depositing at the policy rate. This would make the overnight market redundant

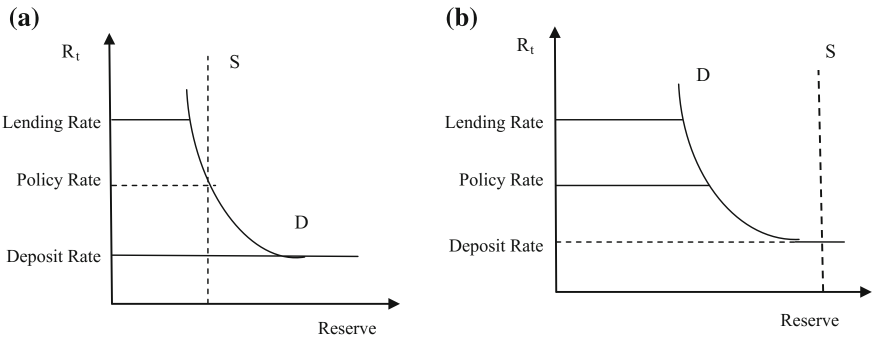

Chart 1 **a** Corridor system. **b** Floor system. *Source* Williamson (2015)

(Tucker 2004) and forfeit the information that banks have on each other's risk profiles (King 2008). It could also lead to the central bank losing control over its balance sheet. Combining a zero corridor with a functioning overnight market may warrant limiting the amounts that can be deposited/lent with/by the central bank (Bindseil and Wurtz 2008). Yet another option proposed in the literature is an asymmetrical corridor, especially in the context of a weak economy and fragile financial sector (Goodhart 2010).

2.3 Reserves

Textbook models based on demand and supply curves suggest that significant changes in reserve supply by the central bank are needed for systematic movements in the relevant interest rate, but empirical evidence for the US, euro area and Japan points to a weak liquidity effect, i.e., changes in supply of bank reserves have an extremely small effect on interest rates, if at all (Friedman and Kuttner 2011; Hamilton 1997). The demand for reserves has been found to be highly interest-inelastic across the maintenance period: for the US, an increase of US $ 1 billion in reserves on any given day leads to a decrease of less than one basis point in the federal funds rate (Friedman and Kuttner 2011). On the supply side, the US Federal Reserve is not found to exhibit any statistically significant response to the level of interest rates, although it responds forcefully to expected deviations of the federal funds rate from its target and also adjusts the supply of reserves in days following the change in its target rate. Reserve averaging procedures, lagged reserve maintenance periods and standing facilities render banks' demand for reserves elastic on a day-to-day basis, but interest-inelastic on a longer term basis. Central banks are able to change the overnight rates with minimal liquidity injection/absorption operations, and this indicates an important role for anticipation effects and expectations of future rates as well as the confidence that the central bank will intervene strongly to keep the overnight rate close to its target. Thus, open mouth operations are potent, provided they are backed by a credible threat of potential OMOs (Taylor 2001; Orphanides 2001). The setting of a short-term interest rate thus depends crucially on how central banks manage the access to money (Disyatat 2008). Standard conceptualization of monetary policy implementation focuses narrowly on central banks' control over the quantity of money, whereas in practice it is the terms on which it is available that plays the primary role in influencing interest rates.

Minimum reserve requirements have evolved as a tool for steering overnight interest rates. The central bank provides an assessment of liquidity needed to meet reserve requirements and banks can even out fluctuations in the overnight rate through the interbank market (Valimaki 2008). In a system based on averaging, reserves held by commercial banks on any day of the reserve maintenance period are perfect substitutes for purposes of satisfying reserve requirements (Hamilton 1996). Therefore, a priori, the federal funds rate on a given day should be equal to the rate expected to hold the following day and any deviations should be eliminated through arbitrage. Thus, the overnight rate should follow a martingale process within the maintenance period, except perhaps for the last day of the maintenance period. In contrast, a highly statistically significant tendency for the federal funds rate in the US to fall during the 2-week reserve maintenance period is observed and empirically confirmed, with sharper than usual drops on Fridays and before holidays and an abrupt upsurge on settlement Wednesday, attributable to transaction costs (Hamilton 1996; Taylor 2001). These results indicate little intra-day speculation to smooth out small fluctuations, and hence the federal funds rate does not display the expected martingale process.

2.4 Volatility

Settlement day rates are found to be more volatile than nonsettlement days for the US, Japan, Germany, France, Italy, and also the euro area (Bartolini and Prati 2006); in Canada and the UK, on the other hand, no such elevated volatility is visible on the settlement day. Moreover, higher settlement day volatility is found to propagate to days immediately preceding settlement. This phenomenon could be due to infrequent liquidity interventions by the central bank, reluctance/inability to fully accommodate large liquidity shocks, or their desire to let interest rates partly absorb shocks in order to induce banks to manage liquidity prudently. Lower volatility in the overnight rates reduces term premium, and hence lower medium- and long-term rates prevail (Carpenter and Demiralp 2011). Thus, an operating framework that reduces volatility in overnight rates can contribute to more stable medium- and long-term interest rates.

Central banks' liquidity management frameworks typically involve collateral to protect themselves from credit risk and

treatment of counter parties on equal footing (Chailloux et al. 2008). A broad cover pool of securities has been favored (Cheun et al. 2009). The broad consensus in the literature has also been for a limited number of counter parties (Chapman and Martin 2007), although the experience during the global financial crisis has called this into question. Liquidity supply through auctions has been recommended in the literature (Bindseil and Wurtz 2008), the virtues being simplicity and transparency. Bidding procedures involve either (1) bidding at fixed rate with 100 % allocation or (2) bidding at variable rate with a preannounced volume (Sveriges Riksbank 2014), the latter eschewing uncertainty on volumes from affecting bidding behavior (overbidding and underbidding). There is, however, a lack of consensus on the appropriate allocation procedure. Uniform rate allocation is found to lead to stabilizing effects on money market rates (Nyborg and Strebulaev 2004), a finding contested in favor of multiple rate allocations (Ewerhart et al. 2010).

3 Country Practices

The period since the 1990s has been characterized by a greater activism in liquidity management globally than before, and a focus on the short end of the market spectrum engendered by the growing integration of financial markets, within and across national borders. Although our focus in this section is on inflation targeting countries simply from the point of view of teasing out lessons for India from the country experiences,[3] a nimble readiness to engage markets characterizes liquidity management across regimes among modern central banks. Our assessment draws heavily from three recent comprehensive surveys of country practices (Hammond 2012; RBI 2014; Sveriges Riksbank 2014) with information updated from websites of central banks/monetary authorities (Annex Tables A.10 and A.11).

The survey of the literature in the preceding section suggests some necessary conditions to appraise the efficacy of liquidity management in the country experience. At the cost of broad generalization, the necessary conditions can be identified as follows: (a) achieving the operating target and (b) minimizing volatility in the operating target. A practitioner's perspective would also point to some sufficient conditions which are: (i) promoting an active short-term money market to ensure onward transmission efficiently and (ii) the wherewithal for the central bank to provide liquidity support to the system when needed and especially in extraordinary times, as the global financial crisis of 2008–2009 so vividly underscored. As the rest of this section will show, the choices that central banks make in each of these areas involve sharp trade-offs and challenges, with implications for their balance sheets and financial stability.

3.1 Operating Target

On the operating target, the predominant country preference—even a norm of sorts—is for a short-term money market rate, with most central banks choosing to steer the overnight money market rate either directly by setting a target (USA) or indirectly through central bank liquidity facilities (usually standing facilities and/or discretionary repo operations linked to the policy rate).[4] Ab initio, a trade-off is encountered: indirectly guiding the operating target through liquidity management operations can generate uncertainty about which interest rate the central bank is targeting, especially if the target is to be set within a corridor. Setting a target directly, on the other hand, places the onus of achieving the target wholly on

[3]27 countries target inflation explicitly (Hammond 2012). Some have an explicit numerical expression for a desirable rate of inflation as in the case of the USA.

[4]By contrast, Switzerland and Hungary explicitly target the 3-month rate and during September 2011 to January 2015, a floor on the exchange rate in the case of the former.

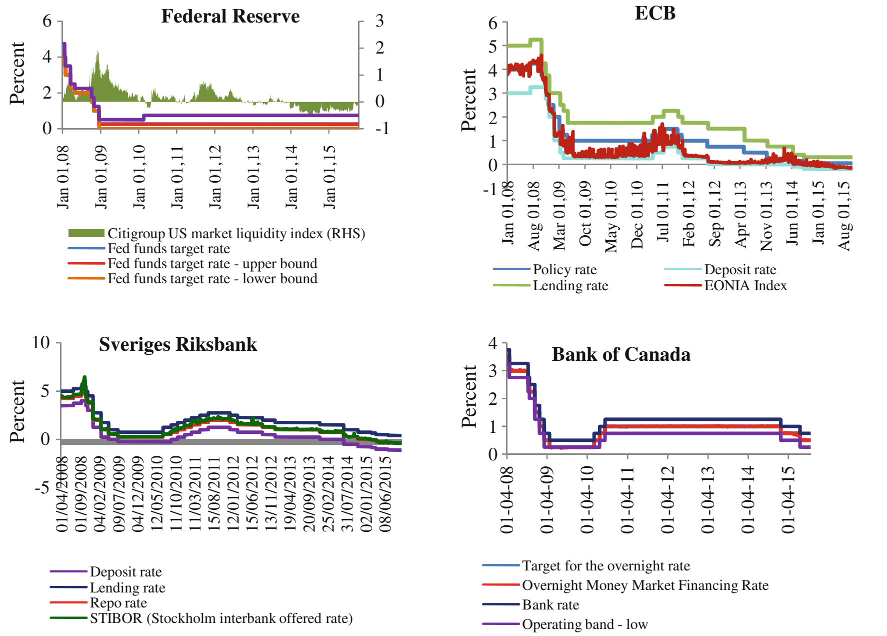

Chart 2 Liquidity management and monetary policy implementation. *Source* Bloomberg

liquidity management operations. This, in turn, necessitates an accurate assessment of liquidity and responses of market participants, and robust forecasts of liquidity that are undermined on a daily basis by both autonomous and frictional factors. The next dilemma is the decision on the width of the corridor. Currently, the cross-country experience suggests that corridor width ranges between 20 basis points and 300 basis points around the policy rate/target, with the operating target in the middle of the corridor and aligned to the policy rate being regarded as ideal[5] (Annex Table A.12).

The actual position of the operating target in the corridor is, however, at the discretion of market participants trading liquidity among themselves on an uncollateralized basis (Chart 2). Monopolistic power, risk aversion, surges in capital flows, and other factors are known to veer the operating target away from the middle of the band to either the ceiling or the floor (the UK prior to 2005; India prior to September 2014). Moreover, as the experience of Sweden and several others shows, even fine-tuning operations do not guarantee the desirable outcome since it is the interest rates on the central bank facilities that effectively determine the corridor.

[5]As noted earlier, in the aftermath of the 2008–09 crisis, several central banks in advanced economies have preferred to operate a floor system with operating targets/deposit rates close to or at zero or even into negative territory.

Table 1 Spread of mean of interbank rate versus target rate: select countries (percent)

	During crisis	Post crisis			
Country	Aug 9, 2007–Dec 2010	Jan 2011–Dec, 12	2013	2014	2015
Australia	0.00	0.00	0.00	0.00	0.00
Canada	0.10	0.00	0.00	0.00	0.00
Sweden	−0.06	0.17	0.05	0.05	0.01
UK	0.07	0.05	−0.02	−0.03	−0.02
Euro Area	−0.40	−0.50	−0.50	−0.10	−0.10
Czech Rep	0.07	0.09	0.13	0.10	0.10
Poland	−0.54	−0.25	−0.14	−0.06	−0.07
Hungary	−1.15	−1.62	−1.25	−1.52	−1.23
US	−0.13	0.00	0.14	0.16	0.12
Switzerland	−1.11	−0.51	−0.52	−0.51	−1.19
Norway	0.14	0.00	0.00	−0.01	−0.01
New Zealand	−0.11	−0.07	−0.03	−0.04	−0.09

Source Data for August 2007 to December 2010 and January 2011 to December 2012 are from Sveriges Riksbank (2014) and those for 2013, 2014 and 2015 are from country websites and Bloomberg

Note Data for Sweden "During Crisis" period are for April 2008 to December 2010, and for Euro Area for January 2008 to December 2010

Countries with narrow symmetrical corridors (±25 basis points in the case of Australia and Canada) seem to "middle" their operating targets better since they seem to encourage market participants to borrow and lend among themselves rather than use the central bank's facilities (Table 1). On the other hand, the choice of a narrow corridor over a wider one confronts central banks with yet another trade-off with a sufficient condition—wide corridors allow scope for variations in the operating target which incentivizes the development of the interbank market.

3.2 *Reserve Requirements*

Reserve requirements work as automatic stabilizers for the liquidity management framework by strengthening the achievement of the operating target. They increase banks' demand for reserves and central banks can "cash in" by providing just enough liquidity to meet reserve requirements at the policy rate in the middle of the corridor or at the target. Critical to this outcome is a correct judgement on liquidity; forecast errors can impart volatility to the operating target by themselves, thereby vitiating the second necessary condition. The country practice reveals a preference for averaging reserve requirement prescriptions. The headroom provided by averaging allows regulated entities to deal with transient and seasonal fluctuations in liquidity without recourse to the central bank. This also stimulates interbank trading of reserves in consonance with the first sufficient condition referred to earlier.

The number of central banks setting daily minimum reserve maintenance is dwindling (India), but averaging can increase the margin of error and undermine the second necessary condition of mitigating volatility in the operating target: the central bank has to ensure that the exact amount of liquidity is supplied over the reserve maintenance period which vary in the country experience from 2 weeks (USA and India) to 6 weeks coinciding with monetary policy meetings (Euro area and the UK). The Swiss National Bank (SNB), Hungary's Magyar Nemzeti Bank (MNB), National Bank of Poland (NBP), and the Czech National Bank (CNB) use a period of 1 month. Even where reserve requirements do not exist (Australia), banks demand reserves for settlement obligations and prudential purposes arising from currency demand and transactions in government accounts. The principal drawback of reserve requirements is that they impose an indirect tax on the banking system as an across-the-board levy and accordingly, some central banks are moving to remunerate reserves in the context of low/modest reserve requirements.

3.3 Managing Volatility

A stable operating target also constitutes a necessary condition for monetary policy transmission. Volatility in the operating target blurs policy signals along the maturity spectrum and gets reflected in higher risk/term premiums as observed in the USA, the UK, and the Euro area during the 2008–2009 crisis (Carpenter and Demiralp 2011). It also impedes the ability of investors to engage in maturity transformations. Reserve maintenance requirements aim to minimize volatility in the overnight rate, but empirically, it is found that volatility tends to heighten in the final days of the maintenance period in contrast to the theoretical view that on any given day, the actual rate will equal the expected rate on the final day when banks know that the central bank will supply the exact amount of liquidity needed (Sveriges Riksbank 2014).

Fine-tuning operations—including intra-day—are widely relied upon to align the operating target with the policy rate and mitigate volatility. They implicitly acknowledge that it is impossible to get liquidity assessments exactly right because of the interaction of autonomous and frictional factors on a real-time basis. Thus, fine-tuning tends to strengthen marksmanship in liquidity management and takes diverse forms, including end-of-the-day operations (Sweden) and auctioning of government balances with the central bank (Canada). Forward guidance is also widely used for the same purpose through indications of future short-term rates (the USA, the Euro area, and the UK), publication of projected policy rate paths (Sweden and Norway), and publication of liquidity forecasts (Australia and Russia). Many central banks also prefer to monitor and correct for term/risk premia in order to ensure stability of monetary policy transmission. Other country practices to minimize volatility include synchronizing main refinancing operations with the reserve maintenance periods (Euro area); indexing the overnight rate to the policy rate (UK); and widely used discretionary operations alongside regular operations.

3.4 Developing Markets

Turning to the "sufficient" conditions , money markets are a key source of bank funding which, in turn, affects financing conditions faced by nonfinancial firms and households. Money market rates are affected by the monetary policy stance and serve as benchmarks for pricing long-term financial products. Given its importance for monetary policy and financial stability, money market development is almost universally supported by central banks so that they remain continuously open even under stress (Carney 2008).

The cross-country experience suggests that several segments of the money market—besides overnight—receive special attention from central banks. Although diminishing in importance in recent times with the development of derivative segments, short-term markets for government securities remain in the focus of central banks as they set benchmarks for the sovereign yield curve and support monetary transmission. Moreover, these securities are also preferred as collateral in the central bank facilities. Consequently, where government debt is small, these securities are issued in order to maintain collateral supply (Australia). Central banks have also intervened to backstop commercial paper markets (the USA and UK) in the 2008–09 crisis, but also in normal times (France, the USA, and the Euro area). By and large, central bank support to short-term unsecured markets is more common in the form of standing and discretionary facilities as also in enabling the evolution of reference rates (Euro area, Poland, Hungary, and Czech Republic). In almost all countries, short-term secured markets as also those for derivatives have evolved largely due to the efforts of central banks, the best examples being repo markets , swap markets, futures and overnight indexed swap (OIS) markets (the USA, UK, Euro area, Canada, Switzerland, and India).

3.5 Providing Liquidity

Finally, central banks stand ready to step in to mitigate the deleterious effects of temporary liquidity shortages and their spillovers across broader segments of the market continuum. Standing facilities (SFs) form the immediate and standard forms of central bank liquidity insurance and constitute key elements of the liquidity management framework. Almost all central banks have a standing credit facility for providing funds to deficit counterparties at a penal rate, usually on an overnight basis but are also known to extend the term to a week (the Euro area) and up to 90 days (the USA, UK, and recently LTROs in the Euro area) and even to 6 months (UK). Eligible collateral has varied, more so in the 2008–2009 crisis and ensuing years. The use of standing deposit facilities is found to be limited, though it helps in setting a floor in the interbank market, especially in liquidity surplus conditions. These standing facilities help in containing the volatility in interbank market within the corridor, thereby facilitating the achievement of the operating rate target. There is, however, asymmetry in credit and deposit SFs in some countries.

In the aftermath of the 2008–2009 financial crisis, discretionary and emergency liquidity facilities have come into existence across central banks or at least there are provisions to use them as needed in relevant legislations. Discretionary operations can be partitioned under two broad subheads: (i) the main refinance operations and (ii) other discretionary operations. OMOs are the most common refinance instruments, conducted on a preannounced date with participation from banks and primary dealers (PDs). OMOs are deployed for both lending and borrowing purposes, cover both outright and repo agreements, and are contingent upon the nature of the liquidity situation—structural or frictional. Other discretionary operations include nonstandard/nonregular operations used in response to some unforeseen developments requiring liquidity support: forex swaps (Australia; Singapore), term deposits (Australia), compulsory deposits (Mexico), additional loans and deposits (Sweden), and funding for lending (UK) (RBI 2014).

All major central banks consider public sector securities as eligible collateral. Since the crisis of 2008–2009, the list of eligible collateral has expanded in several countries covering financial entity debt (Japan, Mexico, Sweden, and UK), covered bonds (Australia and UK), other asset-backed securities (Australia, Canada, Mexico, and UK), corporate debt and loans, and other credit claims (Canada and UK), and cross-border collateral (Australia, Japan, Mexico, and Singapore). Accordingly, countries have different policies relating to pricing, margins, and haircuts (RBI 2014).

To sum up, liquidity management is the essence of what makes monetary policy work. In recognition of this reality, central banks have assiduously developed operating frameworks over the years, centered around modulating liquidity conditions in order to achieve the first leg of policy transmission—anchoring operating targets to policy impulses. As experience and success have been gained in this endeavor, their attention has turned to improving transmission outwards along the market/maturity spectrum. By design rather than by accident, the choice of operating target has predominantly been in favor of the overnight market interest rate which sets the terms at which market participants buy and sell reserves. Central banks have fortified their choice by playing a decisive role in the demand for and supply of reserves, whether by imposing reserve requirements and/or by supplying primary liquidity through a variety of instruments and instrumentalities described in this section. Two concomitant pursuits have been the development of depth and sophistication in other segments of the market to improve the efficacy of the outward transmission of the operating target, and to constantly refine and stress test instruments of liquidity provision to prevent markets from freezing under exceptional binds. Since there are implications for financial stability, central banks regularly resort to nonmonetary instruments as well in the conduct of liquidity management. These instruments are tailored to deal with various exigencies: surges in capital flows, credit allocation, pro-cyclicality and interconnectedness, and the nontrivial fear of hitting the zero lower bound on the nominal interest rate (Table 2).

Table 2 Use of macro-prudential instruments by country-groupings

Instrument	Advanced	Emerging	Total number
Loan-to-value	9	15	24
Debt-to-income	2	5	7
Cap on credit growth	1	5	6
Limit on foreign lending	1	7	8
Reserve requirement	0	5	5
Dynamic provisioning	1	8	9
Countercyclical capital requirement	0	2	2
Restriction on profit distribution	0	6	6
Others	1	12	13

Source Claessens et al. (2013)

4 Indian Experience

The liquidity management framework in India has evolved across several regime shifts.[6] In a fundamental sense, however, it was the RBI's efforts to imbue the conduct of monetary policy with market orientation that can be regarded as a defining starting point.

4.1 *The First Phase (1988–98)*

Inspired by a Working Group on the Money Market,[7] the RBI set up the Discount and Finance House of India (DFHI) in 1988 to offer two-way quotes on Treasury bills (TBs) and activate a secondary market for them. This was followed by the withdrawal of interest rate ceilings and other restrictions on money market instruments, the introduction of interbank participation certificates (IBPCs) , certificates of deposit (CDs) and commercial paper (CPs) over the following year, money market mutual funds in 1991, the progressive recourse to auctions in TBs of various maturities to enable price discovery, the introduction of primary dealers in 1995 to develop secondary market for government securities more generally, and the phasing out of automatic monetization of fiscal deficits through ad hoc TBs by 1997.

[6]See RBI (2004) for a comprehensive, historical overview of monetary policy regimes in India.

[7]The Chakravarty Committee (1985) was the first to make comprehensive recommendations for the development of the Indian money market. In 1987, the Reserve Bank set up a Working Group on the Money Market (Chairman: Shri N.Vaghul) to specifically examine various aspects for widening and deepening the money market. Following the recommendations of these two committees, several new initiatives were undertaken.

The next burst of reforms was triggered by the recommendations of the 1998 Committee on Banking Sector Reforms (RBI 1998).[8] The call money market was transformed into a pure interbank market by phasing out nonbank participants during 2001–2005, who went into collateralised money market segments such as the collateralized lending and borrowing obligation (CBLO) and market repo that were activated by 2003, enabled by the establishment of an anonymous screen-based trading platform for money market instruments—the negotiated dealing system (NDS)—at the Clearing Corporation of India Limited (CCIL) established in 2001.

Currently, money market instruments and participants are free of all restrictions, except for prudential limits that tie borrowings and lendings of banks and PDs in the call/notice market to their net owned funds so as to minimize default risk. They also meet standard asset-liability management guidelines and reporting requirements on nearly real-time basis (within 15 min of conclusion of the transaction). A screen-based negotiated quote-driven system for all dealings in the call/notice and the term money markets (NDS-CALL) was operationalised in the CCIL in 2006 to bring about increased transparency and better price discovery in these segments.

The introduction of money market instruments and segments, withdrawal of restrictive prescriptions, and the progressive development of the interest rate as the key instrument of monetary policy set the stage for the development of the liquidity management framework, which evolved in phases linked to these developments. Initially relying on outright OMOs, the Reserve Bank began conducting repos during 1992–1995, initially for 1, 2, or 3 days covering 5 days in a weekly cycle, which was later replaced by a 14-day cycle covering the reserve maintenance period. The repos were discontinued after March 1995 due to a lack of demand under tight liquidity conditions but they resumed in early 1997 at interest rates linked to the reactivated Bank Rate. In those early days, these repos provided greater maneuvrability in deciding the quantum of liquidity to be absorbed/injected.

4.2 *The Second Phase (1999–2013)*

In April 1999, an Interim Liquidity Adjustment Facility (ILAF), operated through repos and lending against collateral of GoI securities, was introduced under which liquidity was injected at various interest rates, but absorbed at the fixed (reverse) repo rate. A collateralized lending facility (CLF) was established alongside an additional collateralised lending facility (ACLF), with export credit refinance and liquidity support to PDs all linked to the Bank Rate. The transition from ILAF to a full-fledged LAF commenced in June 2000. From November 2004, the LAF began to be operated with only overnight repo/reverse repo auctions and long-term auctions were discontinued. Over the ensuing years, the LAF became the principal

[8]The Committee on Banking Sector Reforms, 1998 (Chairman: Shri M. Narasimham) (RBI 1998) recommended measures to facilitate the emergence of a proper interest rate structure reflecting the differences in liquidity, maturity and risk.

instrument of liquidity management and it set up a corridor varying between 100 bps and 300 bps over the period November 2004 to April 2011, for the short-term interest rates consistent with monetary policy objectives.[9] The Market Stabilization Scheme[10] (MSS) was introduced in April 2004 to provide the Reserve Bank with an additional instrument of liquidity management and to relieve the LAF from the burden of sterilization operations (Mohan 2006).

A major concern with this framework was that swings in macroeconomic and monetary conditions produced wide variations in the operative policy rate, as it alternated between repo and reverse repo rates. Moreover, the call money rates often breached both the ceiling and the floor. Against this background, the operating framework was modified in May, 2011. The repo rate was made the single independently varying policy rate for transmitting policy signals. A marginal standing facility (MSF) was instituted under which banks could borrow overnight at their discretion by dipping up to 1 % (currently 2 %) into the statutory liquidity ratio (SLR) at 100 basis points (bps) above the repo rate to provide a safety valve against unanticipated liquidity shocks. Third, the revised corridor was defined with a fixed width of 200 bps. The repo rate was placed in the middle of the corridor, with the reverse repo rate 100 bps below it and the MSF rate 100 bps above it (Mohanty 2011). The Bank Rate, which had remained unchanged since 2003, was aligned to the MSF rate in February 2012.[11]

This framework was based on the central premise of keeping the system in a deficit mode. Consequently, the transmission of policy rate cuts in the easing phase remained incomplete (Table 3). Other limitations have also been cited (RBI 2014): (a) the policy rate, i.e., the repo rate became the de facto floor rate with the MSF rate setting the ceiling; (b) it implicitly accepted volatility in the call money rate of up to 100 bps, resulting in rising flux in the operating target (Chart 3); (c) access to the LAF was determined by holdings of eligible securities, i.e., government securities as excess SLR at the discretion of banks on a daily basis while the LAF was to be operated at the discretion of the RBI, setting up a contradiction; (d) often monetary policy tightening was followed up by liquidity easing measures, rendering the two inconsistent and the distinction between them blurred (Annex 1 Tables A.4 and A.5); (e) OMOs were repeatedly resorted to as instruments of yield management and for indirect financing of the fiscal deficit—about 30 % of the GoI's net market borrowings were financed by the OMOs in 2011–12 and 2012–13;

[9]In response to suggestions from market participants, the Reserve Bank introduced a second liquidity adjustment facility (SLAF) from November 28, 2005, enabling conduct of repos and reverse repos for fine-tuning operations.

[10]The MSS was an arrangement between the Government of India and the Reserve Bank to mop up the excess liquidity generated on account of the accretion to foreign exchange assets of the Bank and neutralize the monetary impact of capital flows.

[11]The corridor width was reduced to 100 bps, with reverse repo rate and MSF rate placed 50 bps below and above the policy rate, respectively, in April 2016. This was intended to ensure finer alignment of the WACR with the policy repo rate, drawing upon the success of the revised framework in keeping the WACR well within the earlier corridor of 200 bps.

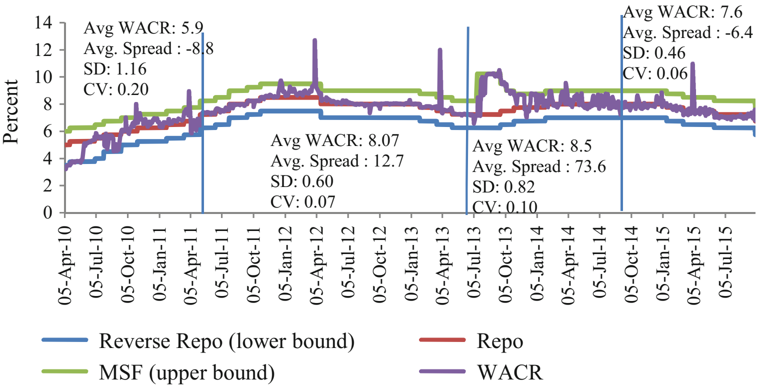

Chart 3 Operating framework. *Source* RBI

(f) liquidity planning/management by banks effectively shifted to the RBI—the LAF became a conduit for gaming central bank liquidity; and (g) the framework also included a quantity variable as an indicative target—(±) 1 % of net demand and time liabilities of banks which was regularly breached.

4.3 The Current Framework

Against this backdrop, the RBI undertook reforms in the liquidity management framework on the recommendations of the expert committee (RBI 2014). In its view, the excessive focus on the overnight segment of the money market had to be eschewed, which would be possible only if the RBI de-emphasized overnight repos for liquidity management and progressively conducted its liquidity management primarily through term repos of different tenors. In time, this would lead to the fuller development of the term money market—the missing segment in the continuum—which would enable smoother transmission of monetary policy and throw up market-based benchmarks for pricing various types of financial products, in particular, bank deposits. Accordingly, it recommended design changes and refinements in the operating framework with flexibility in the use of instruments but consistent with the conduct and goals of monetary policy. The revised liquidity management framework was put in place in September, 2014 and fine-tuned in April 2016 (Annex Table A.4).

The key change in liquidity management has been the end of unlimited accommodation of liquidity needs at the fixed LAF repo rate. Other important aspects of the revised liquidity management framework include: (i) provision of the predominant portion of central bank liquidity through term repo auctions; (ii) introduction of fine-tuning operations through repo/reverse repo auctions of maturities varying from intra-day to 28 days with the assessment of the liquidity undertaken on a continuous basis; (iii) phasing out export credit refinance; and (iv) a path of progressive reduction of statutory preemptions in the form of the SLR.

The main liquidity provision instrument—14-day term repo—is synchronized with the reserve maintenance period and allows market participants to hold central bank liquidity for a relatively longer period. This facilitates on lending in the term money segment in the interbank market and is expected to develop market segments and benchmarks for term transactions. More importantly, term repos have weaned away market participants from the passive dependence on the RBI for cash/treasury management, since liquidity modulation is increasingly at the discretion of the RBI. It has also turned out to be an efficient indicator of underlying liquidity conditions in the market.

In operational terms, the first element in the framework is a set of 4 weeks ahead liquidity projections. This involves forecasting autonomous factors—demand for currency in circulation; bank reserves held with the RBI; GoI balances with the RBI, and operations in the foreign exchange market. Currency demand is projected on the basis of an autoregressive process factoring in seasonality and controlling for festival and quarter-end effects. Banks' reserves are determined by projections of deposits and the cash reserve ratio. GoI balances with the RBI are the Achilles heel of the forecasts and rely almost entirely on information on inflows (tax receipts, auction proceeds, and the like) and outflows (salaries/pensions/subsidies/redemptions/coupons and the like) received from the GoI. Foreign exchange interventions are another discrete element for which forecasts are difficult since they are actual operations in response to real-time developments in the market. Based on these projections, regular liquidity operations are planned.

On a given day, the first indication of liquidity developments is signaled by the opening rate in the call money market and the intensity of trading in the initial hours. The second indication is provided by the response to the fixed rate overnight repo operations through which a fourth of planned liquidity is provided at 11 am. On Tuesdays and Fridays, 14-day variable rate term repo auctions are conducted at 11.30 am for a notified amount equivalent to three-fourths of the planned liquidity. The response to these auctions gives yet another indication of the daily liquidity pressures. Based on these indicators and market intelligence, fine-tuning repo/reverse repo auctions of varying maturities depending on "topping-up" needs are conducted during the rest of the day. Fixed rate reverse repo auctions and access to the MSF are available between 7.00 and 7.30 pm on a daily basis to equilibrate residual liquidity demand. The MSF and fixed rate reverse repo are also available on Saturdays. The result is that since April 2015, the operating target—the WACR –has moved in a tight range of ±40 bps and volatility has declined noticeably. It has effectively signaled the cessation of the corridor system and has honed the RBI's marksmanship significantly (Chart 4). The liquidity management framework was fine-tuned in April 2016, drawing upon the experience with the framework put in place in September 2014 as also in view of the shift of monetary policy stance to an accommodative mode. The Reserve Bank indicated that, going forward, it would smoothen the supply of durable liquidity over the year using asset purchases and sales as needed and also progressively lower the average *ex ante* liquidity deficit in the system to a position closer to the neutrality, moreover, as noted earlier, the policy rate corridor was narrowed from +/- 100 bps to +/- 50 bps

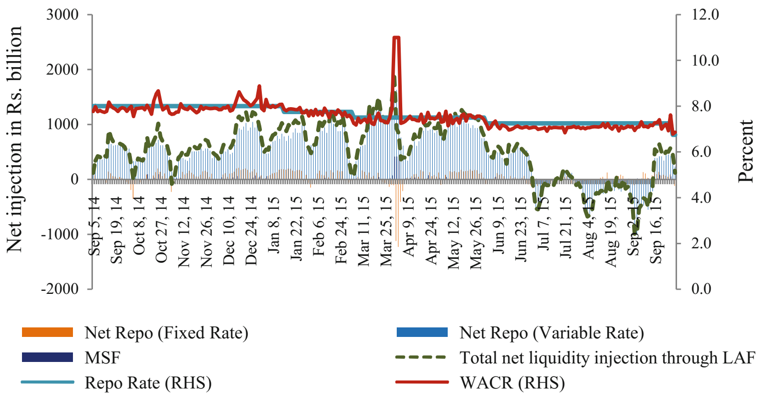

Chart 4 Liquidity conditions. *Source* RBI

Against the backdrop of these significant changes in liquidity management in India, it is useful to turn to contemporaneous developments in respect of the sufficient conditions identified in Sect. 3.

4.4 Development of Money Market

As mentioned earlier, the RBI's sustained support has over the years incentivized the development of the money market and its various segments in terms of turnover, players, and instruments. While these reforms have imparted vibrancy and depth to various money market segments, liquidity distribution is highly uneven, with some private sector banks being chronic borrowers and cooperative banks and public sector banks mostly on the lending side. Furthermore, there has been a steady migration of activity to collateralized segments, viz., CBLO and market repo, and the uncollateralized call money market currently accounts for barely 10–11 % of the

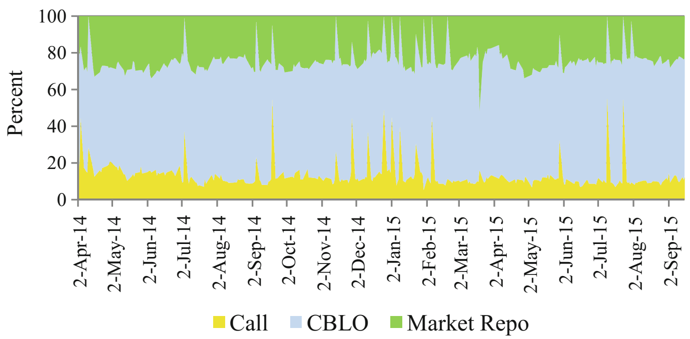

Chart 5 Share in total volume. *Source* CCIL

total overnight turnover (Chart 5). Trading in the call money market tends to be skewed by its microstructure—over 60 % of the activity is concentrated in the opening hour and the closing hour of trading; the top five borrowers account for about 50 % of total daily call volumes on average (Annex Table A.5). These features have occasionally accentuated volatility in the call money market. Furthermore, the collateralized segment (CBLO) continues to be dominated by non-bank participants with mutual funds contributing around 50 % of the total volume. Consequently, extraneous developments such as redemption pressure in the stock market can deter mutual funds from lending in the CBLO segment and tighten overnight market conditions across the board.

4.4.1 Term Money Market

The term money market ranges from 15 days to 1 year. The administered interest rate system in this market was dismantled in 1989. In 1993, select financial institutions were allowed to borrow from the term money market for a maturity period of 3–6 months. The term money of original maturity between 15 days and 1 year was exempted from the CRR in August 2001. Furthermore, no limits are stipulated for transactions in the term money market, unlike under the call/notice money market. Factors still hindering the development of this segment of the money market include: (i) the inability of participants to build interest rate expectations over the medium term; (ii) the skewed distribution of liquidity; (iii) corporates' overwhelming preference for cash credit[12] rather than loans; and (iv) the overwhelming preference of banks to deploy surplus funds in LAF reverse repo auctions rather than in the term money market , reflecting risk-averse behavior (RBI 2006). Under the new framework, however, volumes in term money markets are showing signs of a pick-up. The average daily trading volume in uncollateralized term money and CBLO segments witnessed an increase to Rs.2.65 billion and Rs.93.94 billion, respectively, during the first half of 2015–2016 from Rs.2.10 billion and Rs.91.03 billion during the same period last year.

The efficacy of monetary policy in influencing aggregate demand is determined by the swift and seamless reflection of policy changes in the operating target, i.e., the uncollaterlised call money rate in the case of India. Other segments of the money market respond synchronously to call rate movements (Chart 6).

[12]Cash credit facility is an arrangement under which banks lend money against securities. It runs like a current account, except that the money that can be withdrawn from this account is not restricted to the amount deposited in the account. Instead, the account holder is permitted to withdraw a certain sum called "limit" or "credit facility" in excess of the amount deposited in the account. Cash credits are, in theory, payable on demand.

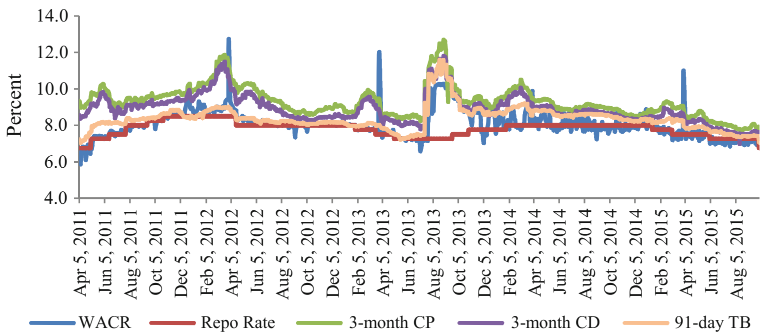

Chart 6 Transmission to short-term rates. *Source* RBI and Bloomberg

4.5 Liquidity Provision

A key to the RBI's operating framework is liquidity insurance, which underpins the achievement of the operating target. Over the years, the RBI has moved away from sector-specific and institution specific liquidity support to system-level liquidity provision. Liquidity support to the market can be loosely disaggregated between normal liquidity facilities and exceptional liquidity provision in the role of the lender of last resort.

Normal or standard liquidity facilities are empowered under Section 17 of the RBI Act. They are essentially intended to enable banks to meet their regular demand for reserves necessitated by the cash reserve ratio prescription as well as frictional liquidity mismatches brought on by payment and settlement obligations and government transactions. Outflows on account of the cash credit system for borrowers and premature deposit withdrawals impart considerable uncertainty to payment and settlement needs. The MSF, which is intended to meet any residual demand for liquidity, effectively provides assured liquidity to the extent of the excess SLR holdings of banks plus 2 % of the SLR stipulation itself. The cumulative access is of the order of 200 % of the CRR requirement. Fixed rate repo auctions and variable rate term repo auctions together provide a fourth of the CRR requirement. Any frictional or additional demand for liquidity is satisfied through fine-tuning operations. Thus, the RBI is empowered to meet all normal liquidity needs through its regular operations and standing facilities which range across the maturity spectrum (overnight to 90 days). Additionally, it also provides intra-day liquidity for facilitating payment and settlement through its real-time gross settlement system. All normal facilities are collateralised (only GoI securities are accepted as collateral with suitable haircuts and margins).

In addition to provision of regular/standing liquidity, the Reserve Bank is also empowered to provide emergency liquidity assistance (ELA) as lender of last resort (LOLR) to a broad spectrum of financial entities (Section 17(4), RBI Act). This power is exercised only when a troubled entity exhausts all its market-based resources. ELA/LOLR assistance is provided against the collateral of sovereign securities or any other security as prescribed by the Reserve Bank for a period not exceeding 90 days. Liquidity support to entities not otherwise eligible for direct access of central bank liquidity can also be provided from the Reserve Bank under exceptional circumstances indirectly through an entity eligible under this Section. Furthermore, under exceptional circumstances/crises, the RBI can extend liquidity support to any entity for the broad purpose of regulating credit in the interest of Indian trade, commerce, industry and agriculture for a period not exceeding 90 days (Section 18, RBI Act).

5 Empirical Analysis

Guided by the review of the literature in Sect. 2 and the central tendencies observed in the country experience in Sect. 3, we now proceed to empirically evaluate the liquidity management framework in India in terms of first principles, i.e., the necessary conditions identified in Sects. 2 and 3—(a) achieving the operating target and (b) minimizing volatility of the operating target. The sufficient conditions—underpinning a vibrant money market and ensuring avenues for adequate liquidity provision by the central bank—have been addressed in the preceding section in terms of the stylized evidence, since they are less amenable to empirical verification.

As brought out in Sect. 4, the current operating framework for liquidity management has evolved over various phases. Although a full-fledged LAF was effectively in operation by April 2004, it took a few years to stabilize and was marked by discretionary interventions in the early years as part of ongoing refinements. Illustratively, sterilizing surges in capital flows through reverse repo ran the danger of the RBI running out of eligible collateral and, there was also a perception that higher domestic interest rates were encouraging capital inflows. Therefore, a temporary ceiling of Rs. 30 billion was imposed on reverse repo operations during March 2, 2007 to August 6, 2007 which produced high volatility in the money markets. Accordingly, to tide over these learning phases from the point of view of objectivity and fullness of the experience in terms of data availability as well as of reaching a state enabling cross-country comparison, we choose the period from April 2008 as a starting point. From then on, two major shifts are detected: first in May 2011 when the repo rate became the single policy rate in the middle of a corridor of 200 basis points defined by the reverse repo rate and the MSF rate; and the second in September 2014 when the current liquidity framework was introduced. Thus, our period of empirical analysis is characterized by three regimes: first, from April 1, 2008 till April 30, 2011; second from May 2, 2011 to June 2013, the end date for this period determined by exceptional operations undertaken during July–September 2013 to stabilize domestic financial markets in the taper tantrum—effectively a system override; and, third from September 5, 2014 up until September 30, 2015. For all variables, daily data are used.

5.1 Achieving the Operating Target

In India, the WACR has been an explicit operating target since May 2011, although it was also the implicit target in earlier years. Unit root tests indicate that the null hypothesis of nonstationarity cannot be rejected for both the call rate and the effective policy rate.[13] Bound tests indicate that the two series are cointegrated. This supports the application of the autoregressive distributed lag (ARDL) approach (Pesaran et al. 2001). The baseline specification for capturing short-run dynamics is given as follows:

$$\begin{aligned}\Delta(\mathrm{WACR})_t = a * (\mathrm{WACR} - b * \mathrm{EFF})_{t-1} + \sum c_i * \Delta\,(\mathrm{WACR}_{t-i}) \\ + \sum d_i * \Delta\,(\mathrm{EFF}_{t-i}) + u_t\end{aligned} \tag{1}$$

in which WACR is defined as earlier, EFF is the effective policy rate, and u_t is the error term. While the baseline estimation of (1) is for the full sample period (April 1, 2008 to September 30, 2015), we also estimate it for each of the regimes defined in this section.

In the next step, we augment (1) with dummies for the full sample period estimation to account for phenomena highlighted in cross-country empirical work as also to capture country-specific developments. First, the unconventional response to the taper tantrum led to temporary restrictions on banks' access to the LAF window and an increase in the MSF rate from 100 bps above the repo rate to 300 bps above the repo rate on July 15, 2013 and it was not until October 29, 2013 that the corridor was fully normalized. The impact of these developments on money market rates is captured through a dummy (d_emp). Second, call money rates tend to spike towards the end of a quarter when banks generally reduce lending in the call market to meet capital adequacy requirements, including avoidance of higher risk weights attracted by lending in the unsecured call market. This phenomenon is captured through an end-quarter dummy (d_quarter), in the full sample estimation as well as in sub-samples. Third, reserve requirement maintenance is subject to a daily end-of-the-day minimum and product averaging, unlike the practice of period averaging widely followed in the cross-country experience. This leads to banks holding excess reserves in the first week of the fortnightly maintenance period, with drawdowns in the second week. This is not unique to India: the complex intertemporal optimization problem confronted by banks on account of reserve requirements can lead to potentially different behavior across the maintenance period as banks optimize their maintenance behavior (Taylor 2001; Orphanides

[13]As noted in Sect. 4, the impact of liquidity movements resulted in the operative policy rate shifting between the LAF's floor and ceiling. During episodes of excess liquidity (2008:4 to 2010:2), the reverse repo rate was the effective policy rate. On the other hand, during episodes of monetary tightening/liquidity shortage (2007:1 to 2008:3 and 2010:3 to 2011:4), the repo rate became the effective policy rate. The effective policy rate, thus defined, is used as the policy rate, following Patra and Kapur (2012).

2001; Friedman and Kuttner 2011). The inadequate availability of eligible collateral with the liquidity deficient banks preventing access to the central bank on specific days in the reserve maintenance period can also lead to fluctuations in daily call rates. Accordingly, these effects are sought to be represented by daily dummies (Dum_daily captured by dummies D3 to D14)[14] to the baseline specification. Thus, the extended specification is

$$\begin{aligned}\Delta(\mathrm{WACR})_t = {} & a * (\mathrm{WACR} - b * \mathrm{EFF} - c * D\_\mathrm{emp} - d * D\_\mathrm{quarter} - \textstyle\sum e_j * \mathrm{Dum\_daily})_{t-1} \\ & + \textstyle\sum f_i * \Delta(\mathrm{WACR}_{t-i}) + \sum g_i * \Delta(\mathrm{EFF}_{t-i}) + \sum h_i * \Delta(D\_\mathrm{emp}_{t-i}) \\ & + \textstyle\sum i_i * \Delta(D\_\mathrm{quarter}_{t-i}) \quad + \sum f_i * \Delta(\mathrm{Dum\_daily}_{t-i}) + u_t\end{aligned} \tag{2}$$

We estimate and report both the baseline and the augmented specifications (Annex Tables A.6–A.8). As the results are qualitatively similar, we focus on the augmented specifications in the narrative of this section.

The long-run coefficient on the effective policy rate is close to unity, indicating that, on average, the call rate is closely aligned to the policy rate across the full sample as well as across regimes. What is striking, however, is that short-run dynamics—captured by the coefficient on the error correction term—indicate an increase in the speed of adjustment in the current regime relative to its predecessors. Deviations of the call rate from the policy rate are more short-lived in the most recent regime than in earlier ones, i.e., 74 % of the deviation of the call rate from the policy rate is adjusted in just one day, on average, in the latest period as against only 24 % in the first. These results could be attributed to a variety of factors: honing of the RBI's liquidity forecasts; the introduction of intra-day fine-tuning operations; improving liquidity management by banks; and, rising efficiency in the money market. The greater precision in achieving the operating target in the current regime is noteworthy, characterized as it has been by extreme volatility associated with expectations of normalization of US monetary policy as well as the meltdown in Chinese stock markets and the renminbi (RMB) devaluation. While these results warrant a caveat in that the duration of the current regime is less than that of the previous two regimes, the empirical evidence does point to efficiency and pro-activeness in liquidity management by the RBI in achieving its operating target of anchoring the call rate to the policy rate. Moreover, the average deviation between the two reduced to (+) 5 basis points during 2014–15; the deviation was (–) 11 basis points during 2015–16 (up to September 30, 2015), consistent with the easing monetary policy stance (Chart 7). Visits of the operating target to the bounds of the corridor—MSF and the fixed reverse repo rate—have become rare.

[14]Dummies D3, D4, D5, D6, and D7 denote Monday, Tuesday, Wednesday, Thursday and Friday of the first week of the 14-day reserve maintenance period, while D10, D11, D12, and D14 denote Monday, Tuesday, Wednesday, and Friday of the second week of the reserve maintenance period. In order to avoid multicollinearity, we do not include a dummy (D13) for the Thursday in the second week.

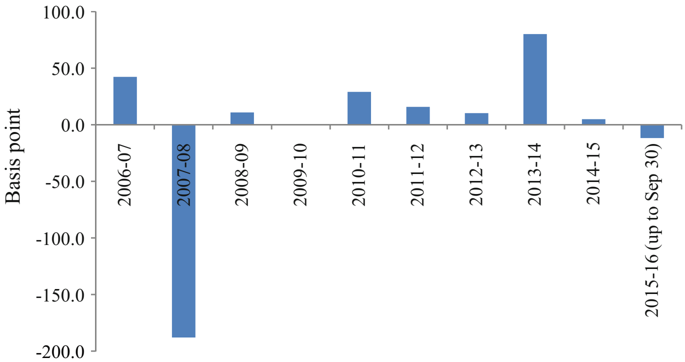

Chart 7 Average spread of WACR over policy rate. *Source* RBI

The end-quarter dummy turns out to be correctly signed, statistically significant, and lower under the current regime, suggesting greater assurance about the central bank's liquidity support. This has encouraged banks to actively participate in the money market and reduce the quarter-end spikes in the WACR.

Maintenance day effects are found to be prominent during the first two regimes, but have reduced in importance in the past 1 year. In particular, no statistically significant effect is found for the final day of the maintenance period during the second and third regimes. These results suggest that the overnight money market rates in India are increasingly conforming to the martingale hypothesis,[15] with unpredictable day-to-day changes across the reserve maintenance period.

Overall, the results for the second and third periods are relatively robust, as they are free from autocorrelation. The full sample as well as the first period residuals exhibit autocorrelation, notwithstanding additional lags—perhaps a reflection of the number of observations being larger.

5.2 *Minimizing Volatility in the Operating Target*

The stylized evidence shows that volatility in the operating target has reduced markedly over the years. Rolling period standard deviations of the call rate for 7–90 days have declined by a tenth from 4.5 % in 2006–2007 to around 0.4 % in 2014–2015 and further to 0.2 % in 2015–2016 (up to September 30). Also,

[15]A martingale is a model of a fair game where knowledge of past events never helps predict the mean of the future outcomes. In particular, a martingale is a sequence of random variables i.e., a stochastic process for which, at any particular time in the realized sequence, the expectation of the next value in the sequence is equal to the present observed value even given knowledge of all prior observed values (Bartolini and Prati 2004).

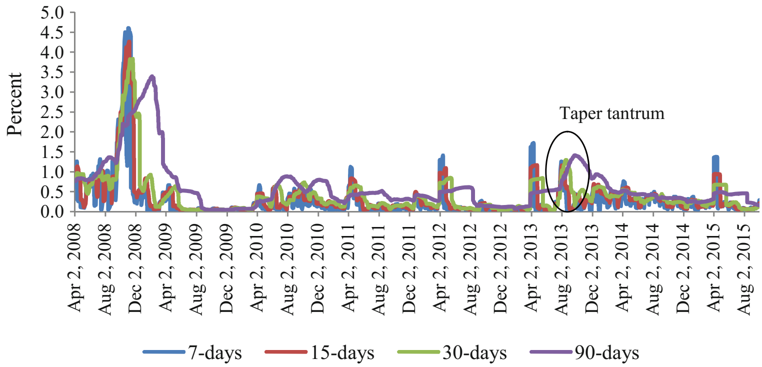

Chart 8 Rolling standard deviation of WACR. *Source* RBI

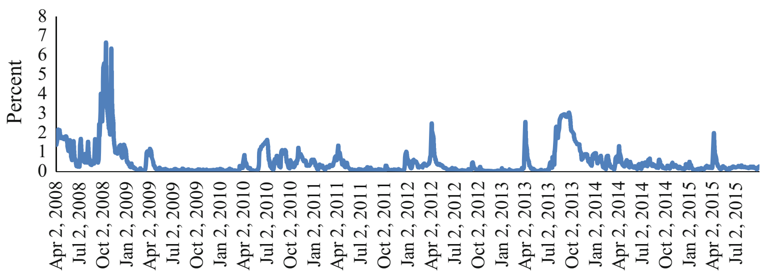

Chart 9 Spread of call money rate over policy rate: conditional standard deviation. *Note* Results are based on an I-GARCH (1,1) model, based on daily data from April 1,2008 to September 30, 2015. *Source* Authors' estimates

end-year spikes associated with balance sheet adjustments have been subsiding, although an uptick related to the taper tantrum is noticeable (Chart 8).

The efficacy of the RBI's revised liquidity management framework in reducing volatility in the overnight money markets is also validated by conditional volatility estimated by an I-GARCH (1, 1) model: spikes now occur with a reduced frequency (Chart 9).

As noted earlier, minimizing volatility in the operating target by itself involves a trade-off; on the one hand, to the extent that variations in the overnight rate are damped, it could inhibit the development of the money market to price and trade different risks. On the other hand, stability in the overnight rate could impart stability to the monetary policy transmission process. Volatility in the overnight rate could potentially spillover outwards to a host of market interest rates along the maturity spectrum and this uncertainty can generate risk premia in longer tenors which impedes the passage of the policy impulse. Following Carpenter and Demiralp (2011), we attempt to decipher the impact of volatility in the overnight rate on the 3-month market—the 90-day TB rate. According to the expectations hypothesis, long-term rates today should equal the average of the expected short-term rates plus some term premium that accounts for liquidity risk, credit risk, and other factors. We use the OIS rate for 3 months to gage market expectations of the short-term rate and run the following regression:

$$\mathrm{MR}_t = a + b * \mathrm{OIS}_t + c * \mathrm{VOL}_t + u_t \tag{3}$$

where MR is the yield on the 90-day Treasury bills, OIS is the overnight indexed swap rate, VOL is the standard deviation in the call money rate, and u is the error term. Volatility in the call rate is measured by rolling standard deviations across a range of days (7 days or 30 days).[16] Unit root tests cannot reject the null hypothesis of nonstationarity for the TB rate and the OIS rate, but reject the null for the standard deviations. Accordingly, the ARDL methodology is employed to estimate Eq. (3). Using daily data from April 1, 2008 to September 30, 2015 the results indicate that the chosen market rates are tightly linked to the OIS rate, with a long-run coefficient of close to unity which is also statistically significant.

For the full sample (April 2008–September 2015), the coefficient on the 7-day rolling standard deviation of the call rate is positive and significant,[17] indicating that volatility in the call rate is transmitted to the TB rate in the form of widening of term premia (Annex Table A.9). As the full sample includes the impact of the global financial crisis of 2008–2009, a robustness cross-check was undertaken by estimating (3) for the period April 2010–September 2015. While the coefficient on the OIS is broadly similar to the full period, the volatility term loses statistical significance though it is correctly signed. This could be reflecting a decline in overall volatility in all money market segments in the second and third regimes, though volatility brought on by large exogenous shocks appears regime-insensitive.

6 Conclusion

This still forming experience with the new liquidity management framework has been rewarding in terms of its specific mandates recommended in the literature—anchoring the RBI's operating target to its policy rate and damping volatility in the operating target itself. To that extent, the new framework has contributed to monetary policy transmission. It has also been associated with success in achieving the target set for inflation by the RBI for January 2015 and January 2016, although in the context of the large fall in global commodity prices and the persisting negative output gap domestically, the role of liquidity management may be judged as less significant. Yet, overall credibility of the RBI in the pursuit of price stability

[16] We also explored standard deviations over alternative time horizons of 15–90 days, but the results were qualitatively similar.

[17] The coefficient on the 30-day rolling standard deviation of the call rate is positive but significant at the 10 % level.

has been enhanced and in this, the liquidity management framework has a role to play. The stability it has provided in immediate transmission has emboldened the RBI to fortify the operating framework in a number of ways—phasing out of sector-specific refinance, bringing down statutory preemptions embodied in the SLR in stages, recommencement of reserve accumulation and setting up of international swap lines to buffer the monetary policy operating framework from external shocks. On its part, the GoI has strengthened the conduct of monetary policy by committing itself to fiscal consolidation and through amendment to the RBI Act to constitute a monetary policy committee (MPC) to empower monetary policy decision making.

The country experience indicates that while liquidity management frameworks vary widely across countries, all central banks strive to put in place sound processes and practices that are tailored to country-specific needs and features. Ample discretionary provisions seem to be a common characteristic, notwithstanding wide differences observed in the institutional setup for liquidity management, instruments, maturity and frequency of operations, counterparty arrangements, and eligible collateral. There is very little evidence of system overhauls even in the aftermath of the global financial crisis. One feature stands out, however, ensuring consistency between interest rate actions and liquidity management is a *sine qua non*.

In this context, the choice of operating target has overwhelmingly been determined by that market variable that the central bank (a) is in a position to influence quickly and seamlessly and (b) judges to be able to best serve as a benchmark for other market prices/quantities along the spectrum. The country experience and India's own suggests that setting a target for the overnight rate works better than steering it indirectly. Narrower corridors yield more efficient outcomes, both in achieving the operational target and in minimizing its volatility. Central banks have also shown certain opportunism in the instruments they have deployed to achieve liquidity management outcomes. Some instruments are regulatory in nature, intended to improve credit culture, mitigate excessive risk taking, boost lending to specific sectors—like funding for lending in the UK—and others are intended to curb excessive exuberance and to contain systemic risks.

Our empirical results indicate that there is a high degree of precision in the RBI's liquidity management framework. Deviations of the operating target from the policy rate have become more transient in the most recent regime than before. Fleetness in anticipating and responding to market aberrations has been playing an important role in these recent outcomes. The current regime is also engendering better liquidity management by banks. Even intraperiod reserve maintenance flux is getting evened out and final day effects during the maintenance period are statistically insignificant. Volatility in the call rate has distinctly declined in the current period relative to earlier ones. Correspondingly, monetary policy transmission across the money markets has improved and stabilized.

What lies ahead? An unfinished agenda of reforms. Deriving strength from the stability achieved at the shortest end of the market, efforts to refine the operating framework further to improve transmission outwards must be persevered with, consistent with the conduct of monetary policy around the nominal anchor of inflation (RBI 2014). This will include: (a) a fuller repertoire of term repos ranging up to tenors of 84 days, with the 14-day repo as the main liquidity management instrument; (b) development of the term money market and term yield curve so as to develop external benchmarks for pricing various financial products; (c) sharpening liquidity assessment by juxtaposing the RBI's top-down methodology with banks' own forecasts through bottom-up approaches; (d) setting a target for the WACR rather than steering it through a corridor, and eventually replacing the WACR with the 14-day term repo rate as the operating target; and (e) supplementing main liquidity operations (14-day repo) with two-way OMOs, fine-tuning operations and a (low) remunerated standing deposit facility.

Two developments have imparted optimism by demonstrating the resolve to stay the course. First, Financial Benchmarks India Limited (FBIL) , a company set up for administration of external benchmarks in February 2014, has introduced the FBIL-MIBOR—a benchmark for overnight markets based on actual traded rates—anchoring the first leg of monetary policy transmission in transparency. Second, the RBI has put in place since April 2016 a revised approach to calculating banks' base lending rates on a marginal cost pricing principle. As banks progressively adopt it, the second leg of monetary policy transmission will be strengthened and the RBI's efforts to develop an efficient liquidity management framework will have come full circle.

Annex 1

Table A.3 Transmission to deposit and lending rates

Period	Change in policy rates (bps)		Liquidity deficit[a]	Median deposit rate (percent)	Median base rate (percent)	WALR (percent)
	Repo rate	CRR	(Rs. billion)			
2013–14						
Q1	−25	–	−954	7.48	10.2	12.21
Q2	25	–	−1,108	7.78	10.25	12.33
Q3	25	–	−1,248	7.75	10.25	12.26
Q4	25	–	−1,563	7.74	10.25	12.21
Change during the year	50	–	−1,218	0.32	0.05	−0.07
2014–15						
Q1	–	–	−1,138	7.74	10.25	12.21
Q2	–	–	−873	7.72	10.25	12.12

(continued)

Table A.3 (continued)

Period	Change in policy rates (bps)		Liquidity deficit[a]	Median deposit rate (percent)	Median base rate (percent)	WALR (percent)
	Repo rate	CRR	(Rs. billion)			
Q3	–	–	−654	7.55	10.25	12.11
Q4	−50	–	−945	7.5	10.2	12.06
Change during the year	−50	–	−903	−0.24	−0.05	−0.15
2015–16						
Q1	−25	–	−818	7.22	9.95	11.94
Q2	−50	–	135	7.02	9.95	11.94#
Change up to Q2	−75	–	−342	−0.48	−0.25	−0.12

–: No change.#: Data relate to August 2015
Note ECR facility has been withdrawn, effective February 7, 2015
Source RBI
[a]Includes LAF (along with MSF), Term Repos (since October 11, 2013) and ECR

Table A.4 Liquidity management (Rs. billion)

	2012–13	2013–14	2014–15	2015–16 so far (up to Oct 2)
A. Autonomous drivers of liquidity (1 + 2 + 3 + 4)	−1,738	−406	1,674	1913
1. Net purchases from ADs	−153	586	3431	449
2. Currency with the Public	−1,174	−1,048	−1,405	−277
3. GoI Cash Balance	−406	−118	−288	1202
4. Others	−5	174	−63	538
B. Management of liquidity (5 + 6 + 7 + 8)	1,970	1,550	−1,248	−2444
5. LAF/MSF/Term Repos	−455	944	−241	−2073
6. OMO	1,546	523	−640	−321
7. Refinance	355	83	−367	−49
8. CRR	525	0	0	0
C. Bank reserves (A + B)	232	1,144	426	−531

Source RBI

Table A.5 OMOs and accommodation

	Change in reserve money (RM)	Net OMO purchases	Net market borrowing[a] (NMB)	Net OMO/change in RM	Net OMO/NMB	Repo rate changes	Repo rate (end of the year or latest)
	Rs. billion	Rs. billion	Rs. billion	Percent	Percent	bps	Percent
2009–10	1677	755	3944	45.0	19.1	−25 and +25	5.00
2010–11	2212	672	3264	30.4	20.6	+175	6.75
2011–12	495	1342	4841	271.0	27.7	+175	8.50
2012–13	885	1545	5074	174.5	30.5	–100	7.50
2013–14	2179	523	4756	24.0	11.0	–25 and +75	8.00
2014–15	1957	–640	4655			–50	7.50
2015–16 (up to Oct 9)	–185	–321				–75	6.75

Table A.6 Call rate and policy rate: baseline specification

Variables	Full sample (Apr 1, 2008 to Sep 30, 2015)	Apr 1, 2008 to Apr 29, 2011	May 2, 2011 to Jun 30, 2013	Sep 5, 2014 to Sep 30, 2015
Selected model[a]	ARDL(12, 8)	ARDL(12, 8)	ARDL(5, 7)	ARDL(1, 0)
Long-run equation: dependent variable: weighted average call rate				
Effective policy rate	1.03 (0.00)	1.02 (0.00)	1.02 (0.00)	0.99 (0.00)
Error correction (-1)	−0.11 (0.00)	−0.16 (0.00)	−0.32 (0.00)	−0.80 (0.00)
Adj.R^2	0.93	0.89	0.78	0.62
Bound test				
F-stat	14.52	8.72	19.2	86.6
Lower and upper bound critical values	10 % [2.44, 3.28]	5 % [3.15, 4.11]	1 % [4.81, 6.02]	
Q-statistic	49.5 (0.00)	34.3 (0.00)	0.32 (0.99)	0.03 (0.87)

Note Figures in parenthesis indicate *p*-value
Source Authors' estimates
[a]Lag length is selected using Akaike Information criteria

Table A.7 Call rate and policy rate: augmented specification I (without daily dummies)

Variables	Full sample (Apr 1, 2008 to Sep 30, 2015)	Apr 1, 2008 to Apr 29, 2011	May 2, 2011 to Jun 30, 2013	Sep 5, 2014 to Sep 30, 2015
Selected model[a]	ARDL(12, 8)	ARDL(12, 8)	ARDL(5, 0)	ARDL(1, 2)
Long-run equation: dependent variable: weighted average call rate				
Effective policy rate	1.00 (0.00)	0.99 (0.00)	1.01 (0.00)	0.99 (0.00)
Dum2	8.16 (0.00)	8.04 (0.00)		
D_emp	2.04 (0.00)			
D_PRLM	0.20 (0.11)			
D_Quarter	2.48 (0.02)	1.83 (0.03)	2.57 (0.08)	1.23 (0.08)
Error correction (–1)	–0.20 (0.00)	–0.21 (0.00)	–0.27 (0.00)	–0.73 (0.00)
Adj. R^2	0.94	0.90	0.80	0.71
Bound test				
F-stat	72.7	30.2	32.3	117.9
Lower and upper bound critical values	10 % [2.44, 3.28]	5 % [3.15, 4.11]	1 % [4.81, 6.02]	
Q-statistic	71.8 (0.00)	47.8 (0.00)	3.6 (0.61)	1.86 (0.17)

Note Figures in parenthesis indicate *p*-value
Source Authors' estimates
[a]Lag length is selected using Akaike Information criteria, with the variables ordered as weighted average call rate and effective policy rate

Table A.8 Call rate and policy rate: augmented specification II (with daily dummies)

Variables	Full sample (Apr 1, 2008 to Sep 30, 2015)	Apr 1, 2008 to Apr 29, 2011	May 2, 2011 to Jun 30, 2013	Sep 5, 2014 to Sep 30, 2015
Selected model[a]	ARDL(12, 8)	ARDL(12, 8)	ARDL(5, 7)	ARDL(1, 2)
Long-run equation: dependent variable: weighted average call rate				
Effective policy rate	0.97 (0.00)	0.92 (0.00)	0.99 (0.00)	0.99 (0.00)
Dum2	8.21 (0.00)	8.18 (0.00)		
D_emp	2.00 (0.00)			
D_PRLM	0.23 (0.07)			
D_Quarter	2.44 (0.02)	1.75 (0.02)	2.60 (0.08)	1.25 (0.08)
D3	0.70 (0.04)	1.19 (0.06)	0.39 (0.03)	
D4	0.45 (0.00)	0.95 (0.00)	0.37 (0.01)	
D5	0.38 (0.01)	0.93 (0.01)	0.36 (0.01)	
D6	0.28 (0.09)	0.63 (0.04)	0.40 (0.03)	
D7	0.53 (0.03)	1.10 (0.04)	0.36 (0.09)	
D10			0.13 (0.05)	0.10 (0.01)
Error correction (–1)	–0.22 (0.00)	–0.24 (0.00)	–0.26 (0.00)	–0.74 (0.00)
Adj. R^2	0.94	0.90	0.81	0.71

(continued)

Table A.8 (continued)

Variables	Full sample (Apr 1, 2008 to Sep 30, 2015)	Apr 1, 2008 to Apr 29, 2011	May 2, 2011 to Jun 30, 2013	Sep 5, 2014 to Sep 30, 2015
Bound test				
F-stat	86.2	44.9	37.2	116.2
Lower and upper bound critical values	10 % [2.44, 3.28]	5 % [3.15, 4.11]	1 % [4.81, 6.02]	
Q-statistic	74.1 (0.00)	51.0 (0.00)	5.4 (0.37)	1.6 (0.21)

Note Figures in parenthesis indicate *p*-value
Source Authors' estimates
[a]Lag length is selected using Akaike Information criteria, with the variables ordered as weighted average call rate and effective policy rate. D3, D4, D5, D6, and D7 are the daily dummies used to represent first week (i.e., Monday to Friday) of the reporting fortnight of the reserve maintenance period while the dummies D10, D11, D12, D13 and D14 represent the second week of the reporting fortnight

Table A.9 Volatility in call money rates and impact on market rates

Explanatory variable	Dependent variable: 3-month Treasury Bills			
	Sample period: April 1, 2008 to September 30, 2015		Sample period: April 1, 2010 to September 30, 2015	
Selected model[a]	ARDL (11, 10, 5)	ARDL (11, 10, 0)	ARDL (7, 10, 4)	ARDL (7, 10, 0)
Constant	–0.07 (0.76)	–0.09 (0.68)	–0.56 (0.00)	-0.59 (0.00)
OIS rate	1.02 (0.00)	1.02 (0.00)	1.09 (0.00)	1.09 (0.00)
SD-7d	0.33 (0.06)		0.13 (0.14)	
SD-30d		0.18 (0.10)		0.10 (0.16)
Adj. R^2	0.998	0.998	0.996	0.996
Q-statistic	3.87 (0.99)	4.03 (0.98)	9.62 (0.65)	8.94 (0.71)
Bound test				
F-stat	8.84	8.24	10.80	10.49
Lower and upper bound critical values	10 % [2.63, 3.35]	5 % [3.10, 3.87]	1 % [4.13, 5.0]	

Note Figures in parenthesis are *p*-values. Q-statistic is for 12 lags
Soruce Authors' estimates
SD-7d and SD-30d are standard deviations of weighted average call rate, based on rolling sample of 7 days and 30 days, respectively
[a]Lag length is selected using Akaike Information Criteria, with the variables ordered as Treasury Bill rate, OIS rate, and SD-7d (or, SD-30d)

Table A.10 Liquidity management framework: key features

	Bank reserves		Standing facility			Main liquidity operations		
Country	Required	Average	Loan	Deposit	Tenor	Instrument(s)	Tenor	Frequency
Australia	N	–	Y	Y	Overnight	Repo/R.repo/OMOs	1 day to 18 months	Daily
Brazil	Y	Y	Y	Y	Intra-day to 1-day	Repo/R.repo/OMOs	1–30 days	Daily
Canada	N	–	Y	Y	Overnight	Repo/R.repo/OMO/Intra-day through special purchase and resale	–	Daily
Euro Area	Y	Y	Y	Y	Overnight	Repos/OMOs/LTROs	Variable	Weekly and 3-months
Hong Kong SAR	N	–	Y	–	Overnight	Two-way convertibility undertaking	–	–
Japan	Y	Y	Y	Y	Fixed term	Repo	Overnight to 1 year	2–3 times a day
Korea	Y	Y	Y	Y	Overnight	Repo/R.repo	7-days	Weekly
Mexico	N	–	Y	Y	Overnight	OMOs	1–25 days	Daily
Singapore	Y	Y	Y	Y	Intra-day/overnight	Exchange rate intervention	FS-spot	Discretionary
Sweden	N		Y	Y	Overnight	Repo	1-week	–
Switzerland	Y	Y	Y	–	Overnight	OMOs/repo/SNB bills	Mostly 1-week	Daily
UK	Suspended in 2009		Y	Y	Intra-day/overnight	Repo short-term (fixed rate), long-term (variable rate)	Long-term	Weekly/monthly
USA	Y	Y	Y	Y	Generally overnight	Repo/R.repo/OMOs	Up to 65 days	Daily/weekly
India	Y	Y	Y	Y	Overnight	Repo/R.repo, OMOs	Overnight to 28-days	Daily

Notes Y = yes; N = No; –: Not available; LTROs: Long-term refinance operations; R.repo: Reverse Repo
Source RBI (2014), BIS Markets Committee and websites of respective central banks

Table A.11 Liquidity management framework: key features

Country	Other discretionary operations			Counterparty
	Instrument	Tenor	Collateral	Lending operations
Australia	Overnight/Fx-swap/term deposit	1-day to 3-months	Australian Government securities and semi-govt. securities	Banks/members of RITS and Austroclear
Brazil	Outright operation: nonregular	Rediscount facility for specific institutions in specific situations	No discretion	Federal Govt. bonds, other securities and assets
Canada	Repos/term repos	1–3 months	Govt. securities, for SF, including US T-bills, notes, CPs by foreign issuers, bonds; list expanded during the crisis	OMOs for PDs, SF for payment and settlement system participation
Euro Area	OMOs and intra-day credit: nonstandard/term	–	Discretion	Institutions subject to reserves; wide in terms of types and participants
Hong Kong SAR	Deposits/forex swaps	–	All exchange fund bill and notes, extended to use US Treasuries under discount window	–
Japan	Complementary deposit and lending facility	–	Japan Government Bonds/other securities: Law generally limits expanding collateral	A/c holders with BoJ and members of financial network system: wide but varies with facilities
Korea	Additional repos	1–3 days	Discretion to extend loan against collateral of any asset	Narrow for OMOs, wide for SF
Mexico	Long-term sterilization of excess liquidity/sporadic use of compulsory deposit	–	Discretion	OMOs for all local banks, SF for private banks
Singapore	Repo/FX swap direct lending/borrowing	1-week to 3 months	Discretion	OMOs only for PDs, SF for all RTGS participants
Sweden	Loan/deposit	Overnight	Act allows expansion	Wide
Switzerland	Injection/absorption through auctions	Mostly overnight	Discretion	Wide in terms of type
UK	Discount window facility/contingent term repo/funding for lending	Long-term	Broad-based security for discount window	Varies with facility

(continued)

Table A.11 (continued)

Country	Other discretionary operations			Counterparty
	Instrument	Tenor	Collateral	Lending operations
USA	OMOs	Variable	Treasury securities under exceptional situation	PDs for OMOs; money market funds, banks/govt. sponsored agencies
India	OMOs	–	Central Govt. bonds	Commercial banks

Notes SF: Standing facility; RITS: Reserve Bank information and transfer system; PDs: Primary dealers Narrow = restricted for selected few institutions (wide otherwise)—Not available
Source RBI (2014), BIS Markets Committee and websites of respective central banks

Table A.12 Main features of the operational frameworks

Country	SF corridor width in basis points	OMO frequency (Term)	RR maintenance period
Australia	50	Daily(variable)	
Canada	50	Daily (o/n)	
Sweden	150	Daily(o/n)	
UK 2001–04	200[a]	Daily (2w), 1–3 daily (o/n)	
UK 2005–06	50[a]	Daily (2w), 1–3 daily (o/n)	
UK Present	50[b]	Weekly (1w) + FT	Inter-meeting
Euro Area	75	Weekly (1w) + LTROs	Inter-meeting
Czech Republic	20	3 Weekly (2w)	1 month
Poland	300	Weekly (1w)	1 month
Hungary	200	Weekly (2w)	1 month
US	50	Daily	2 weeks
Norway	Quota system	Variable (variable)	
New Zealand	Quota system	Daily (variable)	

Source Sveriges Riksbank (2014)
Note SF: Standing facilities; OMO: Open market operations; RR: Reserve requirements; FT: Fine-tuning
[a]BOE did not have a lending facility as such, but rather supplied liquidity via open market operations during the period 2001–06
[b]This is the normal width of the Bank of England's operational standing facilities. Presently it is 75 basis points and BOE is de facto using a floor system by remunerating all reserves at the policy rate (Bank Rate), since 5 March 2009. As long as Bank Rate is 0.5 % or lower, the rate paid on the Operational Standing Deposit Facility is zero

Annex 2

Table A.13 Revised liquidity management framework with effect from September 5, 2014

Instrument	Quantum	Periodicity/timings
Overnight Fixed Rate Repos (at repo rate)	0.25 % of NDTL, bank-wise	Daily (Monday–Friday): 9.30–10.30 AM
Variable Rate 14-day Term Repo Auctions	0.75 % of system-wide NDTL	Starting from September 5, 2014, auctions are conducted four times during a reporting fortnight, i.e., on every Tuesday and Friday, between 11.00–11.30 AM for an amount equivalent to one-fourth of 0.75 % of NDTL in each auction. Regular rollovers of maturing 14-day term repos on every Tuesday and Friday
Overnight Variable Rate Repo Auction	The auction amount, if any, is decided by the Reserve Bank, based on an assessment of the liquidity conditions as well as Government cash balances available for auction for the day	Daily (Monday–Friday): 3.00–3.30 PM. The Reserve Bank may decide to exercise a green shoe option above the notified amount based on the evolving liquidity conditions during the day
Overnight Fixed Rate Reverse Repo	No restriction on quantity	Daily (Monday–Friday): 7.00–7.30 PM
Overnight Variable Rate Reverse Repo Auctions	The auction amount, if any, is decided by the Reserve Bank, based on an assessment of the liquidity conditions and will be conducted on days when it is considered necessary	Reserve Bank announces the notified amount during the day and conducts the auction between 4.00–4.30 PM
Overnight Marginal Standing Facility	Individual banks can draw funds equivalent up to Excess SLR + 2 % below SLR	Daily (Monday–Friday): 7.00–7.30 PM
Export Credit Refinance[a]	As per the existing limits	Available at the fixed repo rate between 10 AM and 5 PM from Monday to Friday and between 10 AM and 1 PM on Saturday

[a]The Export Credit Refinance (ECR) facility was merged with the system-level liquidity provision with effect from February 7, 2015

Annex 3: Money Market Microstructure

In India, the overnight money market comprises three segments, viz., the uncollateralised interbank call money market, collateralised Market Repo and Collateralised Borrowing and Lending Obligation (CBLO). These segments differ in terms of their market operation timings, participants and instruments (Table A.14). In

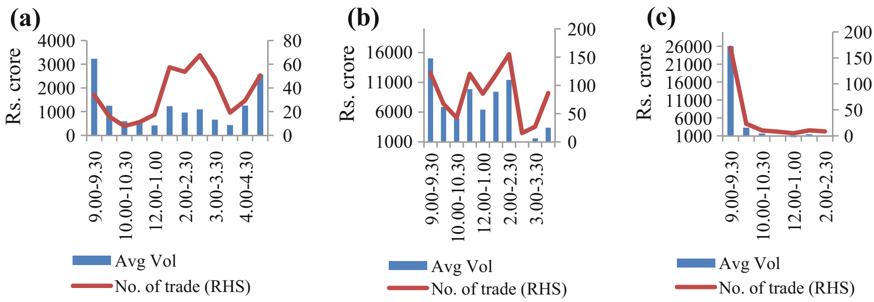

Chart A.10 Intra-day activities in overnight markets. **a** Call market. **b** CBLO. **c** Market repo

Table A.14 Features of money market segment

	Call	CBLO	Market Repo
Timing	9:00 AM to 5:00 PM	9:00 AM to 4:00 PM	9:00 AM to 2:30 PM
Daily Avg. volume (% share of total overnight money market volume) in 2014–15	Rs. 93 billion (10 %)	Rs. 563 billion (60 %)	Rs. 278 billion (30 %)
Major borrowers	1. Private Banks (34 %)	1.Nationalized Banks (21.4 %)	1. Foreign Banks (39.7 %)
	2. Nationalized Banks (25 %)	2. Private banks (20.5 %)	2. Primary Dealers (29.8 %)
Major lenders	1. Nationalized Banks (34 %)	1. Mutual Funds (51.4 %)	1. Nationalized Banks (43.6 %)
	2. Cooperative Banks (30 %)	2. Nationalized Banks (18.8 %)	2. Mutual Funds (27.9 %)

recent years, the share in the volume of the collateralized segment of the overnight money market has increased due to safety of settlement of trades on net basis (CCIL being counterparty for CBLO), and choice for borrower to rollover previous trade. Also, in the aftermath of the global financial crisis, the shift in lending and borrowing activities of foreign banks from uncollateralised market to collateralised markets as a global strategy have affected the call volumes.

The depth of market in the overnight segments varies markedly intra-day (Chart A.10). Foreign banks and primary dealers—major borrowers in market repo —meet around 80 % of their funding requirement for G-sec trading activities during 9–10 a.m., although the market is open up to 2:30 p.m. CBLO transactions of mutual funds, which are major lenders in CBLO, are routed through designated banks within banking hours (generally up to 2.30 p.m.). The CBLO market becomes thin thereafter, often resulting in spikes in call rates which is the only active segment in late trading hours. Call market volumes, therefore, exhibit an intra-day U-shaped pattern.

Interestingly, intra-day, overnight interest rates open at an elevated level in the early session of the market as most players cover their estimated liquidity mismatches and with the competitive trading in deep markets around the morning hours the interest rate differentials across markets are at their minimum as also the volatility in the rates. Subsequently, as volumes dip and volatility rises, interest rates decline at differential pace across markets till about 2.30 p.m., reflecting market specific factors. For example, in case of call market, the participation is largely driven by lending by cooperative banks which typically lend at a rate lower than the prevailing rate in call market, leading to the higher call market volatility (Table 14).

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Part IV
The Constraints on Normal Central Banking in India

Capital Flows and Capital Controls in India: Confronting the Challenges

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1 Introduction

The global financial crisis (GFC) and its aftermath saw boom–bust cycles in cross-border capital flows of unprecedented magnitude, rekindling controversies about the pace and extent of capital account liberalization, and the policy options to manage capital flow volatility. The debate has, however, become more nuanced in recent years: while there is a widespread recognition of the potential benefits of capital flows, there is also increasing awareness that their sheer volume and volatility can pose enormous macroeconomic and financial-stability challenges—especially in countries where financial markets are less developed. Managing these complex trade-offs, and striking the right balance to mitigate the costs while reaping the benefits of financial integration, is a challenge confronting policymakers across the world.

India—one of the largest and fastest growing emerging markets (EMs)—has not been immune to these challenges. Although it has maintained a cautious and calibrated approach to capital account liberalization, the country has become more financially open over time, and thus more exposed to the vagaries of international capital markets. The question of capital account convertibility has been a recurrent

The views expressed in this chapter are those of the authors, and do not necessarily represent those of the IMF or IMF policy. We are grateful to the editors, Chetan Ghate and Ken Kletzer, for useful suggestions, and to Peter Lindner for sharing the data on corporate vulnerabilities in India.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_10

theme in the national policy discourse. Indian policy makers have repeatedly indicated their desire to implement full capital account convertibility, and signaled that it is not a question of *whether* but *when* India will achieve full convertibility.[1] In 2013, for instance, the (former) Governor of Reserve Bank of India (RBI), Duvvuri Subbarao, remarked that "Moving towards full capital account convertibility has always been our policy goal. The only variable was the road map for getting there which, it was agreed, should be redefined from time to time, consistent with the evolving situation."[2] More recently, in April 2015, the current RBI Governor, Raghuram Rajan, indicated that it may not be long before India achieves full convertibility: "My hope is that we will get to full capital account convertibility in a short number of years."[3]

What are the implications of India's move toward further financial openness? And what are the policy options at its disposal to manage the challenges associated with volatile capital flows? In this chapter, we examine these questions in light of advances in academic and policy debates on the issue. Within this framework, we also assess how India's approach to capital account liberalization and management of capital flows has served its broader policy goals, notably economic growth and macroeconomic stability. To provide context to the discussion, we begin in Sect. 2 by tracking the trend toward capital account liberalization in India. Section 3 revisits the debate on the long-run growth benefits of capital account liberalization, while Sect. 4 discusses the short-run costs associated with capital flows, and gauges the implications for India against the evolution of its capital account. Section 5 discusses the policy options for EMs in general to manage the challenges associated with volatile capital flows, and explores India's approach to capital account management in recent years. Section 6 concludes the chapter.

2 Capital Account Liberalization in India

After independence in 1947, India maintained a highly restrictive capital account regime for four decades as part of an inward looking, interventionist policy framework. Restrictions were in place on both private inflows and outflows, and

[1]To deliberate over the path toward capital account convertibility, the government has set up several policy committees over the years. For instance, the Tarapore and Second Tarapore Committees were formed in 1997 and 2006, respectively, to assess the feasibility and prerequisites for implementing capital account convertibility. In addition, the recommendations of committees on financial sector reforms, notably, the Mistry Committee (Government of India 2007) and the Rajan Committee (Government of India 2009), also had implications for India's capital account regime.

[2]Remarks delivered at the IMF conference, "Rethinking Macro Policy II: First Steps and Early Lessons," Washington DC, April 16–17, 2013. https://www.imf.org/external/np/seminars/eng/2013/macro2/pdf/ds2.pdf; last accessed on February 3, 2016.

[3]Remarks delivered at the Kale Memorial Lecture, Gokhale Institute of Politics and Economics, Pune, April 10, 2015. http://www.thehindu.com/business/Economy/rajan-says-full-rupee-convertibility-in-a-few-years/article7089869.ece; last accessed on February 3, 2016.

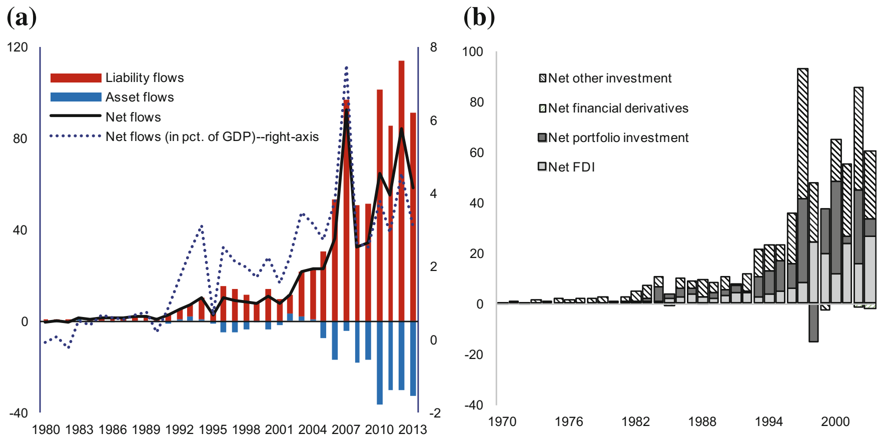

Fig. 1 Financial flows to India, 1980–2013 (in USD bln.). *Source* Authors' estimates based on IMF's IFS database. *Note* Asset flows exclude reserve flows. Liability flows exclude other investment liability flows of the general government (typically official loans). **a** Asset, liability, and net flows, **b** net flows by type of flow

external financing needs were met mostly through multilateral and bilateral official assistance (see Box 1).[4] It was not until 1991, when India experienced a severe external crisis, that economic reforms, comprising trade liberalization and partial capital account liberalization, were ushered in.[5] Capital account policy initially encouraged foreign direct investment (FDI) and portfolio equity inflows, followed by a partial liberalization of debt flows, derivative transactions, and capital outflows (Ariyoshi et al. 2000). Liberalization involved a process of gradually raising quantitative ceilings on inflows and increasing the size of flows that were automatically approved.[6] As a result, India's liability flows (that is, those driven by foreign investors—commonly referred to as "gross inflows") from nonofficial sources increased fourfold from about USD 3 billion (about 1 % of GDP) in 1991 to USD 14 billion in 2000 (Fig. 1a).[7]

The decade of 2000s witnessed further relaxation of controls, especially on inflows, and on the eve of the global financial crisis in 2007, India's liability flows

[4]Baru (1983) describes India's post-independence "self-reliance" policy as an outcome of its colonial experience, which raised hostility towards dependence on foreign powers, and, by extension, on foreign capital.

[5]A significant step in the liberalization process was the adoption of the Foreign Exchange Management Act (FEMA) in 1999, which removed foreign exchange restrictions on current account transactions, and relaxed restrictions for some capital account transactions.

[6]For example, India allowed foreign institutional investors (FIIs) in 1992, but set a ceiling upon total ownership by all FIIs at 24 % of local firms. The ceiling was raised to 30 % in 1997, and further to 40 % and 49 % in 2000 and 2001, respectively. Eventually, the ceiling became sector-specific in 2001.

[7]See Appendix for variable definitions and data sources.

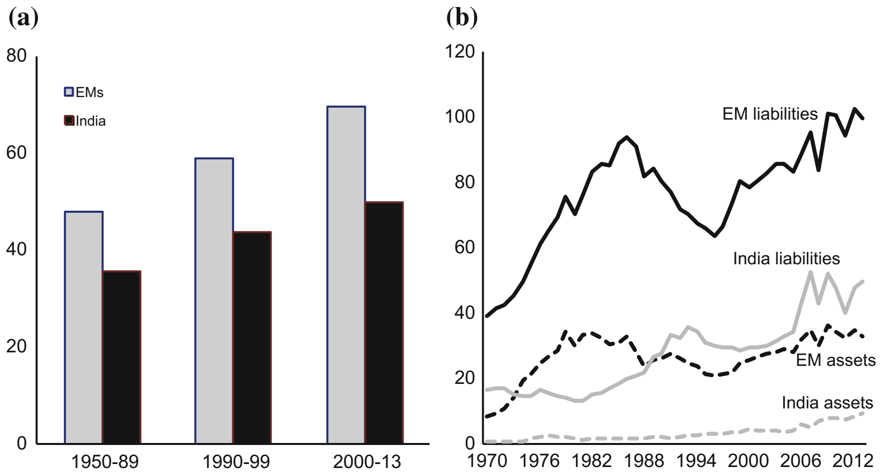

Fig. 2 De jure and de facto capital account openness in India and other EMs, 1950–2013. *Source* Quinn and Toyoda (2008), and Lane and Milesi-Ferretti (2001). *Note* In panel **a**, statistics are averages over the specified period of Quinn and Toyoda's capital account openness index. In panel **b**, the stock of assets excludes reserves; statistics represent the average stock of asset and liability (to GDP) ratio in EMs (excluding India). **a** Capital account openness index, **b** Asset and liability stock (in percent of GDP)

stood at USD 97 billion (or about 8 % of GDP). The bulk was portfolio (especially equity) and other investment flows, while FDI constituted about one-third of total liability flows, but less than one-sixth of total net flows received in 2005–2007 (Fig. 1b). Both liability and total net flows to India dropped sharply during the GFC, but they rebounded quickly as accommodative monetary policies in major advanced economies in the aftermath of the crisis led to a generalized surge of inflows to EMs. In 2012, for example, liability flows to India reached about USD 114 billion, while net flows stood at USD 84 billion. India's share in total liability flows to EMs has thus more than doubled over the years, rising from about 4 % in the 1990s to 9 % in 2009–2013 (while its share of EM GDP has risen from 7.9 to 8.3 % over the same period).

While India has come a long way in terms of capital account liberalization since the early 1990s, on average, it is still less liberalized—both de jure and de facto—than many of its EM peers (Fig. 2).[8] In 2013, for example, India's stock of assets and liabilities stood at about 9 and 49 % of GDP, respectively, yet the

[8]The de jure measures of capital account openness are based on the restrictions and policies in place on cross-border capital movements, while the de facto measures capture the extent of actual cross-border capital flows. A caveat of de jure measures is that they mainly indicate the presence of capital account restrictions, rather than their severity. Moreover, they typically do not cover regulations that may affect capital flows indirectly such as certain prudential regulations.

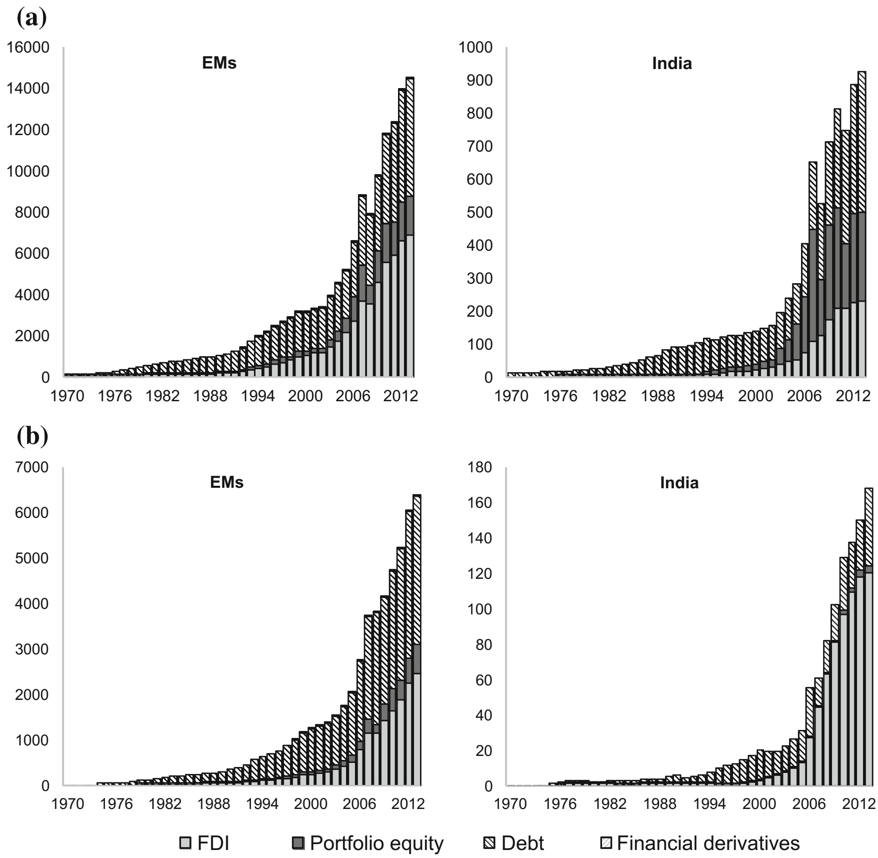

Fig. 3 External liabilities and assets stock in India and other EMs, 1970–2013 (in USD bln.). *Source* Lane and Milesi-Ferretti (2001). *Note* For EMs, statistics for each year are the sum of liabilities and assets stocks for EMs in the sample (excluding India). **a** Liabilities stock, **b** assets stock

corresponding averages for EMs were about 33 and 100 % of GDP.[9] Moreover, the composition of India's inflows and outflows is also different—while EMs tend to receive predominantly FDI inflows, the share of FDI liabilities in India's total external liabilities is only half of that for other EMs (Fig. 3). By contrast, India's asset flows are mainly FDI, but those are mostly debt flows for other EMs.

[9]Countries considered as EMs here are those included in the IMF's Vulnerability Exercise for Emerging Markets (as of May 2015). These are: Albania, Algeria, Argentina, Armenia, Belarus, Bosnia and Herzegovina, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Guatemala, Hungary, India, Indonesia, Jamaica, Jordan, Kazakhstan, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Romania, Russia, Serbia, South Africa, Sri Lanka, Thailand, Tunisia, Turkey, Ukraine, Uruguay, Venezuela, and Vietnam.

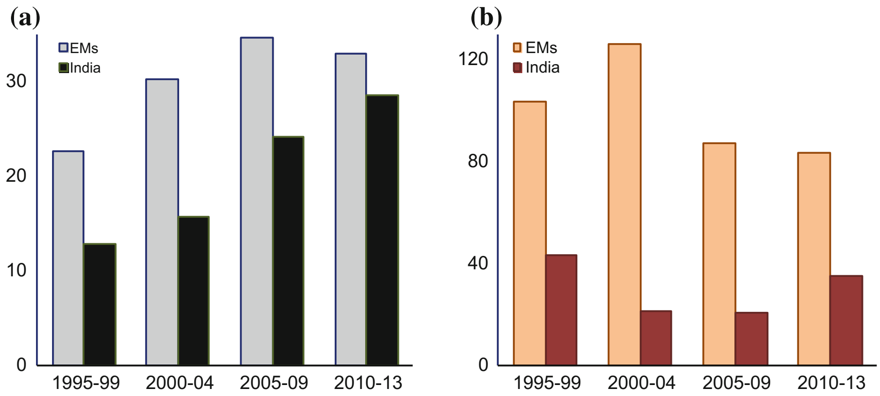

Fig. 4 Short-term debt liabilities in India and other EMs, 1995–2013. *Source* IMF's WEO and IFS databases, and Lane and Milesi-Ferretti (2001). **a** In percent of total debt liabilities, **b** In percent of total stock of reserves

It is interesting to note, however, that the share of FDI and portfolio equity liabilities in total external liabilities is increasing for both India and for other EMs, suggesting a gradual shift in the composition of the external liability structure away from debt liabilities. The share of debt liabilities in the total stock of liabilities was, for example, about 86 % for India during the 1990s, but only half of that in 2009–2013. (The share has dropped relative to GDP as well, and stood at about 20 % in 2009–2013.) Focusing on just short-term debt, however, the picture looks quite different. While the share of short-term debt in external debt has generally been declining for other EMs since 2005, it has increased for India—especially since the GFC (Fig. 4a). The ratio for India is still low compared to other EMs, while the reserves coverage appears much higher (Fig. 4b).

The increase in short-term debt flows to India corresponds to a significant relaxation in controls on portfolio debt inflows over the years, but these flows are still more regulated as compared to FDI and portfolio equity flows.[10] The restrictions on portfolio debt inflows, for instance, include prohibitions on foreign investment in certain type of debt instruments; tight limits on foreign investment in sovereign and corporate debt; and conditions on end use (IMF 2014a). By contrast, the regime for portfolio equity inflows is fairly liberal with registration requirements, and some caps (in percent of paid-up capital) on foreign investment in Indian companies. FDI inflows are also mostly liberalized, with investment prohibited in a few selected sectors (including real estate) mainly for strategic reasons; and sector-specific caps on investment in financial, air transportation, and

[10]For India, the ratio of portfolio debt in total debt liabilities is quite small—and averaged about 5 % during 2009–2013. (By comparison, among other BRICS countries, it was about 17 % for Brazil and 13 % for South Africa, but was 1 % and 5 % for China and Russia, respectively.)

telecommunications sectors. Liquidation and repatriation of FDI is also generally permitted.

Considering India's liberal attitude toward inward FDI since the beginning of its liberalization process, the relatively small share of FDI liabilities in total liabilities is surprising; and may have more to do with other domestic structural factors (such as the general investment climate, domestic taxation system, infrastructure bottlenecks, etc.) than the de jure restrictions in place.[11] In fact, in terms of infrastructure and institutional quality, ease of doing business, and overall competitiveness, India continues to rank below its large emerging market peers (Fig. 5).[12] Labor market inefficiency and unfavorable corporate taxation policies—identified as important determinants of FDI inflows (see e.g., Golub et al. 2003; Hajkova et al. 2006; Ohanian et al. 2015)—may have been other factors that deterred direct investment to the country (Fig. 6). Although labor market efficiency—as captured by the World Economic Forum's index—appears to have improved over the years, it has declined sharply since 2012, and fallen below the average for other EMs.[13] Corporate taxes (including capital gains and dividend taxes), however, have been reduced in India over time; although it still lags behind, for instance, its BRICS counterparts (especially when the corporate tax rate is computed in percent of profits).

India has a less relaxed attitude toward its residents' outflows than it does toward inflows, but even on that front the trend has clearly been toward greater liberalization. While there exists a limit on individual outflows for capital transactions, restrictions on outflows for equity, especially FDI, and for debt investments by Indian corporate sector are more permissive.[14] This shows up in the significantly larger share of FDI in the total stock of external assets in Fig. 3.

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[11]Another possible reason for limited FDI flows could be the attitude towards retail FDI, which was not permitted until January 2012 when single-brand FDI was liberalized (conditional on the requirement that the retailer would source 30 % of the goods domestically). While 51 % FDI in multibrand retail was allowed in December 2012, it remains a contentious issue to date. http://www.thehindu.com/business/india-to-disallow-fdi-in-multibrand-retail-nirmala/article6391737.ece ; http://www.ndtv.com/india-news/government-retains-51-fdi-in-multi-brand-retail-which-bjp-had-opposed-762655; last accessed on February 3, 2016.

[12]In Fig. 5 (panel b), the decline in the institutional quality index for India since mid-2000 s stems from a drop in the underlying regulatory quality, government effectiveness and control of corruption indices as measured by the World Bank. (In terms of some other indicators, such as voice and accountability, and political stability, India has recorded an improvement; see appendix for details). For the global competitiveness index, the drop since 2012 is because of a weakening in technological readiness; labor and goods market efficiency; and financial market development, as measured by the World Economic Forum.

[13]The fall in the labor market efficiency index can be attributed to a decline in labor–employer relations, flexibility of wage determination, and reliance on professional management.

[14]As of March 2015, the limit on individual outflows for capital transactions stood at USD 125,000. Previously, the limit was tightened to USD 75,000 from USD 200,000 in August 2013 after India experienced sudden outflows and currency depreciation pressures following the announcement of tapering of the quantitative easing program by the US Fed in June 2013.

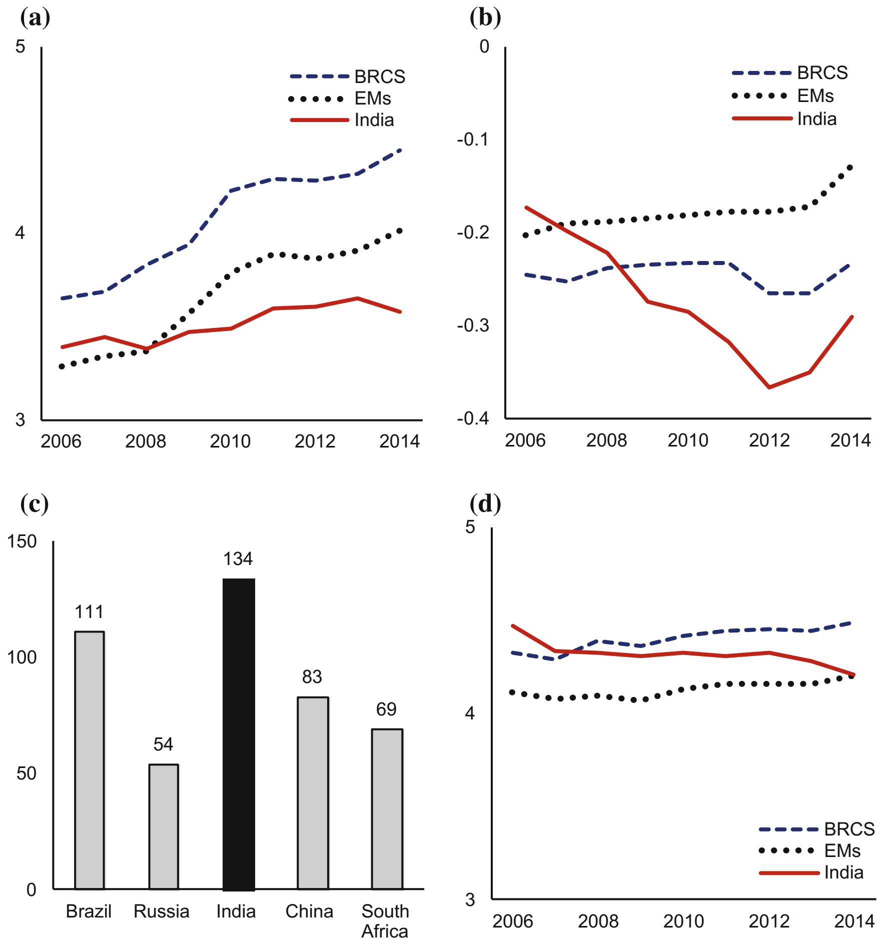

Fig. 5 Institutional quality and investment climate in India and other EMs. *Sources* World Economic Forum; World Bank's Worldwide Governance Indicators; and World Bank's Doing Business Data. *Notes* Infrastructure quality in panel **a** is an index ranking from 1 (=extremely poor) to 7 (=extremely good), which is part of the Global Competitiveness Index compiled by the World Economic Forum. Institutional quality in panel **b** is an index ranging from –2.5 (weak) to 2.5 (strong) that is the average of six different indicators (voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption) compiled by the World Bank's Worldwide Governance Indicators. Ease of doing business ranking in panel **c** measures the extent to which the regulatory environment is conducive to starting and operating a local firm (out of 189 countries), and is compiled as part of World Bank's Doing Business Data. Global competitiveness is an index ranking from 1 (=extremely poor) to 7 (=extremely good) based on 12 underlying components (institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation), which is compiled by the World Economic Forum. **a** Infrastructure quality, **b** institutional quality, **c** ease of doing business ranking, 2015, **d** global competitiveness

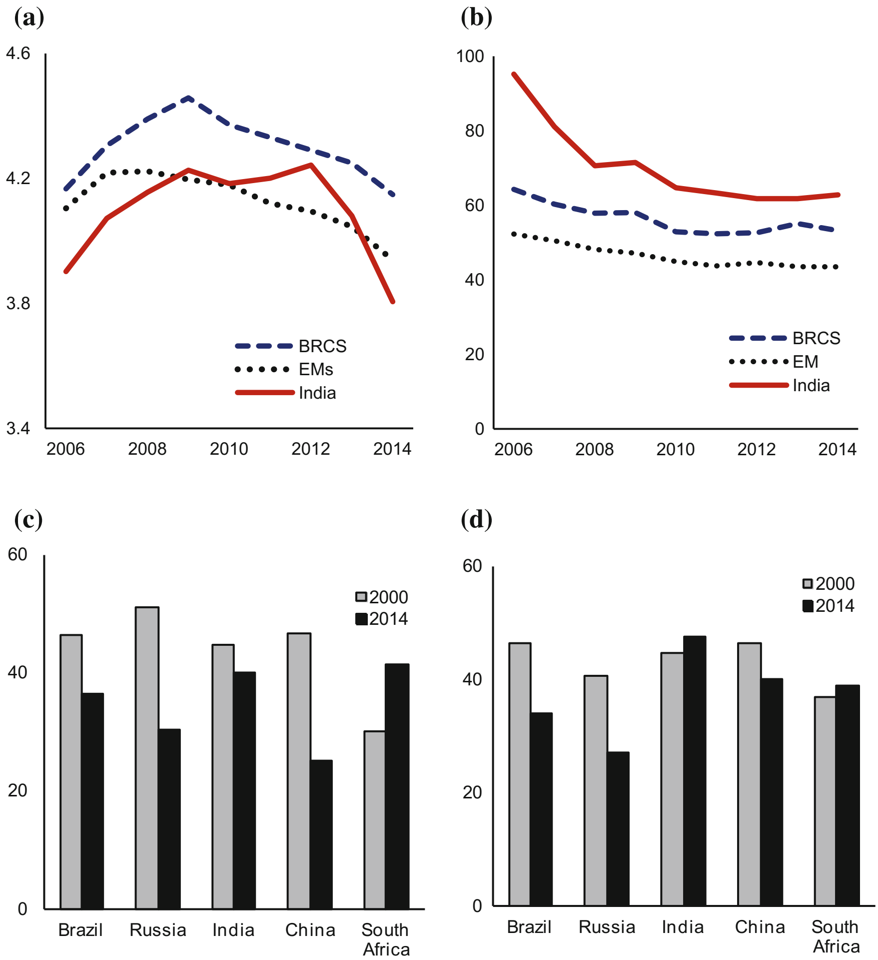

Fig. 6 Labor market efficiency and corporate taxes in India and other EMs. *Sources* World Economic Forum; the Alliance for Savings & Investment; and authors' estimates based on South African Revenue Service, National Treasury, and KPMG International. *Notes* Labor market efficiency in panel **a** is an index ranging from 1 (=extremely poor) to 7 (=extremely good) compiled by the World Economic Forum as part of its Global Competitiveness Index. In panel **b**, the corporate tax rate is in percent of profits, that has been compiled by the World Economic Forum as part of its Global Competitiveness Index and includes profit tax, labor tax and contributions, and other taxes. In panels **c** and **d**, the integrated capital gains and dividend tax rates combine the corporate tax rate with the capital gains tax rate, and dividends tax rate, respectively (see, e.g., http://theasi.org/assets/EY-ASI-2014-International-Comparison-of-Top-Dividend-and-Capital-Gains-Tax-Rates.pdf). **a** Labor market efficiency, **b** Corporate total tax rate (in percent of profits), **c** Integrated capital gains tax rate (In percent), **d** Integrated dividend tax rate (in percent)

In sum, India's capital account restrictions—which are mostly quantitative rather than price- based—appear to have been largely effective in limiting both inward and outward capital flows. In terms of sequencing the liberalization of different types of flows, India's cautious approach accords well with that proposed in the academic literature, and with the "integrated approach" recommended by the IMF (IMF, 2012). Specifically, the IMF's integrated approach to capital account liberalization suggests liberalizing inflows and outflows gradually based on the type of flow (e.g., FDI inflows first, followed by long-term inflows and FDI outflows, and eventually short-term inflows and other outflows); the prevailing macroeconomic and financial conditions; and the level of financial and institutional development. But has this approach economically benefitted India? The next two sections explore this question by analyzing India's performance against the putative pros and cons of financial openness.

Box 1. India's Pre-1991 Capital Account Management Before moving decidedly toward liberalization in 1991, India maintained a highly restrictive capital account regime. Yet, within the given framework of government control, the level of restrictions varied depending on the balance of payments and industrialization needs.

Broadly speaking, the history of India's capital account restrictions can be divided into two phases: from independence in 1947 to the early 1980s, and from then onwards to the balance of payment crisis in 1991. In the first phase, India's reliance on external flows was mainly limited to concessional finance, and attempts at financial integration could be best described as "one step forward, two steps back" (Athreye and Kapur 1999). In 1957, for example, through the Second Economic Plan, India settled on an import substitution policy, which presented highly profitable business opportunities for domestic residents, who then sought foreign investment for capital and technology to capitalize on the favorable environment. The government cooperated in inviting foreign investment by establishing the Indian Investment Centre in 1961 to facilitate foreign collaborations. Consequently, the early 1960s witnessed increased foreign investment inflows—net liability flows to the private sector, for example, rose from negative USD 48 million in 1957 to USD 8 million in 1960, and further to USD 54 million in 1963 (IMF 1962, 1969)—marking "one step forward" toward financial integration.

The foreign exchange crisis of the mid-1960s, however, reversed this trend and marked "two steps back" in government policy (Athreye and Kapur 1999; Panagariya 2008). All large banks were nationalized; hence, 84 % of all the bank branches were incorporated into the public sector. The Foreign Exchange Regulation Act (FERA) was passed in 1973, which—barring a few exceptions such as tea plantations, technology- or export-intensive firms—mandated that nonbank companies in excess of 40 % foreign equity share either dilute the foreign share or wind up. Consequently, the number of approved foreign-owned companies dropped from about 297 in 1959–1966 to 242 in 1967–1979 (Kumar 1990).

In the second phase of the 1980s, motivated by the economy's poor performance, and a growing current account deficit, India relaxed restrictions on external commercial loans, including short-term borrowings and deposits from nonresident Indians, granted exceptions to the 40 % equity participation rule, and relaxed rules on technical imports and royalties. Foreign investment flows thus increased from USD 0.6 billion during 1977–1979 to USD 3 billion over 1980–1988; though a significant proportion of these flows represented short-term debt flows.[1]

Overall, India approached capital account liberalization before 1991 in a piecemeal fashion; yet, it was the pre-1991 experience that framed its concerted post-1991 approach toward liberalization. The later reforms were thus conditioned on the need to correct the problems that had led to external imbalances in 1991 (such as an unsustainable current account deficit, and high short-term debt relative to foreign exchange reserves), and involved a preference for nondebt creating inflows over debt inflows; and sequential, gradual liberalization of outflows.

[1]Source: IMF's IFS database.

3 Is Capital Account Openness Good for Growth?

Traditional neoclassical economics emphasizes the welfare gains of allowing free movement of capital from countries where it is abundant to regions, where it is scarce and its marginal product is correspondingly high. An open capital account potentially allows an efficient allocation of resources, risk sharing, and intertemporal consumption smoothing leading to welfare gains (Grubel 1968; Stockman and Hernandez 1988; Obstfeld 1995). Additionally, financial flows may bring a transfer of technology and know-how, macroeconomic discipline, and the impetus for financial and institutional development in the recipient country—thereby promoting economic growth.

But the empirical literature has generally had difficulty in unambiguously affirming these theoretical predictions about the benefits of financial liberalization. While some studies find a significantly positive association between capital account liberalization and economic growth (e.g., Quinn and Toyoda 2008; Bonfiglioli 2008), others do not find much evidence of direct economic gains from international financial integration in EM and developing countries (Edison et al. 2002; Gourinchas and Jeanne 2006). In fact, some recent evidence suggests the opposite—that EM and developing countries relying more on foreign financing have generally experienced *lower* long-run economic growth (e.g., Prasad et al. 2007; Aizenman et al.

2007).[15] Moreover, the international risk sharing benefits of financial liberalization have been documented to be limited as well (Kose et al. 2009a).

Several studies, however, purport to find *indirect* benefits of financial integration such as improved educational attainment, financial sector development, and stronger institutional quality (Edison et al. 2002; Kose et al. 2009b; Kaminsky and Schmukler 2008). At the same time, there also appear to be some "threshold" effects of financial liberalization such that countries are said to benefit more if they meet certain thresholds of financial and institutional development (Dell'Ariccia et al. 2008; Mukerji 2009). That the effect of financial liberalization may itself depend on meeting certain thresholds of financial and institutional development creates an obvious tension with the finding that liberalization may strengthen these attributes—but this issue remains unresolved in the literature.[16]

A growing body of literature also suggests that the effect of financial openness depends on the type of capital flow. Levine (2001), for instance, shows that the liberalization of portfolio inflows increases stock market liquidity, which in turn spurs productivity and economic growth. He also finds that greater foreign bank presence increases the efficiency of the domestic banking system, which also boosts economic growth. These findings are supported by Bekaert et al. (2001), who show that equity market liberalization has a significant effect on growth. Differentiating across countries that liberalized, they also find that those with greater human capital, a smaller public sector, and an Anglo-Saxon legal system reap larger gains from liberalization. Focusing on FDI, Borensztein et al. (1998) find that such inflows contribute significantly to economic growth, but that the effect is conditional on a sufficient stock of human capital in the country.

A cross-country snapshot of real GDP growth rates and de facto financial openness in EMs suggests that the beneficial effect of liberalization may indeed depend on the type of flow. Figure 7, for instance, shows a strong correlation between real GDP growth and net capital flows (lagged to mitigate endogeneity concerns) across EMs, but this seems to be driven mainly by FDI flows. Results from more formal panel regressions—using both annual data and 5-year averages, while controlling for other factors such as trade openness, per capita income, real GDP growth of trading partners, and country fixed and time effects—confirm these casual observations, and imply that a 1 percentage point increase in net financial flows (to GDP) is associated with higher real GDP growth by, on average, 0.1 percentage

[15]Rodrik and Subramanian (2009) argue that financial globalization has disappointed because the underlying assumption of the neoclassical model that developing countries are saving-constrained (and financial integration, by alleviating that constraint, boosts investment and long-run growth) is invalid. In their view, developing countries are more likely to be constrained in investment opportunities; and greater inflows—by strengthening the value of domestic currency—undermine investment in crucial tradable-goods industries, thus undercutting the growth potential of liberalizing economies.

[16]Academic studies have been unable to pinpoint the thresholds precisely (e.g., Kose et al. 2010) provide much practical guidance on when countries should contemplate capital account liberalization.

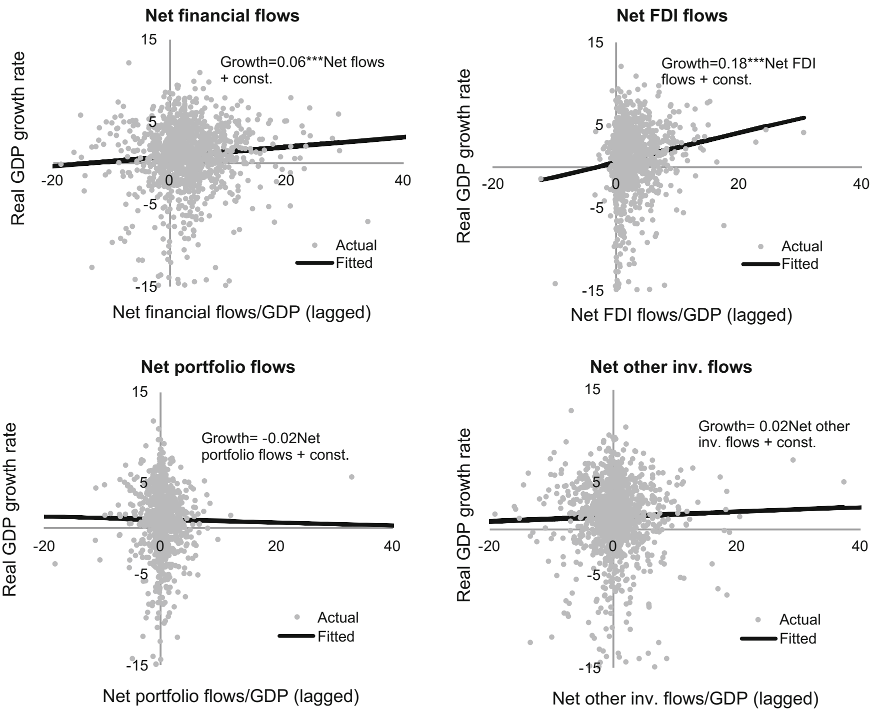

Fig. 7 Real GDP growth and net financial flows in EMs, 1980–2013 (in percent). *Source* Authors' estimates. *Note* Real GDP growth is residuals from regressing real GDP growth rate on (log of) VXO index. ***indicates statistical significance at the 1 % level

point in EMs (Table 1, cols. [1] and [4]). The effect is, however, economically and statistically the most significant for FDI flows, with a 1 percentage point increase in FDI flows (to GDP) raising growth by about 0.2 percentage points (cols [2]–[3], [5]–[6]). After FDI, portfolio equity flows and other investment flows have the largest effect in regressions with annual and 5-year average data, respectively.

Focusing on India, a similarly strong association between net FDI flows (lagged) and real GDP growth holds—with a 1 percentage point increase in FDI to GDP ratio leading to about a 1.5 percentage point increase in the growth rate (Fig. 8). The association between other types of flows and growth including portfolio equity flows—although positive—is statistically insignificant. This is not to say that other types of flows have had no beneficial impact on India's economy—financial openness more broadly may have conferred other indirect benefits to India. For instance, Fig. 9 suggests that greater financial development has been moving in tandem with increased financial openness in India—which way the causality runs is open to question though.[17]

[17]Patnaik and Shah (2007) note that—as per the reform agenda of the early 1990s—policymakers institutionally transformed and modernized the Indian equity market to attract portfolio equity flows.

Table 1 Real GDP growth and net financial flows in EMs, 1980–2013

	Annual			5-year averages		
	(1)	(2)	(3)	(4)	(5)	(6)
Net financial flows	0.053*** (0.018)			0.108*** (0.033)		
Net FDI flows		0.209*** (0.071)	0.232** (0.104)		0.225** (0.097)	0.185 (0.153)
Net portfolio flows		0.030 (0.032)			0.035 (0.159)	
Net portfolio equity flows			0.175* (0.096)			0.131 (0.150)
Net portfolio debt flows			0.028 (0.037)			−0.087 (0.206)
Net other inv. flows		0.013 (0.029)	0.027 (0.036)		0.169** (0.073)	0.182* (0.095)
Trade openness	0.008 (0.012)	0.020* (0.011)	0.023 (0.014)	−0.007 (0.009)	0.001 (0.014)	0.002 (0.016)
Real per capita income (log)	−4.615*** (0.882)	−5.633*** (1.017)	−6.559*** (1.195)	−4.896*** (1.054)	−4.692*** (0.987)	−5.076** (1.257)
Trading partner growth	0.896*** (0.162)	0.720*** (0.182)	0.680*** (0.217)	1.085*** (0.284)	0.843** (0.340)	0.968** (0.398)
Observations	1317	1085	759	289	253	196
R-squared	0.364	0.422	0.485	0.634	0.656	0.656

Note Dependent variable is real GDP growth (in percent). All net flow variables are in percent of GDP. Net financial flows exclude reserve assets and other investment liabilities of the official government. All regressors (except for trading partner growth) are lagged one period in cols. [1]–[3]. Constant, country fixed and year effects included in all specifications. Clustered standard errors (by country) reported in parentheses. *, ** and ***indicate statistical significance at the 10 %, 5 % and, 1 % levels, respectively

While there may be a concern that India's slow moving liberalization process and limited degree of openness have constrained the indirect gains that accrue from greater financial integration—there is also little doubt that India's strategy has served it well in terms of maintaining macroeconomic stability and reducing its vulnerability to financial contagion and crisis. Thus, India remained largely insulated from the EM crises of the 1990s and early 2000s, and its economy remained resilient through the GFC.[18] Going forward, how the situation might change as India's economy integrates further with international capital markets? We turn to this issue next.

[18]Ranciere et al. (2008) show that in liberalized economies with moderate contract enforceability, systemic risk-taking is encouraged, which spurs investment. This leads to higher mean growth, but also to greater incidence of crises.

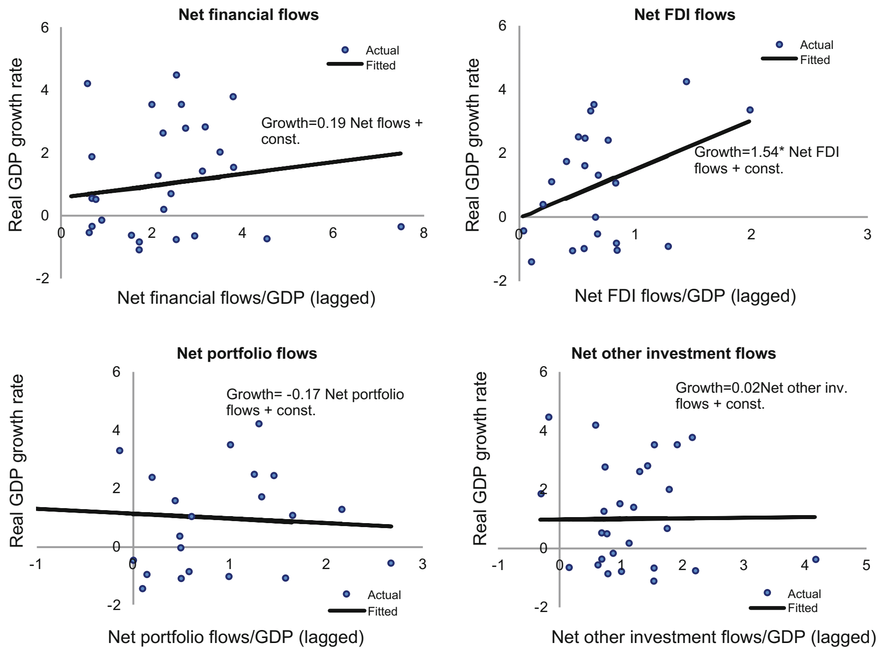

Fig. 8 Real GDP growth and net financial flows in India, 1980–2013 (in percent). *Source* Authors' estimates. *Note* Real GDP growth is residuals from regressing real GDP growth rate on (log of) VXO index. *indicates statistical significance at the 10 % level

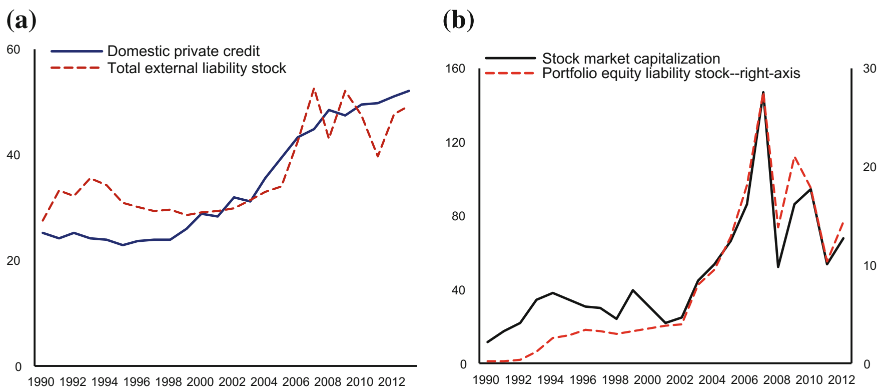

Fig. 9 Financial development and financial openness in India, 1990–2013. *Source* Authors' estimates based on WDI, IFS and Lane and Milesi-Ferretti (2001) databases. **a** External liabilities (In percent of GDP), **b** stock market capitalization (in percent of GDP)

4 Short-Run Risks of Capital Flows

Notwithstanding the benefits of capital flows, financial crises in EM countries during the 1980s and 1990s, and the recent GFC have underscored that financial openness may also entail risks. Too often have EMs experienced inflow surges after pursuing financial liberalization, only to be followed by sudden stops and financial crises with deep socioeconomic costs (Diaz-Alejandro 1985; Kaminsky and Reinhart 1999; Demirguc-Kunt and Detragiache 1998; Kaminsky and Schmukler 2008).

Why are inflow surges associated with crisis? It is now well established that large and sudden capital inflows can raise financial-stability risks (such as domestic credit booms, generation of asset price bubbles, and excessive borrowing in foreign currency by the unhedged private sector), as well as macroeconomic concerns (such as strong currency appreciations that could hurt the tradable sector).[19] Existing literature also shows that a significant share of cross-border flows to EMs is driven by external conditions (e.g., Calvo et al. 1993; Ghosh et al. 2014); thus, even the slightest change in global conditions may trigger a sudden and large reversal of flows—the consequences of which will be more damaging for countries with greater macroeconomic and financial vulnerabilities. Not all types of flows are equally dangerous, however, an obvious example being debt versus equity, where the latter allows for greater risk sharing between creditors and borrowers, thereby carrying a smaller risk of financial disruption in the face of eventual outflows. In fact, Ghosh et al. (2016) find that large capital inflow episodes driven by FDI inflows are significantly less prone to end in a "hard landing" than are debt-driven episodes. Based on the theoretical properties and available empirical evidence, existing studies thus yield a pecking order of capital inflows (in decreasing order of riskiness), with short-term instruments riskier than long-term instruments within each category: (i) foreign currency debt; (ii) local currency debt; (iii) portfolio equity investment; and (iv) FDI.[20]

In the case of India, as noted above, external indebtedness in short-term instruments is limited, but has been increasing. At the same time, as shown in Fig. 1, the volatility of capital flows to India has also risen—especially since the GFC. Examining the sensitivity of flows to global conditions suggests that, on average, net flows (in percent of GDP) to India are less strongly associated with a measure of global risk aversion (VXO index) than for other EMs (Table 2, top

[19]See, e.g., Mendoza and Terrones (2012) and Calderon and Kubota (2012) for evidence on financial-stability risks associated with capital flows; and Reinhart and Reinhart (2009) and Combes et al. (2012) for evidence on macroeconomic concerns.

[20]See Ostry et al. (2010) for a discussion. Kose et al. (2009a) argue that one reason why EMs have not benefitted as much from financial liberalization is that capital flows to these countries are mostly portfolio debt flows, which are not conducive to risk sharing.

Table 2 Global factors and financial flows to EMs and India, 1980Q1–2013Q4

	Financial flows		FDI		Portfolio equity		Portfolio debt		Other investment	
	EMs	India	EMs	India	EMs	India	EMs	India	EMs	India
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
[A] Net flows										
VXO (log)	−2.158*** (0.653)	−1.143** (0.574)	0.023 (0.230)	0.185 (0.155)	−0.604*** (0.150)	−1.090*** (0.275)	−0.983*** (0.331)	1.111* (0.560)	−0.746* (0.444)	−0.380 (0.423)
US govt. bond yield	−0.248 (0.153)	−0.454*** (0.075)	−0.153* (0.082)	−0.163*** (0.030)	0.073** (0.034)	−0.147*** (0.053)	−0.195*** (0.060)	−0.420* (0.211)	0.070 (0.102)	−0.119* (0.064)
Obs.	3469	112	3474	92	2823	92	2951	19	3470	112
R-squared	0.187	0.231	0.277	0.255	0.093	0.151	0.058	0.172	0.107	0.033
[B] Liability flows										
VXO (log)	−3.832*** (0.767)	−1.424** (0.594)	0.063 (0.254)	0.264 (0.249)	−0.658*** (0.111)	−1.088*** (0.276)	−1.533*** (0.303)	1.111* (0.560)	−2.011*** (0.608)	−0.712* (0.423)
US govt. bond yield	−0.517*** (0.152)	−0.690*** (0.074)	−0.295*** (0.074)	−0.321*** (0.040)	0.022 (0.025)	−0.152*** (0.053)	−0.197*** (0.059)	−0.420* (0.211)	−0.063 (0.092)	−0.192*** (0.060)
Obs.	3469	112	3472	92	2547	92	2778	19	3462	112
R-squared	0.157	0.408	0.196	0.343	0.112	0.153	0.080	0.172	0.068	0.111

Notes Dependent variables in panel [A] are quarterly net flows in percent of GDP; and in panel [B] are quarterly liability flows in percent of GDP. (Quarterly GDP is taken as one-fourth of annual GDP.) Other investment flows exclude liability flows of the government (typically official loans). Net flows exclude foreign reserve flows. US government bond yield is that of bonds with 10-year maturity. Data for portfolio equity and debt flows for India is available from 1990 and 2009 onwards, respectively. Regressions for EMs include country fixed effects. All regressions include a constant term. Statistics in parentheses are standard errors (clustered by country in the EM regressions, and robust for India-specific regressions). ***, **, and *indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively panel);[21] flows are, however, more strongly associated with US interest rates than for other EMs. A 10 % increase in the VXO index thus reduces net flows to EMs by about 0.1 percentage point of GDP, but the effect on India is about half as large (cols. [1]–[2]). By contrast, a one percentage point increase in the US interest rate (proxied by the 10-year US government bond yield) lowers net flows to India by about 0.5 percentage points, but the effect is about half of that (and marginally insignificant) for other EMs. The responsiveness of flows to global conditions, however, varies by the type of flow—for EMs, in general, portfolio debt flows react most strongly to changes in global risk aversion and US interest rates (col. [7]), while for India, portfolio equity flows are most sensitive to shifts in global risk aversion but portfolio debt flows react more strongly to changes in US interest rates (cols. [6] and [8]).[22] Overall, FDI flows are correlated with US interest rates, but not significantly with global investor risk aversion—which confirms the greater stability of such flows.

The picture remains similar if instead of net (i.e., the sum of asset and liabilities) flows, liability flows are considered (Table 2, bottom panel); though the sensitivity of liability flows to global factors, especially to US interest rates, is generally higher (as compared to net flows) for both India and other EMs. This suggests that asset flows (i.e., flows driven by domestic residents) play an offsetting role to some extent when global conditions change.

Importantly, flows to India have become more sensitive to global risk aversion over time—this is particularly true for portfolio equity and for other investment flows, but not for FDI flows (Table 3). The rise in sensitivity of flows to global conditions could in part be attributed to the increasing openness of India's capital account, which has attracted different types of investors, notably foreign institutional investors, who tend to be more fickle (see Appendix). It could also be an outcome of a general global shift in investor behavior, especially after the GFC, because of greater uncertainty surrounding global economic prospects.

Whatever the reasons, this increased sensitivity, along with the marked rise in the stock of (especially, short-term) debt liabilities (Figs. 1 and 3), suggests that policy makers need to be vigilant, and should follow a cautious approach to managing capital flows as the country embraces increasing de jure and de facto capital account openness. Already there are some concerns that corporate and bank balance sheet vulnerabilities have increased drastically with the post-GFC surge in inflows, which is restraining economic growth through a corporate debt hangover—or what has been termed by the Indian Ministry of Finance as the "balance sheet

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[21]The VXO index, compiled by the Chicago Board Options Exchange, is a precursor to the commonly used VIX index. We use the VXO index as it is available from 1986, while VIX is available from 1990 onwards. The results, however, remain very similar if VIX is used in the estimations.

[22]The results for portfolio debt flows for India are based on post-2009 years only because of data availability, but for other EMs, data is mostly available from 1980 onward. (For portfolio equity flows, the data for India is available from 1990 onward.).

Table 3 Global factors and financial flows to India by subsample, 1980Q1–2013Q4

	Financial flows			FDI			Portfolio equity			Portfolio debt	Other investment		
	1980–1999	2000–2007	2008–2013	1980–1999	2000–2007	2008–2013	1980–1999	2000–2007	2008–2013	2008–2013	1980–1999	2000–2007	2008–2013
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
[A] Net flows													
VXO (log)	−0.562 (0.505)	−0.776 (0.671)	−2.641* (1.404)	0.240 (0.155)	0.038 (0.162)	−0.343 (0.376)	−0.834** (0.392)	−0.788** (0.373)	−1.613** (0.595)	1.111* (0.560)	0.036 (0.450)	−0.025 (0.619)	−1.259 (0.870)
US govt. bond yield	−0.318*** (0.098)	−0.795* (0.399)	0.116 (0.634)	−0.098* (0.053)	0.151** (0.063)	0.412 (0.240)	−0.113 (0.116)	−0.368 (0.228)	−0.013 (0.398)	−0.420* (0.211)	−0.025 (0.099)	−0.578* (0.309)	−0.032 (0.587)
Obs.	56	32	24	36	32	24	36	32	24	19	56	32	24
R-squared	0.133	0.083	0.159	0.222	0.119	0.147	0.139	0.149	0.191	0.172	0.001	0.050	0.058
[B] Liability flows													
VXO (log)	0.186 (0.453)	−2.590*** (0.833)	−3.464** (1.321)	0.242 (0.161)	−0.704* (0.409)	0.469 (0.320)	−0.834** (0.392)	−0.771** (0.373)	−1.632** (0.597)	1.111* (0.560)	0.789** (0.376)	−1.114** (0.529)	−2.658* (0.897)
US govt. bond yield	−0.518*** (0.094)	−0.141 (0.390)	0.309 (0.559)	−0.101* (0.055)	0.097 (0.141)	0.735*** (0.256)	−0.113 (0.116)	−0.360 (0.225)	−0.022 (0.397)	−0.420* (0.211)	−0.219** (0.082)	0.122 (0.298)	−0.053 (0.481)
Obs.	56	32	24	36	32	24	36	32	24	19	56	32	24
R-squared	0.252	0.192	0.274	0.216	0.133	0.445	0.139	0.145	0.194	0.172	0.135	0.097	0.268

Notes Dependent variables in panel [A] are quarterly net flows in percent of GDP; and in panel [B] are quarterly liability flows in percent of GDP. (Quarterly GDP is taken as one-fourth of annual GDP.) Other investment flows exclude liability flows of the government (typically official loans). Net flows exclude foreign reserve flows. US government bond yield is that of bonds with 10-year maturity. Data for portfolio equity and debt flows for India is available from 1990 and 2009 onwards, respectively. All regressions include a constant term. Statistics in parentheses are robust standard errors. ***, **, and *indicate statistical significance at the 1 %, 5 %, and 10 % levels, respectively

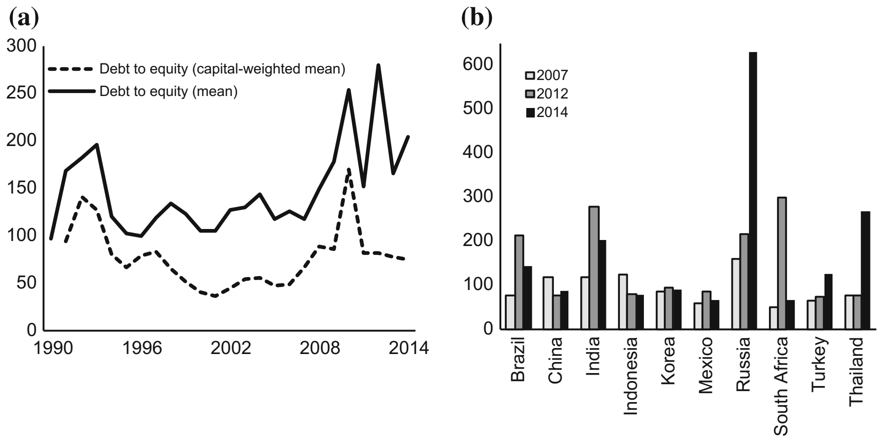

Fig. 10 Corporate leverage ratio in India and other EMs. *Source* IMF's Corporate Vulnerability Utility. *Note* Statistics pertain to non-financial firms

syndrome with Indian characteristics."[23] Corporate leverage doubled between 2008 and 2010, making Indian corporates one of the most leveraged among EM countries (Fig. 10). This rise in leverage can be attributed to credit extended by the domestic banking system—notably, by public banks—as well as to external commercial borrowings (ECBs) in foreign currency (Fig. 11a, b), while there have been relatively few issuances in the equity market amid rather lackluster stock market performance (Fig. 11c, d).

This situation is in contrast to the pre-GFC years, when corporate balance sheets remained strong, the value of stocks rose sharply, and primary equity issuance was the major means of financing for Indian corporations. Although domestic bank credit grew rapidly before the GFC, profitability of Indian firms remained high, and interest burden relative to profits stayed low (Fig. 12). Moreover, increased reliance on external (debt) financing has made Indian corporates increasingly vulnerable to rollover and foreign currency risks. In fact, looking at four commonly used indicators of corporate health—interest cover ratio (ICR), profitability, liquidity, and leverage—corporate vulnerabilities seem to be at their highest levels since the early 2000s (Table 4).[24] Thus, as of 2013, the percentage of debt owed by unprofitable (or loss-making) firms, and those with ICR below one stood at about 27 % and

[23]See *Mid-Year Economic Analysis 2014–15* and *Economic Survey 2014–15*, Ministry of Finance, Government of India, for a detailed discussion.

[24]ICR and profitability assess, respectively, the extent to which firm's current activities allow the funding of interest expenses, and whether a firm's combined operating and financial activities are self-funding (Lindner and Jung 2014). An ICR below one, or a lack of profitability, does not necessarily indicate insolvency (firms may have liquid investments, open credit lines, or other sources of funding available), yet low levels of ICRs are generally considered to be a good indicator of systemic vulnerabilities.

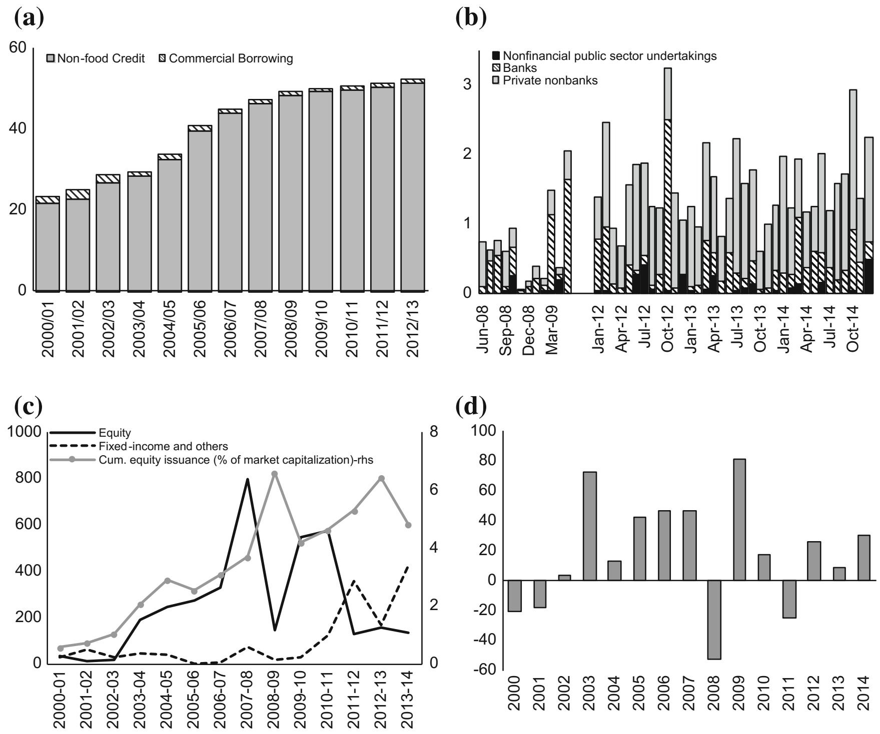

Fig. 11 Corporate financing in India. *Source* Lindner and Jung (2014), SEBI, and BSE. *Note* The BSE SENSEX is the Bombay Stock Exchange Sensitive Index, which is a market-weighted stock market index of 30 well-established and financially sound companies listed on the Bombay Stock Exchange (the largest stock exchange in India). **a** Domestic credit to corporates (in percent of GDP), **b** foreign currency debt payments (in USD bln.), **c** primary market issuance (in Rupees bln.), **d** change in BSE SENSEX (in percent)

17 %, respectively (representing an almost threefold increase since the eve of the GFC).[25]

The deterioration in corporate balance sheets has put pressure on banks' balance sheets as well, and both the expected corporate default probabilities and the "slippage ratio" (defined as the ratio of loans entering nonperforming status to standard assets at the beginning of the year) have increased (Fig. 13). Since a significant share of domestic lending in recent years has been done by public sector banks, especially for (stalled) infrastructure projects, their credit risk has risen sharply: the sum of their nonperforming and stressed assets doubled from 2011 to

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[25]Conducting stress-tests on corporate balance sheets, Lindner and Jung (2014) estimate that as a result of the increase in debt, Indian corporate sector's vulnerability to severe systemic shocks has increased to 2001 levels (when India experienced a stock market crash).

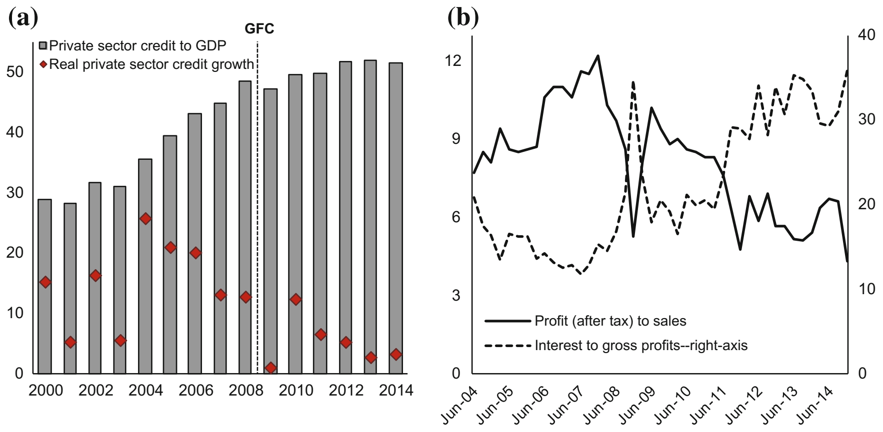

Fig. 12 Domestic credit and corporate profitability in India (in percent). *Sources* IMF's IFS and CEIC databases. **a** Domestic private credit, **b** corporate profitability

Table 4 Interest cover, profitability, liquidity, and leverage for major Indian corporates

Debt held by firms below/above threshold values (in percent of total borrowing)				
	ICR(<1)[a]	Probability (<0)[b]	Liquidity (<0.5)[c]	Leverage (>5)[d]
2000–2001	18.0	29.8	15.6	43.9
2001–2002	21.5	29.2	13.4	43.5
2002–2003	15.7	25.2	14.6	42.1
2003–2004	11.4	17.4	13.5	28.5
2004–2005	8.4	10.4	11.2	12.2
2005–2006	8.7	9.3	9.2	7.9
2006–2007	6.6	8.5	10.0	8.4
2007–2008	6.5	11.1	13.1	10.0
2008–2009	9.4	14.9	13.5	24.9
2009–2010	5.6	9.0	15.1	11.7
2010–2011	6.2	13.9	11.0	15.7
2011–2012	14.8	21.3	15.8	26.7
2012–2013	16.8	26.5	17.7	29.5

Source Lindner and Jung (2014)
[a]ICR = Interest Cover Ratio defined as Earnings before Interest, Taxes, Depreciation and Amortization (EBITDA) divided by interest expenses
[b]Profitability defined as net profit divided by total sales
[c]Liquidity defined as the 'Current Ratio' = Current assets/Current liabilities
[d]Leverage defined as total debt relative to market capitalization

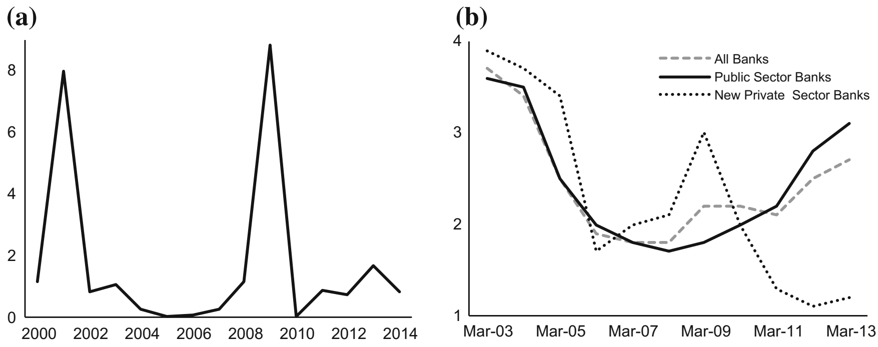

Fig. 13 Domestic default probability and slippage ratios in India. *Sources* IMF's Corporate Vulnerability Utility; Lindner and Jung (2014). *Notes* Corporate default probability is the Black-Scholes-Merton option pricing default probability, which provides the 1-year-ahead probability of default, taking into account all information reflected in stock prices. Slippage ratio is defined as the fresh accretion of nonperforming assets (NPAs) during the year (in percent of total standard assets at the beginning of the year). **a** Corporate default probability for India (Capital-weighted mean; in percent), **b** slippage ratios of Indian banks (in percent)

2014, rising to over 12 % of total advances.[26] This could have significant implications for the economy, as the strains on banks' asset quality may curtail their ability to lend, causing financial challenges for firms, and reinforcing the negative feedback loop between the corporate and banking sectors.

Although the RBI is taking steps to help banks to address their bad loans problems (for example, through debt restructuring, and longer amortization period for loans to infrastructure and core industries), the recent experience underscores the importance of managing inflow surges cautiously.[27] What are the policy options at the disposal of policy makers to mitigate the risks associated with capital inflows? The next section discusses this issue in detail.

[26]See *Economic Survey 2014–15*, Ministry of Finance, Government of India, which also notes that weak institutions relating to bankruptcy are one reason why the over-indebtedness problem cannot be easily resolved, and that is reflected in the persistence of stalled projects (that have stayed at 7–8 % of GDP since 2010–2011). The Survey indicates that unfavorable market conditions are behind the stalled projects in the private sector, while regulatory reasons largely explain project delays (mainly related to public private partnerships in infrastructure) in the public sector.

[27]On RBI's Strategic Debt Restructuring (SDR) and Flexible Structuring of Long-Term Project Loans to Infrastructure and Core Industries schemes, see https://rbi.org.in/scripts/NotificationUser.aspx?Mode=0&Id=9767 and https://rbi.org.in/scripts/NotificationUser.aspx?Mode=0&Id=9498 (last accessed on February 3, 2016).

5 Policy Options to Manage Capital Flows

The debate on how to manage volatile capital flows resurfaces after every boom–bust cycle of capital flows to EMs, but mostly focuses on the feasibility of implementing capital controls to mitigate the severity of the cycle. Doubts about financial liberalization were, for instance, expressed in the aftermath of the Latin American debt crisis of the early 1980s (e.g., Diaz-Alejandro 1985), and after the Asian financial crisis of the late 1990s, with several leading academics arguing that full financial integration may not be desirable when existing financial market distortions violate assumptions of a first-best competitive equilibrium (Cooper 1998; Rodrik 1998; Stiglitz 2000). Similar concerns have been voiced more recently following the GFC as well (e.g., Jeanne and Korinek 2010; Korinek 2011).

While some critics remain skeptical about the effectiveness of capital controls (e.g., De Gregorio 2014; Forbes et al. 2015), there is a growing consensus that dealing with capital flows requires a balanced approach, which may involve the use of capital controls in some circumstances (Ostry et al. 2010, 2011, 2012; IMF 2012; Rey 2013; Ghosh 2014).[28] Central to this approach (outlined in IMF 2012) is to enhance the absorptive capacity of the economy through structural reforms to channel inflows to productive investments; maintain macroeconomic policy discipline; strengthen financial supervision and regulation; and undertake warranted external adjustment. Beyond these, as capital begins to flow to the economy more generally, other policies come into play such as exchange rate management; monetary and fiscal policy response; macroprudential measures; and capital controls. The guiding principles of this approach can thus be summarized briefly as follows:

i. In general, the first buffer against a capital inflow shock is the exchange rate which, in countries without fixed exchange rates, should be allowed to appreciate provided that it does not become overvalued. (In countries with formal pegs, the intervention should not be sterilized, thus allowing the real exchange rate to appreciate.)
ii. Monetary policy may be eased in the absence of overheating to reduce the incentive for further inflows. But if capital flows result in overheating of the economy, then the policy interest rate could be tightened to meet the inflation target.
iii. In addition to safeguarding debt sustainability, fiscal policy should be geared to maintaining a counter-cyclical stance, which will typically imply tightening

[28] A vast body of literature exists assessing the effectiveness of temporary capital controls, especially on inflows (see Ostry et al. 2010; Magud et al. 2011 for a survey), which generally finds little effect of inflow controls on the total volume of inflows (or on exchange rate appreciation), but a statistically significant impact on the composition of liabilities and on mitigating financial-stability risks. Regarding outflow controls, most studies examine their effectiveness in crisis situations and report mixed results (e.g., Edison and Reinhart 2001); though Binici et al. (2010) find that they tend to be associated with significantly lower capital outflows in advanced countries even in noncrisis situations.

in the face of inflows (that will help to curtail the current account deficit, as well as to mitigate inflationary pressures).

iv. Foreign exchange reserves can be accumulated in the face of currency appreciation pressures, especially if reserves are low by country insurance metrics, sterilization costs are manageable, and there is little risk of undermining the clarity and credibility of the monetary policy framework.

v. To safeguard financial stability, macroprudential measures should be deployed when inflows are fueling excessive domestic credit growth. If there are remaining concerns about the possible consequences of inflow surges, then capital controls could be deployed to help stem the aggregate volume of inflows.

vi. Moreover, policymakers need to be mindful of other possible financial-stability risks in the form of balance sheet mismatches and vulnerabilities (such as unhedged foreign currency exposure of corporates or households), and should apply macroprudential measures to limit systemic financial risks. If capital flows are the source of risk, such measures can also be seen effectively as capital controls intended to restrict certain types of capital flows and shift the composition toward less risky forms of liabilities (FDI, equity, and local currency instruments).

So much for managing inflows, but what about managing outflows? Overall, the experience of EMs over the years suggests that that the best way to deal with volatile capital flows is to maintain a disciplined response during the inflow phase to ensure the economy is resilient when inflows recede or reverse. If the inflow surge is managed successfully and ends without a crisis, the policy response when the surge ends is likely to be symmetric: monetary and fiscal policy, together with macroprudential measures and capital controls imposed for flow imbalances, may be relaxed as overheating pressures diminish and credit growth slows. (While the central bank should stop accumulating more reserves, it should not reduce its reserve holdings if the stock of liabilities—such as short-term debt—has settled to a new, higher level.) Conversely, if the inflow surge is poorly managed, or the episode otherwise ends in a large reversal of flows or crisis, this "symmetric" policy response may be untenable—interest rates may need to be raised sharply; intervention might need to be used to stabilize the currency, especially in disorderly market conditions; and, in extremis, capital controls on outflows may need to be imposed as well.

5.1 India's Approach to Managing Capital Flows

Against this backdrop, how has India been managing its capital flows? Figure 14a shows that since liberalization in the early 1990s to the eve of the crisis in 2007, India mostly ran a current account deficit that was more than offset by net (private) capital inflows. At the same time, India tightly managed its exchange rate, with its

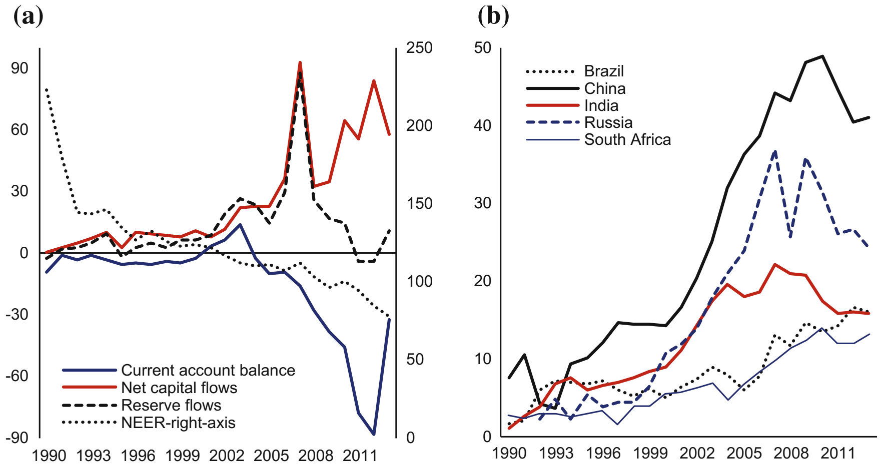

Fig. 14 Current account, financial flows and foreign exchange reserves of India, 1990–2013. *Source* IMF's IFS database. **a** Current account, flows and reserves (in USD bln.), **b** stock of reserves (in percent of GDP)

stock of foreign exchange reserves increasing sixfold from about USD 43 billion in 2000 to USD 275 billion in 2007 (over a twofold increase in terms of GDP; Fig. 14b).[29] Among the BRICS countries, the level and pace of India's reserves accumulation was lower than that of China and Russia, but much higher than those of Brazil and South Africa. Since India was mostly receiving other investment and portfolio flows during that period, the reserve accumulation could largely be attributed to the rise in these flows—which may thus be viewed as a "precautionary" and prudent strategy inasmuch as these are also the most volatile types of flows. Indeed, when the tide turned in 2008, and net capital flows to India dropped sharply while its current account deficit increased, India decumulated reserves to contain the depreciation of the exchange rate.

Since the GFC, however, the surge in net capital flows to India has mostly been financing its large current account deficit; the stock of reserves jumped from USD 256 billion in 2008 to about USD 284 billion in 2009, and further increased to USD 298 billion in 2010, but has stayed fairly constant since then.[30] Looking at quarterly flows to get a clearer picture of how India has been managing capital flow volatility since the crisis, it is evident that the central bank intervened heavily to resist currency appreciation pressures when flows to India surged in 2009 (Fig. 15a). While allowing some exchange rate flexibility, it has also been intervening actively

[29]India does not have a formal exchange rate target, but has been managing the exchange rate to varying degrees over time. It is thus classified as a de facto managed float by the IMF.

[30]A measure of sterilization constructed by estimating monthly changes in net domestic assets on changes in net foreign assets suggests that India sterilized most of its foreign exchange intervention during 2009–2012.

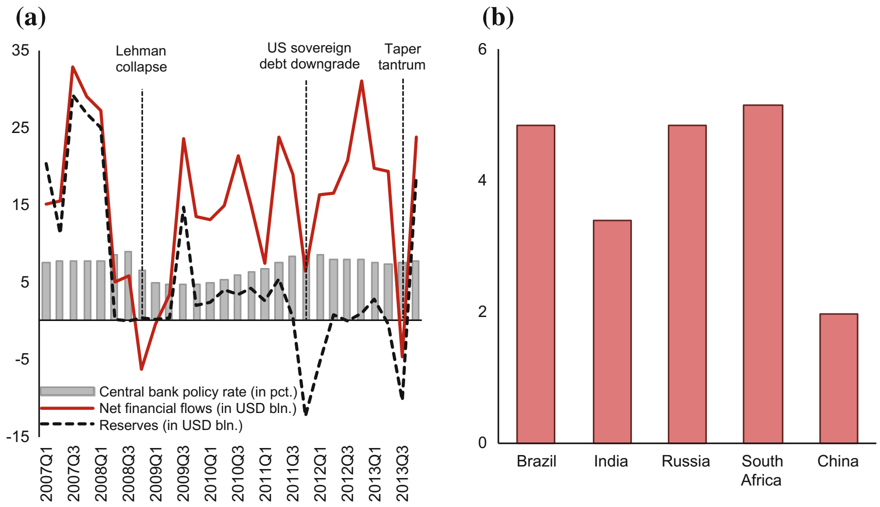

Fig. 15 Net financial flows and foreign exchange intervention in India. *Source* IMF's IFS and INS databases. *Note* NEER volatility computed as the standard deviation of quarterly percentage changes in the NEER over 2009Q1–2013Q4. **a** Net financial flows, reserves and policy rate, 2007Q1–2013Q4, **b** NEER volatility post-GFC (in percent)

in the face of sudden outflows driven by external factors (notably, the US sovereign debt downgrade in the fall of 2011, and the "taper tantrum" in the summer of 2013) to prevent sharp currency depreciation.[31] As a result, India has experienced much less volatility in its nominal effective exchange rate (NEER) as compared to, for example, its BRICS peers (with the exception of China; Fig. 15b).

In terms of monetary policy response, faced with high inflation and faltering real GDP growth, the scope for conventional monetary policy to deal with capital flow volatility has been rather limited in recent years.[32] During the post-crisis surge in inflows, for example, the RBI had to tighten monetary policy to curb inflationary pressures. Then in the midst of outflows and exchange market pressures during the third and fourth quarters of 2013, the RBI could not respond immediately by raising the policy rate, which may have been domestically unpalatable because of weakening growth prospects. At that time, however, it took several other steps to tighten

[31]In addition to FX intervention, the RBI also limited currency depreciation during the taper tantrum by offering FX swaps to banks to attract NRI deposits and to encourage long-term overseas FX foreign borrowing by banks, and provided dollar liquidity to oil importers (IMF 2014b). To maintain investor confidence, the RBI also increased its swap line with the Bank of Japan from USD 15 billion to USD 50 billion.

[32]India's annual CPI inflation averaged about 10 % over 2009–2013, while its real GDP growth rate fell from about 9 % in 2009–2010 to 6 % during 2011–2013.

liquidity, and raise short-term interest rates.[33] To contain the large current account deficit, duties on gold imports were also raised and quantity restrictions were imposed, which led to a significant improvement in the current account balance in 2013 (Fig. 14a).[34] Fiscal policy, however, appears to have remained largely unresponsive to capital movements—thus, India continued to run a large (general government) fiscal deficit of about 9 % of GDP during the 2009–2011 surge in inflows, but the general move toward fiscal consolidation reduced the deficit to about 7 % of GDP over 2012–2013.

Alongside the macropolicy response, India has been using macroprudential tools, as well as adjusting its pace of capital account liberalization in response to developments in the capital account. During the pre-GFC surge in inflows, for example, India tightened restrictions on cross-border banking inflows (Fig. 16a), but generally relaxed capital controls in the immediate aftermath of the crisis when it faced outflows. Further liberalization of inflows then slowed down as India contended with a surge in inflows, while outflow restrictions were relaxed as inflationary pressures built up (Sengupta and Gupta 2014). Inflow restrictions were relaxed again as India faced outflows in the fall of 2011, and the liberalization trend continued afterwards.[35] A broadly similar pattern is evident for the deployment of macroprudential tools as well (Fig. 16b)—a clear tightening of policies in the runup to the crisis, relaxation during the GFC, and tightening afterwards.

Overall, India has clearly been using multiple policy tools to manage the risks associated with volatile capital flows, broadly in line with the policy framework outlined above. Through this intermediate approach—which allows for exchange rate stability, capital account openness and an independent monetary policy to varying degrees depending on the prevailing domestic macroeconomic conditions—India has got around the constraints imposed by the international macropolicy "trilemma" of monetary autonomy, free capital mobility, and fixed exchange rates (Sengupta and Gupta 2014). This approach seems to have worked well for the Indian economy, which survived the GFC as well as the most recent "taper tantrum" episode relatively unscathed. Nevertheless, as discussed above in Sect. 4, corporate and financial sector vulnerabilities have risen post-GFC, which calls into question the appropriateness of the macroprudential policy and capital controls response (especially pertaining to direct commercial borrowing from abroad) in dealing with the inflow surge.

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[33]The liquidity tightening measures included limiting the provision of liquidity to banks; tightening the rules for banks' cash reserve ratio; undertaking open market sales of government securities; and raising the marginal standing facility interest rate (IMF 2014b). These measures were relaxed as external pressures abated.

[34]Arguably, restrictions on gold imports could be considered as a form of capital outflow restrictions since gold was mostly being hoarded as an asset.

[35]Although Fig. 10 does not cover the year 2013, capital account restrictions on FDI inflows, banks' FX borrowings, and external commercial borrowing were loosened further during the taper tantrum, while restrictions on outflows were tightened (IMF 2014b). The latter were however partly reversed as external pressures eased.

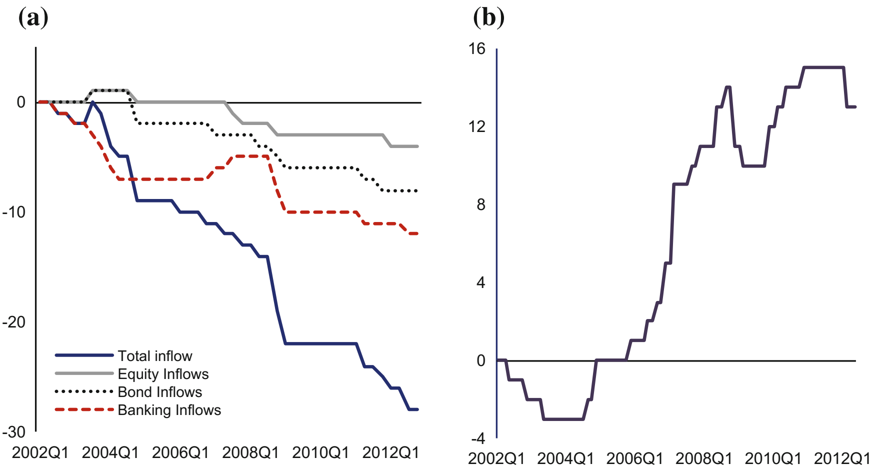

Fig. 16 Changes in capital controls and macroprudential policies in India, 2002Q1–2012Q4. *Sources* Ahmed et al. (2015) and Akinci and Olmstead-Rumsey (2015). *Note* 2002Q1 taken as base period and cumulative changes in measures computed since then with +1 (−1) indicating a tightening (loosening) of restrictions, and 0 indicating no change. **a** Capital inflow controls, **b** macroprudential policies

Going forward, as the country embraces further liberalization and the impact from global financial market volatility could be potentially more disruptive, policy makers will need to be vigilant of macroeconomic and financial-stability risks. They will need more room for maneuver—in this respect, maintaining fiscal prudence, greater central bank independence and credibility, and tackling long-standing structural challenges to improve the general investment climate and to alleviate supply-side bottlenecks are important to help keep inflation in check. These steps will also help to attract more stable, long-term inflows such as FDI and boost growth.

6 Conclusions: A Way Forward

The global financial crisis was a rude reminder that not all borrowing and lending decisions—within and across borders—are rational or welfare improving. While cross-border capital flows bring substantial benefits, surges of capital can also bring macroeconomic and financial-stability challenges. Well-aware of the risks posed by capital flows, Indian policy makers have taken a cautious approach to capital account liberalization. The process has been gradual and deliberate—with inflows liberalized before outflows, and equity inflows, especially direct investment, preferred over debt flows. This approach has worked well to protect the domestic economy from financial contagion and crisis; the liberalization of FDI flows also appears to have conferred direct growth benefits to the Indian economy.

Yet, as India has gone down the path of liberalization, the volatility of capital flows has increased. Consistent with the general policy recommendations of the recent literature, India has responded by deploying multiple policy tools—including foreign exchange intervention, macroeconomic policies, prudential measures, and adjustment of capital controls. Thus, rather than operating at the corners, India has been getting around the policy trilemma by combining some exchange rate stability, partial capital account openness, and retaining some monetary policy independence. Nevertheless, financial-stability concerns have emerged with the rise in debt inflows —in particular, India's corporate sector appears to be under pressure because of the growth in leverage and high interest payment burden that is straining banks' balance sheets.

Clearly more can be done—in terms of removing structural impediments to better absorb the foreign capital and attract more FDI; strengthening prudential regulation and supervision of financial institutions; and creating more room for monetary and fiscal policy to respond in the face of large inflows and outflows. Maintaining macroeconomic discipline in terms of greater fiscal prudence and lower inflation will also be essential to maintain investor confidence.

In terms of further liberalization, whether and to what extent to allow short-term debt flows is a topic of ongoing academic and policy debate. Indian policymakers appear to be fully cognizant of the risks associated with such flows. Recently, RBI Governor Raghuram Rajan remarked: "The only place today that we have some restrictions is inflows into debt, especially very short-term debt…I think most people would agree that opening up to short-term debt flows is usually not very clever for reasons of financial stability."[36] This appears to be a prudent approach; yet to the extent that India's increased capital account openness is inducing some volatility, and raising financial-stability concerns, careful management of capital flows through the policy options discussed above will be essential. In this respect, the best way to deal with volatile capital flows is to maintain a disciplined response during the inflow phase to ensure that the economy is resilient when outflows occur.

Appendix

See Figs. 17, 18, 19 and Table 5.

[36]Remarks delivered at the Kale Memorial Lecture at the Gokhale Institute of Politics and Economics, Pune, April 10, 2015. http://www.thehindu.com/business/Economy/rajan-says-full-rupee-convertibility-in-a-few-years/article7089869.ece.

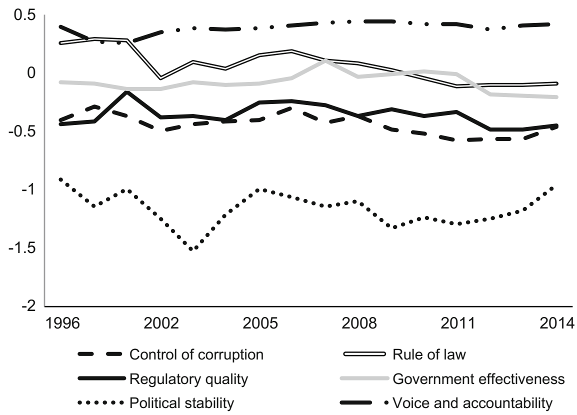

Fig. 17 Governance indicators. *Source* World Bank's Worldwide Governance Indicators. *Notes* Indices range from −2.5 (weak) to 2.5 (strong)

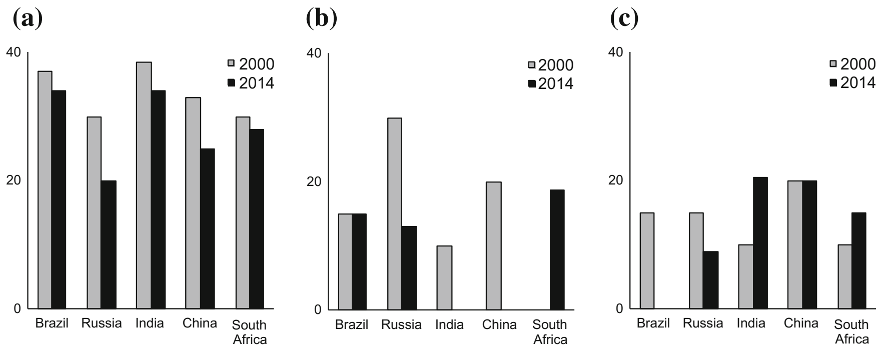

Fig. 18 Corporate, capital gains and dividend taxes in BRICS. *Sources* The Alliance for Savings & Investment; and authors' estimates based on South African Revenue Service, National Treasury, and KPMG International. **a** Corporate tax rate (In percent), **b** top captial gains tax rate (in percent), **c** top dividend tax rate (in percent)

Fig. 19 Equity and bond funds flows to India (in USD billions) *Source* EPFR database. *Note* Flows are total country fund flows, which include the dedicated fund flows along with parts of other fund flows (regional, sector) that are estimated to enter the country. Bond funds flows data begins in 2005

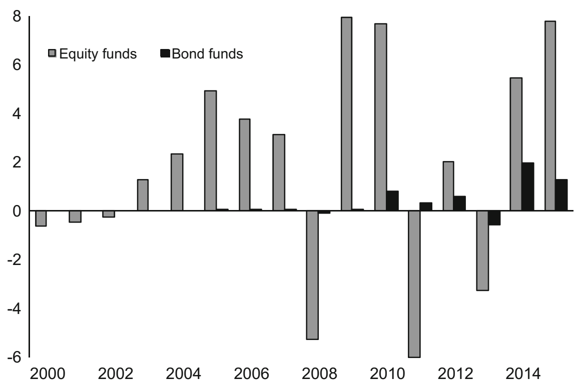

Table 5 Variable definitions and data sources

Variables	Description	Data source
Asset flows	Excluding official reserve flows (in USD bln.)	International Financial Statistics (IFS)
Asset stock	Excluding official reserves (in USD bln.)	Lane and Milesi-Ferretti (2001)
Capital control changes	Index (+ = tightening; − = loosening)	Ahmed et al. (2015)
Central bank policy rate	In percent	IFS
Current account balance	In percent of GDP	IMF's World Economic Outlook (WEO)
De jure capital account openness	Index (0 = closed; 2 = open)	Quinn and Toyoda (2008)
Domestic private sector credit	In percent of GDP	Based on IFS data
Foreign exchange reserve (stock/flows)	In USD bln.	IFS
Liability flows	Excl. other investment liabilities of general govt. (In USD bln.)	IFS
Liability stock	In USD bln.	Lane and Milesi-Ferretti (2001)
Macroprudential regulation changes	Index (+ = tightening; − = loosening)	Akinci and Olmstead-Rumsey (2015)
Net financial flows	Difference between liability and asset flows (In USD bln.)	IFS
Nominal effective exchange rate	Index	IMF's Information Notice System (INS) database
Nominal GDP	In USD billion	IFS
Real GDP growth	In percent	WEO
Real GDP per capita	In USD	WDI
Short-term debt liabilities	In USD bln.	WEO and IMF's Vulnerability Exercise database
Stock market capitalization	In percent of GDP	World Development Indicators (WDI)
Trade openness	Sum of exports and imports (In percent of GDP)	Based on WEO data
Trading partner real GDP growth	In percent	IFS
US govt. bond yield	10-year government bond yield (in percent)	IFS
VXO	Index	Chicago Board Options Exchange

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Measuring Trend Inflation and Inflation Persistence for India

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JEL Codes: E31 · E37

1 Introduction

Price stability is one of the primary objectives of monetary policy. Hence, understanding long-run inflation dynamics assumes a central place in monetary policy analysis. A common conceptual framework assumes that at any given time inflation can be reasonably approximated by the sum of permanent and transitory components. The permanent component is often referred to as the trend inflation and there is a broad consensus amongst economists that this component is pinned down by the behavior of monetary policy. On the other hand the transitory variation around the trend is primarily due to firm's price-setting dynamics, external shocks, etc. (Ascari and Sbordone 2014). The dynamics of these two components of inflation have important implications for the conduct of monetary policy. For instance, many studies have found that variations in the trend component account for a large part of inflation persistence and are associated with shifts in monetary policy targets (Cecchetti and Debelle 2006; Levin and Piger 2004; Stock and Watson 2007). As regards the transitory component, Cogley et al. (2010) define *inflation gap* as the difference between

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_11

inflation and trend inflation, and argue that persistence of the inflation gap is more relevant for assessing the effectiveness of monetary policy in achieving the long-run inflation target.

Given the important role played by trend inflation and the inflation gap in the evolution of monetary policy, in this study we seek to estimate trend inflation and inflation gap in the Indian context. The Reserve Bank of India has formally adopted inflation targeting as a monetary policy strategy in 2015. This move toward formal inflation targeting has been influenced by a very high and persistent inflation in India over the last few years. Though there have been multiple episodes of high inflation in the past, the recent spurt in inflation in India has taken place despite the slowdown in the global and the Indian economy after the 2008 financial crisis. Against this backdrop, we propose to study inflation dynamics in India with a particular focus on distinguishing the long-run and short-run movements in inflation.

In India, conventionally, the wholesale price index (WPI) was used to measure headline inflation. In recent years the Reserve Bank of India (RBI), the monetary policy authority in India, has shifted its focus from the WPI inflation to the consumer price index (CPI) inflation. Since October 2013 the RBI provides inflation projections based on CPI-Combined, a new all India level series introduced in February 2011, by the CSO of India.[1, 2] However, given the short time series available for the CPI-Combined, in this study we approximate the headline inflation by CPI-IW inflation. In Sect. 3 we illustrate the close relationship between these two measures of inflation.

The behavior of CPI-IW inflation in India over the last 10 years displays a high degree of persistence.[3] To understand the long-run behavior of inflation in the Indian context, we follow the literature on inflation dynamics in the U.S. and other developed economies. There are many different ways of capturing the trend in inflation. One common approach is to measure trend inflation with the (recent) past level of inflation (Gordon 1998). A second alternative is to use survey- based long-term inflation expectations as a measure of trend inflation (Clark 2006; Faust and Wright 2013). The rationale is that professional forecasters are able to consider a range of information on monetary policy, some outside the scope of simple models, to assess the long-term trend of inflation. Their long-run (10-year average) forecasts give a more or less direct estimate of trend inflation. In fact, for the U.S. Ang et al. (2007) have shown that survey measures of inflation do a better job in forecasting inflation than macro- variables and asset prices at both the short and long horizons. Finally, more recently a number of studies model trend inflation as a drift-less random walk process (Cogley et al. 2010; Cogley and Sbordone 2008; Kozicki and Peter 2001; Stock and Watson 2007).

[1] http://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/ECOMRF210114_F.pdf.

[2] In India the CPI is traditionally reported for different segments of the population, namely, industrial workers (CPI-IW), agricultural labourers (CPI-AL), and rural labourers (CPI-RL). In February 2011, the Central Statistical Organization (CSO) of India introduced new CPIs with a more comprehensive geographic coverage, namely, CPI-urban, CPI-rural, and CPI-combined. The new measure of headline inflation measured by CPI-Combined inflation.

[3] In Sect. 4 we show empirical evidence for a unit root in CPI-IW.

Unlike developed economies, India does not have a long and consistent measure of long-term inflation expectations.[4] In this study we propose a multivariate unobserved component model to estimate the trend inflation for CPI-IW inflation with the objective of identifying long-run inflation expectations for the Indian economy. Our framework utilizes the information contained in the three components of CPI-IW inflation: CPI inflation excluding food and fuel, food inflation, and fuel inflation. This three-variable unobserved component framework is our baseline model. We argue that using information from food and fuel inflation is valuable in the Indian context since persistent movements in food and fuel inflation can affect long-term inflation in a developing country like India.[5] Our model uses the common trend representation of three components of inflation to estimate trend inflation. The decomposition of inflation into a trend and a cyclical component is motivated by Stock and Watson (2007) who perform a trend/cycle decomposition of inflation for the U.S. economy to capture the slow moving nature of inflation in the 1970s and the 1980s. One of the advantages of our approach is that it provides us a measure of the inflation gap that can be used to measure its persistence. Stock and Watson's analysis suggests that inference on inflation persistence may be quite different when conducted on an "inflation gap" measured as deviation of inflation from a time-varying trend. However in their setting inflation innovations are serially uncorrelated, which makes the model unsuitable to investigate persistence in the inflation gap. This problem does not arise in our setup because we allow serial correlation in inflation gap. We also examine the role of the survey measure in explaining long-run movements in inflation. In a recent RBI report, inflation expectations has been accorded an important place in driving the inflation dynamics.[6] To the best of our knowledge, there has been no study that has undertaken a systematic investigation of the usefulness of the survey measure of inflation expectations in explaining the CPI inflation dynamics in India. Our study attempts to fill this void in the literature. For this purpose, we extend our three-variable unobserved component model by adding 1-year ahead inflation expectations as a fourth variable in the model. The underlying rationale is that if the survey measure of inflation expectations contains any useful information for the long- run

[4] Beginning in 2005, the RBI started collecting data on inflation expectations through a quarterly survey of households. The survey, among other things, gathers household responses on current, 3 month ahead and 12 month ahead inflation rates. The sample size consists of 4000 households from 12 cities across the four regions of the country. However, in the literature, the long-term inflation expectations typically refer to 5–10 year ahead inflation expectations. For example, a commonly used long-term expectations measure for the U.S. is the 10-year ahead expected inflation from Survey of Professional Forecasters. There is no such measure available for India. Later in the paper we highlight the limitations of the 1-year ahead inflation expectation measure from RBI survey in capturing the long-run inflation trend.

[5] Bhatt and Kishor (2015) use monthly WPI data and find that both food and energy prices have significant permanent components. This finding goes against the conventional wisdom of treating variations in these prices as temporary. Bhatt and Kishor (2015) show that a measure of trend inflation that explicitly accounts for long-run price movements in food and energy prices provides a superior forecast of future inflation when compared with alternative measures of the trend inflation.

[6] https://www.rbi.org.in/Scripts/PublicationsView.aspx?id=16216.

inflation trend then the addition of this measure to our baseline three-variable unobserved component model should improve the estimated trend inflation.

There are several findings of interest. First, using monthly CPI data from 2006–2014 we find that there is a unit root in the inflation process implying that the inflation process is highly persistent for India. As a result any model of forecasting inflation must account for slow moving mean. Second, we find that the trend inflation from our baseline unobserved component model captures the long-run dynamics of inflation in India much better than other available measures. For example, if we use trend inflation as a long-run forecast of inflation, then the 1-year and 2-year ahead mean square forecast error (MSFE) from our estimated trend inflation is significantly lower than the survey measure of inflation expectations. In addition, if we just take the last period's inflation as a measure of trend inflation, our estimated trend inflation measure also dominates this in terms of lower MSFE. Third, we confirm the findings of Bhatt and Kishor (2015) and find that even for CPI food and fuel prices play an important role in the evolution of the inflation trend. Fourth, if we augment our baseline three-variable unobserved component model with the survey measure, we find that the resulting inflation trend is superior to the survey measure as well as the past inflation. However, the estimated trend from our baseline three-variable model dominates estimated the trend from the augmented model in terms of lower MSFE at long horizons.

Finally, our approach also allows us to capture the dynamics in the inflation gap. In most models of optimal monetary policy the central bank is assumed to minimize a quadratic loss function that penalizes large variations in the inflation gap (Cogley et al. 2010). Hence, an optimal monetary policy should eventually bring inflation back to its long- run trend. A key question that we can address is how persistent are shocks to the inflation gap? If these shocks decay quickly it means that monetary policy is very effective in the sense that it is able to bring inflation back to the target in a short span of time. To examine the persistence across different time period, we estimate a time-varying parameter model of the inflation gap. The results from this model suggest that there has been significant time variation in the persistence of inflation gap in India. In particular, we find that there was a decline in this persistence measure during the global financial crisis period. We also find that inflation gap persistence started increasing slowly in 2010 and it coincided with the pickup in inflation during that time period.

The remainder of the paper is organized as follows. Section 2 provides a brief review of the related literature. Section 3 details our data and econometric framework. Section 4 presents a discussion of estimation results and Sect. 5 provides a brief discussion of policy implications of our findings. Section 6 concludes.

2 Related Literature on Inflation Dynamics

Many studies have investigated inflation dynamics in the US and other developed countries. The evidence on the US is rather mixed. On one end, we have Cogley and Sargent (2005) who found that the persistence increased in early 1970s and has declined gradually since 1980s. On the other hand, we have Pivetta and Reis (2007) who estimated inflation persistence for the US since the 1960s and found that it has been high and roughly constant over time. In capturing inflation dynamics accurately it is very important to allow for the possibility of variation in the autoregression coefficients of a univariate process fitted to inflation data (Ascari and Sbordone 2014). For instance, Cecchetti and Debelle (2006) showed that allowing for changes in the mean inflation leads to a considerable decline in the measured inflation persistence for many countries in their sample including the US. Similarly Levin and Piger (2004) allow for structural breaks in the inflation process and find considerably lower inflation persistence for many countries in their sample. An alternative view is presented by Cogley et al. (2010) who argue that the difference lies in whether one looks at persistence in inflation or an inflation gap defined as the difference between inflation and Federal Reserve's target inflation. They find that the inflation gap has become less persistent for the US since the Volcker disinflation.

For the Euro-area the evidence seems to suggest a relatively more stable and persistent inflation. For instance, O'Reilly and Whelan (2005) use an annualized quarterly log difference of Gross Domestic Product (GDP) deflator for the EURO-area and document a very high degree of persistence. These findings are supported by Batini (2006) who consider alternative definitions of inflation persistence. An important variable that affects the level of inflation is inflation expectations. Cecchetti and Debelle (2006) find that inflation expectations are directly related to changes in the mean of inflation in many developed countries.

For emerging markets Mohanty and Klau (2001) document a high degree of inflation persistence for many countries in Asia as well as Latin America. This finding is consistent with Baum et al. (1999) who reports high degree of persistence for both developed and developing economics for the time period 1971–1995. Both of these studies find a high degree of inflation persistence for India. Similarly, in a recent study Mahanty (2011) finds that the persistence in nonfood inflation remains high whereas that in food inflation has increased in recent years.

3 Data and Methodology

3.1 Data

Our main measure of the price level is the CPI-IW. In India, historically, the CPI is available for different segments of the population, namely industrial workers (CPI-IW), agricultural labourers (CPI-AL), and rural labourers (CPI-RL). The idea is to capture the variation in consumption baskets across different segments of the population. In the beginning of February 2011, the Central Statistical Organization (CSO) of India, introduced new CPIs. These are the all India CPI-Combined, CPI-Rural, and CPI-Urban. The new CPI data has a more comprehensive geographic coverage than the earlier CPI series. The Expert Committee to Revise and Strengthen the Mon-

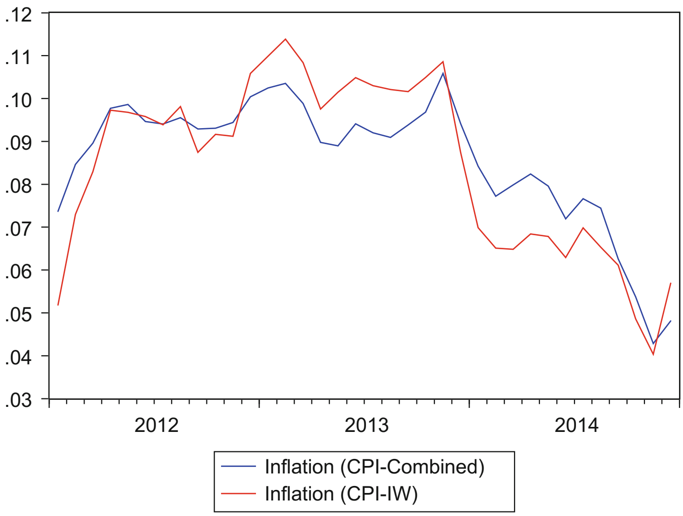

Fig. 1 Two measures of inflation: CPI-Combined versus CPI-IW

etary Policy Framework (2014), recommended that the RBI should use the headline inflation based on CPI-combined as a nominal anchor.[7]

However, given the inadequate history for the new CPIs and a lack of availability of disaggregated data, we approximate headline inflation in India with CPI-IW. Figure 1 plots the two measures of year-on-year inflation for a common sample period of January 2012–December 2014. We find that CPI-IW inflation closely tracks the headline inflation measure based on CPI-combined. Further, there is a strong correlation between the two series as shown by Fig. A.7 in the appendix.[8]

In this paper we use monthly data from 2006 through 2014 for CPI-IW inflation, CPI excluding food and energy prices ($CPIEX$), CPI for food (CPI^{FOOD}), and CPI for energy (CPI^{FUEL}). All of the data used is publicly available from the Labour Bureau, Government of India.[9] For measuring inflation expectations, we utilize the RBI's inflation expectation survey of households and use the 1-year ahead expected inflation series. This data is publicly available from the RBI website.[10]

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[7] http://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/ECOMRF210114_F.pdf.

[8] Such a relationship has also been noted in the report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework, 2014. The committee used the weighting pattern underlying CPI-IW to generate a long time series for the CPI-combined for their analysis.

[9] http://labourbureau.nic.in/indtab.html.

[10] https://www.rbi.org.in/scripts/QuarterlyPublications.aspx?head=Inflation+Expectations+Survey+of+Households.

3.2 *Methodology*

One of the recurring themes of Inflation in India in the recent times has been the high degree of its persistence. To capture this feature, we model the long-run inflation trend as a slow moving random walk process. This allows us to overcome the problem of varying local mean that has been much discussed in the literature on inflation dynamics (Cecchetti and Debelle 2006; Cogley et al. 2010; Cogley and Sbordone 2008; Kozicki and Peter 2001; Stock and Watson 2007, 2010). In this section, we first outline our baseline model which is a three-variable unobserved component model where the three variables are $CPIEX$, CPI^{FOOD}, and CPI^{FUEL}. This is followed by the special case of our baseline model which is the univariate unobserved component model for CPI inflation. Finally, we allow for a role of inflation expectations and present a four-variable unobserved component model that includes 1-year ahead inflation expectations as an additional variable.

3.2.1 A Multivariate Unobserved Common Component Model of Trend Inflation

Our baseline model exploits information from the CPI-IW inflation by considering its three components, namely, $CPIEX$, CPI^{FOOD}, and CPI^{FUEL}. We argue that using information from food and fuel inflation is valuable in the Indian context since persistent movements in food and fuel inflation can affect long-term inflation in a developing country like India (Bhatt and Kishor 2015). As regards CPI, similar views were expressed in the report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework (2014). The report argues that in the Indian context excluding food and energy to arrive at core inflation is not appropriate as these two items capture more than half of the consumption basket. Further, variation in food and energy is strongly related with inflation expectations and hence cannot be excluded from a measure of a nominal anchor.

Our model uses the common trend representation of three components of inflation to estimate trend inflation. The decomposition of inflation into a stochastic trend and a cyclical component is motivated by Stock and Watson (2007), who perform a trend/cycle decomposition of inflation for the U.S. economy to capture the slow moving nature of inflation in the 1970s and the 1980s. Their approach uses a univariate decomposition of inflation. The extraction of trend inflation from a multivariate model in theory should provide us a more precise estimate of long-run inflationary expectations. Following the literature, we define the *inflation gap* to be the difference between CPI-IW inflation and the estimated trend from our model. The multivariate approach has been shown to be useful in a state-space setting by Clark (1989), Basistha and Nelson (2007), Basistha and Startz (2008).[11]

[11] For example, Basistha and Startz (2008) have shown that the uncertainty associated with NAIRU can be reduced if one uses multiple indicators. Specifically, they find that the use of Okun's law is particularly valuable in reducing the uncertainty associated with NAIRU.

Formally, at a given time period t, we assume that inflation for each component of CPI-IW inflation can be decomposed into a common stochastic trend and an idiosyncratic transitory component

$$\pi^{CPIEX} = \tau_t + c_t^{CPIEX} \tag{1}$$

$$\pi^{FOOD} = \mu_2 + \delta_1 \tau_t + c_t^{FOOD} \tag{2}$$

$$\pi^{FUEL} = \mu_3 + \delta_2 \tau_t + c_t^{FUEL} \tag{3}$$

Note that according to our conceptual framework each of three inflation series incorporates the same unobserved long-term-inflation-trend component, τ_t, implying a cointegrating relationship among three variables. In Sect. 4, we provide empirical evidence for such a long-term relationship between these three components of CPI-IW inflation.

Trend Dynamics (τ_t)

A significant amount of work has been undertaken to study the dynamics of inflation in the U.S. and it points toward the existence of a slowly moving trend during the great inflation and the great moderation period. This slow moving trend has been modeled as a random walk. We follow this modeling strategy to model year-on-year inflation in India and model trend inflation as a slow moving random walk process

$$\tau_t = \tau_{t-1} + v_t, v_t \sim iidN(0, \sigma_v^2) \tag{4}$$

Cycle Dynamics (τ_t)

As previously noted, our model allows each inflation series to have an idiosyncratic cycle. The idiosyncratic cycles c_t are assumed to follow an AR(1) process.

$$c_{it} = \phi_i c_{t-1} + u_{it}, u_{it} \sim iidN(0, \sigma_{u_i}^2) \tag{5}$$

In the appendix we provide a state-space representation of our baseline model. We estimate our model using maximum likelihood via the Kalman filter.

3.2.2 Univariate Trend/Cycle Decomposition

For expositional purposes, we also estimate trendinflation using CPI-IW inflation. The univariate decomposition we employ in this study is a special case of the three-variable model discussed in the previous section. Formally, our univariate model has the following structure:

$$\pi = \tau_t + c_t \tag{6}$$

$$\tau_t = \tau_{t-1} + v_t, v_t \sim iidN(0, \sigma_v^2) \tag{7}$$

$$c_t = \phi c_{t-1} + u_t, u_t \sim iidN(0, \sigma_u^2) \tag{8}$$

where π denotes CPI-IW inflation, τ_t is trend inflation and c_t is cyclical inflation.

3.2.3 Augmenting the UC Model with Inflation Expectation

In the literature on inflation dynamics and trend inflation an important role is accorded to inflation expectations (Bernanke 2007; Mishkin 2007). The RBI has also emphasized the importance of inflation expectations in driving long- run inflation dynamics in India.[12] For the U.S. many studies approximate the trend inflation with a survey-based measure of long-term inflation expectations (Clark 2006; Faust and Wright 2013). A natural question that arises in the Indian context is why we do not just use the survey measure as trend inflation. There are two main issues with the RBI' survey measure of inflation expectations. First, we do not have available data on long- term expectations in this survey. The longest forecast window is 12 months ahead. Typically, long-term expectations reflect forecast window of 5–10 years. Second, as argued by Clark and Doh (2014), using survey measure may not be a good idea as they may be biased upwards. Indeed this is true for the RBI's survey measure for India. We find that the 1-year ahead inflation expectations consistently overestimate inflation over our sample period. Further, we believe that our framework, by using information in a multivariate setting provides a more accurate measure of long-term inflation expectations. Still the question remains whether there is any information contained in the RBI survey measure of inflation expectation that can improve the estimated inflation trend. To answer this question, we augment our baseline model by adding the 1-year inflation expectations as the fourth component of the CPI-IW inflation. Formally, the augmented model is given by

$$\pi^{HH} = \mu_1 + \delta_1 \tau_t + c_t^{HH} \tag{9}$$

$$\pi^{CPIEX} = \tau_t + c_t^{CPIEX} \tag{10}$$

$$\pi^{FOOD} = \mu_2 + \delta_2 \tau_t + c_t^{FOOD} \tag{11}$$

$$\pi^{FUEL} = \mu_3 + \delta_3 \tau_t + c_t^{FUEL} \tag{12}$$

[12]See https://www.rbi.org.in/Scripts/PublicationsView.aspx?id=16216.

Here π^{HH}, π^{CPIEX}, π^{FOOD}, and $\pi^{FUEL}$are household's 1-year inflation expectations, CPI inflation excluding food and fuel, food inflation, and fuel inflation. As before we assume that each of the four inflation series share a common unobserved trend, τ_t.

The trend and the cycle dynamics for this model have the same specification as our baseline model.

4 Empirical Results

In this section we present our empirical findings. We begin by testing for the unit root in CPI-IW inflation as well as its three components. Table 1 presents the p-values for the Augmented Dickey Fuller (ADF) tests. At any conventional level of significance, we were unable to reject the null hypothesis of an unit root for each inflation series. This indicates that inflation process is highly persistent for during our sample period and hence lends empirical support to our methodology that models the trend inflation as a random walk.

Our baseline unobserved component model imposes a common stochastic trend that is shared by $CPIEX$, CPI^{FOOD}, and CPI^{FUEL}. This is equivalent to assuming a cointegrating relationship among these three variables. We conduct the single equation cointegration test as well as Johansen's multivariate cointegration test and find that there is a single cointegrating vector.[13]

4.1 Estimation Results for the Baseline Model

The three-variable unobserved component model serves as our baseline model. We write the state-space representation of this model (see Appendix) and estimate the model using maximum likelihood via the Kalman filter. Table 2 presents the estimated parameters and their respective standard errors. There are several interesting findings. First, we find that the shock to trend inflation is much more persistent than those to the idiosyncratic cycles of food and fuel inflation. Second, we find that the

Table 1 Unit root test

Variable	ADF P-value
CPI-IW (π)	0.11
$CPIEX$	0.26
CPI^{FOOD}	0.22
CPI^{FUEL}	0.41

[13]We do not provide these results for brevity. These results are available upon request from the authors.

Table 2 Parameter estimates of the baseline model

Parameter	Estimate	SE
σ_{Trend}	0.337	0.062
σ_{CPIEX}	0.408	0.065
σ_{Food}	1.325	0.127
σ_{Fuel}	1.253	0.094
ϕ_{CPIEX}	0.753	0.130
ϕ_{Food}	0.896	0.041
ϕ_{Fuel}	0.953	0.029
μ_{Food}	−5.210	5.621
μ_{Fuel}	2.221	0.026
$\rho_{CPIEX,Food}$	−0.989	0.024
$\rho_{CPIEX,Fuel}$	0.183	0.157
$\rho_{Food,Fuel}$	−0.320	0.114
δ_{Food}	1.983	0.725
δ_{Fuel}	0.700	0.001

cyclical components of food and fuel inflation are much more persistent than the cycle of CPIEX. Third, consistent with the findings of Bhatt and Kishor (2015), we find that the long-run movements in food and fuel inflation do affect trend inflation. This is supported by significant loadings of these variables on the common trend. Further, we find that loadings of common trend on food inflation is much larger than fuel inflation implying a greater role of food inflation in long-run inflation dynamics in India.

We plot the estimated trend inflation from the baseline model and the CPI-IW inflation in Fig. 2. It can be observed that our estimated trend inflation measure is smoother than the CPI-IW inflation. During our sample period, 2006–2014, the standard deviation of CPI-IW inflation is 2.26 whereas the corresponding value for our estimated trend inflation is 1.48. This is expected as the trend inflation is a long-term forecast of inflation that filters out the short-term noises and cyclical component in the data. The estimated trend inflation shows that a significant portion of the spurt in CPI-IW inflation in 2009/2010 was transitory. Our results also suggest that the trend inflation started declining before the drop in CPI-IW inflation at the end of 2013.

4.1.1 Comparison with Alternative Trend Inflation Measures

Although the trend inflation estimated from our baseline model does a reasonable job of capturing the evolution of CPI-IW inflation, a natural question to ask is how does this measure compare with other possible measures of trend inflation? Before presenting the comparison with alternatives, we first need to decide on the metric that makes such a comparison most insightful. In this paper, we compare alterna-

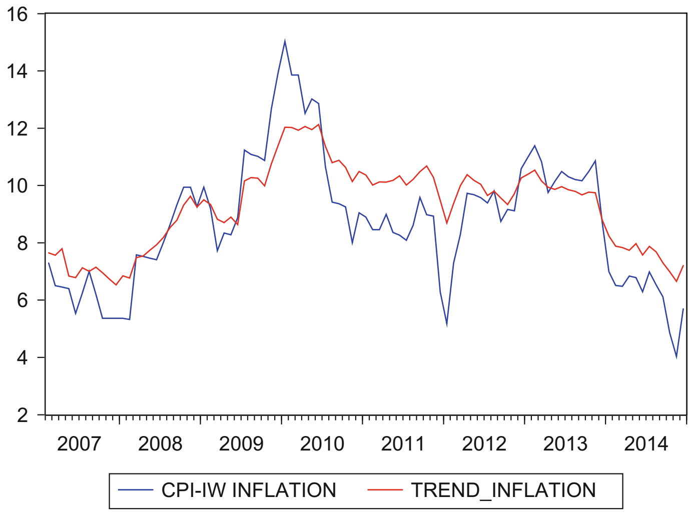

Fig. 2 CPI-IW inflation and baseline trend inflation

Table 3 Mean square forecast errors for different trend models

Measure	12-month	18-month	24-month
UC trend	4.246	9.277	17.821
Random walk model	5.661	14.474	30.590
CPI Ex food and fuel	5.408	13.485	26.250
Inflation expectation	14.192	28.085	50.433

tive measures of trend inflation in terms of their long-run forecasting performance. Such a metric makes intuitive sense as the trend inflation by definition should be the long-run forecast of a nonstationary time series. We consider three alternative measures of trend inflation. First is past inflation. In this case the best forecast of inflation is current inflation. Our second alternative measure of trend inflation is the RBI' survey-based 1-year ahead expected inflation series. Finally, our third measure of trend inflation is *CPIEX*. We compare the forecasting performance of these three alternative measures with that of estimated trend inflation from our baseline three-variable unobserved component model. For this purpose we consider forecasting horizons of 12 months, 18 months, and 24 months. We use the mean square forecast errors (MSFE) as a measure of forecasting performance. Table 3 presents the results of this exercise. We observe that there is a significant payoff in estimating inflation trends based on our multivariate unobserved component approach. The MSFE associated with the trend inflation estimate from our model is significantly lower than the other three measures of trend. In terms of the relative superiority of other three measures, we find that *CPIEX* than the other two candidates of inflation trend.

4.2 Assessing the Informational Content of Survey-Based Inflation Expectation

Finally, we assess the usefulness of the survey-based inflation expectations reported by the RBI in capturing long-run inflation dynamics. The results of the forecasting exercise presented in Table 3 clearly showed that the 1-year ahead inflation expectations from the survey does a poor job of forecasting inflation at longer horizons. This is not surprising for two reasons. First, this measure does not capture long-run expectations given by the 12-month horizon embedded in its definition itself. Second, the evolution of this expected inflation does not capture CPI-IW inflation. This is evident from Fig. 3 that plots both the trend inflation from our baseline model and the 1-year expected inflation from the RBI survey along with the CPI-IW inflation. Nevertheless, we want to examine whether we can tease out some information from the variation of this series by augmenting our baseline three-variable model with this inflation expectation survey measure. The estimated parameters for this augmented model are presented in Table 4. The results for the augmented model are qualitatively similar to the baseline model with few exceptions. We do find that the loading on the common trend (δ_{HH}) for inflation expectation equation is significant and is close to one. We also find that the relative magnitude of the loading on food and fuel inflation changes for the augmented model. One possible reason may be that the correlation between inflation expectation and fuel inflation is much higher than its correlation with food inflation. This may affect the estimate of common trend and hence the loading on the common trend. Figure 6 plots inflation trend from augmented model along with CPI-IW inflation and trend inflation from our baseline model. The estimated trend inflation from the augmented model is smoother than the trend inflation

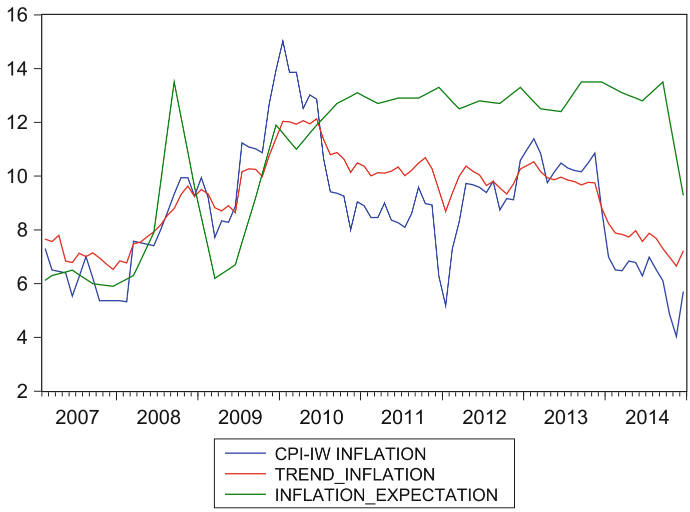

Fig. 3 CPI-IW inflation, trend inflation, and inflation expectation

Table 4 Parameter estimates of four-variable model with inflation expectation

Parameter	Estimate	SE
σ_{Trend}	0.278	0.043
σ_{HH}	0.475	0.044
σ_{CPIEX}	0.460	0.048
σ_{Food}	1.542	0.099
σ_{Fuel}	1.195	0.103
ϕ_{HH}	0.951	0.006
ϕ_{CPIEX}	0.933	0.008
ϕ_{Food}	0.867	0.011
ϕ_{Fuel}	0.942	0.038
μ_{HH}	4.461	1.636
μ_{Food}	3.610	1.411
μ_{Fuel}	−3.361	2.835
$\rho_{HH,CPIEX}$	−0.993	0.003
$\rho_{HH,Food}$	0.152	0.082
$\rho_{HH,Fuel}$	−0.007	0.123
$\rho_{CPIEX,Food}$	−0.037	0.134
$\rho_{CPIEX,Fuel}$	−0.018	0.060
$\rho_{Food,Fuel}$	−0.227	0.105
δ_{HH}	0.971	0.023
δ_{Food}	0.798	0.060
δ_{Fuel}	1.465	0.189

from the baseline three-variable model. However, when we compare the forecasting performance of trend inflation obtained from the augmented model, it has a higher MSFE compared to that of trend inflation from the three-variable model. However, it does outperform the other three alternative measures of trend inflation. Our results indicate that using the multivariate model clearly captures long-run trend inflation more accurately. However, the household survey measure of inflation expectations does not seem to add significant value to the estimation of inflation trend.

4.3 Time-Varying Inflation Gap Persistence

An attractive feature of our multivariate unobserved component model is that it also gives us a measure of the *inflation gap* which is defined as the difference between CPI-IW inflation and estimated inflation trend. By definition, this measure is transitory in nature implying that any shock to this gap will disappear. However, the speed at which the shock disappears gives us a measure of inflation persistence that is more pertinent for assessing the effectiveness of monetary policy (Cogley et al. 2010). If we estimate a fixed coefficient AR model, this will provide us an estimate

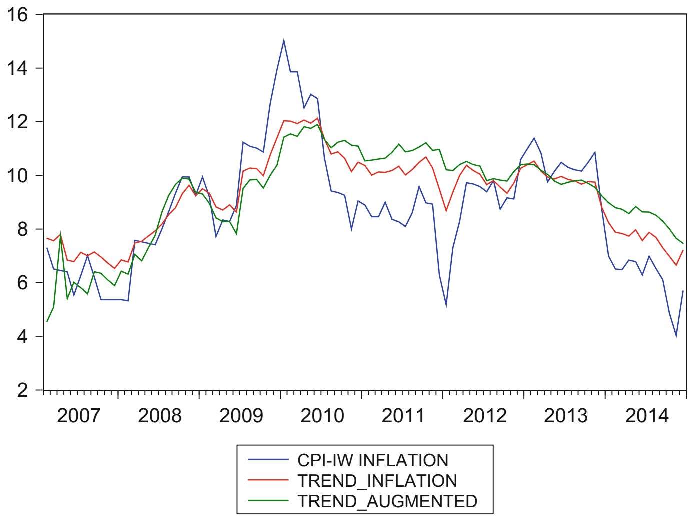

Fig. 4 Time-varying inflation gap persistence

of the persistence of the inflation gap for the full sample. In our sample, the estimated average persistence of inflation gap is 0.85. The fixed coefficient framework imposes a very strong restriction that the persistence of inflation gap for CPI-IW inflation has remained the same for the full sample. We argue that this persistence could vary over time depending upon the monetary policy regime as well as different institutional factors. To capture such time variation in inflation persistence, we estimate

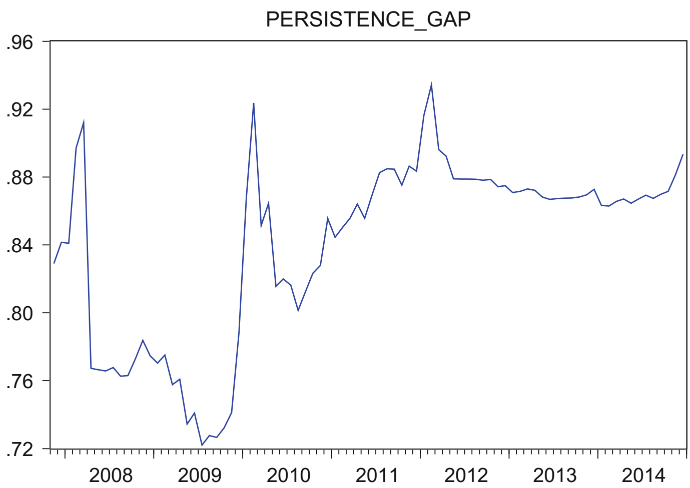

Fig. 5 Time-varying inflation gap persistence for survey inflation

a parsimonious time-varying parameter model that allows for the slow evolution of the persistence parameter. Formally,

$$GAP_t = \beta_t GAP_{t-1} + u_t, u_t \sim iidN(0, \sigma_u^2)$$

$$\beta_t = \beta_{t-1} + \varepsilon_t, \varepsilon_t \sim iidN(0, \sigma_\varepsilon^2)$$

The time variation in persistence parameter is modeled as random walk. To test the significance of time variation, we perform a likelihood ratio test. However, we know that the presence of nuisance parameter under the null leads to over rejection of null hypothesis (Andrews and Ploberger 1994; Hansen 1992), and this leads to critical values which are too low under the standard distribution assumption. The LR statistic for our model is significantly higher than the standard critical value, there is strong evidence against the null of no time variation.

The estimated time-varying persistence measure is shown in Fig. 4. We can observe from the plot that there has been significant time variation in the persistence of the inflation gap. In particular, we find that the persistence measure declined from 2007–2009 which coincided with the global financial crisis period. There was a sharp increase in persistence in 2009 and then a drop and then it increased slowly in the middle of 2010. The increase in persistence coincided with the pick up in inflation in India. This suggests that the persistence measure from our estimated inflation captures overall short-run inflation dynamics. How does it compare with the time-varying persistence derived from the inflation gap that is measured as the difference between inflation and survey measure of inflation expectation. The estimated time-varying persistence is shown in Fig. 5. The results show that the persistence measure

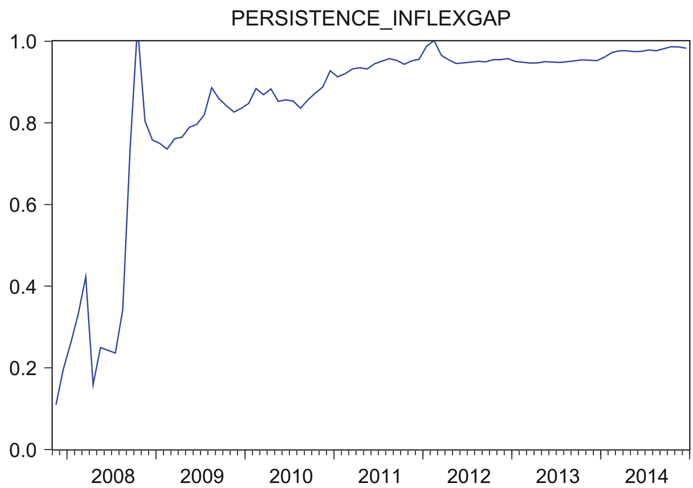

Fig. 6 CPI-IW inflation and different measures of trend inflation

has stayed very close to 1 after the initial increase in persistence at the beginning of the sample. The results for this measure of inflation gap do not show much time variation and moreover. The estimated persistence close to unity would suggest that any shock to the deviation between inflation and trend inflation measured by survey expectations of inflation does not disappear. This is not surprising since we could not reject the null of unit root for the deviation between inflation and survey inflation expectations. To summarize, our results show that the time-varying inflation gap persistence obtained from our approach matches the overall behavior of inflation in India and does a better job than the inflation gap persistence measures obtained from other measures of trend inflation (Fig. A.7).[14]

5 Implications for Monetary Policy

The findings reported in Sect. 4 are of relevance for the conduct of monetary policy in India and this can be assessed in two related ways. First, we can argue that our empirical approach is useful in assessing the effectiveness of the conduct of monetary policy in India. Second, using our estimates we can reasonably capture the evolution of inflation in India in recent years.[15]

An important ingredient for the successful conduct of monetary policy is the central bank's ability to manage and anchor inflation expectations. To this end it is imperative to have a robust understanding of the long-run dynamics underlying the inflation process. Two important components of such dynamics are trend inflation and inflation persistence. Trend inflation captures long-horizon inflation expectations whereas inflation persistence allows us to measure the short- to medium-run success of monetary policy in combating transitory shocks to inflation. Using our empirical approach and the newly available consumer price data, we provide measures of both trend inflation and inflation persistence, and in this sense our analysis is useful for the conduct of monetary policy in India. Our empirical framework can be used to study the effectiveness of the central bank in anchoring long-run inflation expectations as well as its effectiveness in managing shocks to transitory inflation.

The results presented in Sect. 4 indicate that there is a substantial over time variation in trend inflation and inflation persistence for our sample period. How well does this fit with the observed evolution of inflation in India in recent years? We find that a significant portion of the spurt in CPI-IW inflation in 2009/2010 was associated with

[14]We also estimate time-varying persistence of CPI-IW inflation and the results are similar to the survey measure. For sake of brevity, we do not report the results here, but are available upon request.

[15]Another way to interpret the policy relevance of our empirical framework is to use the proposed measure of trend inflation as a proxy for target inflation in the estimation of the Taylor rule (Taylor 1993). We thank an anonymous referee for making this suggestion. However, given the short duration of the CPI data for India, it may not be feasible to carry out a robust estimation of the Taylor rule for India. We estimated the Taylor rule using the 8 years of available data on CPI and were not able to obtain reasonable response coefficients of inflation and output gap to the repo rate for India. We hope that over time this will be an important avenue for future research on the relevance of the Taylor rule for an emerging economy such as India.

the rise in inflation gap and the trend inflation. The inflation gap persistence measure also started increasing in the middle of 2010 and this increase coincided with the peak inflation observed in the recent time period. The recent decline in trend inflation and inflation gap persistence seems to suggest that the central bank has been able to slowly reduce the long-run inflation expectation and has also been relatively successful in neutralizing shorty run and long-run shocks to transitory inflation.

6 Conclusion

Facing high and persistent inflation over the last few years, monetary policy in India has undergone significant changes with the objective of achieving a better understanding of the long-run inflation dynamics in India. In this paper we attempt to provide a measure of trend inflation that aids this understanding. Using CPI-IW inflation as a proxy for headline inflation, we use a multivariate unobserved component model that decomposes the CPI-IW inflation into trend inflation and a transitory inflation gap. Our multivariate framework utilizes the information contained in the three components of CPI-IW inflation: CPI-IW inflation excluding food and fuel, food inflation, and fuel inflation. Further, a distinct advantage of our approach is that it provides us with a measure of the inflation gap, which is defined as the difference between the CPI-IW inflation and our estimated trend inflation. The over time evolution of this inflation gap measure provides a natural measure of inflation persistence that captures how quickly a shock to the inflation gap disappears and brings inflation back to its trend. To examine the persistence across different time period, we estimate a time-varying parameter model of inflation gap.

We find that trend inflation from our baseline unobserved component model more accurately captures the long-run dynamics of inflation in India than other available measures. Using a forecasting performance at long horizons as the relevant metric, we find that our estimated trend inflation has a mean square forecast error (MSFE) that is significantly lower than the one associated with core inflation and the survey measure of inflation expectations. We also find that CPI food and fuel prices play an important role in the evolution of the inflation trend. Further, if we augment our baseline three-variable unobserved component model with the survey measure of inflation expectation, we find that the resulting inflation trend is superior to the survey measure as well as past inflation. However, the estimated trend from our baseline three-variable model still dominates the estimated trend from the augmented model in terms of a lower MSFE at long horizons. The results from the time-varying inflation gap persistence model suggest that there has been significant time variation in the persistence of inflation gap in India. In particular, we find that there was a decline in this persistence measure during the global financial crisis period. We also find that inflation gap persistence started increasing slowly in 2010 and it coincided with the pickup in inflation during that time period.

Appendix: State-Space Representation of the Baseline Model

In this appendix, we present the state-space representation for our baseline three-variable unobserved component model. The measurement equation can be written as

$$\begin{bmatrix} \pi^{CPIEX} \\ \pi^{FOOD} \\ \pi^{FUEL} \end{bmatrix} = \begin{bmatrix} 0 \\ \mu_{FOOD} \\ \mu_{FUEL} \end{bmatrix} + \begin{bmatrix} 1 & 1\,0\,0 \\ \delta_{FOOD} & 0\,1\,0 \\ \delta_{FUEL} & 0\,0\,1 \end{bmatrix} \begin{bmatrix} \tau_t \\ C_t^{CPIEX} \\ C_t^{FOOD} \\ C_t^{FUEL} \end{bmatrix}$$

The transition equation is represented as

$$\begin{bmatrix} \tau_t \\ C_t^{CPIEX} \\ C_t^{FOOD} \\ C_t^{FUEL} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \phi^{CPIEX} & 0 & 0 \\ 0 & 0 & \phi^{FOOD} & 0 \\ 0 & 0 & 0 & \phi^{FUEL} \end{bmatrix} \begin{bmatrix} \tau_{t-1} \\ C_{t-1}^{CPIEX} \\ C_{t-1}^{FOOD} \\ C_{t-1}^{FUEL} \end{bmatrix} + \begin{matrix} v_t \\ u_t^{CPIEX} \\ u_t^{FOOD} \\ u_t^{FUEL} \end{matrix}$$

The measurement equation in matrix form can be written as

$$y_t = \mu + H_t \beta_t$$

Using the matrix notation the above system equation can be rewritten as follows:

$$\beta_t = F\beta_{t-1} + w_t,\ w_t \sim N(0, Q)$$

where the variance-covariance matrix has the following structure:

$$Q = \begin{bmatrix} \sigma_v^2 & 0 & 0 & 0 \\ 0 & \sigma_{u,CPIEX}^2 & \sigma_{CPIEX,FOOD} & \sigma_{CPIEX,FUEL} \\ 0 & \sigma_{CPIEX,FOOD} & \sigma_{u,FOOD}^2 & \sigma_{FOOD,FUEL} \\ 0 & 0 & \sigma_{FOOD,FUEL} & \sigma_{u,FUEL}^2 \end{bmatrix}$$

The prediction equations and updating equations for the Kalman filter model are as follows[16]:

Prediction:

$$\beta_{t/t-1} = F\beta_{t-1/t-1}$$

$$P_{t/t-1} = FP_{t-1/t-1}F' + Q$$

[16]Please see Kim and Nelson (2000) for details.

$$\eta_{t/t-1} = y_t - H_t \beta_{t/t-1}$$

$$f_{t/t-1} = H_t P_{t/t-1} H_t'$$

Updating:

$$\beta_{t/t} = \beta_{t/t-1} + K_t \eta_{t/t-1}$$

$$P_{t/t} = P_{t/t-1} - K_t H_t P_{t/t-1}$$

where $K_t = P_{t/t-1} H_t' f_{t/t-1}^{-1}$.

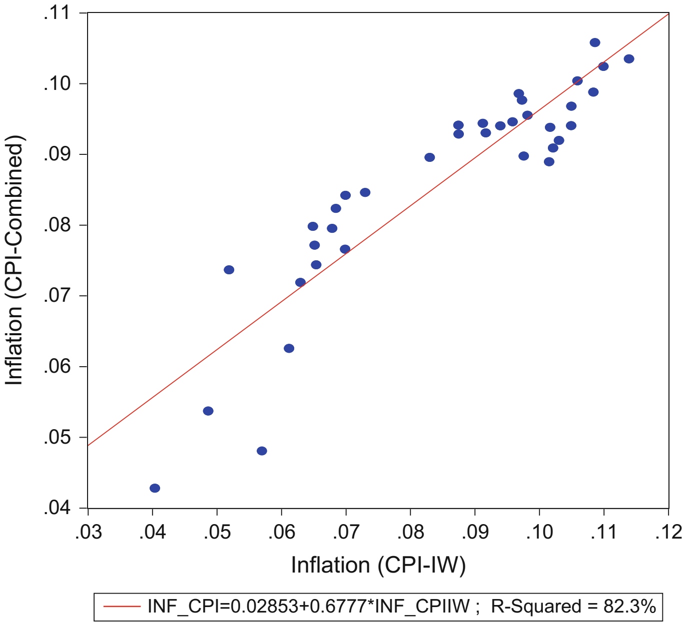

Fig. A.7 Relationship between CPI-Combined and CPI-IW

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Exchange Rate Trends and Management in India

Michael M. Hutchison and Gurnain Kaur Pasricha

1 Introduction

This chapter evaluates developments in India's nominal and real exchange rates over the past two decades, describing longer term trends as well as short-term movements and volatility. Exchange rate movements are influenced by a host of real and nominal determinants, including government policy, especially foreign exchange market intervention, capital controls, and monetary policy. We explore how these policies in India responded to exchange rate movements and how they have, in turn, influenced the exchange rate.

India has been developing its foreign exchange market and the average *daily* turnover in the onshore market, sum of spot, and forward transactions, increased tenfold in about 15 years—from 2.7 billion USD in March 1999 to about 30 billion USD in March 2015.[1] Rapid growth in the foreign exchange market reflects India's rise in international trade, especially in services, the broadening and deepening of the financial sector, and increasing globalization of the economy.

We would like to thank Bryce Shelton for excellent research assistance, and Rose Cunningham, Mark Kruger, and Errol D'Souza for helpful comments. The views expressed in this paper are those of the authors. No responsibility for them should be attributed to the Bank of Canada.

[1]Source: Reserve Bank of India, Database on the India economy. The numbers cited are the sum of merchant and interbank purchases and monthly averages of daily data.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_12

Maintaining orderly conditions in the foreign exchange markets is an official objective of the Reserve Bank of India (RBI).[2] RBI is the manager of the Foreign Exchange Regulation Act (FEMA, 2004), which also gives it the power to impose capital controls.[3] In practice, this objective has meant very active management of controls on international capital movements and frequent foreign exchange market intervention operations, as well as at least one episode of interest rate defense of the exchange rate in 2013.[4] These considerations make understanding the linkages between monetary policy, capital controls, and foreign exchange market intervention operations central to a study of exchange rates in India.

We begin in Sect. 2 with a statistical representation and analysis of the Rupee exchange rate, comparing the bilateral rate against US dollar (USD) with the trade-weighted multilateral nominal and real exchange rates. The bilateral exchange rate against the USD is the rate that the RBI monitors most closely and attempts to stabilize, through its interventions in the spot and forward markets. However, the multilateral rate is probably the most important, measured in real terms, for the Indian economy. Overall, the bilateral and multilateral measures point to large cumulative nominal depreciation of the rupee over January 1998–December 2014. Trend inflation in India over this period was much higher than inflation in the U.S., however, resulting in substantial real (price-adjusted) appreciation of the rupee against USD. By contrast, nominal trend depreciation of the rupee currency on a multilateral basis largely offset moderate inflation differentials between India and a broad index of its trading partners, leading to a fairly stable real multilateral real exchange rate—formal tests of long-term purchasing power parity (PPP) cannot be rejected. Exchange rates by either measure have not moved uniformly since 1998, leading us to identify several distinct "regimes" during which exchange rate trends and volatilities exhibited quite different patterns. Exchange rate volatility rose markedly in the mid-2000s, especially since the Global Financial Crisis (GFC).

Section three considers the policy levers that affect exchange rates—exchange rate management—and in particular whether foreign exchange market intervention and changes in the intensity of capital controls are consistent with, and directed toward, an exchange rate objective. This section also considers how intervention and capital controls interact with monetary policy in navigating a balance between external and internal policy objectives. Section four concludes. We argue that the

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[2]See for example, Khan (2011) which notes "Excessive volatility in exchange rate is a potential source of macroeconomic instability, and accordingly, the RBI aims at containing volatility to ensure a stable macroeconomic environment.".

[3]Quotation from RBI website: https://www.rbi.org.in/scripts/FS_Overview.aspx?fn=5.

[4]That is to say that the exchange rate enters into the RBI's policymaking not only due to its impact on inflation but also its potential impact on economic growth directly and on financial stability. In countries where central bank targets inflation (since 2015 for the RBI) and the central bank credibility is high, exchange rate pass-through to inflation is typically low. Many advanced economies have seen the exchange rate pass-through decline over time (BIS, 2005), and central banks worry about exchange rate movements mainly to the extent that they affect current or expected inflation.

gradual rise in financial openness in India has pushed the RBI to accept more instability in the exchange rate in favor of greater monetary independence. Monetary independence since the GFC has primarily focused on stimulating output growth and employment, and not controlling inflation.

2 Nominal and Real Exchange Rates: Bilateral and Trade-Weighted Baskets

2.1 Trends

Chart 1 shows the development of two *nominal* exchange rate measures for the Indian rupee (INR) from January 1998 through December 2014: the U.S. Dollar/INR exchange rate and the INR against a trade-weighted basket of 36 trading partners.[5] The base for each index is set as 100 for January 1998, and a decline in the index represents a fall in the value of the rupee. Monthly data is shown.

Cumulative nominal depreciation in the USD/INR rate over January 1998–December 2014 was about 40 %, while declining on a broad trade-weighted basis by almost 30 %. However, three phases in the nominal exchange rate are identifiable from Chart 1, consistent across the two INR measures and denoted by vertical lines: (a) a period of moderate fluctuations during 1998–2007, initially characterized by gradual nominal depreciation until 2006, followed by robust appreciation; the result was quite similar exchange rate values in 1998 and early 2008; (b) a period of sharp depreciation and very high volatility from mid-2008 to mid-2013; (c) a period of relative stability since October 2013.

Measures of the *real* exchange rate, by contrast, reveal quite different *longer-term* patterns. Chart 2 shows the corresponding real USD/INR exchange rate and the 36-country trade-weighted real multilateral exchange rate. The base is set to 100 in January 2001 (sample is limited by data availability on relative prices). A rise in each index implies a real exchange rate appreciation. We again distinguish the three nominal exchange rate episodes by vertical lines, contrasting nominal with real exchange rate developments. As is apparent, real exchange rate developments are more difficult to classify than nominal exchanges into distinct phases and show substantial medium-term swings.

The indices demonstrate substantial cumulative real exchange rate appreciation against the U.S. Dollar over the 15-year period (more than 40 %). But against a broad basket of 36 currencies the INR has appreciated relatively little (9 %) and was at virtually the same real value in September 2013 as early 2001. Strong real appreciation in 2014 pushed the real value of the 36-country weighted exchange rate again above its stable "Purchasing Power Parity" (PPP) value. Despite the larger movements in real bilateral than trade-weighted index, the two series are

[5]See appendix A for data sources and descriptions.

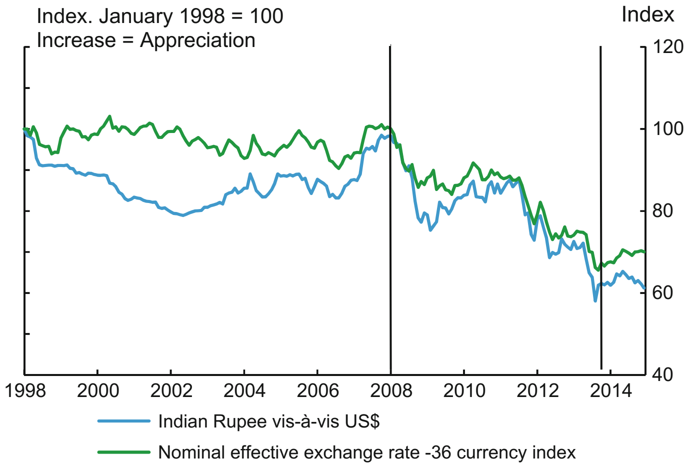

Chart 1 Nominal exchange rate movements *Sources* U.S. Federal Reserve, Reserve Bank of India, and Bank of Canada calculations

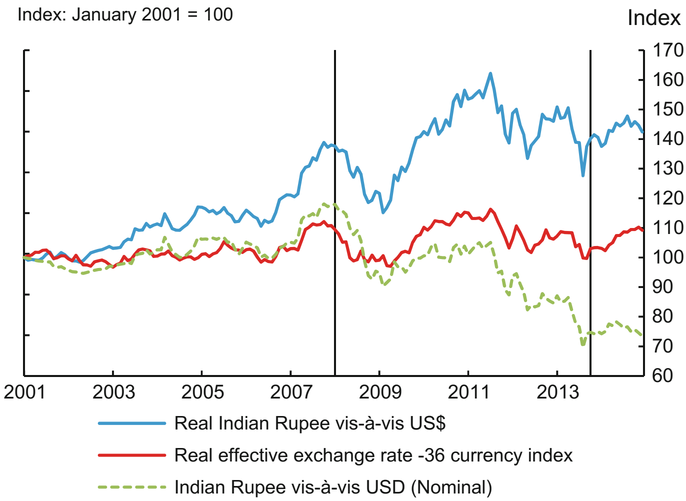

Chart 2 Real exchange rate movements *Sources* Bloomberg, Reserve Bank of India, and Bank of Canada calculations

highly correlated, with a correlation coefficient of 0.83 over the period January 2001–December 2014. The nominal series, by contrast, have a correlation coefficient of only 0.23 over the same period.

The divergent trends in nominal and real exchange rates are explained, of course, by relative price developments in India vis-à-vis the U.S. and vis-à-vis India's counterparts in the currency baskets. Chart 3 shows two series—the relative Indian

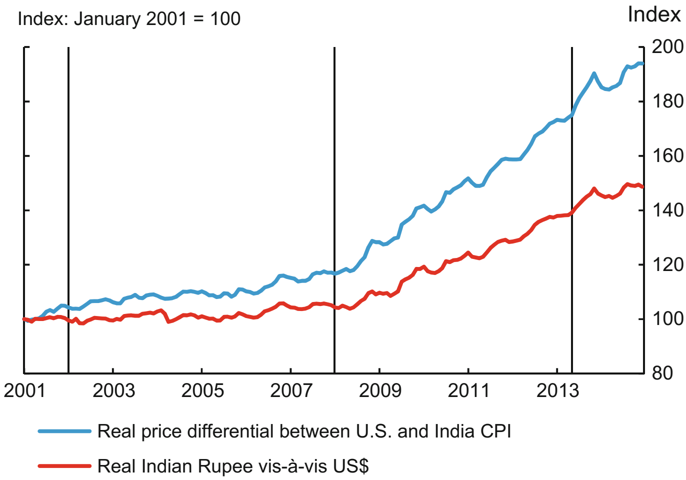

Chart 3 Relative price movements *Sources* U.S. Bureau of Labor Statistics, India Ministry of Statistics and Programme Implementation, Reserve Bank of India, and Bank of Canada calculations

price level against the U.S. and the relative Indian price level against a trade-weighted average of 36 countries. The chart shows that, since 2001, the relative Indian price level climbed more than 90 % compared to the U.S. price level and almost 50 % against a broad price index of trading partners. The comparatively rapid rise in the Indian price level explains why the USD/INR exchange rate appreciated by 42 % in real terms over this period despite an almost 30 % depreciation in the nominal exchange rate. By contrast, the modest 11 % real appreciation of the INR against the broad currency basket during 2001–2015 reflects the effect of a 25 % nominal deprecation largely offsetting the larger rise in the Indian price level relative to its trading partners.

A few other noteworthy observations emerge during the subsamples. First, trend real appreciation against the USD is evident in the second phase (mainly during 2009–2012). This contrasts markedly with the relatively steady nominal exchange rate values during this period. Second, the substantial instability and volatility in the real exchange rate with alternating bouts of depreciation followed by rebounds is particularly noteworthy in the second phase. Movements in the real USD/INR rate were greatest, with a real value index of 138 in December 2007, falling to a low of 115 in February 2009 and then sharply appreciating to 162 by July 2011. Substantial depreciation again followed, reaching 128 by August 2013. The real trade-weighted index followed a similar pattern, but with less extreme movements, ending this episode (August 2013) with about a 10 % cumulative real depreciation against the broad (36 country) multilateral index. Third, the final episode in our sample, August 2013 through January 2015, showed substantial real appreciation.

2.2 Volatility

Chart 4 shows that high volatility and turbulence in the INR during 2008–2013 is quite distinct compared with the relative stability of the two other periods. Generally, month-to-month fluctuations in the INR/USD rate over most of the sample have been within a ±2.5 % band. The exchange rate volatility increased post-2004, but the volatility of the Global Financial Crisis and its aftermath—characterized by a higher frequency of days exceeding the 2.5 % ± band—is clearly distinct from the other periods. The volatility of the nominal trade-weighted index also increased between 2008 and 2013, but the shift is not as dramatic as for the INR/USD spot rate.

Though volatility of the INR/USD was relatively high compared to the broad trade-weighted index, it was comparatively low compared to the two other most actively traded and heavily weighted (in the broad currency basket) international currencies in the index—the British pound (GBP) and the euro. This reflects the RBI's focus on mitigating volatility in the INR/USD rate over much of the period. Chart 5 plots the annualized volatility of the INR spot exchange rate against the USD, the GBP, and the euro. These are computed as the annualized volatility of the daily percentage spot exchange rate changes in the month, and smoothed by taking the lagged 6-month moving average. The chart shows that, through the end of 2006, volatility of the INR/USD pair was much lower than that of INR against these two other major international currencies. Although other factors were at work, this pattern is consistent with central bank actions attempting to mitigate INR/USD volatility. However, post-2007, and particularly between 2008 and 2013, volatility

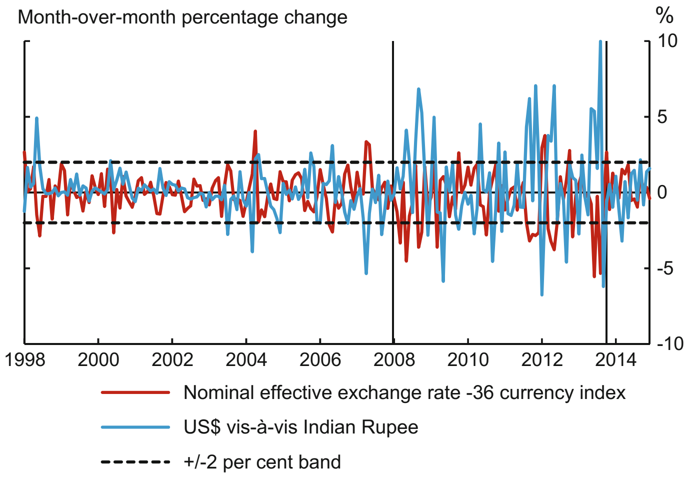

Chart 4 Monthly percentage change in nominal exchange rates *Sources* Bloomberg and authors' calculations

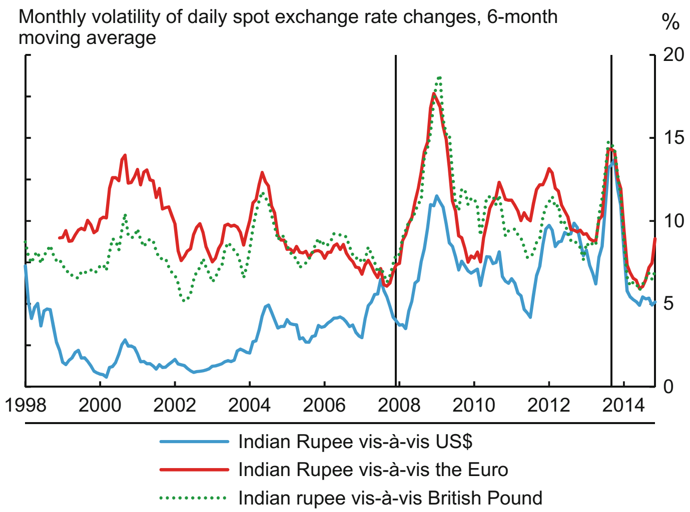

Chart 5 Annualized Volatility of Rupee spot exchange rates *Sources* Datastream, Reserve Bank of India, and Bank of Canada calculations

in the INR/USD was closer to the volatility of INR against the GBP and the euro, suggesting limited intervention (or limited effectiveness of such intervention).

In terms of real exchange volatility, shown in Chart 6, both bilateral and multilateral indices show substantial fluctuations over the sample period, frequently exceeding the ±2.5 % band. There are two similarities between the nominal

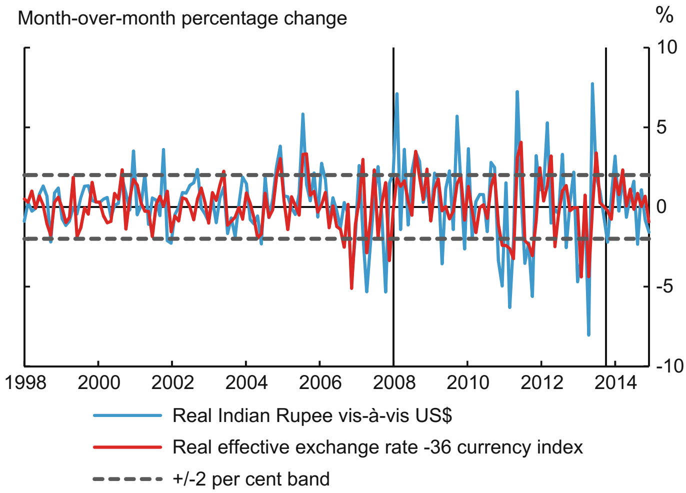

Chart 6 Monthly percentage change in real exchange rates *Sources* Bloomberg, Reserve Bank of India, and Bank of Canada calculations

exchange rate volatilities (Chart 4) and real exchange rate volatilities (Chart 6). As with nominal exchange rates, volatility was greatest for real exchange rate during the GFC and its aftermath (2008–2013). Nominal and real exchange rate volatility against USD has also been larger than that against the trade-weighted basket of currencies. The main difference between the nominal and real exchange rate volatilities is that real exchange rate volatility was relatively higher even in the pre-2006 period, with frequent deviations outside the ±2.5 % band.

2.3 Long-Term Linkages Between Prices and Exchange Rates: PPP and Cointegration Tests

The descriptive analysis indicates the Indian real exchange rate against the USD has shown a much larger trend appreciation, and greater volatility, than against a broad basket of currencies. These observations are borne out by formal cointegration tests where we investigate whether purchasing power parity (PPP) holds in the longer term. This procedure amounts to testing for a long-term linkage (cointegration) between the (log) nominal exchange rate and (log) relative prices. Formal PPP would indicate a 1:1 long-term (negative) linkage between the nominal exchange rate and relative prices. However, we postulate a weaker relationship, testing whether a cointegrating vector exists between the nominal exchange rate and relative price, allowing for a linear trend as a deterministic variable. We consider both the Granger–Engle and the Phillips–Ouliaris (residual) tests of cointegration and report both the tau-statistic and the Z-statistic. The null is that the nominal exchange rate and relative prices are not cointegrated, hence rejecting the null indicates a long-run relationship between the two series.

Table 1 reports the results of the cointegration tests for the USD/INR exchange rate and the Indian/US relative CPI price. Table 2 reports the results between the

Table 1 Cointegration between nominal INR/USD exchange rate and relative CPI

Variable	Coefficient	Standard error	t-Statistic	Probability
Constant	0.073	0.021	3.523	0.001
Log(RPRICE_IND_US)	−0.416	0.063	−6.582	0.000
R^2	54.9			
Adjusted R^2	54.6			
Null hypothesis: series are not cointegrated				
	Value	Probability[a]		
Engle–Granger tau-statistic	0.549	0.694		
Engle–Granger Z-statistic	0.546	0.660		
Phillips–Ouliaris tau-statistic	0.078	0.670		
Phillips–Ouliaris Z-statistic	0.028	0.634		

[a]MacKinnon (1996) p-values

Table 2 Cointegration between nominal rupee trade-weighted (36 countries) exchange rate and relative prices

Variable	Coefficient	Standard error	t-Statistic	Probability
Constant	4.621	0.006	822.186	0.000
Log(RPRICE36)	−0.828	0.038	−21.818	0.000
R^2	88.5			
Adjusted R^2	88.5			
Null hypothesis: series are not cointegrated				
	Value	Probability[a]		
Engle–Granger tau-statistic	−3.371	0.058		
Engle–Granger Z-statistic	−21.911	0.043		
Phillips–Ouliaris tau-statistic	−3.528	0.039		
Phillips–Ouliaris Z-statistic	−23.991	0.027		

[a]MacKinnon (1996) p-values

broad multilateral exchange rate index and the Indian price level vis-à-vis the foreign country weighted price index. The first part of each table reports the point estimates of the long-run relationship (using fully modified least squares), including a constant term and linear trend, and the second part reports the formal cointegration tests on the residual series.

Comparing the point estimates across the two series, it is evident that the linkage of relative Indian price level bilaterally against the USD is much weaker than against the multilateral basket of currencies, i.e., the point estimate of the former is −0.42 (USDINR rate depreciates only 0.42 % in response to a 1 % rise in relative price level in India relative to U.S.) and the point estimate of the latter is −0.82 (trade-weighted nominal exchange rate depreciates 0.82 % in response to a 1 % rise in relative price level in India relative to group of trading partners). However, the strict PPP restriction of −1.0 as a cointegrating term is decisively rejected for both equations at the 1 % level of significance. In line with observations of volatility, the long-run variance estimate against the USD is much larger than against the basket of currencies.

Not surprisingly, the weaker test of cointegration (any stable longer-term link, not necessarily 1:1) is strongly rejected between exchange rates and prices in India and the U.S. by both the Granger–Engle and Phillips–Ouliaris tests (Table 1). Trend movements in the USD/INR exchange rate simply do not reflect longer term movements in relative prices between the two countries.

Cointegration is not rejected, however, between relative prices and the multilateral exchange rate (Table 2). Three of the test statistics reject the "no cointegration" null at the 5 % level of significance, and the fourth rejects at the 6 % level. This is strong descriptive and statistical evidence that longer term trends in the Indian nominal exchange rate, measured as a weighted average of a large group of trading partners, reflects relative movements in price levels. It appears that a weak form of PPP holds, meaning that the real exchange rate for a broad basket of currencies shows large fluctuations over the short- and medium-term horizons but reverts to a stable trend over longer periods—the nominal exchange rate largely adjusts (about 82 % of the movement) to offset relative price movements over longer periods.

3 Exchange Rate Policy: Intervention, Capital Controls, and Monetary Policy

Although long-term movements in the INR exchange rate may largely reflect relative price trends between India and its trading partners, as well as real factors such as relative productivity developments and other "real" shocks, short-and medium-term fluctuations are influenced by a host of factors including government policy, especially foreign exchange market intervention, capital controls and monetary policy.

The objectives of an exchange policy are typically multifaceted, but generally focus on mitigating exchange rate volatility and turbulence as well as influencing the medium-term path of the exchange rate. However, the mix of policies is also constrained by the "trilemma" which suggests limits to independent policies across three dimensions: exchange rates, external capital controls (financial openness), and monetary policy. We explore how different dimensions of policy in India may have influenced the exchange rate. In what follows, we discuss intervention, capital controls, and monetary policy as they relate to capital inflows and exchange rates.

Mitigating exchange rate volatility has been an explicit objective of the Reserve Bank of India (RBI) for decades, long acknowledged in official documents and speeches.[6] RBI is also the manager under the Foreign Exchange Management Act (FEMA) 1999, which gives it the objective of "promoting the orderly development and maintenance of foreign exchange market in India" and the powers to restrict transactions in foreign currency.[7] In consultation with the government, the RBI may specify the class of capital account transactions that are permissible and the limit up to which foreign exchange can be made available for these transactions. Further, the RBI has broad powers to issue regulations to prohibit, restrict, and regulate transactions between residents and nonresidents in securities, lending, immovable

[6]For example, page 15 of RBI's (2014) Annual report states that RBI's response to the developments following the US Fed's indication that it would taper its large-scale asset purchase program "aimed at containing exchange rate volatility, compressing the current account deficit (CAD) and rebuilding buffers.".

[7]FEMA 1999 was passed to replace the Foreign exchange Regulation Act, (FERA) 1973 (later amended as FERA 1993). FERA 1973 was a draconian law that made violation of foreign exchange regulations a criminal offense and presumed guilty until proven innocent. In addition to reversing these provisions of the FERA and other liberalizations, the FEMA 1999 also made the rupee convertible on the current account. However, the RBI and the Government of India continued to have the power to regulate transactions on both current and capital account and the market for foreign exchange. The full text of the act is available here: http://finmin.nic.in/the_ministry/dept_eco_affairs/capital_market_div/FEMA_act_1999.pdf.

property, deposits, and currency notes. The RBI used capital controls as well as foreign exchange intervention to stabilize the exchange rate or to lean against the wind, to give some room to monetary policy responsive to domestic conditions. However, the constraints of the trilemma seemed to bind to some degree for the entire sample period, limiting monetary policy autonomy.

3.1 Exchange Rate Policy and Intervention

The policy shifts between maintaining exchange rate parities and allowing flexibility are evident throughout our sample period, with the RBI choosing different configurations over time. Considerably more exchange rate variation is evident in recent years, caused partly by the nature of the domestic and external environment (i.e., larger and more variance in external shocks) and partly by gradually opening of the external financial flows and willingness of the authorities to allow greater exchange rate flexibility as a “shock absorber” to external shocks.

Greater financial openness and flexibility in exchange rates has also been encouraged by the IMF. For example, the 2013 IMF Article IV Consultation Report lauds the virtues of exchange rate flexibility and states that: “The floating Rupee is an important shock absorber. Rupee flexibility has offset inflation differentials and prevented exchange rate misalignment. Such flexibility would be particularly important in case of renewed global financial stresses.” (IMF 2013, p. 20).[8] Policymakers allowing greater flexibility in recent years are consistent with the evidence in the Sect. 2 on how exchange rate depreciation is offsetting high inflation rates in India compared with its trading partners, Similarly, even in the face of quite high exchange rate volatility following the GFC and its aftermath, the 2015 IMF Article IV Report states: “Given India’s increased and adequate reserve buffers, greater exchange rate flexibility would be welcome and thereby encourage private sector entities to limit excessive risk taking. Foreign exchange intervention should be limited to preventing disruptive movements in the exchange rate. If global financial market volatility resurfaces, exchange rate flexibility should be an important shock absorber.” (IMF 2015, p. 21).

Although the Indian authorities may accept greater exchange rate flexibility, the authorities have nonetheless continued to engage in extensive interventions in the foreign exchange market. Chart 7 shows the accumulation of foreign exchange reserves in India from the RBI database and measured in (monthly) flows in billions of USD. This is a measure of foreign exchange intervention, with increases representing purchases of USD in the foreign exchange market and decreases representing sales of USD in the foreign exchange market. Generally, purchases of dollars (sales of INR) by the RBI in the foreign exchange market are designed to

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[8]The reports are not always consistent in the views expressed about the merits of exchange rate flexibility, however.

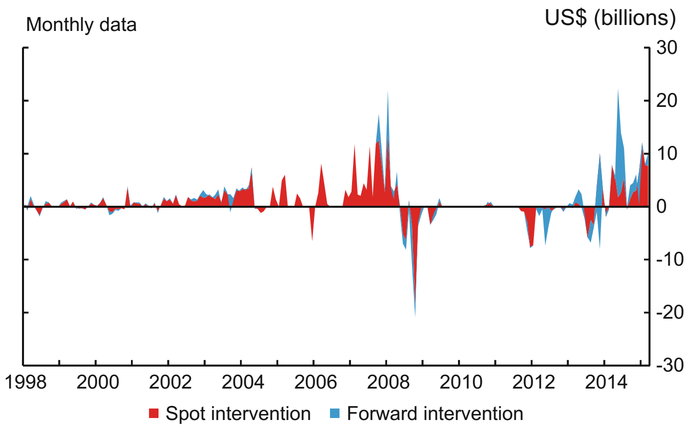

Chart 7 Foreign exchange reserve accumulation *Source* Reserve Bank of India

limit INR appreciation and are one measure of how the RBI is attempting to influence the exchange rate through intervention operations. Sales of dollars (purchases of INR) are designed to limit INR depreciation.

There is a sharp asymmetry in the use of official reserves policy to manage nominal exchange rate. During periods of nominal exchange rate appreciation pressures, particularly from January 2002 to May 2008, reserves accumulation was actively used to "lean against the wind." India's international reserves (excluding gold) climbed more than sixfold during this period, from 47 billion USD to 305 billion USD. However, during periods of depreciation, there was a reluctance to sell off reserves. The total intervention (spot and forward) during the global financial crisis period of June 2008–May 2009, amounted to only 19 % of India's total foreign exchange reserves (excluding gold) of 305 billion USD—spot sales of the USD during June 2008–May 2009 totalled 43 billion USD—and the exchange rate depreciated significantly. Similarly, the level of USD purchases during the tapering episode of May–September 2013 did not match the rate of reserves accumulation in the pre-2008 period or the rate of accumulation during 2014 when Rupee appreciation pressure reemerged. Overall, the RBI accumulated reserves rapidly during periods of exchange rate appreciation pressures, but resisted using reserves to limited nominal depreciations. This strategy reflected a "fear of losing reserves" as India is largely a current account deficit country, and has been outlined in RBI documents.[9]

It appears that much of foreign exchange purchase operations, involving large-scale sales of the Rupee, were sterilized so as not to allow an expansion of the monetary base. For example, when the RBI ran out of government bills/bonds to sell to sterilize foreign exchange reserves purchases, on February 23, 2004, it

[9]See Reserve Bank of India (2013).

announced the launch of a market stabilization scheme to issue additional government bills/bonds explicitly as sterilization instruments.[10] At the peak, reserve purchases (both spot and forward) were about 22 billion USD a month in 2007. However, during the 2008 global financial crisis, foreign exchange reserves were not used to stabilize a depreciating exchange rate, with sales being negligible. During 2009, the reserves accumulation resumed in periods of appreciation pressures, but compared to the pre-2008 period, the extent of accumulation remained subdued, until picking up again in 2014.

In summary, intervention policy in India has been mainly one-sided, directed toward limiting exchange rate appreciation, during which times dollar purchases were generally large, and *not* directed toward limiting depreciation. The general trend in exchange rate depreciation in nominal terms over our sample period was facilitated by intervention policy. This policy may have allowed relative stability in the real exchange rate, hence maintaining India export competitiveness, as the exchange rate depreciated over longer periods to offset relative high inflation in India. Intervention policy and exchange rate depreciation also allowed greater monetary autonomy, especially during a period associated with increased financial liberalization of the international capital account. Moreover, reserve accumulation—through USD purchases on the foreign exchange market—is a desirable objective to the extent that it provides a stock of precautionary reserves in the event of a balance of payments/currency crisis or sudden stop in private capital inflows that generally finance persistent current account deficits in India. On the other hand, the exchange rate did not play the role of a "nominal anchor" of monetary policy and high inflation in India as a consequence has been a recurring problem.

3.2 Capital Controls and Exchange Rates

Control of international financial capital movements is another policy instrument that has been frequently employed to influence financial flows in and out of India and the exchange rate. Although the overall trend was toward financial liberalization of the capital account, capital control actions (i.e., tightening and easing of restrictions on capital flows) have been actively used as an instrument to "lean against the wind" of exchange rate pressures in both directions.

A measure of cumulative changes in the capital account is shown in Chart 8. These data are from Pasricha et al. (2015). Each of the capital account openness indices is the cumulative sum of the number of weighted capital control easings less tightenings per quarter. The changes are weighted by the share of the country's international balance sheet that the measures are designed to impact (The weights

[10]See RBI announcement at: https://www.rbi.org.in/scripts/BS_PressReleaseDisplay.aspx?prid=9788.

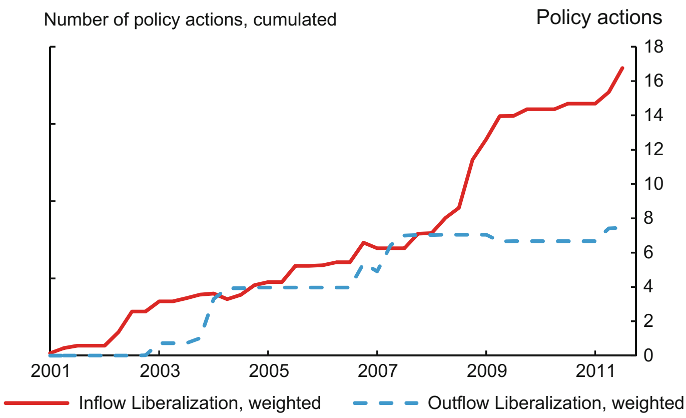

Chart 8 Capital control liberalization in India *Notes* Each of the capital account openness indices is the cumulative sum of number of (unweighted or weighted) capital control easings less tightenings per quarter. The changes are weighted by the share of the country's international balance sheet the measures are designed to impact. The weights are from Lane and Milesi-Ferretti (2007), as in Pasricha et al. (2015). *Source* Pasricha et al. (2015)

are from Lane and Milesi-Ferretti). Four indices are shown: cumulative changes for easings less tightenings for total capital inflows (outflows) and the total less FDI.

Chart 8 shows that both inflow and outflow restrictions have been gradually liberalized. However, there were some reversals in the inflow liberalization process, and the timing of the actions on both inflow and outflow sides appear to be associated with the major changes in nominal exchange rate trends:

- There are two periods during which inflow liberalization trend was temporarily reversed through a net tightening of inflow controls—2003–2004 and 2006–2008.[11] Both these were periods of appreciating nominal INR/USD exchange rate. These periods also saw several net liberalizations of outflow controls, as authorities attempted to reduce exchange rate appreciation pressure associated with surging net capital inflows.
- There was significant net liberalization of inflow controls after 2008, particularly during 2008, 2011, and 2013, the years that saw sharp depreciations of the Rupee. The year 2013 also saw tightening of outflow controls in response to the net capital outflow pressures, as authorities responded to the taper tantrum.

[11]The de-jure liberalization resulted in de facto liberalization, as measured by deviations from covered interest parity. Hutchison et al. (2012b) use a self-Exciting Threshold Auto-Regressive (SETAR) model to the interest differentials between the onshore interbank rate and offshore-NDF implied (covered) yield over the period 1998–2011 and find that prior to 2008, capital control tightenings were able to create a wedge between the offshore and onshore interest rates, but only in periods in which the controls were actively tightened (March 2003–August 2005 and August 2006–October 2008). They also find that post-2008, the no-arbitrage band for the differentials fell to close to zero.

The issue of whether changes in capital inflow controls in India systematically responded to exchange rate pressures is addressed directly using an event study methodology by Pandey et al. (2015). A figure from their work is shown as in Chart. 9. This study finds that the 68 episodes of net capital inflow easing are systematically associated with periods of INR exchange rate depreciation (rising INR/USD four weeks prior to changes in controls) and the 8 episodes of net capital

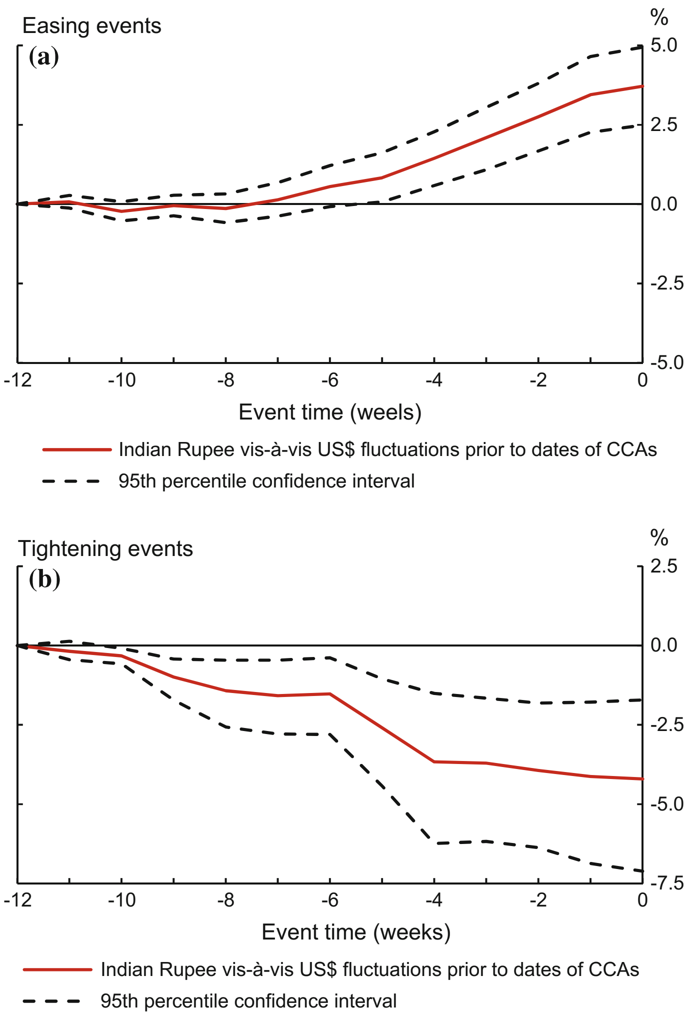

Chart 9 **a** Capital controls responded to exchange rate pressures *Note* Sample includes 68 easing events. *Source* Pandey et al. (2015), **b** Capital controls responded to exchange rate pressures *Note* Sample includes 8 tightening events. *Source* Pandey et al. (2015)

inflow tightening are associated with periods of INR appreciation (fall INR/USD ten weeks prior to changes in controls). This suggests that the timing of changes in capital controls was influenced by the movements in exchange rate.

While capital controls on both inflows and outflows were used to respond to nominal exchange rate pressures, it is not clear that these measures delivered on reversing the exchange rate trend or even stabilizing it. Pandey et al. (2015) also address this issue. They employ a propensity score matching methodology to assess the causal impact of changes in a certain type of inflow controls (those on foreign borrowing by Indian residents) for the period from January 2004 to September 2013. The propensity score matching methodology controls address selection bias that would arise in a simple event study or regression if policymakers use capital controls for exchange rate management purposes. The weeks in which capital control actions (CCAs) were implemented will differ in identifiable ways, from weeks in which CCAs were not implemented.

The propensity score matching (PSM) methodology is a way of building the counterfactual of what would have happened if the controls had not been employed. Instead of trying to model the outcome variables, the methodology shifts focus to modeling the policy variable (the use of a CCA) and estimating the conditional probabilities for the use of CCAs. These conditional probabilities, called propensity scores, are used to identify time periods that had similar characteristics to those prior to the date of the CCA but where no CCA was employed (control group). The behavior of the outcome variables for the control group gives a counterfactual for how each of these variables would have behaved had the CCA not been employed. Outcomes of the weeks after the CCA are compared between the treatment and control groups.

Chart 10, which is an updated version of the one in Pandey et al. (2015), plots the difference between nominal INR-USD spot exchange rate between treatment and control weeks for easing of capital controls on foreign borrowing. It shows no significant difference between the outcomes after easing CCAs and the outcomes in control periods. This result also held for other outcome variables. Therefore, they conclude that these controls did not significantly impact either nominal or real exchange rate movements.

Pandey et al. consider a longer sample, but one interesting episode is the period of "taper tantrum," May–September 2013. The taper tantrum began after Bernanke's testimony to the US congress on May 22, 2013 that the Federal Reserve "could take a step down in our pace of purchase" of assets under the QE program, conditional on improving economic conditions.[12] These events led to considerable market volatility and a global retrenchment from risk taking, with market

[12]The FOMC press conference in June further reiterated that the asset purchases could slow in the fall of 2013, conditional on the economic recovery continuing to take hold.

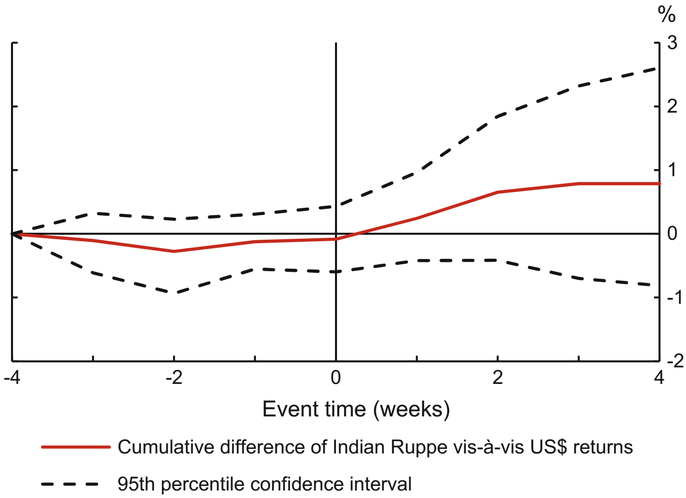

Chart 10 Causal impact of capital controls on nominal INR-USD exchange rate *Source* Pandey et al. (2015)

participants interpreting the statements to suggest that the Federal Reserve may start normalizing policy earlier than markets had so far expected.

This retrenchment from risk-taking hit India particularly hard, as at that time the economic fundamentals appeared to be weak, with slowing growth, high inflation, high fiscal deficit, and political uncertainty due to the upcoming 2014 general elections. The Indian policy response consisted of tightening of monetary policy, curbs on gold imports and currency trading, and liberalization of inflow controls. However, the Rupee depreciation continued unabated (Chart 11, Panel-a). The Rupee's value hit the lowest among the other emerging markets that formed the "fragile five," i.e., Brazil, Indonesia, South Africa, and Turkey (Chart 11, Panel-b). All the fragile five countries responded by raising interest rates, while Indonesia, Brazil, and Turkey also intervened in the currency markets. Sahay et al. (2014) assessed the domestic policy responses in an event study specification and found that EME policies during the taper tantrum did have a dampening effect on the pace of depreciation. However, the taper tantrum was officially over—and all the fragile five currencies stabilized—only when the Federal Reserve did not reduce its monthly purchases under QE in its September 18 monetary policy announcement.

The upshot of this analysis is that a general trend of international capital market liberalization has occurred in India, particularly on the liberalization of capital inflows. Moreover, the intensity of liberalizations coincided with bouts of exchange rate pressure, such as the taper tantrum episode, with changes in capital controls

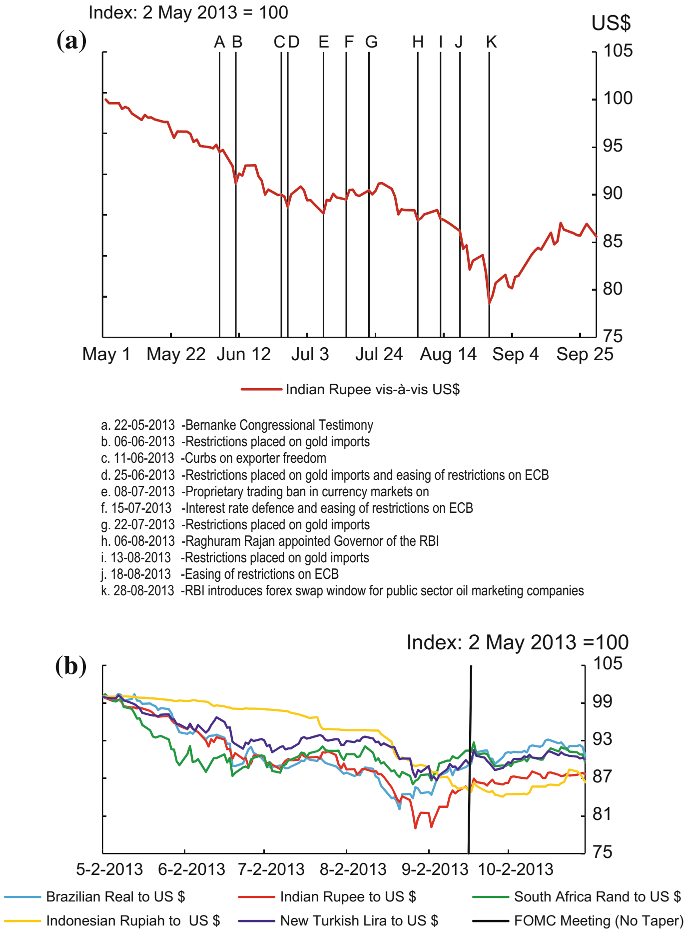

Chart 11 **a** Capital controls and INR-USD exchange rate during "taper tantrum" *a* 05-22-2013—Bernanke Congressional Testimony, *b* 06-06-2013—Restrictions placed on gold imports, *c* 06-11-2013—Curbs on exporter freedom, *d* 06-25-2013—Restrictions placed on gold imports and easing of restrictions on ECB, *e* 07-08-2013—Proprietary trading ban in currency markets on, *f* 07-15-2013—Interest rate defense and easing of restrictions on ECB, *g* 07-22-2013—Restrictions placed on gold imports, *h* 08-06-2013—Raghuram Rajan appointed Governor of the RBI, *i* 08-13-2013—Restrictions placed on gold imports, *j* 08-18-2013—Easing of restrictions on ECB, *k* 08-28-2013—RBI introduces forex swap window for public sector oil marketing companies *Source* Reserve Bank of India and Bank of Canada calculations, **b** Fragile 5 currencies during the "taper tantrum" *Source* Datastream

attempting to moderate exchange rate movements. However, it is not clear from the empirical evidence that capital control changes had much impact on exchange rate movements.

3.3 Monetary Policy, the Trilemma, and Exchange Rate Management

Monetary policy in India, especially the use of policy interest rates, has occasionally been influenced by external developments as well as directed toward moderating exchange rate movements (Hutchison et al. 2012, 2013). The trade-offs between an independent interest rate (monetary) policy, exchange rate stability, and financial openness (deregulation of capital controls)—the well-known trilemma constraint—is clearly evident in India. The trilemma configuration is an important part of an analysis of factors determining exchange rates in India as exchange rate stability is compromised (given a particular external environment) when authorities pursue greater capital market openness (financial liberalization) or follow an interest rate policy that diverges from the rest-of-the-world (monetary independence).

Policy constraints between these three policy instruments were operating in India over the past decade, as shown in Chart 12. The chart shows the evolution of interest rate policy independence (monetary policy autonomy, MPA), international capital account openness (KO), and exchange rate stability (ES). The monetary policy autonomy index (MPA) is computed as in Aizenman et al. (2008). This index measures the inverse of the correlation between nominal money market interest rates in India and the US, and varies between 0 and 1, with higher values indicating greater monetary policy autonomy.[13] The exchange rate stability index is also computed as in Aizenman et al. (2008), as the normalized annual standard deviation of the monthly percentage changes in nominal INR/USD spot exchange rate. To measure capital account openness (KO), we compute the index as the sum of total financial assets and liabilities as percentage of GDP.[14]

The MPA index suggests very low monetary policy autonomy during 1999–2006, taking values below 0.3 for the entire period. The MPA index is declining from 1999 to 2004, a period when the volatility of exchange rate against the USD was lowest, as seen in Chart 2.[15] This period is also characterized by heavy foreign exchange market purchases of USD, leading to large reserves accumulation. Up to 2003, RBI sterilized the reserves purchases using open market

[13]We use IFS data on money market interest rates, where available, and monthly average of interest rates. For the US, this series is the federal funds rate. For India, the IFS series on money market rates is missing between June 1998 and April 2006. For this period, we use the MIBOR data from Haver's EMERGE database.

[14]Exchange rate data is the monthly average nominal spot exchange rate against the USD series from IMF IFS. International investment position data is also from IMF IIP statistics.

[15]The monetary policy autonomy index is based on money market interest rates, rather than actual policy rates. The RBI was reducing interest rate and cash reserve ratios over the period 1999–2004. However, sterilized intervention increased the supply of domestic bonds held by the public, which may have prevented full transmission to market interest rates. Real rates also did not decline in this period as inflation was low (fiscal policy was contractionary, with declining fiscal deficit). The index therefore seems to capture well the declining monetary policy autonomy over the period of sterilized intervention.

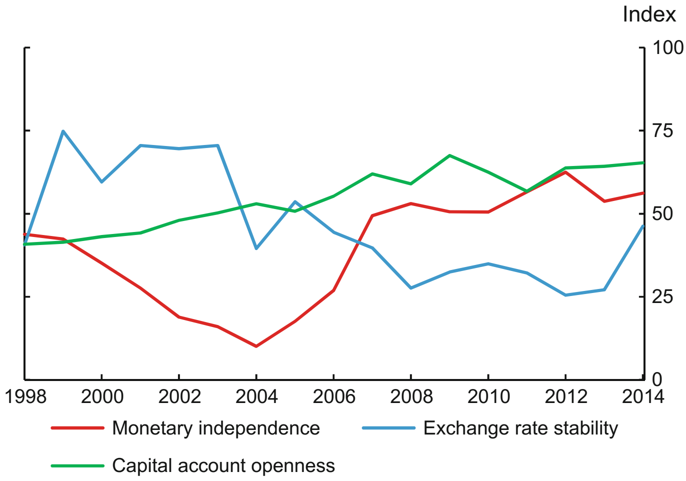

Chart 12 Trilemma indices for India *Source* Haver (IMF IFS and EMERGE databases) and the authors' calculations

operations. In 2003, RBI ran out of government bonds with which to sterilize and the government of India issued special market stabilization scheme bonds to sterilize intervention. As the fiscal cost of sterilization became more apparent under the MSS, this may have led to a slowdown in the rate of sterilization. The year 2004 also marks the lowest point in the MPA index, after which it started increasing, as RBI shifted the focus from sterilized intervention to using more capital controls (tightening of controls on foreign borrowing and easing of outflow controls), as well as gradually allowing (or accepting) more exchange rate volatility.

The year 2008 marked a shift in nominal exchange rate volatility, seen in Chart 2 and measured by lower values of the exchange rate stability index of Chart 12. This allowed the authorities to maintain a high degree of monetary policy autonomy despite increasing capital account openness. The MPA index was fairly stable at around 0.5 in 2007–2010, climbing somewhat from in 2011–2012. The exchange rate stability index continued to fall continuously from the mid- to late-2000s and, by 2012, reached a level below that observed in late 1990s. A small decline in monetary policy autonomy is evident in 2013, as the RBI reacted to taper tantrum by an interest rate defense, intervention in spot, and forward markets as well as capital controls.

To provide a sense of how the three policies: monetary, capital controls, and intervention were used to manage the exchange rate, Table 3 puts together the three policies and the trends in nominal exchange rate of the rupee against the USD for our sample period January 1, 1998–December 31, 2014. We divide the sample period into 6 subperiods, based on the direction of monetary and capital controls policies. Specifically, we use capital control regime change dates identified by Hutchison et al. (2012a) and update these beyond 2011, together with our judgement of the monetary policy cycle turning points (based on information on the

Table 3 Policy regime description

Begin	End	Exchange rate trend	Regime	Description		
				Capital controls	Monetary policy	Total intervention (Spot + Forward)
January 1, 1998	July 7, 2003	Depreciation up to Jan 02, then appreciation	MP: Easing CC: Some NKI increasing measures Intervention: Yes, purchases	Slow and tentative liberalization of inflows but few changes	Easing, on all 4 policy rates	USD 42 billions
July 8, 2003	October 10, 2008	Appreciation — moderate up to April 2006, then rapid	MP: Neutral/Tight CC: NKI reducing measures Intervention: Yes, purchases	Outflow liberalizations and net tightening of restrictions on inflows, particularly between 2006 and 2008	Tightening, starting in August 2004 with CRR and October 2005 in repo rate	USD 149 billions
October 11, 2008	November 20, 2009	Depreciation	MP: Easing CC: NKI increasing measures Intervention: Yes, sales	Inflow liberalizations, no change in outflow controls	Easing	(Sales) USD 30 billion

(continued)

Table 3 (continued)

Begin	End	Exchange rate trend	Regime	Description		
				Capital controls	Monetary policy	Total intervention (Spot + Forward)
November 21, 2009	October 25, 2011	Appreciation, till Apr 2011	MP: Tightening CC: NKI increasing measures Intervention: **No**	Inflow liberalizations, no change in outflow controls	Tightening	None (Sales of USD 1 billion)
October 26, 2011	May 9, 2013	Depreciation	MP: Easing CC: NKI increasing measures Intervention: Yes, Sales	Inflow liberalizations, some outflow tightening	Easing	(Sales) USD 29 billion
May 10, 2013	Dec 31, 2014	Sharp depreciation till September 2013, then stabilization or appreciation	MP: Tightening CC: NKI increasing measures Intervention: Yes, Sales and purchases	Inflow easing, outflow tightening	Tightening	Sales during taper tantrum (USD 27 billion between June and Nov 2013), heavy purchases since (USD 77 billion between Dec 2013 and Dec 2014)

RBI's key policy rates). The capital control regimes are characterized as NKI increasing measures regime (i.e., when most measures taken during the time period were either inflow easing or outflow tightening measures, both of which would tend to increase net capital inflows) or NKI reducing measures regime (where most measures taken were either inflow tightening or outflow easing measures). Monetary policy regimes are described as easing or tightening cycles. We divide the full sample period into 6 regimes. It turns out that most of these subperiods also fit well with the changes in exchange rate trends.

For the three regimes—July 2003–September 2008, October 2008–November 21, 2009, as well as between November 2011 and April 2013—capital control changes (and reserves accumulation) seem to be neutralizing the expected impact of monetary policy changes on the exchange rate. Easing of monetary policy is associated with NKI increasing measures, both simulative measures for the domestic economy but with opposing impacts on net capital inflows and therefore the exchange rate. Reserves sales are used to stem depreciation pressures. Tightening of monetary policy in these periods is associated with NKI reducing measures, both of which would have countered overheating of the economy, but also to reduce exchange rate appreciation pressure from capital flow response to interest rates. Intervention response to appreciation was also strong.[16] These policy responses are consistent with what one would expect, if monetary policy was used to respond to domestic conditions, but capital controls and intervention were used to neutralize the expected impact of monetary policy on the exchange rate.

In contrast, there are two periods where the direction of capital controls and monetary policies reinforced each other in terms of their impact of the exchange rate: the first period is November 21, 2009–October 2011 and the second period is May 2013–May 2014. Both these periods saw monetary policy tightening being conducted at the same time as NKI increasing measures (which may counteract the effect of monetary tightening on domestic liquidity conditions). Both periods seem to suggest some policy response to the value of the currency, although only the second period involved a full interest rate defense of the currency, as we discuss below.

In the period November 21, 2009–October 2011, monetary policy tightening (starting from February 2010) was a response to high prevailing inflation (and high output growth).[17] The inflow increasing measures undertaken at this time were mostly easing of controls on foreign borrowing for infrastructure investment or on FDI in infrastructure, which could be thought of as measures that could ease future supply bottlenecks, and are consistent with RBI's understanding of the inflation problem at this time as being one of supply bottlenecks (Khan 2011).[18] Foreign exchange intervention was not used in this period.

[16]Whether the focus on exchange rate made monetary policy is less effective is a question we do not address here.

[17]Note that real interest rates (measured ex-post using CPI inflation) remained negative throughout this period.

[18]RBI was also concerned during this period with exchange rate pass-through to inflation, as the exchange rate had started depreciating in 2011.

On the other hand, in the May–November 2013 period, all the three policies—capital controls, intervention and monetary tightening—were used in defense of the currency. Monetary policy in this period was clearly reacting to outflows of capital. The RBI acknowledged as much in its 2014 annual report in stating that monetary policy between July and September 2013, characterized as a "post-taper tantrum," was geared toward stemming capital outflows by increasing interest rates.

For India, this period which coincided was one of slowing growth, high inflation, and a sharp decline in exchange rate. These episodes contrast sharply with the 2004 cycle of monetary tightening which occurred as controls on outflows were reduced (while controls on inflows were little changed). Both monetary and capital control policies in 2004 were therefore leaning against the wind, limiting exchange rate changes, and slowing an overheated economy.

In summary, monetary independence in India rose sharply in the mid-2000s against a background of increased financial openness and rising volatility of the exchange rate. By our measure, monetary independence was at a low point in 2004, and climbed sharply until 2007. Monetary independence remained at a high level by historical standards, with some minor fluctuations, through 2014. This is an especially important development since capital account openness rose almost continuously during this period. The natural constraints on monetary independence associated with greater financial openness were therefore facilitated by allowing greater exchange rate flexibility. Greater monetary independence may have allowed the RBI in principle to choose its domestic priorities. But this was against a background of an economy buffeted by the GFC. Annual consumer price inflation jumped from an average of less than 5 % during 2002–2007 to 10 % during 2008–2013, declining sharply in 2014. The domestic priority of the RBI from 2008 to 2013 appeared to output and employment growth at the cost of higher inflation in the aftermath of the GFC.

4 Conclusion

This chapter surveys nominal and real exchange rate developments in India since the late 1990s, both in terms of trend movements and volatility, and investigates the roles of Indian international economic policy—primary foreign exchange market intervention, opening of the capital account and discretionary capital controls, and monetary policy—in influencing the path and volatility of the Rupee exchange rate.

In considering longer term exchange rate trends in India, we find a strong linkage between a broad-based nominal currency index and relative price movements between India and its trading partners. Cointegration between the exchange rate and relative prices cannot be rejected, implying that the exchange rate adjusts to reflect relative inflation differentials over longer periods of time. As a consequence, the nominal exchange rate—against a background of relatively high inflation—has maintained international competiveness between India and its trading partners. Relatively high inflation rates in India are the main factor underlying long-term trend nominal depreciation of the Rupee—the external value of the currency is clearly influenced by domestic price and monetary policy developments over longer periods of time.

While the long-term trend in the *nominal* value of the Rupee since the 1990s has been one of depreciation, the Rupee has not generally been a "weak" currency in *real* terms, with a relatively stable trend value against a broad basket of currencies and substantial appreciation bilaterally against the USD. Beyond long-term trends, the Rupee exchange rate has evolved through several distinct episodes during our sample. Most importantly, exchange rate volatility has increased markedly since the mid-2000s, especially since the Global Financial Crisis and its aftermath (standard deviation of month-to-month percentage changes more than doubled).

Higher exchange rate volatility in India is influenced by greater volatility in the external environment and recognition among policymakers that exchange rate flexibility may be a necessary short-term trade-off to facilitate both a more open capital account and greater monetary policy independence. The IMF, in consultations with the Indian government, has also lauded the benefits of greater exchange rate flexibility as a "shock absorber" to economic disturbances.

We have argued that trend depreciation of the Rupee is necessary to maintain international competitiveness when inflation in India is higher on average than its trading partners. This has been facilitated by official intervention operations in the foreign exchange market. The India government has attempted to moderate exchange rate appreciation of the Rupee by foreign exchange purchases, substantially increasing the stock of international reserves. This may have had some limited effect on reducing upward pressure on the Rupee during periods of large financial capital inflows. By contrast, little attempt to use intervention operations to limit currency depreciation is evident. Tightening of restrictions on net capital inflows has also been a policy instrument attempting to limit currency appreciation, although evidence suggests that this policy has limited effectiveness.

The long-standing policy of gradual international capital market liberalization would normally be expected to place severe constraints on monetary policy. However, greater exchange rate exchange rate variability in India has largely offset the constraints on monetary policy independence implied by the deregulation of capital controls. In fact, we find that monetary autonomy increased significantly in line with greater exchange rate volatility and the backdrop of gradual liberalization of capital controls. Greater monetary autonomy was not associated with lower inflation rates in India, however, at least not through 2013. The main concerns of the RBI during the turmoil of the GFC and post-GFC period appear to have been maintaining output and employment. Relaxation of the external (exchange rate) constraint may have allowed the RBI to focus more on domestic policy objectives, but concerns about the rise in inflation were apparently dominated by output and employment objectives until quite recently.

Appendix: Data Sources

Series	Source	Notes
Indian Rupee vis-à-vis US$	Bloomberg	Spot exchange rate
Nominal effective exchange rate—36-currency index (NEER36)	Reserve Bank of India	Index: 2004–2005 (April–March) = 100; Trade-based weights. Current series begins. Data prior to July 2005 spliced from the discontinued NEER series with earlier base year
Real Indian Rupee vis-à-vis US$	Bloomberg	Index: January 2001 = 100; spot exchange rate normalized by the authors to an index
Real effective exchange rate—36-currency index (REER36)	Reserve Bank of India	Index: 2004–2005 (April–March) = 100; Trade-based weights. Current series begins. Data prior to April 2004 spliced from the discontinued NEER series with earlier base year
Real price differential between India and trade-weighted 36 index (RP36)	Construction by authors	Index: January 2001 = 100. RP36 = NEER36/REER36
Real price differential between India and US$	Construction by the authors	India CPI/US CPI
Spot intervention	Reserve Bank of India	
Forward intervention	Reserve Bank of India	Forward intervention series is a net amount outstanding. We take month-over-month level change to show intervention
Capital control liberalization indices (inflow and outflow liberalizations, including and excluding FDI)	Pasricha et al. (2015)	Weighted number of capital control actions, cumulated over time. Noncumulated, weighted data from source
Monetary independence Index	IMF IFS and Haver	Constructed by the authors using methodology in Aizenman et al. (2008). This measures the correlations between nominal short-term money market interest rates in India and the USA. Higher numbers indicate lower correlations, i.e., higher monetary policy autonomy. IFS data is used except for India between June 1998 and April 2006 (when the IFS series is missing). For this period, MIBOR data from Haver is used

(continued)

(continued)

Series	Source	Notes
Exchange rate stability Index	IMF IFS	Constructed by the authors using methodology in Aizenman et al. (2008). This measure is the normalized annual standard deviation of the monthly percentage changes in nominal INR/USD spot exchange rate
Capital account openness Index	Lane and Milesi-Ferretti (2007)	Total foreign assets and liabilities, as percentage of nominal GDP. Both measured in US Dollars

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Capital Flows and Central Banking: The Indian Experience

Poonam Gupta

Due to steady liberalization of the capital account since the early 1990s and increased financial integration of the Indian economy, capital flows to India have moved in tandem with broad global trends. This paper looks at the extent to which India's monetary policy is affected by the ebbs and flows of capital it receives. For ease of narration it divides the post liberalization period since the early 1990s into three phases—early 1990s–early 2000s, a period of increasing but still modest capital flows; early 2000s–2007–2008, a period of capital flow surge when inflows increased rapidly; and a period of sudden stops and volatility, starting in 2008–2009 when capital flows reversed in the post-Lehman Brothers collapse, and again during the tapering tantrum of 2013. It shows that while ordinarily domestic policy imperatives such as price stability and growth have taken precedence over issues related to exchange rate or capital flows in policy rate setting, some accommodation in money supply is evident during the surge-and-stop episodes. The broad policy mix to handle large increases or reversals of capital flows have included reserve management, liquidity management, and capital flow measures.

I thank Tito Cordella, Chetan Ghate, Vijay Joshi, Muneesh Kapur, Ken Kletzer and an anonymous referee for useful comments. The views are personal. Comments are welcome at pgupta5@worldbank.org.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_13

1 Introduction

How do emerging countries central banks handle spillovers from monetary policy in advanced economies or from volatile capital flows? In particular how do they allocate the burden of policy across monetary policy, exchange rate, reserve management, or capital flow measures?

Emerging market economies have traditionally been wary of excessive volatility in their exchange rates, and have tended to either peg their exchange rates or maintain defacto managed floats. Their reluctance to allow the exchange rates to be determined freely by markets, termed as the "fear of floating," has been attributed to their net open foreign positions. Unable to raise external debt in domestic currency (the so-called "original sin"), emerging markets have held debts denominated in foreign currency, implying that exchange rate depreciations inflict adverse balance sheet effects.[1] Countries thus often tailor their monetary policy to cushion the impact of capital flows on exchange rates. Due to capital flows to emerging markets generally being procyclical, they have tended to loosen the monetary policy during periods of high economic growth (to resist exchange rates appreciation) and tighten it during economic slowdowns (to moderate the extent of exchange rate depreciation).[2]

This scenario has changed somewhat in the last one and a half decade. After a series of high-profile currency crises in the mid-1990s–early 2000s, many emerging markets have moved from pegged exchange rate regimes to floating exchange rates. They maintain less negative foreign currency positions, and have built a larger stock of reserves to limit the impact of large reversals of capital flows and modulate excessive volatility in their exchange rates. An increasing number of central banks now operate under an inflation targeting framework, which accords them the mandate to formulate monetary policy to primarily meet domestic policy imperatives, and in many cases to conduct countercyclical monetary policy. All these developments have somewhat insulated the monetary policy in emerging economies from external concerns but not fully.

Besides it has been widely observed that capital flows to emerging economies are driven more by global liquidity conditions than domestic economic conditions. As such emerging markets receive capital flows in bunches. There are periods of surges when countries receive large capital flows in a short period of time, which in turn fuel domestic credit booms and asset price inflation. Surges are eventually followed by reversals of capital, when credit has to be quickly unwound as well.

[1]For a discussion of "fear of floating" see Calvo and Reinhart (2002), and for a discussion of "original sin" see Eichengreen et al. (2007).

[2]Procyclical capital flows and procyclical monetary policies result in amplified business cycles in emerging markets, leading to what is known as the "when it rains it pours" phenomenon. See Kaminsky et al. (2004) for evidence on procyclical capital flows, monetary policy and fiscal policy. They show that capital flows are procyclical across countries at all levels of income; fiscal policy is procyclical in developing and middle income countries; and the procyclicality of monetary policy is most pronounced in middle income countries.

Thus, financial stability issues are intricately linked with the capital flow cycles. Even if the currency mismatch and balance sheet concerns have subsided overtime, financial sector stability concerns remain as relevant and require appropriate response to capital flows. This response has tended to take the form of counter-cyclical macro prudential measures as well as capital flow measures.

The Indian experience has evolved in sync with the experience of other emerging markets. Its exchange rate, which was largely pegged to the US dollar until the early 1990s, has increasingly become more market determined. Consistent with trends elsewhere, India has been liberalizing its capital flow steadily, and has become more financially integrated. Reflecting the broad global trends, capital flows to India have been subject to both surges and sudden stops of capital flows.[3] And just like in the other emerging countries, India too has built a large buffer of external reserves and for the most part has used it to modulate excessive fluctuations in the exchange rate.

This paper looks at the extent to which India's monetary policy has been affected by capital flow cycles. In the post liberalization period since the early 1990s, capital flows have evolved in three phases—a first phase from early 1990s–early 2000s, during which capital flows increased steadily but remained modest compared to the size of the economy or monetary aggregates; a second phase of "surge" from early 2000s–2007–2008, when inflows increased rapidly in some years, outpacing GDP or monetary aggregates; and a third period of stops and volatility, starting in 2008–2009 when capital flows reversed in the post-Lehman Brothers period and again during the tapering tantrum and remained volatile.

While monetary policy mostly focused on price stability during the first phase, it was also impacted by the capital flow cycle in the later phases. Monetary outcomes were eased during the period of surge and tightened during the stop episodes. The full policy response to capital flows included reserve management, liquidity management, and capital flow measures. Specifically, India increased money supply, accumulated reserves, sterilizing them partially, accelerated the pace of liberalization of capital outflows, and slowed the pace of further liberalization of inflows during the "capital surge" episode of 2003–2008. It tightened monetary policy, used reserves to deter large exchange rate depreciation or volatility, and increased the pace of liberalization of inflows, while restraining outflows, during the reversal of capital in 2008–2009 and in 2013.[4]

Going forward, the new inflation targeting framework is likely to further reinforce the "domestic orientation" in monetary policy. At the same time due to a progressively liberalized capital account over the last two-and-a half decades, the scope to actively use capital flow measures seems rather limited. Thus in years ahead, reserve management and macroprudential measures are likely to play a more

[3]See Ghosh et al. (2012a) on surges of capital flows and Forbes and Warnock (2012a) on sudden stops of capital flows.

[4]See Basu et al. (2015) for a discussion of the policy response in India during the tapering talk episode in May 2013.

significant role in helping respond to capital flow cycles, just as the policymakers and the economy develop greater tolerance for exchange rate adjustments.

The rest of the paper is organized as follows. Section 2 discusses the experience of emerging market economies in handling volatile capital flows. Section 3 puts the Indian experience in perspective. Section 4 elaborates the response of monetary policy to capital flows in India. Section 5 discusses the capital flow measures that India have deployed in response to capital flow cycles, and Sect. 6 concludes.

2 The Experience of Emerging Market Economies with Monetary Policy, Capital Flows, Exchange Rate, and Reserve Management

Emerging market economies' policy space is said to be governed by an "impossible trinity," or what is also known as a policy "trilemma". The constraint that countries face is that they can typically choose only two out of the following three objectives —an independent monetary policy, stable exchange rate, or full capital account mobility. A country, e.g., can have fully autonomous monetary policy if it either imposes restrictions on its capital account, or does not strive for exchange rate stability. While in the 1980s and 1990s countries navigated this trilemma by fixing their exchange rates, and pursuing a monetary policy which was committed to a large extent to maintaining the exchange rate; a large number of countries since the early 2000s have moved to more flexible exchange rates and are able to pursue more independent monetary policy.

Aizenman et al. (2013) constructed the "trilemma index" for a large number of countries to measure the extent to which countries tradeoff between the three policy goals of monetary independence, exchange rate stability, and financial integration. Tracing the policy configuration of countries over time they make some interesting observations. Since the early 2000s, a growing number of developing countries have opted for greater financial integration, more monetary policy autonomy, and somewhat greater flexibility in exchange rate. Countries have, however, not abandoned exchange rate stability fully, instead retaining an intermediate level of stability. One factor which has facilitated the emerging countries to manage their policy space in this specific way is an increase in the level of reserves that they hold. Indeed the ratio of international reserves to GDP has increased dramatically across emerging market economies—from about 10 % in 1990 to nearly 25 % in recent years. A higher reserve level has allowed countries to better integrate financially while also stabilizing their exchange rates and not losing their monetary autonomy completely.

This evolution of policy choices across emerging countries has been noted in several contemporary papers, see Cordella and Gupta (2015). The impact of financial integration on monetary policy and exchange rate in particular has been discussed in the context of procyclical capital flows. It has been pointed out that the capital flows to emerging markets have traditionally been procyclical—emerging countries receive larger capital flows during periods of high economic growth, which increase the demand for their currency, and appreciate their exchange rate (Fig. 1, Panel A). The converse is true during the periods of slow economic growth —capital flows slow down or reverse and the exchange rate depreciates. Since emerging economies hold liabilities denominated in foreign currency (Fig. 1, Panel B), they are short in foreign currency and resist currency depreciation to limit valuation losses. The confluence of these factors is that the emerging countries have traditionally pursued procyclical monetary policy to resist the depreciation of their exchange rates, by tightening it when GDP growth is low, and loosening it when GDP growth is high.[5] In emerging market economies, the exchange rate appreciates when GDP growth is high and depreciates when GDP growth is low; and this correlation is stronger in countries which receive procyclical capital flows, (Fig. 1, Panel C); the countries with procyclical capital flows are the ones more likely to pursue procyclical monetary policy, (Fig. 1, Panel D).[6]

In recent years, however, emerging economies appear to be making a transition from procyclical monetary policy to countercyclical monetary policy. The evidence points at the consistently improved net foreign exchange position of emerging economies—countries have reduced the mismatch in their external balance sheets (Fig. 2), due to improved current account positions, larger foreign reserves (Fig. 3), shift in the composition of capital flows to equity from debt; and the success in developing local currency debt markets. Aizenman et al. (2015) particularly emphasize the role of larger reserve holdings of the emerging countries for this shift in the policy orientation of emerging countries.[7] A move to inflation targeting could be another reason for this transition, as noted in McGettigan et al. (2013). Evidence therein shows that the countries that have successfully transitioned to countercyclical monetary policy are the ones which have adopted an inflation targeting framework, possibly reflecting strengthened monetary institutions allowing them to pursue independent monetary policy. Cordella and Gupta (2015) corroborate these findings, and in addition note that in recent years, monetary policy in emerging market economies is influenced less by exchange rate movements, and more by economic growth.

[5]See Ghate et al. (2013) for evidence on procyclical monetary policy in India in the post reform period, attributed to procyclical capital flows and managed exchange rate.

[6]Examples abound from emerging countries, especially those with open capital accounts and flexible exchange rate regimes, where similar experiences have been observed. Example as noted in Calvo and Reinhart (2002), in the aftermath of the Russian crisis in August 1998, Chile and Mexico increased their interest rates to limit exchange rate depreciation despite a marked slowdown in their economies.

[7]See Lane and Shambaugh (2010) for trends in the foreign currency position of emerging countries. Aizenman et al. (2015) document the increase in the international reserves held by emerging markets since the early 2000s, attributing it to insure against volatile capital flows, mercantilist motive for specific countries, and possibly even to a regional demonstration effect—a country may gather reserves to keep up with the other countries in the region, termed as the "keeping up with the Joneses" effect.

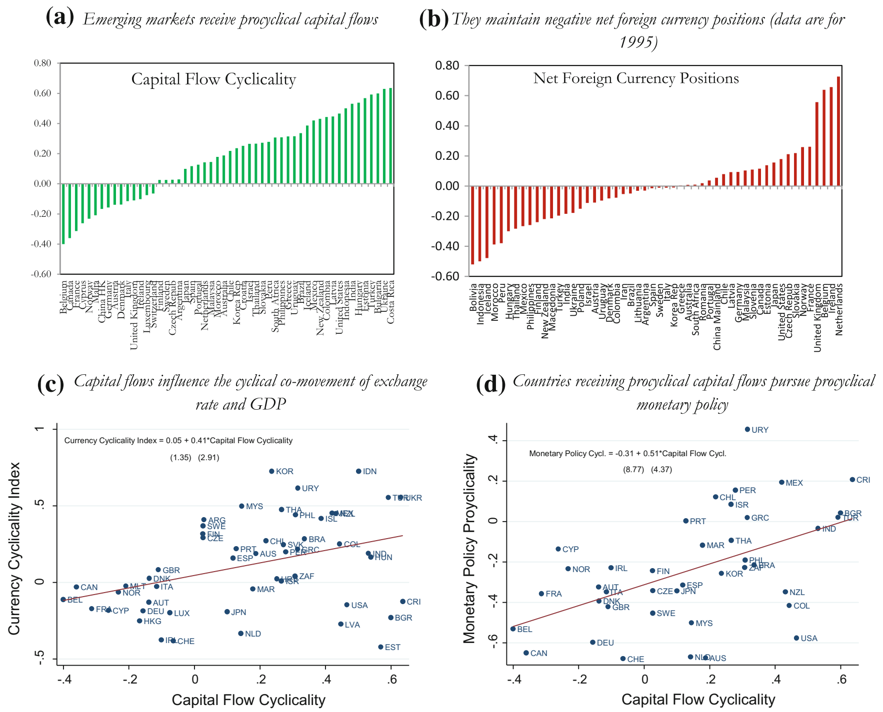

Fig. 1 Emerging economies monetary policies seem to have been influenced in the past by procyclical capital flows and negative Foreign Currency Positions. **a** Emerging markets receive procyclical capital flows. **b** They maintain negative net foreign currency positions (data are for 1995). **c** Capital flows influence the cyclical comovement of exchange rate and GDP. **d** Countries receiving procyclical capital flows pursue procyclical monetary policy. *Note* Procyclicality of capital flows is calculated as the correlation between the cyclical components of quarterly GDP and private net capital inflow. The currency cyclicality index is computed as the coefficient of correlation between the cyclical components of GDP and exchange rates, where the cyclical components are deviations from the trends for quarterly data for 62 countries from 1975, q1 to 2013, q1. Cyclicality of monetary policy is calculated as the correlation between the cyclical components of GDP and short-term interest rates; monetary policy stance is considered to be procyclical if the interest rates are high during the periods of low economic growth. Data on net foreign currency position is from Benetrix et al. (2015) and refers to 1995

An alternative view is provided by Rey (2015), by pointing out that the scale of financial globalization, and in particular the role of global banks in mediating capital flows from advanced economies to emerging economies, has restricted the choice set available to emerging countries even further. It argues that financial integration has allowed the monetary policy of advanced economies to be transmitted to emerging economies. The latter, losing the option to pursue independent monetary policy, only face a dilemma and not a trilemma—they can either have unhindered capital flows or independent monetary policy. In order to pursue independent monetary policy, countries need to either manage their capital account

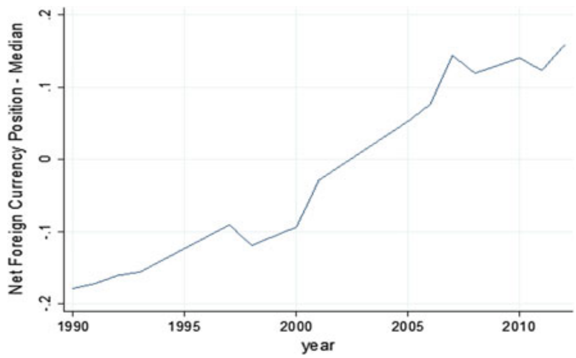

Fig. 2 Net Foreign Currency Positions have improved in Emerging Economies. *Note* Data on net foreign currency position is from Benetrix et al. (2015). The median is calculated for 33 emerging markets included in Cordella and Gupta (2015), wherein more details are provided

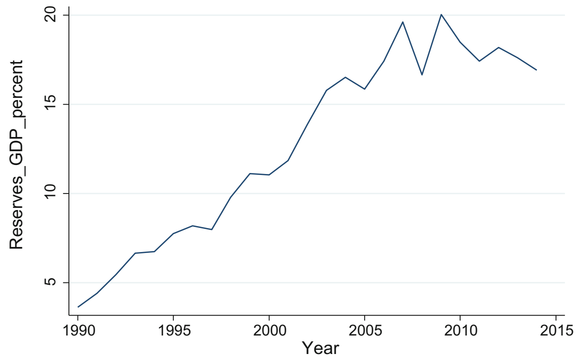

Fig. 3 Emerging economies have accumulated Reserves

directly or via countercyclical macroprudential measures. It dismisses international monetary policy coordination on practical grounds—advanced economies are unlikely to consider anything but domestic policy consideration in formulating their monetary policies.[8]

3 Capital Flows, Exchange Rates, and Reserve Management in India

The Indian experience is broadly consistent with the emerging market trends as discussed above. India maintained a fixed exchange rate regime, a relatively closed capital account and a financially repressed financial sector until the early 1990s. Due to low financial integration with the global economy India was largely insulated

[8]See Korinek and Sandri (2014), Claessens et al. (2013) on the use of macroprudential measures or capital controls in order to modulate the impact of capital flows on credit growth, and thereby reclaim the monetary policy independence.

from external shocks during this period. Monetary policy was thus geared toward maintaining price stability and supporting growth. Nevertheless, large fiscal and current account deficits, and dwindling external reserves culminated in a balance of payments crisis in 1991, when India had to negotiate an IMF program. Sweeping structural reforms were introduced as part of the "conditionality" of the program, which subsequently acquired a momentum of their own and continued even after the program was over. One of the reforms undertaken was to transition from a pegged exchange rate regime to a more flexible one; and another to gradually open the economy to international capital flows. External reserves were accumulated for most of the post liberalization period to keep up with increasing external liabilities.

Capital flows were liberalized starting in the early 1990s, and since then various restrictions on capital inflows have been eased steadily over time. The limit on FDI in specific sectors has been raised and completely removed in several sectors; portfolio equity flows have been liberalized; the ceiling on foreign investment in government debt has been increased from $1 billion in 1998 to 30 billion in 2013; and the limit on corporate debt has been increased from $½ billion in 1998 to 51 billion in 2013.[9]

Besides, firm specific as well as sectoral limits on the share of portfolio equity have been raised, from 24 % in 1992 to 49 % in 2001 and later up to the sectoral limit on the exposure to overall foreign equity investment. The amounts that Indian corporates can borrow abroad have been increased, while the maximum rate at which these borrowings can be raised have been relaxed. Limits on capital outflows by individuals and firms have been liberalized as well.

As a result of the steady relaxation of capital inflows and outflows, India has rapidly become more financially integrated, Fig. 4. It is currently one of the largest recipients of private capital flows in the emerging world, and on average attracts about 8 % of private capital flows and loans to the emerging countries (excluding China, which attracts almost one-hird of total private capital flows to all emerging markets).[10]

Capital inflows to India comprise of FDI, portfolio debt and equity flows, corporate borrowing abroad (called external commercial borrowings or ECB), and deposits held by Indian diaspora in the Indian banks (known as nonresident Indian deposits or NRI deposits). As a result of continued capital inflows, the stock of external liabilities has increased rapidly, far outpacing the size of the economy. The balance of liabilities has tilted in favor of equity liabilities over time, the share of which has increased from about one-fifth in the mid-1990s to about half in recent years, Fig. 5.

Indeed this large exposure to foreign capital has also rendered India vulnerable to external shocks, as, e.g., was the case during the tapering tantrum of summer

[9]Subsequently in September 2015, the RBI announced to increase the limit on FPI investment in government securities to 5 % of the outstanding stock by March 2018. This measure is expected to generate additional inflows of $17 billion.

[10]Though among the largest in absolute terms, India does not rank as high for capital inflows in proportion to GDP.

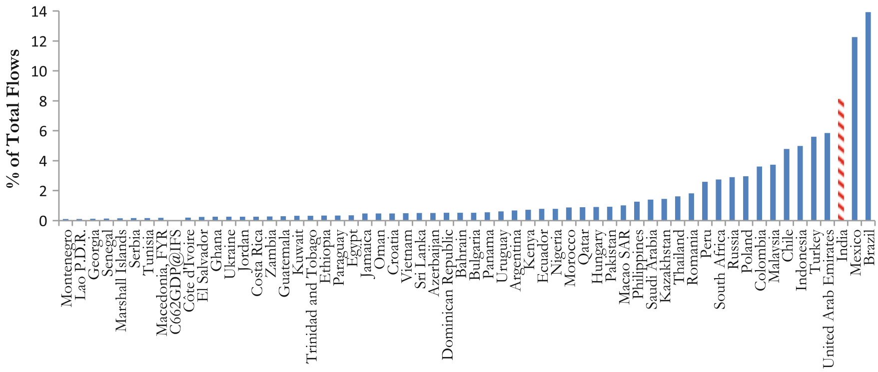

Fig. 4 Allocation of private capital flows (equity, bonds and loans) across emerging markets, 2014 (% of flows to all emerging markets excluding China). *Source* Global Financial Stability Report, IMF, 2015

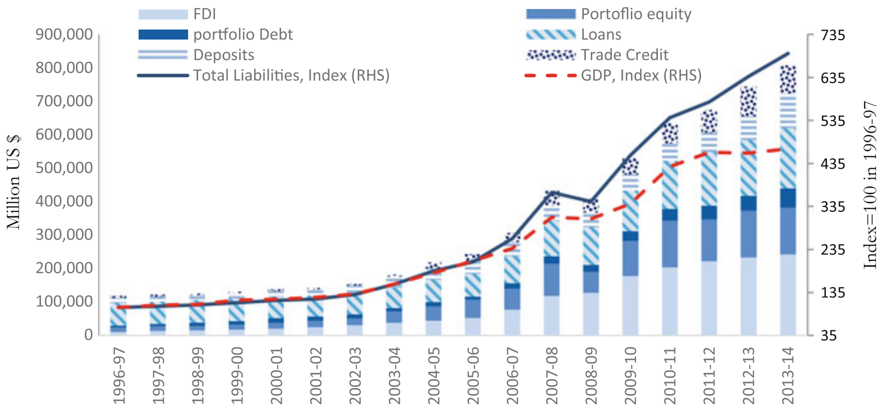

Fig. 5 Total external liabilities have built up in India, outpacing GDP; while its composition has tilted toward equity. *Source* RBI Handbook of Statistics on the Indian Economy; World Development Indicators, World Bank. Capital flows refer to net capital flows

2013, when India was among the most affected countries. Eichengreen and Gupta (2014) analyzed the impact of the Fed's tapering talk on exchange rates, foreign reserves, and equity prices in emerging markets between April–August 2013. They established that an important determinant of the impact across emerging markets was the volume of capital flows that countries received in prior years and the size of their local financial markets. Countries receiving larger inflows of capital and with larger and liquid financial markets experienced more pressure on their exchange rates, reserves, and equity prices once the Fed's "tapering talk" began. Since India ranked high in terms of the size and liquidity of its financial markets, and in the extent of capital flows it received in prior years, it was an easy target for investors seeking to rebalance away from emerging markets.

3.1 *Three Phases of Capital Flows to India Are Evident Since Early 1990s, Which Includes a Surge-and-Stop Cycle*

For easy narration, we divide the post liberalization period in India into three phases. A first phase, lasting for about a decade from the early 1990s until early 2000s, is best described as one of modest capital inflows and a managed exchange rate. The exchange rate was devalued twice in the early 1990s and was later floated, but it continued to be defacto managed. The pace of capital inflows doubled during this period, from an average of nearly $5 billion a year in the early 1990s, to $10 billion a year by the early 2000s. The stock of reserves, which had dwindled to $5 billion prior to the 1991 crisis, was enhanced to about $75 billion by the early 2000s. For most of this period, the monetary policy instrument, money supply until the late 1990s and policy rate thereafter, was broadly set in sync with domestic considerations.

A second phase can be said to last from 2003–2004 to 2007–2008, when India experienced a surge in capital flows. The surge reflected prominently in all components of capital inflows—portfolio flows, FDI flows, and other flows, Fig. 5. Capital inflows accelerated to an average $44 billion a year in the 5 years between 2003 and 2007, compared to an average of 10 billion in three prior years, and at its peak in 2007–2008 exceeded $100 billion in 1 year, Fig. 6. A sudden stop in 2008–2009, when capital flows declined precipitously to $7 billion, then started the third phase, the genesis of which can be traced to the collapse of Lehman Brothers. Capital flows, particularly portfolio and other flows, fluctuated sharply in

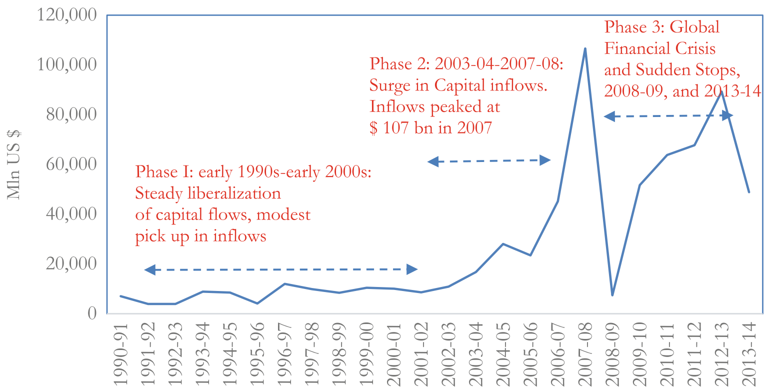

Fig. 6 A surge-and-stop capital flow cycle was evident in India starting in the early 2000s. *Source* RBI Handbook of Statistics on the Indian Economy. Capital flows refer to net capital flows

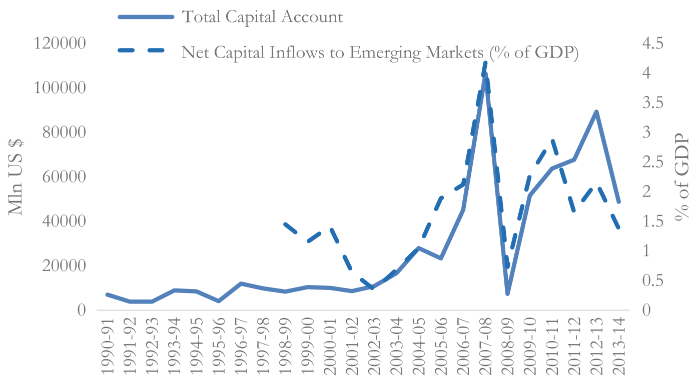

Fig. 7 Capital flows to India follow the same broad trend as flows to emerging markets starting in the early 2000s

subsequent years.[11] Another bout of capital outflows and volatility was evident during the "tapering talk" episode in 2013q3.[12] The discussion below is organized around these three phases of the capital flow cycle (Figs. 7 and 8).

3.2 Exchange Rate Management in India Since Early 1990s—a Steady Move Toward More Flexibility

India's exchange rate regime has become progressively more flexible over time. After the breakdown of the Bretton Woods System in 1971, the rupee was initially pegged to the pound sterling, and then from 1975 with a basket of currencies. Following the balance of payments crisis in 1991 the exchange rate was depreciated twice in quick succession, by 9 and 11 % on July 1, 1991 and July 3, 1991 and was floated subsequently. Even though officially the exchange rate was floated in 1993, in practice it continued to be managed. As per the Reinhart and Rogoff's defacto classification of exchange rates, as well as the IMF's classification, India's exchange rate is broadly characterized as a pegged or managed float from the early 1990s until late 2000s, and as floating since 2010, Appendix Table 1. Increased flexibility of India's exchange rate regime over time is confirmed in monthly

[11]Using methodology standard in the literature, using quarterly data we identify 2008q3–2009q2 as the period of a sudden stop. The criteria used is similar to that in Forbes and Warnock (2012b) wherein a sudden stop is identified if inflows fall one standard deviation below the average of previous 20 quarters for at least consecutive two quarters; and if in at least one quarter, flows fall two standard deviations below the prior years' average.

[12]However, since this event lasted only for a quarter, it does not qualify as a sudden stop as per the standard criteria used in the literature, which require the reversal of capital flows to last more than a quarter.

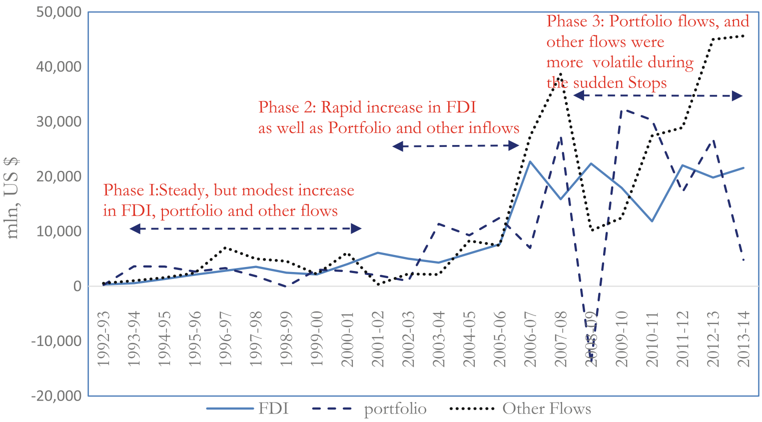

Fig. 8 Portfolio, FDI, and other inflows all accelerated during the "surge," portfolio and other flows have been rather volatile since 2009. *Note* Other flows include NRI deposits, ECB, and short-term credit; portfolio flows include equity and debt flows. Capital flows refer to net capital flows. *Source* is RBI's Handbook of Statistics on the Indian Economy

percent changes in Fig. 9 below as well as in higher frequency data (which we have not presented here for brevity).

Looking at the movement in exchange rate across the three phases of capital flows, the nominal exchange rate depreciated during the 1990s, more than offsetting the impact of inflation on the real exchange rate, which depreciated as well. Subsequently, during the capital surge phase, even as the burden of maintaining the exchange rate shifted to reserves, the nominal exchange rate appreciated mildly. With inflation running high as well, this reflected in a sharp appreciation in the real exchange rate. The nominal exchange rate then depreciated starting in 2008–2009, but not sufficiently to offset the impact of high inflation on the real exchange rate. As inflation picked up during this period, the real exchange rate continued to appreciate.[13]

3.3 Reserve Management—The Level of Reserves Has Increased for the Most Part, Keeping with Increased External Liabilities

Emerging markets hold reserves for a variety of reasons—mercantilism, insurance against shocks to their current and capital accounts, as an indicator of external solvency, and to use it to stabilize the exchange rate. While in the 1980s and 1990s

[13]Basu et al. (2015), Joshi (2013) attribute the increase in current account deficit during this period to the loss of exchange rate competitiveness.

Table 1 Money supply and policy rates during capital flow surge (Annual averages over the period indicated)

	Reserves change ($ bn)	Exchange rate (% change) +	Reserve money growth (% change)	Reserve money in circulation with public (% change)	M3 growth (% change)	Policy rate: Repo/Reverse Repo/MSF rate	CRR
Pre-surge 2000–2001, 2002–2003	12.7	3.96	9.6	12.8	15.2	8.08[a]	6.7
Surge first 3 years: 2003–2004, 2004–2005, 2005–2006	25	−3.3	15.8	14.9	16.6	6.3	4.8
Surge last 2 years: 2006–2007, 2007–2008	79	−3.5	27.4	17.4	21.5	7.53	6.1

Note [a]Average over 2001–02 and 2002–2003. + a positive change is depreciation
Source RBI Handbook of Statistics on the Indian Economy

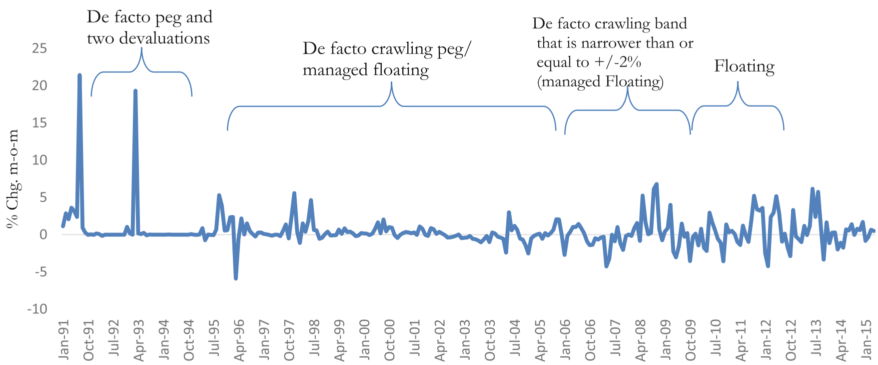

Fig. 9 Monthly percent change in nominal exchange rate confirm defacto managed float until late 2000s, and increased flexibility since 2008. *Source* RBI Handbook of Statistics on the Indian Economy

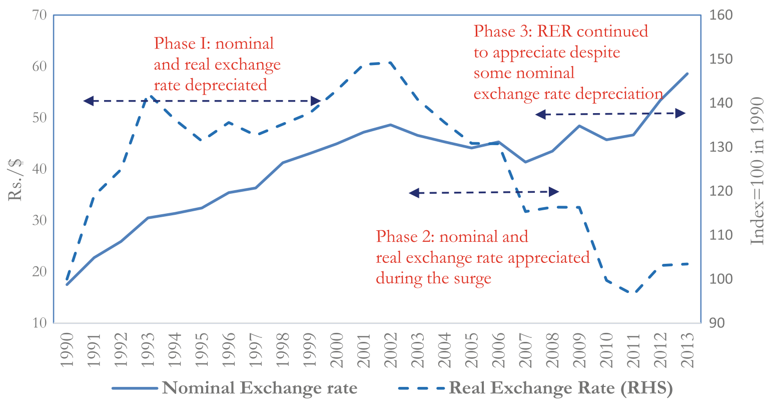

Fig. 10 Trends in nominal and real exchange rate. *Note* Both nominal and real exchange rate are with respect to US $, and are defined such that an increase is depreciation. *Source* is RBI's Handbook of Statistics on the Indian Economy

countries held reserves mainly to defend the level of their exchange rate or to insure against shocks to the current account, insuring against capital account shocks has become a more important motive in the last two decades. Thus, it is perhaps unsurprising, that keeping up with the increased volume of capital flows, the average reserve holding in emerging markets increased sharply in the last four decades, from about 5 % of GDP in the 1980s to 25 % in 2010s (Ghosh et al. 2012b; Aizenman et al. 2013) (Fig. 10).

India too has accumulated reserves over time, Fig. 11. During the early 1990s–early 2000s, the stock of reserves increased at a measured pace keeping with moderate volume of capital flows. It was followed by a sharp accretion of reserves during the period of rapid capital flows, when reserves increased from $76 billion in

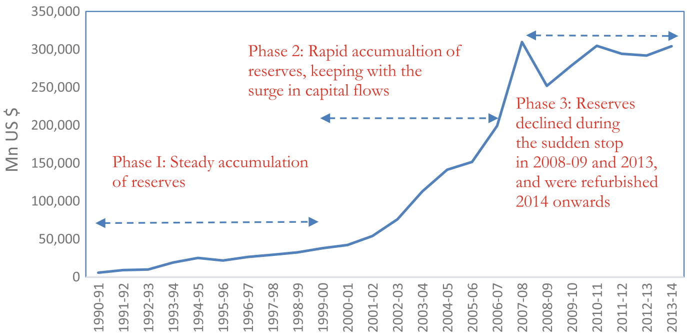

Fig. 11 The stock of external reserves increased in tandem with capital flows until 2008, but remained stagnant in 2009–2013. *Note* Reserve assets comprise foreign exchange assets (currency, deposits, securities, and financial derivatives), monetary gold, SDR holdings, reserve position in the IMF and other claims (loans and other financial instruments). *Source* is RBI's Handbook of Statistics on the Indian Economy

2002–2003 to $310 billion in 2007–2008.[14] Reserves then declined to $250 billion in 2008–2009, due to capital flow reversals after the collapse of Lehman Brothers. Reserves were rebuilt to some $300 billion during 2009–2011, but only to the level last seen before the collapse of Lehman Brothers, at which level they were then maintained in subsequent years. Basu et al. (2015) indicate no attempts to increase the reserve coverage further during this period heightened vulnerability to external shocks, while providing a narrower room to intervene in the foreign exchange market. A corollary being that exchange rate volatility increased during this period (as highlighted in Fig. 9).

The inclination to use reserves to modulate exchange rate volatility seems to have evolved in India since the early 1990s and is mirrored in the volatility of the exchange rate, Fig. 12. While the monthly percent change in reserves were larger in the 1990s, consistent with observed exchange rate stability in the 1990s, the use of reserves declined in the 2000s continuing until 2013. The policy toward building reserves or to use them to modulate excessive exchange rate volatility that prevailed during 2009–2013, seems to have reversed after the tapering talk episode.[15] Reserve accumulation has picked up again since 2014, and as of end April 2015, reserves were at an all-time high of about $350 billion.

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[14]The issue of optimal level of reserves for India, whether India was holding excess reserves, and whether they adversely impacted growth was vigorously debated in the mid-2000s, see Joshi and Sanyal (2004).

[15]One might argue that the increased volatility of the exchange rate is a global phenomenon, and afflicted all emerging markets post 2008. Basu et al. (2015) calculated measures of volatility for a number of emerging countries, and observed that besides India no other country experienced a similar increase in volatility. Empirical evidence shows that high exchange rate volatility can distort investment decisions and affect long-term growth, especially in countries with low levels of financial development see Serven (2003), Aghion et al. (2009).

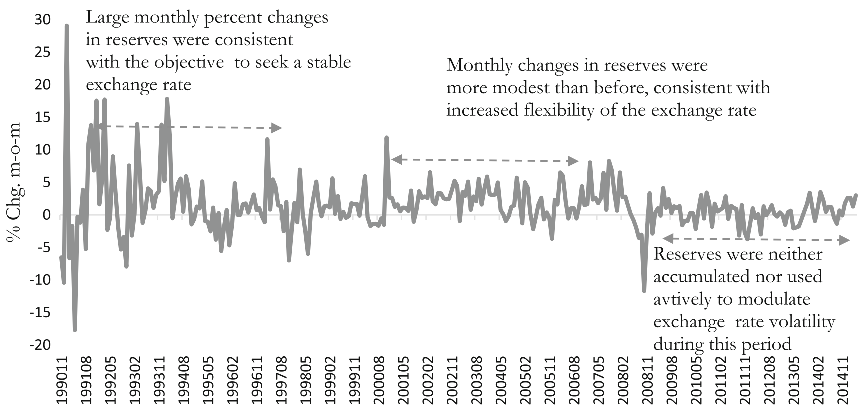

Fig. 12 Monthly percent change in reserves. *Note* calculated using data from Bloomberg

How reserve management affects money supply, interest rates, and the real economy depends on whether they are sterilized or not. Sterilized intervention by keeping money supply unchanged is unlikely to have an impact on interest rates, investment, and growth; but imposes the cost of sterilization on the central bank or the government—known as the quasi fiscal deficit in some parlance. Non-sterilized intervention on the other hand increases money supply, drives the interest rates lower and may have a positive impact on investment on one hand and generate the tendency for the economy to overheat on the other. India has for the most part in the past partially, but not fully, sterilized its reserve accumulation.

Looking broadly at the decomposition of reserve accumulation into sterilized and nonsterilized components since 1991, the RBI partially sterilized the accumulation of reserves (through open-market operations as well as increasing the cash reserve ratio). This is reflected in a decline in the stock of domestic assets with the RBI. The extent of sterilization increased so much in the wake of large capital

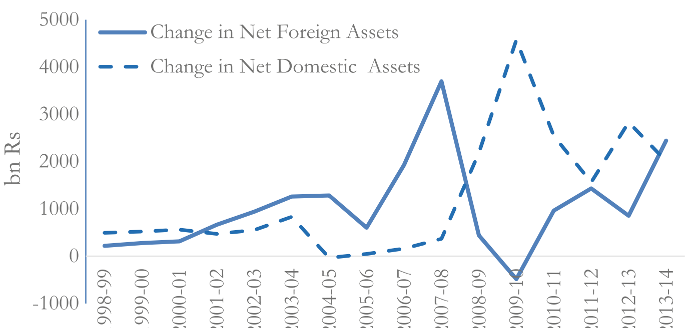

Fig. 13 Increase in reserves in early 2000s was partially sterilized as reflected in a decline in net domestic assets

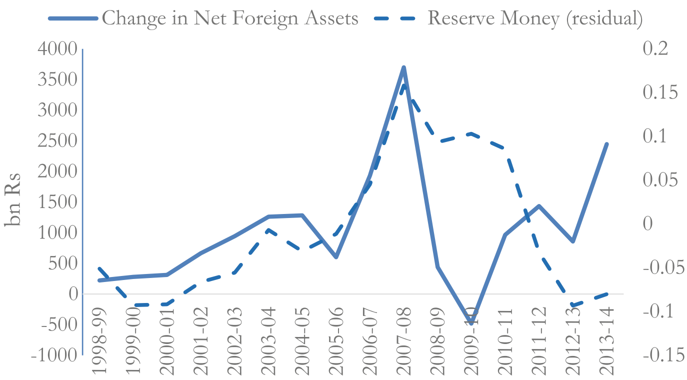

Fig. 14 Increase in reserves in early 2000s was not sterilized fully as reflected in an increase in reserve money, after accounting for growth in nominal GDP. *Note* reserve money series (right axis) is the residual money supply after regressing log reserve money on log nominal GDP

inflows that by end 2003 the RBI had completely exhausted its stock of domestic assets. The government had to create new "market stabilization bonds" in March 2004 that could be sold by the RBI (Joshi and Sanyal 2004). Despite being significant, the sterilization was not 100 %. Increase in reserves was associated with an increase in reserve money supply, Fig. 13. In order to look at the unsterilized part of the reserve intervention we regress log reserve money on nominal GDP—since the demand for money is closely related to nominal economic growth. The excessive money supply is then attributed to the unsterilized reserve intervention by the RBI, Fig. 14.

3.4 Monetary Policy Framework

The major factors influencing monetary policy as well as the instruments of monetary policy have evolved in India.[16] The policy was primarily driven by the financing need of the government until the early 1980s. Besides fiscal dominance, financial repression, in the form of high Statutory Liquidity Requirement (SLR) and Cash Reserve Ratio (CRR), interest rate regulations and directed credit to various sectors limited the availability of credit to the private sector. The policy framework changed in the late 1980s, when price stability was formally accepted as the dominant objective of monetary policy, and a range of 5–7 % was adopted as the target range for inflation. In the monetary framework from the mid-1980s until the late 1990s, described as "monetary targeting with feedback," broad money supply was to be used as the monetary aggregate, to be set in line with projected GDP

[16]See Mohan and Kapur (2009), Patra and Kapur (2012) for a discussion of the evolution of monetary policy in India, from where I have drawn here as well.

growth and inflation target. The move to this framework coincided with wider financial sector reforms–interest rates were initially rationalized and subsequently deregulated completely; and the automatic monetization of fiscal deficits was phased out in 1994–1997.

Another major change in the framework was ushered starting in the mid-late 1990s when interest rates progressively became the main instrument of monetary policy. The bank rate was used as the principal policy rate until 2002, and the reverse repo rate provided the floor for the call money rate. This was followed by a Liquidity Adjustment Facility (LAF) as the operating framework of monetary policy in 2004, wherein the repo rate provided the upper bound of the policy interest rate corridor, while the reverse repo rate provided the lower bound. The operating framework was modified again in 2011, when repo rate was made the only rate to transmit the policy, and reverse repo continued as the lower bound; but a new Marginal Standing Facility (MSF) was introduced under which banks could borrow overnight from the RBI up to 1 % of their net demand and time liabilities (NDTL) at 100 basis points above the repo rate to meet unanticipated liquidity shocks.[17]

The Government of India and the RBI signed an inflation targeting framework as the new guiding framework for monetary policy on February 20, 2015. The framework, based on the recommendation of the Urjit Patel Committee Report (submitted in January 2014), is expected to enhance the credibility of monetary policy and anchor inflationary expectations. As per this framework, the RBI would adhere to a “flexible inflation target,” and strive to attain a CPI inflation target below 6.0 % by January 2016 and a target of 4 %, within a band of (±) 2 % around it, by the end of fiscal year 2017–2018. The objective of monetary policy is set to “primarily maintain price stability while keeping in mind the objective of growth.” The agreement with the government requires the RBI to bring out a document every 6 months explaining the sources of inflation and providing inflation forecast for the following 6–18 months.

It further ascribed that the RBI would be deemed to have missed its target if inflation exceeds more than 6.0 % for three straight quarters in 2015–2016 and all subsequent years; or if inflation is below 2.0 % for three straight quarters in 2016–2017 and all subsequent years. If the RBI is thus deemed to have failed to meet the target, it would have to send a report to the government citing the reasons, propose remedial actions to be taken by the RBI, as well as an estimate of the time period within which it would expect the target to be achieved after implementing the proposed remedial actions.

Further changes in the liquidity management framework were introduced in September 2014 to coincide with the move to inflation targeting framework as per the recommendations of an expert committee (RBI, 2014).[18] The committee recommended that rather than focusing mainly on the overnight segment of the money

[17]As for the objectives of monetary policy, the RBI stated them to be price stability, growth, and financial stability.

[18]See Patra et al. (2016), Chapter X in this volume for details.

market through overnight repos for liquidity management, it should conduct its liquidity management primarily through term repos of different tenors. Some of the key changes in LAF included ending unlimited accommodation of liquidity needs at the fixed LAF repo rate; provision of the predominant portion of central bank liquidity through term repo auctions; fine-tuning operations through repo/reverse repo auctions of maturities varying from intra-day to 28 days; the main liquidity provision instrument—14-day term repo rate—synchronized with the reserve maintenance period, allowing market participants to hold central bank liquidity for a relatively longer period; and progressive reduction of statutory preemptions through the SLR.

The earlier LAF consistently faced the conflict between its monetary policy function or liquidity provision, which often would demand opposite stance, as well as fiscal dominance. As discussed at length in the Patel committee report, either directly or indirectly the government financing needs would be met by the RBI conducting open-market operations.[19]

Another concern has been weak transmission of monetary policy. This primarily happens due to banks not being a great conduit of interest rate transmission, specifically the public sector banks. The transmission has been considered particularly weak in transmitting interest rates cuts as compared to the interest rate hikes. Another reason for weak transmission is a large informal financial sector, where the interest rate at which transactions happen are several times the interest rates in the formal financial sector. These are unlikely to be affected by changes in the policy rates at the margin. These are the issues that are debated actively in the Indian monetary policy context.

4 Monetary Policy Reaction Function—Domestic Policy Objectives of Price Stability and Growth Have Been the Most Important Influences on Policy Interest Rates

In practice what all does monetary policy in India react to? Most existing studies which have estimated the monetary policy reaction function for India find inflation and the output gap to be the major influences on policy rates, with some variation in relative quantitative estimates across studies and over time.[20]

Mohanty and Klau (2004) estimate an open economy Taylor rule for India (as well as for a few other emerging market economies) during 1995–2002 and found the relationship between short-term interest rate and inflation as well as between

[19]It was partly because of RBI managing both government's debt as well as conducting its monetary policy. One belief is that the separation of the debt management office from the RBI would likely make the monetary policy more autonomous (see RBI, Patel).

[20]See Mohanty and Klau (2004), Hutchison et al. (2010), Singh (2010), Verma and Prakash (2011), Patra and Kapur (2012), among others.

interest rates and the output gap to be statistically significant; and the relationship to be somewhat stronger for the output gap. Consistent with these results, in Hutchison et al. (2010) coefficients of output and inflation are significant in the estimates of reaction function over 1980–2008; the coefficient of output is more significant than inflation. Patra and Kapur (2012) estimate several different models using data for 1996–2011 and found that even though the quantitative results are specific to the estimated model, both inflation and the output gap are significant in the policy reaction functions.

Studies using longer time series data show the relative importance of inflation and the output gap in policy reaction function has evolved over time. Singh (2010), e.g., shows the output gap to have a larger influence on monetary policy until the 1980s, and the effect of inflation to be stronger in the following two decades. Mohanty (2013) also finds the impact of inflation to be stronger than that of the output gap (and the latter to be statistically insignificant) during a more recent period, 2000–2001 to 2012–2013.

How may concerns related to exchange rate or capital flows affect monetary policy in an emerging country? As discussed in Sect. 2, capital inflows usually cause exchange rate appreciation and capital outflows result in exchange rate depreciation. Central banks in order to resist these exchange rate movements, may lower the policy rates to deflect capital inflows and raise them to deter outflows. In addition, central banks may buy foreign exchange to build its reserve cover or to avoid exchange rate appreciation during capital inflows or sell them during outflows, but may choose not to sterilize them fully. Thus, the monetary stance often becomes expansionary during capital inflows and contractionary during outflows.

Has monetary policy in India been affected by issues related to capital flows? The evidence is more tenuous on the impact of exchange rate or capital flows on monetary policy in India. Mohanty and Klau (2004) find changes in policy rates to be correlated with exchange rate in India as well as other emerging markets, highlighting the support for the "fear of floating" hypothesis. Additionally, they find the response of policy rates to the exchange rate to be larger than that to inflation or the output gap.[21] Hutchison et al. (2013) estimate the monetary policy rule in India at different times over the 1987–2008 period. They show that external considerations influenced RBI policy over the sample period—taking the form of responding to exchange rate depreciation (appreciation) by raising (lowering) the interest rate. Patra and Kapur (2012) find exchange rates to be broadly insignificant, and to only have a lagged impact on money supply, but not on policy rates.[22]

In our own analysis we correlate reserve money supply (total reserve money supply as well as reserve money in circulation held by public), broad money supply

[21]They also indicate an interesting asymmetry in some countries in that the central bank's response to a negative inflation shock is weaker than to a positive shock.

[22]Taking a different tack in a RBI working paper, Verma and Prakash (2011) find capital inflows to be unresponsive to the interest rate differential, and conclude that the policy rates may primarily focus on domestic inflation and growth objectives, and the response to the magnitude and composition of capital flows may well be through other instruments.

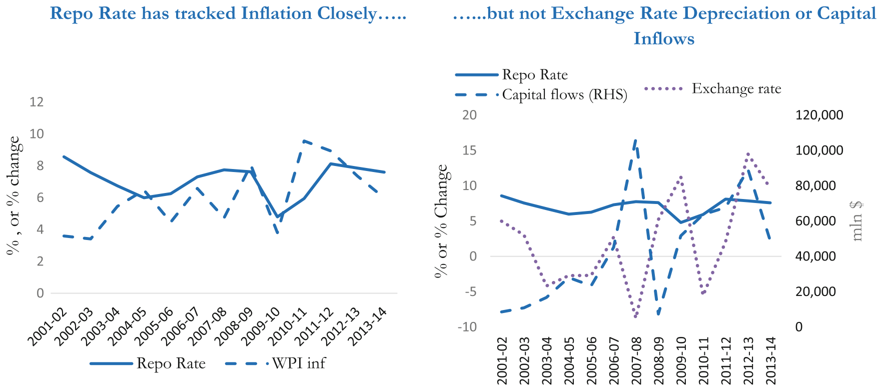

Fig. 15 Policy repo rate seems to have tracked inflation closely, but not exchange rate depreciation or capital flows. *Source* RBI Handbook of Statistics on the Indian Economy

(M3), and the repo rate with capital inflows, and exchange rate movements.[23] We focus on the period from early 2000, since this is the period from when capital inflows have the potential of being an important influence on monetary policy, and since it also coincides with the period when repo rate started to be used as the policy rate.[24] We compare the policy response during the pre-surge period with that during the surge period as well as during the stops. We estimate simple regressions, in which we control for the impact of GDP growth or inflation (WPI inflation being the relevant inflation series during this period) on monetary outcomes (the policy interest rate or money supply).

Our results indicate two regularities. First, domestic policy priorities take precedence over exchange rate or capital flows in the setting of policy interest rates—we find the policy rate to be correlated positively with inflation but not ordinarily with capital flows or exchange rate depreciation, Fig. 15.

Second, the policy response to surges and stops consists of reserve management, liquidity management, and capital flow measures. The "domestic orientation" in monetary policy was tested during the period of capital surge in 2003–2008. During the surge episode, unprecedented large inflows of capital were associated with an acceleration in money supply. Statistics in Table 1 below confirm the policy approach to surges. The Reserve Bank of India confronted with large capital inflows accumulated reserves, and initially sterilized capital inflows by way of open-market operations. However, it did not sterilize the entire impact of its reserve accumulation, because of the finite stock of government securities it held, which it

[23]Mohan and Kapur caution that in analyzing the growth in reserve money supply, one needs to adjust for changes in the CRR. An increase in CRR, even as it impounds excess liquidity from the banking system, ends up showing a larger expansion in reserve money in the Reserve Bank's balance sheet.

[24]During the 1990s bank rate as well as money supply tracked domestic inflation closely.

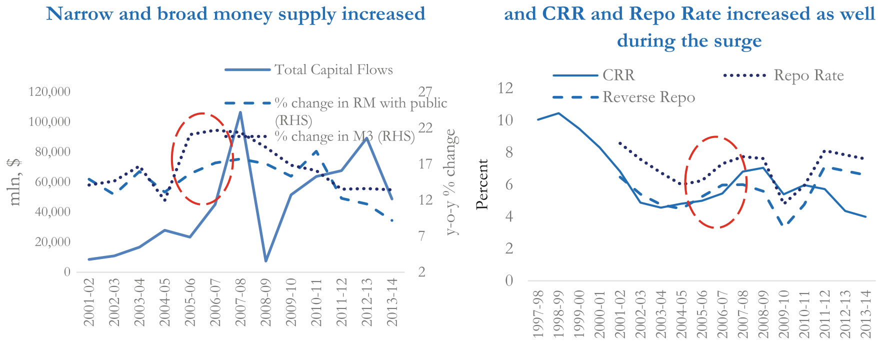

Fig. 16 A multipronged approach was used during the capital surge in mid-2000s which included an increase in CRR and policy rate but also resulted in some increase in money supply. *Source* RBI Handbook of Statistics on the Indian Economy

could use for this purpose. Thus, it signed a Memorandum of Understanding with the Government of India in 2004 for issuance of Treasury Bills and dated Government Securities under the Market Stabilization Scheme (MSS), and used it to absorb liquidity. Due to the partial sterilization of reserve accumulation, both narrow and broad money supply increased during the surge; the extent of which increased in the later years of the surge (also see Fig. 16).

While policy interest rates in India have not ordinarily reacted to the surges and stops of capital flows, some monetary accommodation seems to have occurred through changes in money supply during 2003–2008. Besides the open-market operations and market stabilization scheme, the cash reserve ratio was used to neutralize the expansionary impact of foreign exchange purchases on domestic monetary and liquidity conditions.[25] Policy interest rates increased during the surge, due to a spike in inflation during this period.[26]

The increase in money supply is also evident in quarterly data. In Table 2, using data from 2000–2007, we regress measures of money supply for a dummy for surge years, alternatively takes value 1 for years 2005–2007, or 2006 and 2007. Results show an acceleration in money supply, which picked up in the later years of the surge. It was most pronounced in reserve money supply but less so in the reserve money in circulation and in broad money supply, due to the increase in the CRR. The acceleration is evident even after controlling for GDP growth in the regressions in Table 2.

[25]The increase in CRR was reflected in a much larger increase in reserve money that the RBI issued, but a smaller increase in reserve money in circulation that was held by people.

[26]The episode reversed the steady decline in CRR and policy rates that started in the 1990s as a part of the broader financial liberalization.

Table 2 Money supply during capital flow surge (Quarterly data from 2000–2007)

Dependent Variables →	(1)	(2)	(3)	(4)	(5)	(6)
	% growth in reserve money supply	% growth in reserve money supply	% growth in reserve money supply in circulation with public	% growth in reserve money supply in circulation with public	% growth in broad money supply (M3)	% growth in broad money supply (M3)
Surge dummy = 1 for 2005, 2006, 2007	9.15***		2.31***		3.36***	
	[6.80]		[3.03]		[3.91]	
Surge dummy = 1 for 2006 and 2007		10.17***		3.02***		5.20***
		[6.70]		[3.76]		[7.38]
Constant	10.72***	11.60***	12.82***	12.93***	15.12***	15.1***
	[13.0]	[15.3]	[27.5]	[32.2]	[28.7]	[42.8]
Observations	32	32	32	32	32	32
Adj. R-squared	0.59	0.59	0.21	0.30	0.32	0.63

4.1 Handling Sudden Stops in India—The Role of Monetary Policy

Has India been prone to reversals of capital flows and volatility? After the balance of payments crisis in 1991, India managed to ride the wave of high profile crises in Asia, Latin American and elsewhere in the mid-1990s–early 2000s relatively unscathed. This resilience is attributed to its closed capital account and deft handling of exchange rate and reserve management. However, since then India has had two episodes of capital flows reversal (see Appendix III). First in 2008–2009 when there was a massive sell-off of equities across emerging markets in the immediate aftermath of the collapse of Lehman Brothers. There were large capital outflows by portfolio investors from India putting pressure on the exchange rate between 2008 Q3 and 2009 Q2. This sudden stop episode was handled in a typical manner, through the exchange rate defense using reserves, some exchange rate depreciation, and liquidity management. Reserves declined by $40 bn, about 14 % of the total, within a quarter and exchange rate depreciated by 17 %, over subsequent four quarters. This time around rather than a textbook interest rate increase in response to the sudden stop, policy rates were cut. The repo rate was reduced from 7.8 in 2008 Q2 to 4.8 % in 2009 Q2.

A second episode of reversal was evident in summer 2013, when the expectations that the Federal Reserve would begin reducing the pace of its securities purchases had a large adverse impact on emerging markets. India was among those hit the hardest. Between May 22, 2013, and the end of August 2013, the rupee depreciated by 18 %, and stock prices, foreign reserves and portfolio flows all declined. The reaction was sufficiently pronounced for the press to warn that India might be heading toward a financial crisis.[27] Even though exchange rate depreciated sharply at the time, India was nowhere close to a situation where it would have faced a BOP crisis and sought the IMF program. Contrary to some discussion that took place at that time, given its large reserve level of about $280 bn, a flexible exchange rate, there was no imminent risk of a full-fledged balance of payments crisis.

A more comprehensive defense was mounted this time. A range of policies were announced to contain the impact on exchange rate and financial markets. It intervened in the foreign exchange market, hiked interest rates, raised the import duty on gold, encouraged capital inflows from nonresident Indians, established a currency swap window for oil importing companies, extended a swap line with the Bank of Japan, and restricted capital outflows from residents and Indian companies.

The RBI lost some $13 billion of reserves between end-May and end-September, 2013. It increased its overnight lending rate (the marginal standing facility rate) by 200 basis points to 10.25 % on July 15, 2013, and tightened liquidity through open-market operations and by requiring banks to adhere to reserve requirements more strictly. Gold imports being partly responsible for a large current account deficit, the government raised the import duty on gold multiple times, increasing it from 6 to 15 % cumulatively. India being an oil importing country, demand for foreign exchange from companies that import oil can add significantly to the overall demand for foreign currency and thus affect the level and volatility of the exchange rate. The RBI opened a separate swap window for three public sector oil marketing companies in order to exclude their demand from the private foreign exchange market and reduce its volatility.[28]

New measures were announced to attract capital including from the nonresident Indians; the duration of an existing swap line with Japan was extended, and its limit increased from $15 billion to $50 billion. The RBI increased the foreign borrowing limit for banks (those with the capital adequacy ratio of at least 12 %) from 50 % of unimpaired Tier-I capital to 100 % (for borrowings of at least 3 years); and offered to swap these borrowing with the RBI at a concessional rate of 100 basis points below the swap rate prevailing in the market. The RBI imposed new measures to restrict capital outflows, including reducing the limit on the amount residents could

[27]Basu et al. (2015) suggest that India was affected because it had received large capital flows in prior years and had large and liquid financial markets that were a convenient target for investors seeking to rebalance away from emerging markets. An additional factor was that macroeconomic conditions had weakened noticeably in prior years—reflected in high fiscal and current account deficit and appreciated real exchange rate, rendering the economy vulnerable to capital outflows and exchange rate depreciation and narrowing policy space. Rebalancing by global investors when the Fed began to talk of tapering highlighted these vulnerabilities.

[28]None of these policy measures were novel in the Indian context, having been implemented at different times in the past. Example. the import duty on gold was prevalent until early 1990s; deposits from the Indian diaspora were attracted in a similar fashion twice in the past, in 1998 and in 2000; a separate swap window was made available to oil importing companies in 2008 to reduce volatility in the foreign exchange market after the collapse of Lehman Brothers.

invest abroad or repatriate for various reasons, including for purchasing property abroad. Basu et al. (2015) estimate the impact of these measures on the exchange rate and financial markets. They show that some of these measures, including the separate swap window for oil importing companies, were of limited help in stabilizing the financial markets. Others, like initiatives restricting capital outflows, possibly undermined investors' confidence.

5 Capital Flow Measures—India Regulates Capital Flows Countercyclically Through a Variety of Quantitative and Price Measures

Despite the increased liberalization over time, capital flows continue to be regulated in India through quantitative as well as price restrictions. The overall thrust of policy has been to encourage equity flows over debt flows and long-term flows over short-term flows. There are firm level, sectoral, or aggregate limits on different kinds of capital inflows. There are also restrictions on capital outflows by residents —individuals can remit abroad a limited amount each year, and firms' investment abroad cannot exceed a certain multiple of their net worth. Due to these measures, even as the volume of capital inflows to India has increased overtime, corporate, bank, and sovereign balance sheets have remained relatively insulated from the impact of the occasional reversals of capital and sharp adjustments in exchange rate.[29]

While portfolio equity and FDI inflows have been liberalized steadily over time, the pace of liberalization of debt flows, and outward investment, has synchronized with the underlying capital flow cycles. Further liberalization of debt inflows slowed down during the period of capital surge, and picked up right after the sudden stops. On the other hand, the pace of liberalization of outflows picked up during the surge, but slowed down or even reversed during sudden stops. For example, the quantitative ceilings on foreign investment in government and corporate bonds were liberalized slowly until 2008, but the pace of liberalization picked up after 2009, the phase of slower and more volatile capital flows. Starting from a \$1 billion limit on foreign investment in government bonds and \$½ billion in private bonds in 1998, the limit was enhanced to \$5 billion and \$6 billion, respectively, by 2008. The ceilings were then relaxed rapidly in the aftermath of the sudden stop in 2008–2009 to their current levels of \$30 billion for government debt and \$51 billion for corporate debt. Are these the current levels?

NRI deposit flows to India gained momentum in the 1980s after the RBI introduced NRI deposit schemes to tap flows from the Indian diaspora. It made

[29]Countercyclical macroprudential measures—especially sectoral provisions requirements and risk weights—have been implemented, complementing countercyclical liberalization of capital flows. See Mohan and Kapur, and Patel et al. for details on these.

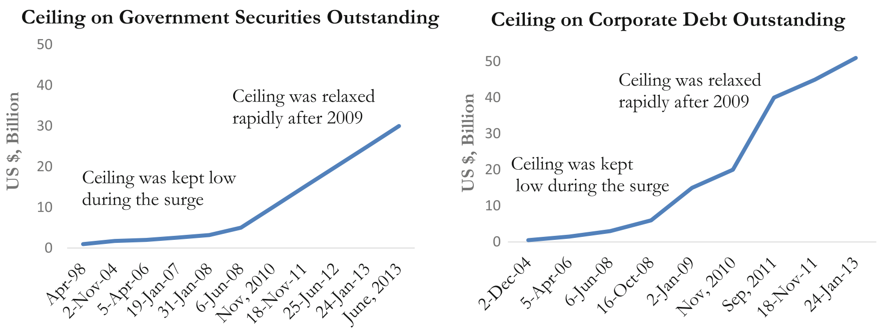

Fig. 17 Ceilings on investment by Foreign Institutional Investors in Government and Corporate debt were liberalized rapidly after the sudden stop of capital in 2008–2009. *Source* RBI Notifications on Foreign Investment in India, and Mohan and Kapur (2009)

deposits fully repatriable, offered attractive interest rates, and assumed the exchange rate risk on foreign currency denominated accounts. These schemes proved to be vulnerable during the 1991 balance of payments crisis, when the outflows of deposits compounded the pressure on the external accounts. Subsequently the composition of deposits was shifted toward rupee-denominated accounts; their repatriable component was reduced; and the exchange risk on foreign currency deposits was shifted to the banks. The deposit inflows resumed and continued to be substantial during the 1990s (Fig. 17).

Authorities responded to the robust inflows and India's strong external position by linking the interest rates offered on foreign currency deposits with Libor rate, i.e., essentially lowering the interest rates on NRI deposits; by granting the banks flexibility to set interest rates on rupee deposits; and by making all new deposits fully repatriable.[30] These measures resulted in the interest rates on NRI deposits declining sharply, and in moderating their inflows. Subsequently the maximum permissible spread on NRI deposits over Libor was lowered during surges, and increased during the period of capital flow slowdown (Fig. 18).

Among other avenues to raise capital, the access of the nonfinancial corporate sector to external debt has been liberalized gradually (external commercial borrowings), but is subject to adherence to criteria on purpose, interest rate spreads and magnitudes of borrowing. Just like for other debt flows, the criteria were relaxed after the collapse of Lehman Brothers, including the interest rates at which these loans could be raised were increased across maturities, Table 3 below.

Capital outflows too have been liberalized progressively. Thus, while inflows by nonresidents have been made freely repatriable, resident nonfinancial companies have been enabled to invest abroad with fewer restrictions, and individuals are

[30]Gordon and Gupta (2004) established that the nonresident deposits respond positively to the differential between the interest rates on these deposits the return on competing international assets; with the impact of the interest rate differential outweighing the impact of other factors.

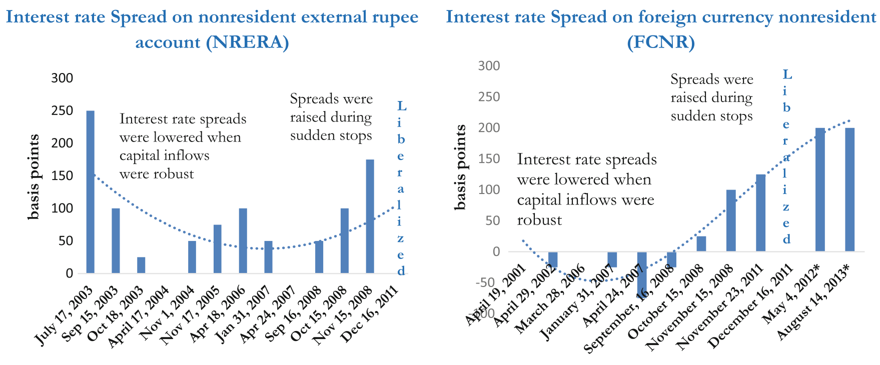

Fig. 18 Ceilings on interest rate spreads (over Libor) for NRI Deposits have been revised in sync with the capital flow cycle. *Source* RBI Master Circulars on Interest Rates on NRI Deposits, various years

Table 3 Cost of external commercial borrowings (over 6 month Libor, in basis points)

	More than 3 years and up to 5 years	More than 5 years and up to 7 years	More than 7 years
Jan-31-04	200	350	350
May-21-07	150	250	250
May-29-08	200	350	350
Sep-22-08	200	350	450
Oct-22-08	300	500	500
Jan-2-09	Fully liberalized	Fully liberalized	Fully liberalized
Nov-23-11	350	500	

allowed to invest abroad within specified quantitative limits (individuals are, however, not permitted to borrow abroad). Individual limits on outward remittances by residents was increased repeatedly during the period of the capital surge, 2003–2007, and lowered in response to capital withdrawals around the tapering talk (Fig. 19).

In wake of the capital account reversal during the tapering talk, the RBI announced restrictions on capital outflows from Indian corporates and individuals. It lowered the limit on Overseas Direct Investment under the automatic route (i.e., the outflows which do not require prior approval of the RBI) from 400 to 100 % of the net worth of Indian firms, reduced the limit on remittances by resident individuals (which were permitted under the so-called Liberalized Remittances Scheme) from $200,000 to $75,000, and discontinued remittances for acquisition of immovable property outside India.

Basu et al. (2015) note that the amounts remitted under the schemes were small, of the order of $100 million a month. There was no surge in remittances during the period of the tapering talk. Outflows were a paltry $92 million in June and $110

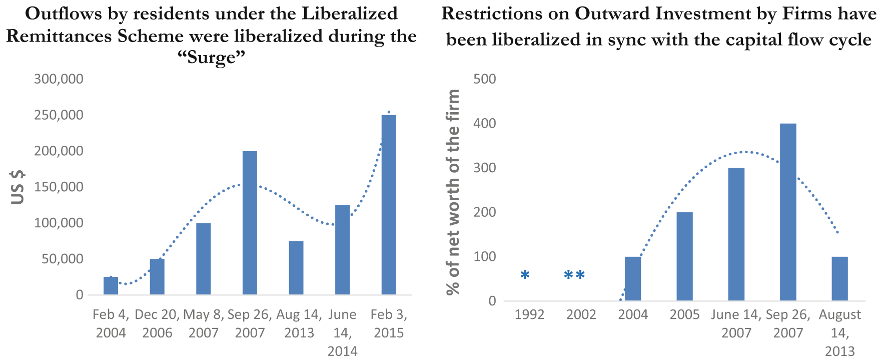

Fig. 19 Outflows permitted under liberalized remittances scheme for residents and overseas direct investment scheme for firms. *Source* RBI Notifications on Liberalized Remittance Scheme for Resident Individuals, and on Overseas Direct Investment, various years. * While overseas investment up to $4 mn can be made via the automatic route, those between 4 mn and 15 mn require the RBI's approval, and investments worth more than 15 mn can only be made with the approval of the Ministry of Finance. ** automatic approval limit raised to 100 mn

million in July 2013, hence there does not seem to be an apparent justification for this restriction. If anything, outflows once underway can be difficult to stem with such restrictions, with the incentive and scope for evasion remaining strong. Results in Basu et al. (2015) indicate that in the 5 days from the time when this announcement was made, exchange rate depreciation and decline in stock market index were accentuated, while equity flows declined. Commentary in the international financial press reflected the fears that these controls evoked (*Economist*, August 16, 2013, "…. India's authorities have planted a seed of doubt: might India 'do a Malaysia' if things get a lot worse? Malaysia famously stopped foreign investors from taking their money out of the country during a crisis in 1998…"; and *Financial Times*, August 15, 2013, "… the measure smacks more of desperation than of sound policy").

6 Summary

Due to steady liberalization of the capital account since the early 1990s and increased financial integration of the Indian economy over time, capital flows to India reflect broad global trends. Just like in other emerging markets, capital flows to India have been subject to a surge-and-stop cycle. The policy response has included reserve management, liquidity management, countercyclical capital flow measures, and some monetary accommodation. Specifically, India eased money supply, accumulated reserves, accelerated the pace of liberalization of capital outflows, and slowed the pace of further liberalization of inflows during the "capital surge" episode of 2003–2008. It tightened monetary policy, which used reserves to meet the demand for foreign exchange and avoid large exchange rate movements, and increased the pace of liberalization of inflows, while restraining outflows, during the periods of tepid inflows or outflows of capital, such as in 2008–2009 or 2013.

Going forward, under the new inflation targeting framework, monetary policy will likely respond even more than before to meet the inflation target and adjust less than before to the capital flow cycles. One concern some people have with the move of a developing country such as India to inflation targeting is that it could result in greater exchange rate flexibility. Having liberalized the capital account progressively over the last two and a half decades, the scope to use capital flow measures countercyclically has perhaps diminished as well. Thus in years ahead, reserve management and macroprudential measures are likely to play a more significant role in helping respond to capital flow cycles, just as the policymakers and the economy develop greater tolerance for exchange rate adjustments.[31]

Appendix 1: India's Exchange Rate Classification

Period	Reinhart and Rogoff (Fine classification)	IMF classification
1992–1995	De facto peg	Conventional fixed peg to a single currency[a]
1996–2005	De facto crawling peg	Managed floating with no preannounced path for the exchange rate
2006–2010	De facto crawling band that is narrower than or equal to ±2 %	Managed floating (with no predetermined path for the exchange rate)
2010–2013		Floating

[a]*Source* Babula and Otker-Robe (2002) (IMF WP/02/155); IMF AREAER reports; Reinhart and Rogoff (2010)

[31]Pontines (2011) examines whether countries that target inflation experience higher exchange rate volatility. After accounting for the self-selection of countries into inflation targeting, he finds that the nominal and real exchange rate volatility is lower in inflation targeting countries, particularly in developing countries.

Appendix II: Liberalization of Capital Flows

FDI Flows

Date	Policy Announcement
July 1991	Restriction of FDI in low technology areas removed, NRIs, and Overseas Corporate Bodies allowed to invest up to 100 % in high priorities sectors, foreign equity limit increased to 51 % for existing companies
October 1991	Power sector opened to foreign and domestic private investment
1991	FDI allowed in passenger cars
October 1998	FDI permitted in mining and production of Titanium ores and Zirconium minerals
2000	FDI up to 100 % permitted under the automatic route in industrial parks
May 2001	49 % FDI in private sector banks under the automatic route
2005	100 % FDI in construction development projects under the automatic route
February 2006	100 % FDI in distillation and brewing of potable alcohol; manufacture of industrial explosives, hazardous chemicals; greenfield airport projects; natural gas/liquid natural gas pipelines, petroleum and natural gas; cash and carry wholesale trading and export trading; coal and lignite mining for captive consumption; infrastructure for marketing, retail of petroleum and natural gas; exploration and mining of diamonds and precious stones
April 2007	FDI in certain telecom services raised from 49 to 74 %
December 2011	100 % FDI under the automatic route for green field investments in pharmaceuticals
December 2012	51 % FDI allowed in multi brand retail under law
July 2013	FDI in basic and cellular service raised to 100 % (49 % under the automatic route, the rest subject approval of the FIPB); 49 % FDI in single brand retail under the automatic route and beyond through the Foreign Investment Promotion Board (FIPB)route; FDI hiked from 74 to 100 % for asset reconstruction companies, 49 % FDI in commodity, power and stock exchanges under automatic route, 100 % in Courier services under automatic route; FDI in PSU oil refineries, commodity bourses, power exchanges, stock exchanges and clearing corporations (up to 49 %) put under automatic route not through FIPB
August 2014	FDI cap in defense and insurance sectors raised to 49 %; and to 100 % in Railways
December 2014	FDI policy for construction eased

Portfolio Equity Flows

Date	Policy Announcement
1992	Foreign institutional investors (FIIs) were permitted into the country in 1992. These could be pension funds, mutual funds or endowments, etc., with at least 50 investors, where no investor held more than 5 % stake in it. They were allowed access to primary and secondary market for securities, and products sold by mutual funds, but had to hold at least 70 % of their investment in equities. Each FII could hold up to 5 % ownership of any firm, and all FII together could not hold more than 24 % of a firm's equity

(continued)

(continued)

Date	Policy Announcement
1996	100 % debt FIIs" were allowed, which could invest in corporate bonds subject to a 30 % ceiling on this investment. Total ownership by all FIIs of local firms raised from 24 to 30 %
1998	In 1998 FIIs were allowed to invest in government bonds, up to a combined ceiling of $1 billion. The ceiling on ownership by each FII in any firm was raised from 5 to 10 %. FIIs permitted to partially hedge currency exposure using the currency forward market
	The same year investment limits by NRIs, PIOs, and OCBs in a firm enhanced from 1 to 5 % of the equity
1999	In 1999 the requirement that FII must have at least 50 investors eased to 20 investors; and in 2000 Requirement that no investor can have over 5 % of the FII fund eased to 10 %
2000	In 2000 only the ceiling upon total ownership by all FIIs of local firms raised from 30 to 40 % (subject to shareholder resolution)
2001	In March 2001, the ceiling was further raised to 49 %, and again in September same year to the sectoral cap of the industry (subject to shareholder resolution)
2003	FII approval process changed from a dual (both RBI and SEBI approving) to a single approval process by the SEBI
2006	FII of up to 23 % permitted in market infrastructure institutions in the securities markets (such as stock exchanges, depositories, and clearing corporations.)
2009	FIIs allowed to participate in interest rate futures
2010	FIIs allowed to offer domestic government securities and foreign sovereign securities with AAA rating as collateral (in addition to cash) to recognized stock exchanges in India for their transactions in the cash segment of the market

Portfolio Debt Flows

Date	Policy Announcement
1995	SEBI released regulations governing FII investment in debt markets in India. Debt limit kept at USD 1–1.5 bn. FIIs allowed to invest in debt markets via 70:30 route, of which equity investments not to be less than 70 % of total funds and maximum of 30 % investment allowed in debt
1996	100 % debt FII allowed to those FII's who were interested only in debt securities. Overall debt limit maintained at $1–1.5 bn for FII investments routed through both kinds of categories. Investment also allowed in corporate bonds of listed (or to be listed) companies
1998	FII in unlisted debt securities permitted. Debt limit in government securities set at USD 1 bn
2004	Debt limit in government securities raised to USD 1.75 bn while that of corporate bonds set at USD 0.5 bn. Under the 70:30 route there was a cap of USD 100 mn and for 100 % debt route this was kept at $900 mn. This cap was raised to USD 200mn and USD 1.55 bn, respectively in November 2004
2006	Debt limit in government securities raised to USD 2 bn while that of corporate securities raised to USD 1.5 bn. The total debt limit was raised from $2.25 bn to $3.5 bn. Separate limit for investment in Upper Tier II instruments introduced and kept at USD 0.5 bn. Limits changed for the 70:30 route and decreased through the 100 % debt category. For the 70:30 route, Government debt increased from USD 225 mn to USD 540 mn and corporate bond from USD 135 million to USD 450 mn, respectively

(continued)

(continued)

Date	Policy Announcement
2007	Debt limit for government securities raised again to USD 2.6 bn
2008	Debt limit for investment in government securities increased to USD 3.2 bn in Jan 2008 and further to USD 5 bn in June 2008
	Limit for investment in corporate bonds doubled to USD 3 bn in June 2008 and further to USD 6 bn in Oct 2008
2009	Limit for investment in corporate bonds increased to USD 15 bn
2010	Debt limits doubled to USD 10 bn in government securities while that in corporate bonds increased to USD 20 bn
2011	Investment limit in government securities increased to USD 15 bn. The incremental maximum of US$5 billion may be invested in securities without any residual maturity criterion
	The limit for investment in corporate securities increased to USD 40 bn in Sep 2011 and further to USD 45 bn in Nov 2011. The incremental limit of US$5 billion may be invested in listed corporate bonds. (3) The limit for infrastructure bonds (separate from corporate bonds) was retained at US$25 billion
2012	Investments limits increased further to USD 20 bn in government securities
2013	Limit for investment in government securities increased to USD 25 bn in Jan 2013 and to USD 30 bn in June 2013
	Corporate debt investment limit increased to USD 51 bn
	The requirement that the government securities have a residual maturity of 3 years at the time of the purchase was eliminated, but FIIs and long-term investors may not purchase treasury bills within the US$15 billion sublimit. In order to simplify the investment limits for FIIs and long-term investors in government securities and corporate debt, the debt limits were merged into two broad categories: (1) The government debt limit merged the two sublimits under government securities to (a) US $10 billion for investment by FIIs in government securities, including treasury bills and (b) US$15 billion for investment in dated government securities by FIIs and long-term investors. (2) The corporate debt limit merged the existing sublimits under corporate debt to (a) US$1 billion for qualified foreign investors (QFIs), (b) US$25 billon for investment by FIIs and long-term investors in sectors other than infrastructure, and (c) US$25 billion for investment by FIIs/QFIs/long -term investors in the infrastructure sector
2014	In Apr 2014, FIIs were permitted only in government dated securities having residual maturity of 1 year. In Jul 2014, investment limit in government securities available to FIIs/QFIs/FPIs was raised by USD 5 billion by correspondingly reducing the amount available to long-term investor from USD 10 billion to USD 5 billion within the overall limit of USD 30 billion. The incremental investment limit of USD 5 billion shall be required to be invested in government bonds with a minimum residual maturity of 3 years. Further, all future investment against the limit vacated when the current investment by an FII/QFI/FPI runs off either through sale or redemption shall also be required to be made in government bonds with a minimum residual maturity of 3 years. It was also clarified that there will be no lock-in period and FIIs/QFIs/FPIs shall be free to sell the securities (including that are presently held with less than 3 years of residual maturity) to the domestic investors
2015	In Sep 2015, the RBI increased the limit that FPIs can invest into government bonds to 5 % of the outstanding stock by March 2018. It also introduced a separate limit for

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Date	Policy Announcement
	investment in State development loans, increased in phases to reach 2 % of the outstanding stock by March 2018. The RBI permitted issuance of Rupee bonds in offshore markets with a minimum maturity of 5 years within the ceiling of investment in corporate debt of $51 billion

External Commercial Borrowings

Date	Policy Announcement
Jan 2004	Prepayment of ECB up to USD 100 mn is permitted without prior approval of RBI; All in cost ceiling on ECBs with maturity of more than 3 years and up to 5 years set at 200 bp above 6 month LIBOR. Ceiling on ECBs with maturity between 5 and 7 years and more than 7 years set at 350 bp above 6 month LIBOR
Jul 2006	Corporates can avail of ECB of an additional amount of USD 250 mn with average maturity of more than 10 years under the approval route, over and above the existing limit of USD 500 million under the automatic route, during a financial year
Dec 2006	Prepayment limit on ECB was enhanced to $300 mn
May 2007	All in cost ceiling on ECBs with maturity of more than 3 years and up to 5 years reduced to 150 bp above 6 month LIBOR. Ceiling on ECBs with maturity between 5 and 7 years and more than 7 years reduced to 250 bp above 6 month LIBOR
May 2008	ECB in infrastructure sector allowed up to USD 100 mn while that in industrial sector allowed up to USD 50 mn for Rupee capital expenditure within the overall limit of USD 500 million per borrower, per financial year, under Automatic Route. Corporates in the services sector allowed ECB up to USD 100 mn, per borrower, per financial year, for import of capital goods. NGOs engaged in micro finance activities can raise ECB up to USD 5 mn during a financial year
	Prepayment of ECB up to USD 500 mn may be allowed by AD banks without prior approval of RBI subject to compliance with the stipulated minimum average maturity period as applicable to the loan
	All in cost ceiling on ECBs with maturity of more than 3 years and up to 5 years raised to 200 bp above 6 month LIBOR. Ceiling on ECBS with maturity between 5 and 7 years and more than 7 years raised to 350 bp above 6 month LIBOR
Sep 2008	All in cost ceiling on ECBs with maturity of more than 7 years raised to 450 bp above 6 month LIBOR
Oct 2008	All in cost ceiling on ECBs with maturity of more than 3 years and up to 5 years raised to 300 bp above 6 month LIBOR. Ceiling on ECBs with maturity between 5 and 7 years and more than 7 years raised to 500 bp above 6 month LIBOR
Jan 2009	Ceilings fully liberalized on ECBs of all maturities
July 2009	Corporates can avail of ECB of an additional amount of USD 250 mn with average maturity of more than 10 years under the approval route, over and above the existing limit of USD 500 mn under the automatic route, during a financial year. Other ECB criteria, such as end-use, recognized lender, etc., need to be complied with. Prepayment and call/put options, however, would not be permissible for such ECB up to a period of 10 years
Sep 2011	Eligible borrowers under the automatic route other than corporates in the services sector viz. hotel, hospital, software, and miscellaneous services can avail of ECB

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(continued)

Date	Policy Announcement
	beyond USD 750 mn or equivalent per financial year. Corporates in the services sector viz. hotels, hospitals, software sector and miscellaneous services are allowed to avail of ECB beyond USD 200 mn or its equivalent in a financial year for meeting foreign currency and/or Rupee capital expenditure for permissible end-uses. The proceeds of the ECBs should not be used for acquisition of land
Nov 2011	Ceilings on ECBs of maturities between 3 and 5 years set at 350 bp over the 6 month LIBOR while that of between 5 and 7 years set at 500 bp over 6 month LIBOR.
June 2012	The maximum permissible ECB that can be availed of by an individual company limited to 50 % of the average annual export earnings realized during the past three financial years. Overall ceiling for ECBs to be USD 10 bn
Aug 2013	Limit on Overseas Direct Investment under automatic route reduced from 400 % of the net worth of the Indian party to 100 %. Resident individuals may set up/acquire JV/WOS abroad within the limit of the LRS. ODI in excess of 100 % of net worth is considered under the approval route by the RBI. Indian companies, statutory bodies, and registered partnership firms (Indian parties) making ODI in overseas JVs or WOS may invest up to 100 % and 400 % of their net worth through the automatic route and approval route, respectively
Sep 2013	Limit on overseas direct investments, through External Commercial Borrowings, reinstated to 400 % of net worth. ECBs permitted to finance general corporate purposes subject to conditions such as average maturity of at least 7 years, the foreign lender should have a minimum direct stake of 25 % in the Indian company; repayment should not commence before completion of 7 years
May 2014	Foreign equity shareholders of Indian companies in the manufacturing, infrastructure, hotels, hospitals and software sectors to be allowed to provide loans (ECBs) for general corporate purposes, which includes for working capital purposes. This would be available with the approval of the authorized dealer bank, subject to: (a) the direct foreign equity shareholder being a 25 % shareholder; (b) the ECB not being used for prohibited purposes; and (c) the principal repayments to start after 7 years from the date of disbursement. The same is available to all eligible borrowers for all other sectors with approval from the RBI
Jan 2015	Authorized money changing banks allowed to create a charge on securities. Until now the choice of security to be provided to the overseas lender or the supplier for securing ECB was left to the borrower
Nov 2015	ECB framework revised to comprise of three tracks. Track I to comprise of Medium term foreign currency denominated ECB with a minimum average maturity from 3 to 5 years. Track II to comprise of long-term foreign currency denominated ECB with a minimum average maturity of 10 years. And Track III comprises of Indian rupee-denominated ECB with minimum average maturity from 3 to 5 years

NRI Deposits

Date	Policy Announcement
February 1970:	Rupee-denominated account—the Nonresident (External) Rupee Account (NR(E)RA)—was introduced. This provided for repatriation of both principal and interest

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(continued)

Date	Policy Announcement
November 1975:	Foreign currency denominated deposit facility—the FCNRA—was added. These deposits were also repatriable and were made attractive to the banks through the RBI assuming the exchange rate risk
November 1990:	A nonrepatriable scheme, the FC(B&O)D, was introduced which was open to both foreigners and NRIs. The scheme was terminated in July 1993
June 1991:	A new foreign currency scheme, the FCON was introduced. Its distinguishing feature was that the principal was not repatriable
June 1992:	A nonrepatriable rupee-denominated scheme, the NR(NR)D, introduced. Banks allowed to fix interest rates on these deposits.
May 1993:	A new repatriable foreign currency scheme, the FCNRB, was introduced, which differed from the FCNRA in that the banks were made to bear the exchange rate risks themselves
May 1994:	The maximum interest rate on rupee deposits reduced to 10 % (the same as on domestic deposits)
Aug 1994	FCNRA scheme was closed to new deposits with effect from August 1994. By 1997, all remaining balances had been repaid
Oct 1994	The maximum interest rate on rupee deposits was further reduced to 8 % (2 % points below the ceiling on domestic deposits)
Oct 1995	The maximum interest rate on rupee deposits increased to 12 %
April 1996	Interest rates on term deposits with maturity of 2 years or higher freed
April 1997	Interest rates on term deposits with maturity of 1 year or higher freed; interest rates on FCNR(B) permitted to be determined by the banks subject to ceilings
Sep 1997	Interest rates on deposits of all maturity freed
Oct 1997	FCNR (B) deposits to be offered at LIBOR of the relevant currency and maturity
April 1998	FCNR (B) deposits of maturity of 1 year or higher to be offered at 50 basis points above LIBOR and lesser maturity deposits to be offered at 25 basis points below LIBOR
Oct 1999	Minimum maturity of foreign currency deposits raised from 6 months to 1 year
April 2001	FCNR (B) deposits to be offered at 25 basis points below LIBOR
April 2002	FCNR(B) deposits with 1–3 years maturity to be offered at LIBOR/swap rates for respective maturities/corresponding maturities minus 25 basis points
April 2002	No fresh deposits to be accepted under NRNR scheme, overdue NRNR deposits not to be renewed, may be credited to the NRE accounts. If the NRNR deposits holder does not hold NRE account, he may be allowed to repatriate the maturity proceeds of the NRNR deposits outside India
July 2003	Ceiling on interest rates on NRE deposits fixed at 250 bps above the LIBOR
Sep 2003	Ceiling on interest rates on NRE deposits fixed at 100 bps above the LIBOR
Oct 2003	Ceiling on interest rates on NRE deposits fixed at 25 bps above the LIBOR
Apr 2004	Ceiling on interest rates on NRE deposits fixed at LIBOR
Nov 2004	Ceiling on interest rates on NRE deposits raised to 50 bps above LIBOR
Nov 2005	Ceiling on interest rates on NRE deposits raised to 75 bps above LIBOR
March 2006	FCNR (B) deposits to be offered at LIBOR
April 2006	Ceiling on interest rates on NRE deposits raised to 100 bps above LIBOR

(continued)

(continued)

Date	Policy Announcement
Jan 2007	Ceiling on interest rates on NRE deposits reduced to 50 bps above LIBOR; FCNR (B) deposits to be offered at 25 bps below LIBOR
April 2007	Ceiling on interest rates on NRE deposits fixed at LIBOR; FCNR (B) deposits to be offered at 75 bps below LIBOR
Sep 2008	Ceiling on interest rates on NRE deposits raised to 50 bps above LIBOR; FCNR (B) deposits to be offered at 25 bps below LIBOR
Oct 2008	Ceiling on interest rates on NRE deposits raised to 100 bps above LIBOR; FCNR (B) deposits to be offered at 25 bps above LIBOR
Nov 2008	Ceiling on interest rates on NRE deposits raised to 175 bps above LIBOR; FCNR (B) deposits to be offered at 100 bps above LIBOR
April 2009	Banks were prohibited from granting fresh loans or renew existing loans in excess of Rs. 100 lakh against security of funds held in NR(E)RA and FCNR (B) deposits either to the depositors or third parties
Nov 2011	FCNR (B) deposits to be offered at 125 bps above LIBOR
Dec 2011	Deregulated interest rates on NonResident (External) Rupee (NRE) Deposits and Ordinary NonResident (NRO) Accounts (the interest rates on term deposits under Ordinary NonResident (NRO) Accounts are already deregulated). Accordingly, banks are free to determine their interest rates on both savings deposits and term deposits of maturity of 1 year and above under NonResident (External) Rupee (NRE) Deposit accounts and savings deposits under Ordinary NonResident (NRO) Accounts with effect from December 16, 2011. However, interest rates offered by banks on NRE and NRO deposits cannot be higher than those offered by them on comparable domestic rupee deposits
Mar 2012	AD Category I banks may allow repayment of such loans to the NRE/FCNR (B) account of the lender concerned subject to conditions
May 2012	FCNR (B) deposits of maturity of 1 and 3 years to be offered at 200 basis points above LIBOR while deposits of maturity between 3 and 5 years to be offered at 300 bps above LIBOR
Oct 2012	Loans against NRE/FCNR(B) Fixed Deposits: Rupee loans to be allowed to depositor/third party without any ceiling subject to usual margin requirements**
	Loans against NRE/FCNR(B) Fixed Deposits: Foreign Currency loans to be allowed to depositor/third party without any ceiling subject to usual margin requirements
Aug 2013	Banks were exempt from the CRR on incremental FCNR (B) deposits and NRE deposits with a reference base date of July 26, 2013, and maturity of 3 years or more, i.e., banks were given the freedom to offer interest rates on NRE deposits with a maturity of 3 or more years without any ceiling
Mar 2014	Interest rates offered by banks on NRE deposits cannot be higher than those offered by them on comparable domestic rupee deposits. Banks no longer exempt from the CRR on incremental FCNR (B) deposits and NRE deposits with a reference base date of July 26, 2013 and maturity of 3 or more years

Outward FDI Flows

Date	Policy Announcement
1992	Relaxation on overseas investment began in 1992. The first step was to introduce an automatic route for overseas investment up to USD 2 mn with a cash component not exceeding US$0.5 million in a block of 3 years

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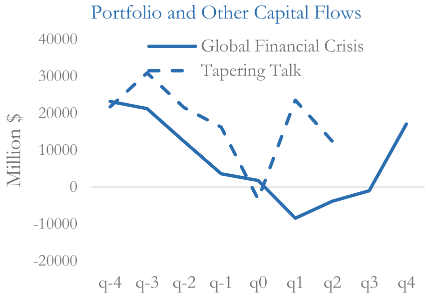
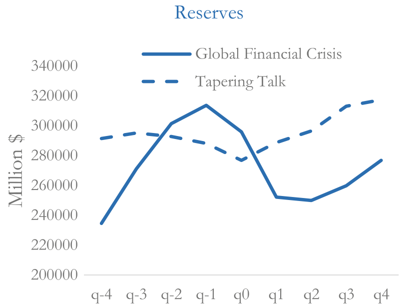
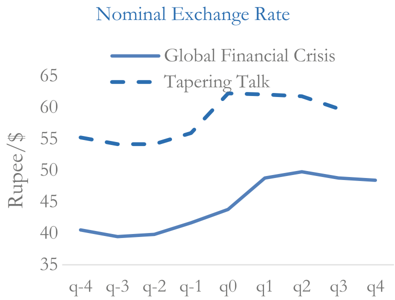
Date	Policy Announcement
1995	A fast track route was adopted where the limits were raised from US$2 million to US$4 million and linked to average export earnings of the preceding 3 years. Cash remittance continued to be restricted to US$0.5 million. Beyond US$4 million, approvals were considered under the 'Normal Route' approved by a Special Committee comprising the senior representatives of the Reserve Bank of India (Chairman) and the Ministries of Finance, External Affairs and Commerce (members). The authority for approval of proposals up to $15 million was vested in the reserve Bank of India, but proposals of more than $15 million still had to be approved by the minister of Finance
1997	Exchange earners, other than exporters, were also brought under the fast track route. Indian promoters were allowed to set up second and subsequent generation companies, provided the first generation company was set up under the Fast Track Route
2002	Per annum upper limit for automatic approval raised to US$100 million of which 50 % could be obtained from any authorized dealer of foreign exchange
2003	Upper limit discontinued when the automatic route for outward FDI was further liberalized in March 2003 to enable Indian parties to invest to the extent of 100 % of their net worth
2005	Limit was raised to 200 % of net worth, prior approval from the RBI dispensed with, and firms were permitted to remit transfer funds through any authorized foreign exchange dealer. Indian firms' access to international financial markets was also progressively liberalized and they were granted permission to use special purpose vehicles in international capital markets to finance acquisitions abroad
2007 (June)	Limit for overseas investment by an Indian company was raised to 300 % from 200 % of its net worth. Resident employees of a foreign company's office, branch, or subsidiary in India in which the foreign company holds not less than 51 % equity, either directly or indirectly, may invest under an employee stock option plan without limit, subject to certain conditions
2007 (Sep)	Limit for overseas investment by an Indian company was raised to 400 % from 300 % of its net worth
2010	Unregistered partnership and proprietorship firms subject to certain conditions may invest abroad up to 200 % of their net worth with RBI approval
2012	Previous condition that the foreign company have a direct/indirect holding of at least 51 % in an Indian company was eliminated. ADs may also allow remittances from resident individuals for acquisition of qualifying shares for the position of director in the overseas company according to the laws of the host country. The limit of these remittances is within the overall ceiling prescribed for resident individuals under the LRS in effect at the time of acquisition. Resident individuals may acquire shares of a foreign entity in part or full consideration of professional services rendered to the foreign company or in lieu of director's remuneration within the overall ceiling under the LRS in effect at the time of acquisition
2013	Limit on Overseas Direct Investment under automatic route reduced from 400 % of the net worth of the Indian party to 100 %. Resident individuals may set up/acquire JV/WOS abroad within the limit of the LRS. ODI in excess of 100 % of net worth is considered under the approval route by the RBI. Indian companies, statutory bodies, and registered partnership firms (Indian parties) making ODI in overseas JVs or WOS may invest up to 100 and 400 % of their net worth through the automatic route and approval route, respectively
2013 (Sep)	Limit on overseas direct investments, through External Commercial Borrowings, reinstated to 400 % of net worth

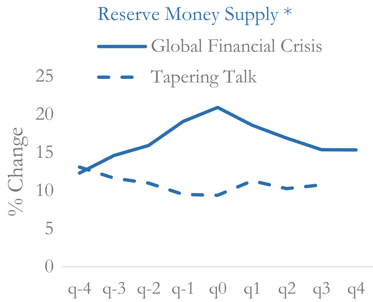
Appendix III: Sudden Stops in India

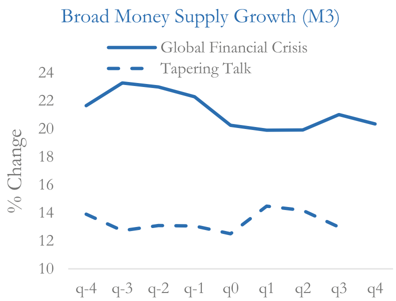
Portfolio and Other Capital Flows	Reserves

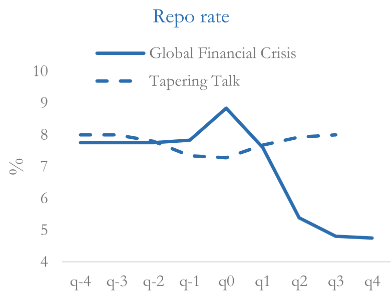












*Narrow money in circulation with public. q0 refers to the quarter the sudden stop started, q-i to quarters before it started, and qi to quarters after it.

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What is Responsible for India's Sharp Disinflation?

Sajjid Z. Chinoy, Pankaj Kumar and Prachi Mishra

1 Introduction

Over the past 15 years, inflation has consistently been a symptom of macroeconomic stability—or lack thereof—in India. Between 2000 and 2006, for example, headline CPI averaged just 4 %, a period during which growth and investment began a secular acceleration and external imbalances narrowed rapidly. However, things began to change from the second-half of the past decade. Headline CPI began a worrying ascent from 2006, and averaged more than 9 % between 2006 and 2013. The stickiness of inflation coincided with growing macroeconomic stability concerns: the post-Lehman growth rebound was temporary, external imbalances began to widen as households flocked to physical assets and gold, and the currency came under sustained depreciating pressures, with things coming to a head during the taper tantrum of 2013.

But, as sticky as headline CPI was between 2006 and 2013, the disinflation since then has been equally dramatic. After peaking at 12.1 % year-on-year growth in November 2013, headline CPI inflation collapsed to 4.3 % in December 2014—a fall of nearly 800 bps in 13 months—before accelerating to 5.5% in April, 2016. The dramatic decline has led to two obvious and related questions. First, what was

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_14

responsible for the sharp decline over the past 3 years? And, therefore, is the decline durable or transitory?

Answers to these questions are not trivial, given the various moving pieces during this period. The disinflation over the past 3 years has been accompanied by a collapse in global oil and commodity prices, a sharp fall in global food prices, a new monetary policy regime aimed at anchoring inflation expectations, a new government working on alleviating food supply bottlenecks, and continued restraint on agricultural support prices. So how does one ascertain the extent to which different factors contributed to the disinflation? This paper uses a simple econometric model and tries to quantify the contribution of the different factors.

Overall, our findings suggest that the evolution of inflation in India is a complex mix of the state of the business cycle (output gaps), adaptive and forward-looking expectations, institutional mechanisms such as the determination of agriculture support prices and backward-looking wage indexation that amplify the persistence of inflation shocks, and global factors that include oil and food prices, and exchange rates.

Simulations based on our econometric model suggest that close to half of the disinflation between fiscal years 2013/2014 and 2014/2015 can be attributed to a moderation in the historical dynamics of inflation which influence contemporaneous inflation. This likely reflects both a softening of backward-looking (adaptive) expectations as well as in the institutional process of wage and MSP setting that increase the persistence of past shocks. In addition, about 20 % of the disinflation can be explained by a sharp decline in the growth of the discretionary component of MSPs, after controlling for the effects of wages, other input costs, and global food prices that go into the determinants of MSP setting. Finally, about a third of the disinflation can be attributed to forward-looking expectations. This likely captures the effect of the new monetary policy regime announced in January 2014, and potentially the fact that the collapse in oil and commodity prices was, over time, perhaps believed to be increasingly permanent, thereby altering future inflation expectations and underpinning wage and price setting behavior. An additional interesting finding that emerges from our analysis is that lagged inflation is a significant determinant of wages and once we include these in the model, the explanatory power of wages reduces sharply; therefore wages are more an "outcome" than a "driver" of the inflation process, which is consistent with the backward-looking nature of wage indexation

The rest of the paper is organized as follows. Section 2 provides some context on the state of play before the disinflation, and Sect. 3 documents the sources of disinflation. In Sect. 4, we estimate an augmented Phillips curve for India and use it to quantify the extent to which different factors were responsible for the disinflation. Sect. 5 concludes with relevant policy implications.

2 Some Context: The Stubbornness of Retail Inflation

To appreciate how dramatic the recent disinflation has been, it is important to understand what preceded it. As indicated above, retail inflation (as proxied by CPI-Industrial Workers) averaged 9.1 % year-on-year between January 2006 and

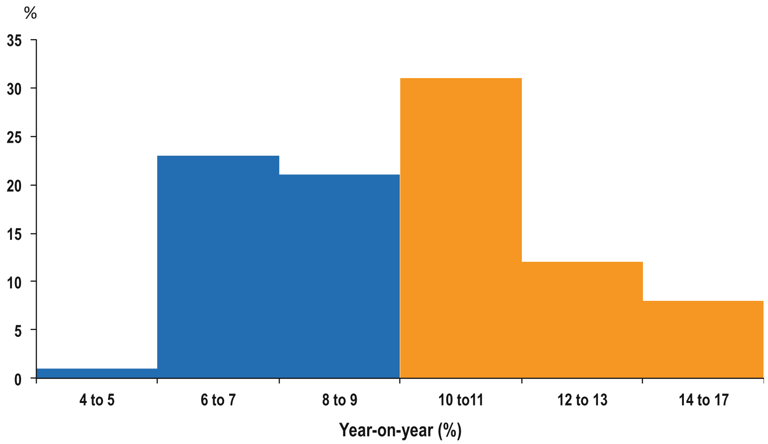

Fig. 1 Frequency distribution of CPI-IW inflation: 2006–13

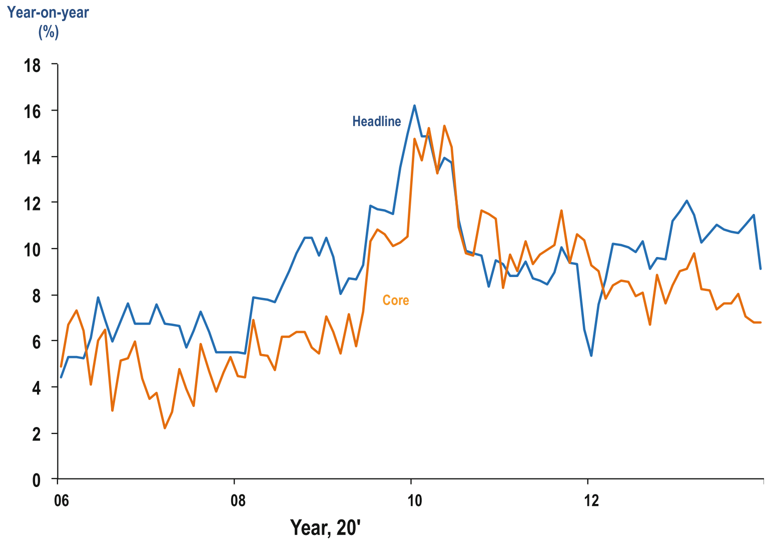

Fig. 2 CPI: Headline and Core-2006–13

December 2014, i.e., a period of 8 years. Of particular salience is both the persistence and breadth of CPI inflation during this time. Of the 96 months under consideration, CPI was above 9 % for 51 % of those months and above 8 % for 63 % of those months. Therefore, 1 or 2 years of abnormally high inflation were not skewing the average (Figs. 1 and 2).

Apart from its persistence, the breadth of inflation was equally worrying. There is a perception that food was the only factor responsible for the high and rising retail inflation. But nonfood, nonfuel (core) inflation averaged 7.8 % during this period, just 130 bps below headline, suggesting that inflation was not only persistent, but also broad based.[1]

3 Followed by the Sharp Disinflation

It is against this backdrop that we need to assess the magnitude of the recent disinflation and its contributors. The new all-India CPI was close to doubledigits between 2012 and 2014, averaging 10.1 % in 2012/2013 and 9.8 % in 2013/2014. Since then, however, there has been a dramatic plunge. Average inflation fell to 6 % in 2014/2015—400 bps lower than the previous 2 years. And in 2015/2016, it was another 110 bps lower, averaging 4.9 %.

How has the disinflation been distributed? 62 % of the decline in headline CPI inflation between 2013/2014 and 2014/2015 is attributable to the disinflation in food, and 38 % is attributable to nonfood. Within nonfood, 22 % of the decline is attributable to core and 16 % to fuel prices.[2] Although the decline in food is a dominant factor, the fact that almost 40 % of the disinflation was on the nonfood side would suggest a relatively broad-based disinflation driven by various factors (Tables 1 and 2).

For now, however, we dig one level deeper into food inflation and examine what has driven the sharp moderation in this category. The decline in food inflation is concentrated in a few commodities. Cereals and vegetables—which account for less than 35 % of the CPI food basket—are responsible for 92 % of the disinflation in food between 2013/2014 and 2014/2015.

Figure 3 below digs deeper into inflation dynamics for various food groups. The decline in the overall CPI inflation rate almost coincides in timing with the reversal of vegetable inflation, which accelerated sharply through the middle of 2013, but then started decelerating from November 2013. Cereals, on the other hand, showed a declining trend even before the drop in overall inflation. In contrast, inflation rates for food groups such as pulses and spices remained firm, despite the overall decline in headline and food inflation.

[1]However, core inflation was persistently below headline for most of the period between 2006 and 2010. The purpose of a core inflation index is to get an accurate measure of the current inflation trend. Since core inflation was lower than the headline till 2010, that may have been suggestive of a downward pressure on future headline inflation (see for example Anand et al. 2014 and also Cecchetti 2007 for a critique of using core as a forecast for future headline inflation).

[2]Core excludes food, fuel, and transport and communication. The latter is included in the contribution of the fuel category.

Table 1 Disinflation dynamics: 2013/2014 and 2014/2015

	CPI	Food	Fuel	Core
Quantum of disinflation	3.8	5.1	4.0	2.2
Contribution by group (%)	100.0	62	16	22

Note Fuel includes "transport and communication" which has a large component of fuel. Core excludes food, fuel, transport, and communication

Table 2 Food disinflation dynamics: FY15 versus FY14

	Food	Vegetable	Cereals
Quantum of disinflation	5.1	22.5	8.2
Contribution by group (%)		58	34

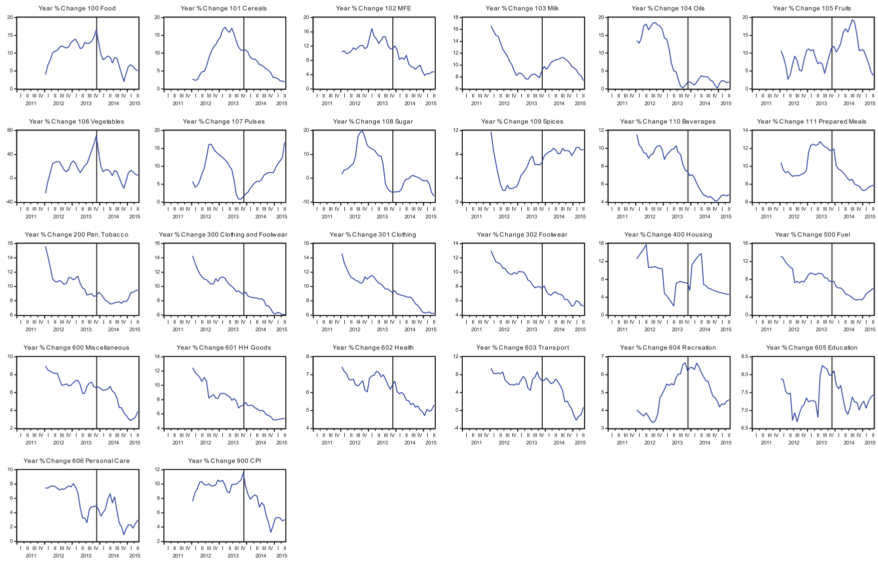

Fig. 3 Y-o-Y Inflation in the major groups and subgroups of CPI

4 Why Has Inflation Declined? Quantifying the Contribution of Different Factors

In this section, we analyze the drivers of inflation in India, to help quantify the drivers of the recent disinflation. We do so in two ways. We start by estimating a single-equation augmented Phillips curve approach, where we model inflation as a function of the output gap, inflation expectations, global factors such as crude and food prices, and structural characteristics unique to India. In the Appendix, we also estimate a general vector auto regression (VAR) model in order to have a more structured approach to identification, to allow for the fact that several key variables in our model are simultaneously determined, and to capture the full dynamic interactions among the variables included in the model. We then use the estimated parameters from these models to quantify the factors contributing to disinflation over the past 3 years.

4.1 Single-Equation Model

We start with a very simple single-equation model representing the Phillips curve introduced in Milton Friedman's Presidential Address to the AEA (1968). This relation can be written as

$$\pi_t = \pi_t^e + \alpha(x_t - x_t^*) + \in_t \tag{1}$$

where π_t is inflation, π_t^e is expected inflation, and x_t is a measure of economic activity, typically either the log level of output or the unemployment rate. The variable x_t* is the long run level of x, which is called the natural rate when x is unemployment and potential output when x is output. The term $x_t - x_t*$ captures short-run fluctuations in output or unemployment, which could be attributed to, e.g., fiscal and monetary policies. The error term $\in_t$ captures unobservable factors that influence inflation. The expected inflation term captures the idea that expectations of inflation tend to be self-fulfilling: if price and wage setters expect a certain level of inflation, they raise their nominal prices and wages to keep up with that expected level of inflation and, in so doing, they perpetuate the very inflation they expected. The $x_t - x_t^*$ term captures the idea that an increase in activity relative to the economy's normal level raises firms' marginal costs, which causes them to raise prices by more than they otherwise would.

Since modeling inflation expectations is not our key focus, we remain relatively agnostic about the expectations-formation process and assume a hybrid expectation formation process with both an adaptive (backward looking) and a rational (forward looking) component present.[3] We capture adaptive expectations by introducing lags of headline CPI inflation. To capture forward-looking or rational expectations, we introduce a "dummy" variable, which takes a value of one during 2014Q1–2015Q1. The dummy captures the timing of the introduction of the new monetary policy regime by the RBI.[4] The new regime of "flexible inflation targeting" with a public commitment to quantitative targets was a structural break from the old

[3]See the Patel Committee report (2014) for a hybrid model of expectation formation, and Ball et al. (Ball 2015) for estimation of a partial-adjustment model of expectations for India. See also Ball (Ball 2011), and references therein for a review of the voluminous literature on estimating inflation dynamics.

[4]See RBI monetary policy statement, January 2014.

"multiple-indicator" regime, and specifically intended to anchor inflation expectations. Once we control for backward-looking expectations, as well as all other potential determinants of inflation, we assume that the dummy can be considered to be a proxy for forward-looking expectations. Admittedly, the dummy is a crude proxy for any anchoring of inflation expectations through the introduction of an inflation targeting regime. The dummy, for example, could also reflect forward-looking expectations of oil and commodity prices on the back of their collapse in 2014, to the extent that forward-looking expectations are not fully captured by current price changes.[5]

Furthermore, we augment the basic Phillips curve model to include several other domestic and global factors that could potentially influence quarterly movements of inflation in India, quite separate from slack in the economy. Domestic variables include (i) changes in minimum support prices for agriculture (which are a policy variable) that along with a system of open-ended procurement by the government set a floor for market prices for many commodities; (ii) rural wages–which are influenced both by slack—and therefore already captured in the output gap—but are also potentially influenced by changes in administratively set minimum wages or Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) wages which will not be captured by the output gap; (iii) a dummy variable for rainfall shortages, which impacts agricultural production and therefore food inflation, and could lead to a more generalized inflation spiral. The global variables we add are international crude prices, global food prices and exchange rate movements to capture pass-through effects.

Specifically, we assume that inflation is determined by the following equation:

$$\pi_t = \sum_{n=1}^{n=8} \zeta_n \pi_{t-n} + \theta D_{new-regime} + \alpha(x - x^*)_{t-1} + \beta w_{t-1} + \gamma msp_{t-1} + \delta Rain_t + \sum_{n=1}^{n=8} \rho_n GF_{t-n} + \tau X_{t-1} + v_t \quad (2)$$

where π_t is the year-on-year growth of headline CPI by quarter; $x_t - x_t^*$ represents the aforementioned output gap which is lagged by a quarter with the potential output being calculated by a simple HP filter[6]; w_{t-1}, and msp_{t-1} are the one-quarter lagged year-on-year growth rates in rural wages, and minimum support prices (MSP) respectively. MSP is set at an annual frequency based on the crop year from July to June. We spread the annual growth in MSP smoothly over the quarters using a cubic spline methodology. $Rain_t$ is a dummy for below-normal monsoon, which takes a value of 1 when the southwest monsoon rainfall for the year is less than

[5]Note that actual crude prices are already controlled for in the empirical framework, therefore the dummy could only reflect the effect of crude prices on expectations.

[6]We use a standard HP filter with a smoothing parameter λ equal to 1600. HP filter is likely to suffer from an end-point bias, i.e., potential output may be affected by actual output at the end-point of the sample; we also use other measures of potential output which may be less subject to this concern (see Table 4 and the robustness section).

85 %.[7] $D_{new-regime}$ is a dummy variable, which takes a value of 1, for the period starting the first quarter of 2014, GF_{t-n} denotes global food prices, X_{t-1} denotes other global factors, namely, one quarter lagged year-on-year growth in crude prices, and the Rs./$ exchange rate.[8] If we compare Eqs. (1) and (2), π_t^e in Eq. (1) is reflected in the first two terms in Eq. (2), $x_t - x_t^*$ is the standard output gap term in both the equations, and all the other expressions in Eq. (2) are captured by $\in_t$ in Eq. (1). The variables in $\in_t$ denote factors that go beyond the standard Phillips curve specification, and are potentially important determinants of inflation in India.

All variables are entered as year-on-year growth rates, and we use quarterly data from 2000Q2 to 2015Q1.[9] We choose eight lags of CPI inflation in our baseline specification. Our choice of eight lags is influenced by tests of optimal lag length and the need to introduce several lags to minimize serial correlation. Previous work also suggests that a shock to inflation impacts expectations by a lag of at least 4–8 quarters (see Patel Committee Report). In our baseline specification, the output gap is estimated using the HP filer. In alternative specifications, we try different measures of the output gap. We lag output gap, global crude prices, and exchange rate by one quarter to capture the fact that transmission from these variables into inflation takes time and will not be instantaneous.

One major concern in the estimation of our baseline specification is that of reverse causality. Wages and MSP could be determined by contemporaneous inflation (see the box below on the potential simultaneity of MSPs, wages and inflation). To start with we lag MSP and wages by one quarter. In the absence of serial correlation in inflation, contemporaneous inflation is less likely to influence past MSPs or wages, unless these variables have a forward-looking component to them, i.e., if for example, expectations about future inflation determine current wages [see the attached box for why this is unlikely in the Indian context].

Additionally, however, if there is serial correlation in the inflation series, contemporaneous inflation is determined by past lags of inflation, which could be correlated with lags of wages and MSP, and bias these coefficients if the past inflation lags are not explicitly included as regressors.

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[7]There is a significant variation in rainfall across geographic regions in India. If rainfall is, for example, below-normal, in regions where crops with high weight in the food basket are grown, that may have a larger impact on food and overall inflation. However, given the absence of a good measure of the spatial distribution of rainfall, it is not included in the empirical analysis. In addition, food inflation is also determined by food management policies of the government, which could be interacted with the monsoon dummy. Again, the lack of good proxies for the latter precludes their inclusion in the empirical specification.

[8]The results are unchanged if we use the nominal effective exchange rate (NEER) instead of the Rs./$ rate. We keep the latter in the baseline as most imports are invoiced in US$.

[9]We tested for nonstationarity in the three key variables of interest—inflation, MSP growth, and wage growth. Using the methodology in Clemente et al. (Clemente et al. 1998), we rejected the null hypothesis of a unit root in the series for inflation and MSP growth at the 10 % level of significance. We could not, however, reject the null of a unit root in the wage growth series. Therefore, we included the first difference of wage growth in the single-equation model for robustness, but the main findings remained unchanged (see Table 5).

Alternatively, there could be omitted variables that determine MSP, wages, and inflation. The government sets MSPs based on recommendations by the Commission for Agricultural Costs and Prices (CACP). CACP calculates future MSPs based on costs of inputs such as fuel, fertilizer, wages, and global food prices. Since costs of inputs feed into inflationary pressures, lags of inflation are likely to be correlated with MSPs. Similarly, lagged inflation could also play some role in the wage setting process. Although wage indexation is not widespread in India, some wages, for example, those under the rural employment guarantee scheme (MNREGS, or the Mahatma Gandhi National Rural Employment Guarantee Scheme)—which are administratively set—are formally indexed to past inflation. For these reasons, omitting lags of domestic inflation would potentially bias the wage coefficients, while omitting lags of both domestic headline inflation and global food inflation would bias the MSP coefficient. Since MSP and administered wages are typically set annually and are likely to take into account the previous year's inflation (either directly or indirectly), we include eight lags of domestic headline inflation and global food inflation to address the omitted variables problem. So the choice of eight lags is dictated both by statistical and economic reasons.

4.2 Empirical Findings

Table 3 below presents our main results. The basic variables of the Phillips curve—the output gap and inflation expectations—are found to have both economic and statistical significance in explaining changes in India's CPI inflation. A one-percentage point increase in the output gap (a negative gap closing or a positive gap widening) increases headline inflation by 52 bps, with a lag of one quarter, and the result is statistically significant at the 5 % level.

Inflation expectations too have an economically and statistically significant impact. Several lags of inflation, even beyond a year, are statistically significant, underscoring the persistence of inflation shocks in India.[10] Having controlled other determinants of inflation, we interpret lagged inflation to proxy for adaptive inflation expectations. More generally, however, lags of inflation could also capture other institutional mechanisms (MSP setting and wage indexation—see Box 1) that propagate the persistence of inflation in India.

The "New Regime Dummy" reduces headline CPI, on average, by 143 bps, and is statistically significant at the 5 % level. As discussed above, the new regime dummy is likely to proxy for forward-looking expectations after controlling for backward-looking expectations, output gap, and other structural determinants of inflation. Given that regime credibility—or lack thereof—is a function of time, we

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[10]Because we use year-on-year inflation rates and a quarterly data, concerns may arise that the serial correlation is by construction. However, even if we use annual data, where there is no correlation by construction, we find lagged CPI to be economically and statistically significant—suggesting it is proxying inflation expectations.

Table 3 Determinants of inflation in India

Dependent variable: year-on-year CPI inflation rate	
Output gap—HP filter—1Q lag	0.52**
Annual growth in wages—1Q lag	−0.04
Annual growth in MSP—1Q lag	0.06^
Dummy for below-normal monsoon	0.67*
Annual growth in \$/Re. exchange rate—1Q lag	−0.08**
Annual growth in world food price index—1Q lag	0.02
Annual growth in world food price index—2Q lag	−0.03^
Annual growth in world food price index—3Q lag	0.01
Annual growth in world food price index—4Q lag	0.00
Annual growth in world food price index—5Q lag	0.01
Annual growth in world food price index—6Q lag	−0.02
Annual growth in world food price index—7Q lag	0.04*
Annual growth in world food price index—8Q lag	0.00
Annual growth in world crude price—1Q lag	0.01^
Dummy for new monetary policy regime#	−1.43**
CPI inflation—1Q lag	0.41**
CPI inflation—2Q lag	0.23
CPI inflation—3Q lag	0.18
CPI inflation—4Q lag	−0.30**
CPI inflation—5Q lag	0.47**
CPI inflation—6Q lag	0.01
CPI inflation—7Q lag	0.01
CPI inflation—8Q lag	−0.21**
Observations	60
R-squared	0.96
D-W-statistic	1.96
B-G serial correlation test (LM test)	0.16
AIC	2.50
SBC	3.33

**indicates significant at 5 % level, *indicates significant at 10 % level, ^indicates significant at 15 % level. #: NEWREGIME is a binary 1 for 2014Q1–2015Q1, a substantially low yoy inflation period

would expect this coefficient to evolve over time. Moreover, while the dummy could reflect the effect of the introduction of the new monetary policy regime, the fact that it is turned on starting from the first quarter of 2014 suggests it could also be capturing how forward-looking expectations may have been influenced by the dramatic collapse in oil prices that year. Therefore, we remain more agnostic about what the dummy captures. Overall, our findings suggest that inflation expectations—both backward and forward looking—are important determinants of inflation in India.

Importantly, the estimated coefficient on minimum support prices (MSPs) is also weakly statistically significant at the 15 % level. A one-percentage point increase in growth of MSP is associated with a 6 bps increase in headline CPI inflation. MSPs are typically a function of input costs, global food prices, and a variety of other factors (see the attached box for details) Therefore, some of the determinants of MSP are likely to be correlated with historical CPI inflation and lags of global food prices that are already included as regressors in our model. Therefore, the estimated coefficient on MSP can be thought of as the "discretionary" increase in MSPs after controlling for other drivers. So while the influence of MSPs in univariate regressions is larger, they are likely reflecting input cost pressures and the influence of global food prices. After one controls these factors, what remains—and is of policy interest—is the discretionary component of MSP setting, which we find is economically but only weakly statistically significant. The significant role of MSP in explaining India's inflation is also consistent with other work such as Anand et al. 2016.

In contrast to the role of MSPs, wages—which are commonly perceived to be a key driver of inflationary pressures—turn out to be statistically and economically insignificant, once we control for the lags of inflation. Specifically, we lag wages by 1 quarter, so that concerns about reverse causality are mitigated, and wages are considered a "predetermined variable." If the inflation series exhibits serial correlation, the latter assumption would not be valid. Including several lags of inflation addresses any problems of serial correlation, and also controls for any role of lagged inflation in the wage setting process. The DW statistic is close to 2, and does not suggest much evidence for serial correlation in the errors. The fact that wages drop out in the presence of inflation lags, suggest that they have no incremental explanatory power, and largely capture variability in previous inflation, which should not be a surprise given the wage indexation process (see Box 1). Wage variability, therefore, can be thought of more as an outcome of the inflation process than a driver of it.

We find that a subpar monsoon has an appreciable, but nonlinear, effect on inflation. When the monsoon is below 85 % of its normal quantum, headline inflation rises by almost 67 bps, and it is statistically significant at the 10 % level. Some lags of global food prices also have some independent explanatory power (at least at the 20 % level of significance), but their primary impact appears to be through influencing the MSP setting process.[11]

Other variables have a smaller impact on inflation in our baseline specification. A one-percentage point increase in global crude prices results in a 1 bps increase in headline CPI, and is statistically distinguishable from zero at the 15 % level. Importantly, the elasticity estimates from our regression model only capture the effect of crude prices on inflation, after controlling for all other potential determinants of inflation. Oil prices could also have effects on inflation through some of the

[11]See, for example, "India's food inflation: worrying about the wrong problem," JP Morgan, July 30, 2015.

other determinants such as MSP and global food prices, and so the composite impact of oil could be larger.

Finally, a 1 % point appreciation of the rupee against the US$ is associated with a reduction in the inflation rate by 8 bps and is significant at the 5 % level. The low estimates for the pass-through of exchange rates into inflation are consistent with some of the prior work on India (see for example, Bhattacharya et al. 2008).

Overall our baseline specification is able to explain about 96 % of the variation in headline CPI.

Box 1: Inflation, Wages, and MSPs: What is Driving What?
Given the institutional structures in India, there is an inherent simultaneity about the evolution of rural wages, minimum support prices, and inflation in India. As we discuss below, each of these variables is potentially a function of the other two. Understanding these relationships, particularly the temporal element, is important to (i) formulating the right specification for modeling inflation, but also (ii) understanding "what's driving what," i.e., whether MSPs and rural wages are outcomes of inflation or drivers of it, and (iii) understanding the reasons behind high degrees of inflation persistence in India.

The simultaneity between wages and inflation is well understood, particularly in developed economies, where organized labor is a substantial fraction of the labor force, and a centralized wage negotiation process largely determines wages. Higher wages, by pushing up input costs, are a key determinant of inflation. Equally, however, inflation drives the wage setting process, either ex ante or ex post. Higher expected inflation has long been hypothesized to put upward pressure on inflation through the expectations-augmented Phillips curve. Equally, unanticipated inflation feeds into wages "after the fact" so as to restore real wages and equilibrate the labor market.

In India, however, this relationship is less typical, because a large fraction of the labor force—particularly in the rural economy—is employed in the unorganized sector that is bereft of unionizations and centralized wage negotiation. Therefore, the feedback from inflation to rural wages is largely "ex post" in the form of administered increases to the rural employment guarantee scheme (MGNREGA) wages. These wages are formally indexed every year to the previous year's CPI-RL inflation and, because they have essentially become the floor of all rural wages, put upward pressure on all rural, and with a lag urban, wages. But, because wages are indexed in this "backward-looking" manner, worries about "reverse causality" are less of a concern, i.e., today's wages are less influenced by expectations of tomorrow's inflation and more by yesterday's inflation.

The real question, therefore, is to understand whether changes in wages exert independent pressure on inflation, or are simply reflecting past fundamentals: inflation and MSPs. As it turns out, it is the latter. Wages have economic and statistical significance in the presence of MSPs. But they cease to become significant as soon as we add more than one lag of inflation. What this suggests is that wage variability, controlling for slack, are more an outcome of previous inflation—which ties in with the "backward-looking" nature of the wage indexation—rather than an independent source of pressure.

The relationship between MSPs and inflation is equally intriguing. By effectively serving as the floor price of key food groups, MSP inflation has an important influence in shaping food, and therefore headline, inflation. The question is whether there is a feedback loop from inflation to MSPs, and whether MSPs too suffer from the same fate as wages, i.e., become insignificant once past inflation is taken into account.

As it turns out, that is not the case. MSPs retain their significance which is unsurprising given that the Commission for Agricultural Costs and Prices (CACP)—which sets the MSPs—has repeatedly indicated that input costs, which would be expected to correlate with past inflation, are only one factor that drives MSPs, and a variety of other factors play a role. Specifically, the CACP cites a variety of other factors apart from input costs (demand and supply; price trends in the market, both domestic and international; inter-crop price parity; terms of trade between agriculture and nonagriculture; likely implications of MSP on consumers of that product) as factors that influence MSP setting.

The fact that the influence of MSPs on inflation is robust to the addition of multiple other controls adds credence of this independent explanatory power of MSPs on inflation. Furthermore, concerns about "reverse causality" are mitigated given that the CACP methodology appears to be based more on historical inputs rather than expected inflation.

Therefore, in the absence of serial correlation, the reverse causality issue is less of a concern.

Finally, MSPs and wages have their own independent dynamic. As the CACP makes clear, past wages clearly have a role in the MSP setting process. But the reverse is also likely true, that MSPs drive the demand for agricultural labor and thereby likely drive rural wages, quite independent from the state of the business cycle or supply shocks.

All told, there is a complex and dynamic interrelationship between MSPs, wages, and inflation. Our empirical work suggests wages are much more of an outcome of the inflation process, rather than a driver of it. In contrast, a component of MSPs is more "exogenous" and seems to have independent explanatory power, even after controlling for other factors. Finally, the backward-looking nature of wage indexation and MSP setting suggest the existence of specific institutional structures in India that can accentuate the impact of exogenous shocks, and lead to persistence of inflation in India.

4.3 Quantifying the Contribution of Different Factors

Figure 4 below shows the fit of our regression model. Since the quarterly movements are volatile, we show the annual average of the predicted and realized values of inflation. As is evident, the predicted and realized values are strongly correlated and our model explains more than 95 % of the quarterly variation in inflation.[12]

Next, we decompose the predicted inflation into its components. The quarterly components are averaged over the year. Predicted inflation declined by 3.5 % points between 2013/2014 and 2014/2015, compared to an actual decline of 3.3 % points.

Table 4 below shows the contribution of various factors in percentage terms, which sum to 100. Lags of inflation—which are a proxy for adaptive inflation expectations but also reflect the persistence of the inflation process resulting from the manner in which wages and MSPs are set in India—account for 46 % of the disinflation. The second biggest contributor is the new regime dummy—which proxies forward-looking inflation expectations—and accounts for 33 % of the disinflation. The discretionary component of MSPs is the third largest contributor, which account for 21 % of the disinflation between 2013/2014 and 2014/2015. Therefore, inflation expectations and MSPs setting seem responsible for the bulk of the disinflation over the past year.

In contrast, the role of global factors is much smaller during this period, with global crude prices and exchange rate stability together accounting for less than 13 % of the disinflation. As explained in the attached box, however, the low contribution of oil prices in explaining the disinflation is both the choice of time period but, more importantly, the fact that only a small fraction of the oil price decline was passed through. Global food prices and a closing output gap, on the other hand were exerting upward pressures on inflation in 2014/15, and therefore contribute negatively to explain the disinflation. We are agnostic in the paper about how fiscal and monetary policies could have contributed to the closing output gap; but clearly despite a fiscal consolidation between 2013/2014 and 2014/2015, the overall policy stance led to closing output gaps. It is perhaps puzzling that we do not find a bigger role for global factors (food, oil, commodities) in explaining the disinflation. Box 2 argues that it is partly due to the time period during which we are trying to explain the disinflation process. If we choose a different period, the role of global factors increases, but domestic factors continue to be the predominant drivers of the disinflation in India.

[12]There could be a legitimate concern that the high R^2 is a sign of overfitting given that we have 60 observations and 24 explanatory variables. However, even if we drop several lags to generate a more parsimonious model, the R^2 is still 91 %, which should allay concerns about overfitting.

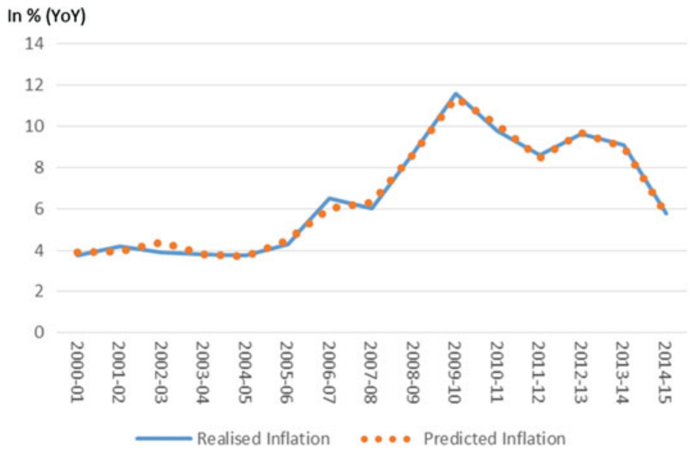

Fig. 4 Fit of the single-equation model

Table 4 Contributors to disinflation between 2013/14 and 2014/15

	In percentage Points	In %
Decline in model predicted inflation	3.3	100
Lagged inflation	1.5	46
MSP	0.7	21
New regime	1.1	33
Global crude	0.1	2
Exchange rate	0.4	11
Output gap	−0.3	−8
Global food	−0.1	−4

Note The decomposition exercise is based on the estimated coefficients in Table 3. The predicted values and the decomposition is based on only those coefficients which are statistically distinguishable from zero at least at the 20 % levels

Box 2: Why not a Larger Role for Oil?

One puzzle is why we do not find a bigger role for oil in explaining the disinflation. Part of it has to do with choice of time period. The exercise we conduct is trying to explain the disinflation across two fiscal years: 2013–2014 and 2014–2015. During this time, for example, (one-quarter lagged) year-on-year oil prices only declined by 8 % on average, which is the reason why oil only accounts for a miniscule percentage (2 %) of the disinflation during this period. If one changes the time horizon, however, global factors play a more important (though still not a predominant) role. For example, oil prices dropped by a massive 66 % during the first three quarters of 2015, relative to the same period in 2014. As a consequence, their contribution to the disinflation rose to 11 % during that period. More generally, the role of global factors (food, exchange rate, oil) in explaining the disinflation rose to 42 % during that particular time period (as is laid out in Table 5)—compared to just 10 % in the baseline period. So the choice of period matters.

That said, even if we choose the specific time period during which global factors were most important, they explain less than half the disinflation. Lagged inflation—proxying for inflation expectations and institutional mechanisms at home—still account for 52 % of the disinflation and, together with MSPs, accounts for 60 %. So "domestic factors" are still the predominant driver of the disinflation, no matter what the time period under consideration. What may be driving that? Key is that a very small fraction of the oil price flowed through into actual price cuts both (i) because the retail price for many petroleum products was subsidized before oil prices began to fall; and (ii)a large fraction of the decline was captured by the government through successive tax hike increases. For example, between October 1, 2014 and March 15, 2016, crude prices fell 56 %, but retail prices of gasoline and high speed diesel only fell 13 and 21 %, respectively, explaining the relatively lower share of oil in explaining India's disinflation.

4.4 Robustness

In this section, we check the robustness of the estimated coefficients in Table 3 to a number of alternative specifications. The results are presented in Table 6. Column [1] repeats the specification in Table 3.

Table 5 Contributors to disinflation between 2015 and 2014 (Q1–Q3)

	In percentage	
	Points	In %
Decline in model predicted inflation	4.40	100
Lagged inflation	2.29	52
MSP	0.36	8
New regime	0.00	0
Global crude	0.48	11
Exchange rate	0.68	15
Output gap	−0.11	−2
Global food	0.71	16

Note The decomposition exercise is based on the estimated coefficients in Table 3. The predicted values and the decomposition is based on only those coefficients which are statistically distinguishable from zero at least at the 20 % levels

Table 6 Determinants of inflation in India: robustness checks

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
	Preferred	Differenced wage	Rain Def >10 %	Alternatives to output gap			Alternative to rain	MSP's total effect by dropping several explanatory variables	Alternative lags of wor ld food prices	
Dependent variable: year-on-year CPI inflation rate										
Output gap—GDP HP filter—1Q lag	0.52**	0.50**	0.48**				0.56**	0.77**	0.40**	0.40**
Output gap—Nonagriculture GDP HP filter 1Q lag				0.54**						
Output gap—GDP Christiano Fitzgerald 1Q lag					0.60**					
Output gap—IIP 1Q lag						0.15*				
Annual growth in wages—1Q lag	−0.04		−0.04	0.00	−0.03	0.01	−0.03		0.01	0.00
Change in annual growth in wages—1Q lag		0.02								
Annual growth in MSP—1Q lag	0.06 ^	0.07*	0.06^	0.07**	0.06^	0.05	0.05	0.32**	0.12**	0.11**
Dummy for below-normal monsoon (def > 10 %)			0.27							

(continued)

Table 6 (continued)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
	Preferred	Differenced wage	Rain Def >10 %	Alternatives to output gap			Alternative to rain	MSP's total effect by dropping several explanatory variables	Alternative lags of wor ld food prices	
Dummy for below-normal monsoon (def > 15 %)	0.67*	0.70*		−0.13	1.02**	0.28		2.20**	0.86**	0.79**
Annual growth in agri-production—1Q lag							−0.05*			
Annual growth in $/Re. exchange rate—1Q lag	−0.08**	−0.07**	−0.08**	−0.06**	−0.08**	−0.05*	−0.07**		−0.04*	−0.04*
Annual growth in world food price index—1Q lag	0.02	0.02	0.02	0.02	0.01	0.01	0.03^		0.00	0.01
Annual growth in world food price index—2Q lag	−0.03^	−0.03^	−0.03	−0.03^	−0.02	−0.03	−0.03^			−0.02
Annual growth in world food price index—3Q lag	0.01	0.02	0.00	0.00	0.02	0.01	0.00			0.00
Annual growth in world food price index—4Q lag	0.00	0.00	0.01	0.00	−0.01	0.00	0.00			0.01

(continued)

Table 6 (continued)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
	Preferred	Differenced wage	Rain Def >10 %	Alternatives to output gap			Alternative to rain	MSP's total effect by dropping several explanatory variables	Alternative lags of wor ld food prices	
Annual growth in world food price index—5Q lag	0.01	0.01	0.01	0.02	0.02	0.01	0.02			
Annual growth in world food price index—6Q lag	−0.02	−0.02	−0.01	−0.03	−0.01	−0.01	−0.02			
Annual growth in world food price index—7Q lag	0.04*	0.04*	0.04*	0.04*	0.03	0.02	0.04*			
Annual growth in world food price index—8Q lag	0.00	0.00	0.00	0.00	0.00	0.01	0.01			
Annual growth in world crude price —1Q lag	0.01^	0.01**	0.00	0.01	0.00	0.01**	0.01	0.01	0.01*	0.01*
Dumm—y for new monetary policy regime#	−1.43**	−1.10**	−1.67**	−1.25**	−2.65**	−1.20*	−1.54**	0.71	−0.66	−0.71
Year-on-year CPI inflation—1Q lag	0.41**	0.36**	0.43**	0.38**	0.44**	0.49**	0.41**		0.49**	0.52**
Year-on-year CPI inflation—2Q lag	0.23	0.22	0.23	0.22	0.19	0.15	0.23 A		0.14	0.18
Year-on-year CPI inflation—3Q lag	0.18	0.14	0.17	0.21	0.19	0.12	0.22		0.15	0.13

(continued)

Table 6 (continued)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
	Preferred	Differenced wage	Rain Def >10 %	Alternatives to output gap			Alternative to rain	MSP's total effect by dropping several explanatory variables	Alternative lags of wor ld food prices	
Year-on-year CPI inflation—4Q lag	−0.30**	−0.28*	−0.30**	−0.39**	−0.21	−0.28*	−0.36**		−0.33**	−0.35**
Year-on-year CPI inflation—5Q lag	0.47**	0.43**	0.45**	0.41**	0.45**	0.39**	0.45**		0.44**	0.42**
Year-on-year CPI inflation—6Q lag	0.01	−0.01	0.02	0.05	0.00	0.06	0.03		−0.01	0.03
Year-on-year CPI inflation—7Q lag	0.01	−0.04	0.01	0.02	−0.05	−0.06	0.00		−0.06	−0.05
Year-on-year CPI inflation—8Q lag	−0.21**	−0.16*	−0.21**	−0.24**	−0.16*	−0.14	−0.21**		−0.20**	−0.21**
Observations	60	60	60	60	60	60	60	60	60	60
R-squared	0.96	0.96	0.96	0.96	0.96	0.94	0.96	0.60	0.95	0.95
D-W-statistic	1.96	1.91	1.90	1.78	1.85	1.67	1.79	0.45	1.74	1.75
B-G serial correlation test (LM test)	0.16	0.01	0.00	1.58	0.60	0.16	0.99	36.66	1.40	1.07
AIC	2.50	2.51	2.56	2.45	2.57	2.82	2.50	4.14	2.54	2.58
SBC	3.33	3.35	3.40	3.29	3.41	3.66	3.34.	4.32	3.14	3.28

*indicates significant at 5 % level, *indicates significant at 10 % level, ^indicates significant at 15 % level. #: NEWREGIME is a binary 1 for 2014Q1–2015Q1, a substantially low year-on-year inflation period

In column [2], we include first difference in wage growth to address any potential nonstationary issues in wages. Column [3] uses an alternative definition of weak monsoon, i.e., a deficiency of 10 % below-normal is defined as a year with below-normal monsoon. Columns [4]–[6] use alternative definitions of output gap. Finally in column [7], we use growth in agriculture production instead of a dummy for weak monsoon.

The key variables of interest reported in Table 3 are robust to all these additional specifications. The coefficient on wages, on the other hand, is statistically indistinguishable from zero in all the specifications. Several lags of inflation and the regime change dummy remain significant across most specifications. Furthermore, the baseline results are also robust to measurements of the output gap. For example, if we use the Christiano–Fitzgerald filter, the effect of output gap on inflation increases to 60 bps, without affecting any of the other results. The impact of the monsoon also remains positive though a deficiency greater than 15 % has a much larger impact on headline inflation (67 bps) against the 10 % threshold (27 bps) reinforcing the non-linearity, and consistent with earlier findings.[13] World food prices—first, second, and the seventh lags remain statistically significant at least at the 20 % level.

The coefficient on MSP ranges from 0.05 to 0.12 in columns [1]–[10] of Table 6, with a one-percentage point increase in MSP being associated with in a 5–12 bps increase in headline CPI inflation. The estimated coefficient is statistically significant at least at the 20 % level in all specifications. We also repeat the decomposition exercise using the estimated coefficients in columns [2]–[10] of Table 6. The results remain broadly robust. Based on the estimated coefficients in columns [3]–[10], the lagged dynamics of inflation continue to be the biggest contributor of the disinflation between 2013/14 and 2014/2015, with their contribution ranging from 37–52 %. The new regime dummy accounts for 14–44 % of the decline in inflation.

Box 3: The Role of MSPs: Separating the Wheat from the Chaff

One ostensible puzzle is that MSPs are only explaining a small fraction of the disinflation—20 % in our baseline—when in fact several commentators have postulated a much greater role for them. The difference arises, in part, because we believe MSPs, themselves, are influenced by a variety of factors (input factors proxied by historical lags of CPI, global food prices) and therefore once we control for those factors independently, the "discretionary" component of MSPs explains a much smaller part of the disinflation. To further tease this out, we run regressions that successively drop these determinants, and would expect to see the role of MSPs correspondingly rise. This would proxy for the "overall effect" of MSPs that other studies may find. In columns [8]–[10] of Table 3, for example, we examine the sensitivity of the coefficient of MSP to dropping some of its potential determinants. In column [8], we

[13]These findings are consistent with earlier work; see, "India's food inflation: worrying about the wrong problem," JP Morgan, July 30, 2015.

estimate a very basic specification with only the output gap, MSP, dummy for monsoon, and a dummy for the new monetary policy regime—thereby dropping all the lags of global food prices and CPI. Not surprisingly, the estimated coefficient of MSP rises sharply from 0.06 in the preferred model to 0.32 in column [8]. These results are important because they suggest that, in fact, MSP growth is proxying the impact of lagged global food inflation and domestic inflation. By excluding these variables, we are mistakenly attributing the role of these factors to MSPs. Importantly, the model in column [8] may also be misspecified because the omitted variables (inflation lags and global food price lags) could also be independently determining inflation, and thereby biasing the MSP coefficient. In columns [9] and [10], we repeat the idea in column [8], but drop only selected determinants of MSP. Specifically, we include only one and four lags of world food price in column [9] and [10] respectively. Not surprisingly, the estimated coefficients on MSP rise relative to our baseline model in column [1], but are lower than that that in column [8] which strips out a larger set of factors determining MSP.

If we use these larger coefficients, the role of MSPs in explaining the disinflation unsurprisingly rises. For example, MSP completely explains the disinflation between 2013/2014 and 2014/2015 if we use the estimates in column [8] where we omit several factors that may be driving the MSP. However, as we alluded to above, this approach is misspecified, given some of the omitted variables are also found to influence CPI inflation. Based on specifications where some of these omitted variables are included, [columns 9 and 10], the contribution of MSP reduces to between 43 and 48 %, suggesting that world food prices, for example, are a significant determinant of MSP, and that the contribution of the exogenous component of MSP reduces once we account for previous years' world food prices. All told, however, we believe that specifications where any of these variables are omitted, may end up bumping up the MSP coefficient, but (a) are misspecified, and (b) the higher MSP coefficient is actually just capturing other underlying forces. To confirm this, we estimate a simple regression of MSP on lags of CPI inflation and lags of world food prices. Lags of inflation are included to capture broader input costs. We include eight lags of each. The variables explain a substantial fraction—68 %—but not all of the variation in MSPs (see Fig. 6). This is not surprising given that the CACP itself explicitly indicates that it uses a multitude of information to set MSPs (see Box 1).

4.4.1 More on wages and inflation

In order to explore further the relationship between wages and inflation, we modify the baseline specification in Table 3. Table 7 shows the results. Column [1] repeats the results from Table 3. In column [2], we use contemporaneous wages instead of one-quarter lags. Column [3] drops all lags of inflation. Column [4] use contemporaneous wages and drops the lags of inflation. Column [5] includes only one lag of inflation.

Column [2]–[4] of Table 7 reveals that wages have a positive association with headline CPI, but only in the absence of lags of inflation. The relationship is strongly positive and statistically significant in columns [3] and [4]. Using contemporaneous wages instead of lags also increases the explanatory power of wages,

Table 7 Inflation and Wages in India

	Wages and prices				
	[1]	[2]	[3]	[4]	[5]
	Preferred	Contemp oraneous wages	CPI lags absent	[2] and [3]	One CPI lag
Dependent variable: year-on-year CPI inflation rate					
Output gap—HP filter—1Q lag	0.52**	0.44**	0.37**	0.30**	0.29**
Annual growth in wages		0.06		0.25**	
Annual growth in wages—1Q lag	−0.04		0.22**		0.04
Annual growth in MSP—1Q lag	0.06^	0.09**	0.13**	0.14**	0.06^
Dummy for below-normal monsoon (def > 15 %)	0.67*	0.75**	1.12*	1.26**	0.78*
Annual growth in $/Re. exchange rate—1Q lag	−0.08**	−0.06**	−0.05	−0.05*	−0.03
Annual growth in world food price index—1Q lag	0.02	0.01	0.04^	0.02	0.03^
Annual growth in world food price index—2Q lag	−0.03^	−0.03	−0.04	−0.01	−0.04
Annual growth in world food price index—3Q lag	0.01	0.01	0.02	0.00	0.02
Annual growth in world food price index—4Q lag	0.00	0.00	−0.01	0.00	−0.01
Annual growth in world food price index—5Q lag	0.01	0.01	0.00	−0.01	0.02
Annual—growth in world food price index—6Q lag	−0.02	−0.02	−0.01	−0.01	0.00
Annual growth in world food price index—7Q lag	0.04*	0.03^	0.00	0.01	0.02
Annual growth in world food price index—8Q lag	0.00	0.00	0.04**	0.03^	0.00
Annual growth in world crude price—1Q lag	0.01^	0.01**	0.00	0.01	0.00
Dummy for new monetary policy regime#	−1.43**	−0.61	0.38	0.67	−0.38
Year-on-year CPI inflation—1Q lag	0.41**	0.37**			0.68**
Year-on-year CPI inflation—2Q lag	0.23	0.15			

(continued)

Table 7 (continued)

	Wages and prices				
	[1]	[2]	[3]	[4]	[5]
	Preferred	Contemp oraneous wages	CPI lags absent	[2] and [3]	One CPI lag
Year-on-year CPI inflation—3Q lag	0.18	0.14			
Year-on-year CPI inflation—4Q lag	−0.30**	−0.28**			
Year-on-year CPI inflation—5Q lag	0.47**	0.38**			
Year-on-year CPI inflation—6Q lag	0.01	−0.06			
Year-on-year CPI inflation—7Q lag	0.01	−0.02			
Year-on-year CPI inflation—8Q lag	−0.21**	−0.15			
Observations	60	60	60	60	60
R-squared	0.96	0.96	0.86	0.91	0.93
D-W-statistic	1.96	1.81	1.09	1.10	2.05
B-G serial correlation test (LM test)	0.16	0.66	13.65	11.19	0.61
AIC	2.50	2.48	3.45	3.02	2.84
SBC	3.33	3.32	4.01	3.58	3.43

**indicates significant at 5 % level, *indicates significant at 10 % level, ^indicates significant at 15 % level.#: NEWREGIME is a binary 1 for 2014Q1–2015Q1, a substantially low YOY inflation period

but the main effect comes from dropping the lags of inflation. Specifically, a one-percentage point increase in wage growth increases headline inflation by 0.26 bps in column [4], and the effect is statistically significant at the 5 % level. Even adding just one lag of CPI in column [5] causes the economic significance to drop by 80 %. The results confirm that lagged inflation is a significant determinant of wages; and once we include these in the model, the explanatory power of wages reduces sharply, which is consistent with the backward-looking nature of wage indexation, as discussed in Box 1.

Importantly, this is also true after controlling for the output gap. Therefore, the wage coefficient can be interpreted as the portion of wage growth impacting inflation that only arises from administrative increases, (e.g., increases in MGNREGA or minimum wages) since the variability of wages on account of slack is likely correlated with, and captured by, the output gap variable. What this suggests is that administrative increases in wages are correlated with lagged inflation—which is understandable because they are typically motivated by cost of living adjustments—and therefore have no independent explanatory power. Overall, wages are determined within the system and, once we control for MSPs, output gaps, and lagged inflation, wages have no *independent* influence on headline CPI.

The results seem to suggest that wages are more an "outcome" than an independent "driver" of the inflation process. The results do not imply that wages do not matter for inflation; they suggest that wages affect inflation, but through lags of inflation; to the extent there is a wage indexation process, wages do indeed matter.

Figure 5 shows the fitted values from a simple OLS regression of wages on eight lags of inflation. The eight lags of inflation explain about 80 % of the variation in

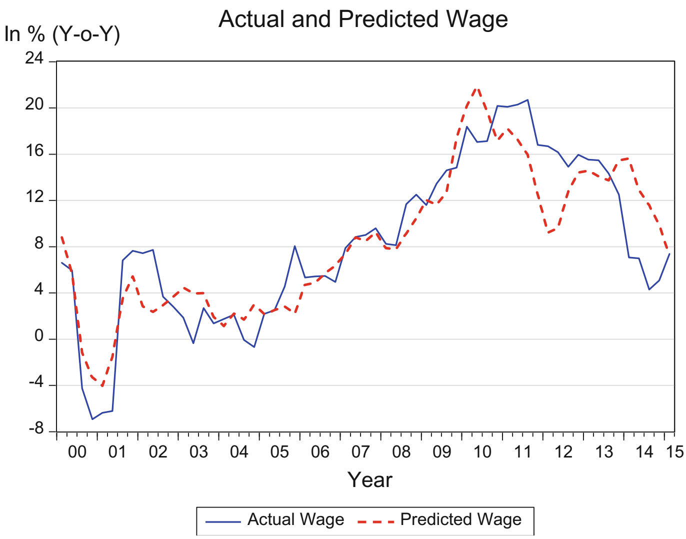

Fig. 5 Growth in wages and lagged CPI inflation

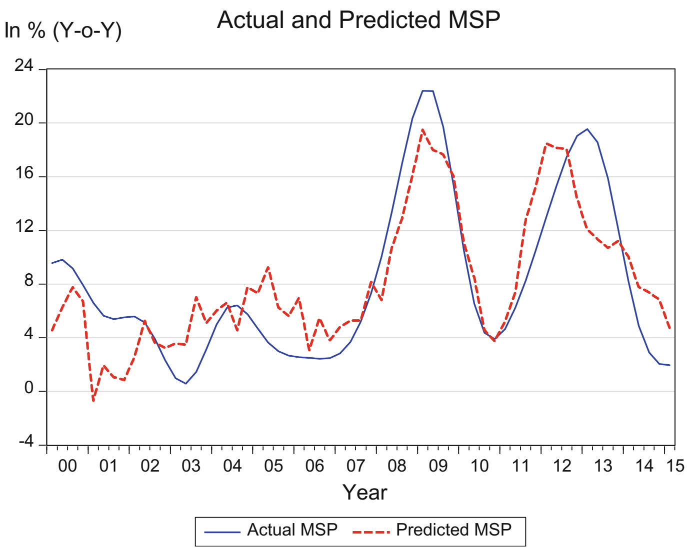

Fig. 6 Growth in MSP, lagged CPI inflation, and world food prices

wage growth. The figure clearly shows that lags of inflation do a good job of predicting the wage process. Figure 6 plots the actual growth in MSP and the fitted values from a regression of MSP growth on eight lags of CPI inflation and world food price growth.

Figure 5 plots the actual wage growth and the fitted values from a regression of growth in wages on eight lags of CPI inflation.

5 Conclusions and Policy Implications

Over the past decade, inflation has emerged as a primary concern for India's policymakers. Worries grew as the inflation rate rose since 2006 and remained elevated and sticky at around the 9 % level between 2006 and 2013. The inflation rate, however, has fallen dramatically since then. After peaking at 12.1 % year-on-year growth in November 2013, headline CPI inflation collapsed to 4.3 % in December 2014 and has averaged 5.1 % in 2015 and the first half of 2016. This paper analyzes the dramatic decline in inflation, and quantifies the contribution of different factors in explaining the disinflation process.

We estimate an augmented Phillips curve for India and use it to quantify the extent to which different factors were responsible for the disinflation between 2013/14 and 2014/15. Our main findings are described as follows:

- 20 % of the disinflation can be explained by a sharp decline in the growth of the "discretionary" component of MSPs.
- The bulk of the disinflation (45 %), however, can be attributed to a moderation in the historical dynamics of inflation that influences contemporaneous inflation. This moderation is likely reflecting a softening of backward-looking (adaptive) expectations as well as capturing the institutional process of wage and MSP setting that amplifies the effects of shocks and leads to persistence in inflation.
- We also find an important role for forward-looking expectations. Almost 35 % of the disinflation can be attributed to this. That said, forward-looking expectations could capture both the effects of the new monetary policy regime announced in the first quarter of 2014, but may also be reflecting more benign future expectations of oil and commodities, that may have translated into wage and price setting behavior.
- Finally, we find that the role of global factors, namely global crude prices and exchange rates, in explaining the disinflation between 2013/2014 and 2014/2015 is less than 15 %, though the contribution of global factors rises if we choose alternative time periods.
- Finally, output gaps are estimated to have closed during this period, and hence the business cycle was actually putting upward pressure on inflation at that time.

There seems a general perception that India's disinflation has been achieved mainly at the altar of good luck due to the collapse in global commodity prices, or through a sacrifice in domestic growth emanating from a sharp fall in domestic demand. Our empirical analysis, however, finds that these factors do not explain the bulk of the disinflation between 2013/2014 and 2014/2015. Instead, our findings suggest that the evolution of inflation is a complex mix of the state of the business cycle, inflation expectations, institutional structures, and global factors. What we essentially find is that exogenous shocks to inflation—from lower discretionary component of MSPs, a new monetary regime, global commodities—were perpetuated through backward-looking expectations and domestic institutional structures that amplified the influence of the original shocks.

6 Appendix: Vector Autoregression Model

A natural extension of our single-equation model is a more general vector autoregressive model (VAR) where we can consider several endogenous variables together so that they are simultaneously determined, and we can accommodate a more generalized lag structure so that each variable evolves dynamically. The VAR captures the full dynamic interactions among the variables included in the model, so, for example, we can shock MSP and trace out the empirical response of inflation to that shock by quarter.

Based on the institutional processes for the determination of inflation, and tests of residual autocorrelation, we specify a lag length of 8 quarters. We assume a simple Choleski ordering with the global factors being the most exogenous, followed by output gap, wages, MSP, and inflation. We assume that shocks to inflation do not affect any of the other variables within the quarter (so that inflation is last in the Choleski ordering). The results are similar if MSP is ordered before wages.

The resulting impulse responses are plotted in Fig. 7. The impulse responses suggest that a one standard deviation shock to growth of MSP increases inflation by 0.3 % points, which is statistically significant. The effect, however, is not persistent, and is statistically indistinguishable from zero by the second quarter. Wages have a much smaller effect than MSP, and are not persistent. About 50 % of the variability in inflation over the entire sample is explained by output gap, 30 % by MSP, and 10 % by dynamics of inflation. Although the direction of change in the output gap does not play a role in explaining the recent disinflation, the output gap, per se, does play a dominant role in explaining the variability over the sample, confirming the existence of a Phillips curve in India.

The VAR broadly validates our single-equation results vis-à-vis the drivers of the disinflation. Lagged inflation, MSP, and the regime change dummy still account for the largest share of the disinflation between 2013/2014 and 2014/2015. The role of MSPs is almost identical in both the models. Like the single-equation model, crude and the exchange rate only played a minor role in the disinflation, in the time period under consideration, whereas a closing output gap and a bad monsoon actually put upward pressure on inflation.

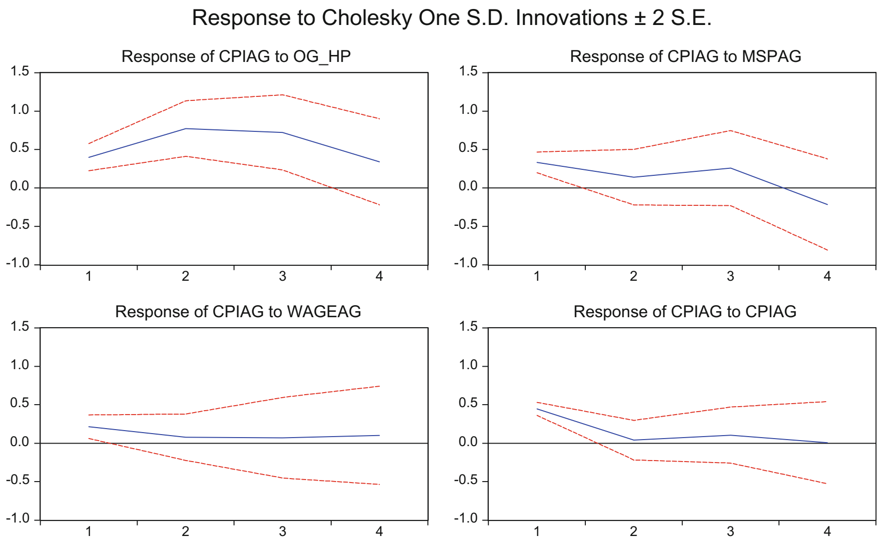

Fig. 7 Impulse responses from a vector autoregression model

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Part V
Towards a Theoretical Framework for Monetary Policy in India

An Estimated DSGE Open Economy Model of the Indian Economy with Financial Frictions

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JEL Classification: E52 · E37 · E58

1 Introduction

Recent episodes of financial turmoil have highlighted the need to understand how large external shocks are propagated in small open economies. This is particularly relevant in emerging market countries, since these economies face additional vulnerabilities in the form of imperfect access to capital markets. These include sudden and sharp reversals of capital inflows (the "sudden stops" highlighted in Calvo (1998)), the inability of firms to borrow in domestic currency only (a phenomenon dubbed "liability dollarization") or the presence of significant monitoring costs in credit markets, thus exacerbating finance premiums faced by borrowers (the "financial accelerator" mechanism).

We acknowledge financial support for this research from the Foreign Commonwealth Office as a contribution to the project "Building Capacity and Consensus for Monetary and Financial Reform" led by the National Institute for Public Finance Policy (NIPFP). We also acknowledge constructive comments from an anonymous referee and Chetan Ghate. The paper has benefited from excellent research assistance provided by Rudrani Bhattachrya and Radhika Pandey, NIPFP.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_15

These features may substantially amplify the effects of large external disturbances to the domestic economy. For example, a depreciation will deteriorate the balance sheets of borrowers relying on foreign currency denominated debt and increase the external finance premium accrued on top of the international interest rate. The ensuing fall in the demand for capital reduces the value of the borrowers' existing capital stock and corresponding net worth, further amplifying the increase in the costs of borrowing and the swings in investment and production.

While there is a substantial body of literature devoted to understanding business cycle dynamics (and financial frictions) in developed economies, research focusing on emerging economies is relatively sparser. Data limitations have often been identified as a cause, but the real challenge is to provide sensible explanations for the markedly distinct observed fluctuations in these economies. In fact, some stylized facts may be pointed out: (i) output growth tends to be subject to larger swings in developing countries; (ii) private consumption, relative to income, is substantially more volatile; (iii) terms of trade and output are strongly positively correlated, while real interest rates and output/net exports display large countercyclicality relative to developed economies; (iv) capital inflows are subject to dramatic "sudden stops" (see Agenor et al. (2000), Aguiar and Gopinath (2007) and Neumeyer and Perri (2005), for example).

By sharing some of these characteristics, India provides a particularly interesting challenge for macroeconomic modeling. From the early 90s, high growth rates were accompanied by a significant wave of trade and financial liberalization, with high-growth and highly skilled services and exports sectors coexisting with a sizeable informal, low-skilled labor intensive sector. Given the stage of development of India's financial sector, frictions of this nature, affecting both firms and households, may be greatly exacerbated in adverse conditions. Such a scenario implies that policymakers, in their quest for price and financial stability, face extra significant trade-offs when setting monetary conditions in response to shocks. This, in turn, requires careful investigation of the mechanisms that contribute to the propagation and amplification of economic and financial shocks hitting the economy.

Indeed, many emerging economies conduct their monetary and fiscal policy according to the "three pillars macroeconomic policy framework": a combination of a freely floating exchange rate, an explicit target for inflation over the medium run, and a mechanism that ensures a stable government debt–GDP ratio around a specified long run, but may allow for countercyclical adjustments of the fiscal deficit over the business cycle. By contrast, the Reserve Bank of India (henceforth RBI) intervenes in the foreign exchange market to prevent what it regards as excessive volatility of the exchange rate. On the fiscal side, Central Government has a rigid fiscal deficit target of 3 % of GDP irrespective of whether the economy is in boom or recession (Shah 2008). Therefore, understanding these differences and carefully modeling the transmission mechanism of internal and external shocks may be crucial to the assessment and design of stabilization programs and the conduct of economic policies in India.

The move to more flexible exchange–rate regimes in emerging open economies has been accompanied by a variety of frameworks to conduct monetary policy, including inflation targeting. Over the next few years, the trend toward adoption of flexible exchange–rate regimes, and inflation targeting in particular, is expected to continue. A recent IMF survey of 88 nonindustrial countries found that more than half expressed a desire to move to explicit or implicit quantitative inflation targets. While there are undoubtedly countries where inflation targeting may not be a suitable framework, it is a flexible framework that can be adapted to particular needs of nonindustrial countries, which face a number of challenges that differ in character or in degree from those faced in industrial economies. Since 2015, the RBI has entered into a formal flexible inflation targeting (FIT) agreement with the Ministry of Finance and is moving toward a FIT regime over the next 2 years with an explicit target of 4 % within a band of ±2 %. The RBI's proposed stabilization objective combined with the change of its nominal anchor to headline CPI inflation under the FIT framework have strong implications for policy making in the presence of financial frictions. The transmission of monetary policy is stronger through the credit channel to affect asset prices since firms' external premiums are more sensitive to their financial leverage. The financial systems of emerging open markets are more vulnerable to external disturbances, which may be beyond the control of the monetary authorities—this may cause inflation to deviate from its target thus lowering the credibility of the FIT regime without the support from strong financial and monetary institutions (e.g., an effective MPC). Again understanding and modeling the transmission mechanism of the frictions is important for designing policy rules that are robust and can minimize agents' vulnerability to these shocks particularly those arising from international openness.

Gabriel et al. (2012), in a closed economy setting, show that the introduction of financial frictions in the form of liquidity-constrained consumers and a financial accelerator mechanism are not only realistic, but also conducive to a better empirical performance. Thus, in this paper we develop both closed and open economy DSGE models of India as an emerging small open economy (SOE) interacting with the rest of the world and estimate them by Bayesian Maximum Likelihood methods using Dynare. We build up in stages to a model with a number of features important for emerging economies, small open economies in general, and the Indian economy in particular: as a combination of producer and local currency pricing for exporters, a large proportion of credit-constrained consumers, a financial accelerator-facing domestic firms seeking to finance their investment and "liability dollarization".[1] As mentioned above, this intensifies the exposure of a SOE to internal and external shocks in a manner consistent with the stylized facts listed above. Papers close to ours include Gertler et al. (2003), Cespedes et al. (2004), Cook (2004), Devereux et al. (2006), and Elekdag et al. (2005).

Using data on five key macroeconomic variables (output, investment, inflation, nominal interest rates, and the real exchange rate), the main purpose of the paper is to ascertain whether or not the data supports the inclusion of these financial frictions in an open economy framework. We do so by employing Bayesian sys-

[1] In a parallel paper, Gabriel et al. (2012) focuses on a further important feature of emerging economies, informality, but only in a closed economy model.

tem estimation techniques, in the vein of Smets and Wouters (2003), Smets and Wouters (2007), and Fernandez-Villaverde and Rubio-Ramirez (2004) (for a survey, see Fernandez-Villaverde 2009). We then examine the properties of the estimated model under a generalized inflation targeting Taylor-type interest rate rule with forward and backward-looking components.

We take a Bayesian approach for several reasons. First, these procedures, unlike full information maximum likelihood, for example, allow us to use prior information to identify key structural parameters. In addition, the Bayesian methods employed here utilize all the cross-equation restrictions implied by the general equilibrium setup, which makes estimation more efficient when compared to the partial equilibrium approaches. Moreover, Bayesian estimation and model comparison are consistent even when the models are misspecified, as shown by Fernandez-Villaverde and Rubio-Ramirez (2004). Finally, this framework provides a straightforward method of evaluating the ability of the models in capturing the cyclical features of the data, while allowing for a fully structural approach to analyze the sources of fluctuations in the Indian economy.

The rest of the paper is organized as follows. In Appendix, we describe a baseline New Keynesian (NK) DSGE closed economy model, from which we subsequently build up our model in stages. In Sect. 2, we develop a standard open economy counterpart to the baseline model. Section 3 then introduces the financial frictions and, in addition, an open economy aspect, namely liability dollarization which outlines the novel features that distinguish our SOE model from the standard open economy model. Up to this point the open economy models assume complete exchange rate pass-through. Section 4 relaxes this assumption. Section 5 describes the equilibrium. Section 6 shows the workings of the financial frictions and highlights the precise mechanism thought which the frictions affect the shocks and variables. Section 7 describes our empirical strategy and presents the estimation results. Section 8 studies the empirical applications for India and Sect. 9 discusses the implications for policy making. The final section summarizes our findings and points directions for further study.

2 A Standard Open Economy NK Model

This is a model built on our baseline closed economy model with producer currency producers in the retail sector and therefore complete exchange rate pass-through. The law of one price therefore applies to each differentiated good. We first set up a model without financial frictions where UIP holds (see Gali (2008)). Then we assume households face a risk premium on international markets leading to a modified UIP condition.

First, define composite Dixit–Stiglitz (D–S) consumption and investment indices consisting of home-produced (H) and foreign (F) goods:

$$C_t = \left[\mathrm{w}_C^{\frac{1}{\mu_C}} C_{H,t}^{\frac{\mu_C - 1}{\mu_C}} + (1 - \mathrm{w}_C)^{\frac{1}{\mu_C}} C_{F,t}^{\frac{\mu_C - 1}{\mu_C}} \right]^{\frac{\mu_C}{\mu_C - 1}} \tag{1}$$

$$I_t = \left[\mathrm{w}_I^{\frac{1}{\mu_I}} I_{H,t}^{\frac{\mu_I - 1}{\mu_I}} + (1 - \mathrm{w}_I)^{\frac{1}{\mu_I}} I_{F,t}^{\frac{\mu_I - 1}{\mu_I}} \right]^{\frac{\mu_I}{\mu_I - 1}} \tag{2}$$

The corresponding D–S price indices are

$$P_{C,t} = \left[\mathrm{w}_C (P_{H,t})^{1-\mu_C} + (1 - \mathrm{w}_C)(P_{F,t})^{1-\mu_C} \right]^{\frac{1}{1-\mu_C}} \tag{3}$$

$$P_{I,t} = \left[\mathrm{w}_I (P_{H,t})^{1-\mu_I} + (1 - \mathrm{w}_I)(P_{F,t})^{1-\mu_I} \right]^{\frac{1}{1-\mu_I}} \tag{4}$$

Let the proportions of differentiated goods produced in the home and foreign blocs be ν and $1 - \nu$, respectively. With each variety produced by one firm and the number households proportional to the number of firms then ν and $1 - \nu$ may be considered as measures of the relative size of the two blocs. Weights in the consumption baskets in the two blocs are then defined by

$$\mathrm{w}_C = 1 - (1 - \nu)(1 - \omega_C)\,; \quad \mathrm{w}_C^* = 1 - \nu(1 - \omega_C^*) \tag{5}$$

In (5), ω_C, $\omega_C^* \in [0, 1]$ are parameters that capture the degree of "bias" in the two blocs. If $\omega_C = \omega_C^* = 1$ we have $\mathrm{w}_C = \mathrm{w}_C^* = 1$, i.e., autarky, while $\omega_C = \omega_C^* = 0$ gives us the case of perfect integration with $\mathrm{w}_C = \nu$ and $\mathrm{w}_C^* = 1 - \nu$, i.e., weights are in proportion to the proportions of goods produced in the two countries. In the limit, as the home country becomes small $\nu \to 0$. Hence $\mathrm{w}_C \to \omega_C$ and $\mathrm{w}_C^* \to 1$. Thus the foreign bloc becomes closed, but as long as there is a degree of home bias and $\omega_C > 0$, the home country continues to consume foreign-produced consumption goods. Exactly the same applies to the investment baskets where we define ω_I and ω_I^* by

$$\mathrm{w}_I = 1 - (1 - \nu)(1 - \omega_I)\,; \quad \mathrm{w}_I^* = 1 - \nu(1 - \omega_I^*) \tag{6}$$

Then standard intratemporal optimizing decisions for home consumers and firms lead to

$$C_{H,t} = \mathrm{w}_C \left(\frac{P_{H,t}}{P_{C,t}} \right)^{-\mu_C} C_t \tag{7}$$

$$C_{F,t} = (1 - \mathrm{w}_C) \left(\frac{P_{F,t}}{P_{C,t}} \right)^{-\mu_C} C_t \tag{8}$$

$$I_{H,t} = \mathrm{w}_I \left(\frac{P_{H,t}}{P_{I,t}} \right)^{-\mu_I} I_t \tag{9}$$

$$I_{F,t} = (1 - \mathrm{w}_I) \left(\frac{P_{F,t}}{P_{I,t}} \right)^{-\mu_I} I_t \tag{10}$$

In the small open economy, we take foreign aggregate consumption and investment, denoted by C_t^* and I_t^*, respectively, as exogenous processes.[2] Define one real exchange rate as the relative aggregate consumption price $RER_{C,t} \equiv \frac{P_{C,t}^* S_t}{P_{C,t}}$ where S_t is the nominal exchange rate. Similarly, define $RER_{I,t} \equiv \frac{P_{I,t}^* S_t}{P_{I,t}}$ for investment. Then foreign counterparts of the above-defining demand for the export of the home goods are

$$C_{H,t}^* = \mathrm{w}_C^* \left(\frac{P_{H,t}^*}{P_{C,t}^*} \right)^{-\mu_C^*} C_t^* = \mathrm{w}_C^* \left(\frac{P_{H,t}}{P_{C,t} RER_{C,t}} \right)^{-\mu_C^*} C_t^* \tag{11}$$

$$I_{H,t}^* = \mathrm{w}_I^* \left(\frac{P_{H,t}^*}{P_{I,t}^*} \right)^{-\mu_I^*} I_t^* = \mathrm{w}_I^* \left(\frac{P_{H,t}}{P_{I,t} RER_{I,t}} \right)^{-\mu_I^*} I_t^* \tag{12}$$

where $P_{H,t}^*$, $P_{C,t}^*$, and $P_{I,t}^*$ denote the price of home consumption, aggregate consumption, and aggregate investment goods in foreign currency and we have used the law of one price for differentiated good, namely $S_t P_{H,t}^* = P_{H,t}$.

We incorporate financial frictions facing households as in Benigno (2010). There are two noncontingent one-period bonds denominated in the currencies of each bloc with payments in period t, $B_{H,t}$, and $B_{F,t}^*$, respectively, in (per capita) aggregate. The prices of these bonds are given by

$$P_{B,t} = \frac{1}{1 + R_{n,t}}; \qquad P_{B,t}^* = \frac{1}{(1 + R_{n,t}^*)\phi(\frac{S_t B_{F,t}^*}{P_{H,t} Y_t})} \tag{13}$$

where $\phi(\cdot)$ captures the cost in the form of a risk premium for home households to hold foreign bonds, $B_{F,t}^*$ is the aggregate foreign asset position of the economy denominated in home currency and $P_{H,t} Y_t$ is nominal GDP. We assume $\phi(0) = 1$ and $\phi' < 0$. $R_{n,t}$ and $R_{n,t}^*$ denote the nominal interest rate over the interval $[t, t+1]$.

The representative household must obey a budget constraint:

$$P_{C,t} C_t + P_{B,t} B_{H,t} + P_{B,t}^* S_t B_{F,t}^* + TL_t = W_t L_t + B_{H,t-1} + S_t B_{F,t-1}^* + \Gamma_t \tag{14}$$

where $P_{C,t}$ is a D–S price index defined in (3), W_t is the wage rate, TL_t are lump-sum taxes net of transfers, and Γ_t are dividends from ownership of firms. The intertemporal and labor supply decisions of the household are then

[2] Aggregate variables such as C_t and C_t^* are aggregates over varieties and in fact per capita measures. Relative total consumption in the two blocs is then given by $\frac{\nu C_t}{(1-\nu) C_t^*}$.

$$P_{B,t} = \beta E_t \left[\frac{\Lambda_{C,t+1}}{\Lambda_{C,t}\Pi_{t+1}} \right] \tag{15}$$

$$P^*_{B,t} = \beta E_t \left[\frac{\Lambda_{C,t+1}S_{t+1}}{\Lambda_{C,t}\Pi_{t+1}S_t} \right] \tag{16}$$

$$\frac{W_t}{P_{C,t}} = \frac{\Lambda_{L,t}}{\Lambda_{C,t}} = -\frac{\Lambda_{h,t}}{\Lambda_{C,t}} \tag{17}$$

where

$$\Lambda_{C,t} = (1-\varrho)C_t^{(1-\varrho)(1-\sigma)-1}(1-h_t)^{\varrho(1-\sigma)} \tag{18}$$

$$\lambda_{h,t} = -C_t^{(1-\varrho)(1-\sigma)}\varrho(1-h_t)^{\varrho(1-\sigma)-1} \tag{19}$$

$$\Pi_t \equiv \frac{P_{C,t}}{P_{C,t-1}} \tag{20}$$

Note that now in the open economy Π_t is consumer price inflation.

The retailer's and wholesaler's decisions are as before for the closed economy except Π_t is replaced with domestic price inflation $\Pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$ which differs from consumer price inflation. Equilibrium and Foreign asset accumulation is given by

$$\begin{aligned} Y_t &= C_{H,t} + I_{H,t} + \frac{1-\nu}{\nu}\left[C^*_{H,t} + I^*_{H,t}\right] + G_t \\ &\equiv C_{H,t} + I_{H,t} + EX^*_t + G_t \end{aligned} \tag{21}$$

$$\begin{aligned} EX_t &= \frac{1-\nu}{\nu}(1-\mathrm{w}^*_C)\left(\frac{P_{H,t}}{P_{C,t}RER_{C,t}}\right)^{-\mu^*_C} C^*_t \\ &\quad + \frac{1-\nu}{\nu}(1-\mathrm{w}^*_I)\left(\frac{P_{H,t}}{P_{I,t}RER_{I,t}}\right)^{-\mu^*_I} I^*_t \end{aligned} \tag{22}$$

$$\frac{S_t}{S_{t-1}} = \frac{RER_{C,t}\,\Pi_t}{RER_{C,t-1}\,\Pi^*_t} \tag{23}$$

$$\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}} = \frac{\Pi_{F,t}}{\Pi_{H,t}} \tag{24}$$

$$RER_{C,t} = \frac{\left[\mathrm{w}^*_C + (1-\mathrm{w}^*_C)\mathcal{T}_t^{\mu^*_C-1}\right]^{\frac{1}{1-\mu^*_C}}}{\left[1-\mathrm{w}_C + \mathrm{w}_C\mathcal{T}_t^{\mu_C-1}\right]^{\frac{1}{1-\mu_C}}} \tag{25}$$

$$RER_{I,t} = \frac{\left[\mathrm{w}^*_I + (1-\mathrm{w}^*_I)\mathcal{T}_t^{\mu^*_I-1}\right]^{\frac{1}{1-\mu^*_I}}}{\left[1-\mathrm{w}_I + \mathrm{w}_I\mathcal{T}_t^{\mu_I-1}\right]^{\frac{1}{1-\mu_I}}} \tag{26}$$

$$\Pi_t = [\mathrm{w}(\Pi_{H,t})^{1-\mu_C} + (1-\mathrm{w})(\Pi_{F,t})^{1-\mu_C}]^{\frac{1}{1-\mu_C}} \tag{27}$$

$$\log(1+R_{n,t})/(1+R_n) = \rho_r \log(1+R_{n,t-1})/(1+R_n) + (1-\rho_r)(\theta_\pi E_t[\log \Pi_{t+1}]/\Pi + \theta_s \log S_t/S) + \epsilon_{r,t+1} \tag{28}$$

For the SOE $\nu \to 0$, $\mathrm{w}_C \to \omega_C$ and $\mathrm{w}_C^* \to 1$; but $\frac{1-\nu}{\nu}(1-\mathrm{w}_C^*) \to 1-\omega_C^*$ so a large "closed" economy imports consumption goods from the SOE. Similarly, $\mathrm{w}_I \to \omega_I$ and $\mathrm{w}_I^* \to 1$; but $\frac{1-\nu}{\nu}(1-\mathrm{w}_I^*) \to 1-\omega_I^*$ and the same applies to investment goods. The risk-sharing condition, foreign Euler and Fischer equations are

$$RER_t^r = \frac{\Lambda_{C,t}^*}{\Lambda_{C,t}} \tag{29}$$

$$\frac{1}{1+R_{n,t}^*} = \beta E_t\left[\frac{\Lambda_{C,t+1}^*}{\Lambda_{C,t}^*\Pi_{t+1}^*}\right] \tag{30}$$

$$1+R = \frac{1+R_{n,t-1}}{1+\Pi_t} \tag{31}$$

$$1+R_t^* = \frac{1+R_{n,t-1}^*}{1+\Pi_t^*} \tag{32}$$

Then add a risk premium shock in period $t-1$, $\exp(\epsilon_{UIP,t})$ and use (16) and (30) to obtain

$$\phi\left(\frac{S_t B_{F,t}^*}{P_{H,t}Y_t}\right)\exp(\epsilon_{UIP,t})E_t\left[\frac{\Lambda_{C,t+1}^*}{\Lambda_{C,t}^*\Pi_{t+1}^*}\right] = E_t\left[\frac{\Lambda_{C,t+1}S_{t+1}}{\Lambda_{C,t}\Pi_{t+1}S_t}\right] \tag{33}$$

Noting that $\frac{S_{t+1}}{\Pi_{t+1}S_t} = \frac{S_{t+1}P_t}{P_{t+1}S_t} = \frac{RER_{C,t+1}}{RER_{C,t}\Pi_{t+1}^*}$, and using (29), we then obtain the consumption real exchange rate as

$$RER_{C,t} = RER_t^d RER_t^r \tag{34}$$

where the deviation of the real consumption exchange rate from its risk-sharing value, RER_t^d is given by

$$E_t\left[\frac{\Lambda_{C,t+1}}{\Lambda_{C,t}}\frac{RER_{t+1}^r}{RER_t^r}\frac{1}{\Pi_{t+1}^*}\left(\frac{1}{\phi(\frac{S_t B_{F,t}^*}{P_{H,t}Y_t})\exp(\epsilon_{UIP,t})} - \frac{RER_{t+1}^d}{RER_t^d}\right)\right] = 0 \tag{35}$$

Current account dynamics are given by

$$\frac{1}{(1+R^*_{n,t})\phi(\frac{S_tB^*_{F,t}}{P_{H,t}Y_t})}S_tB^*_{F,t} = S_tB^*_{F,t-1} + TB_t \tag{36}$$

$$\phi(\frac{S_tB^*_{F,t}}{P_{H,t}Y_t}) = \exp\left(\frac{\phi_B S_t B^*_{F,t}}{P_{H,t}Y_t}\right); \ \chi_B < 0 \tag{37}$$

$$TB_t = P_{H,t}Y_t - P_{C,t}C_t - P_{I,t}I_t - P_{H,t}G_t \tag{38}$$

Exogenous shocks are assumed to follow AR(1) processes:

$$\log\frac{A_{t+1}}{A} = \rho_a \log\frac{A_t}{A} + \epsilon_{a,t+1} \tag{39}$$

$$\log\frac{G_{t+1}}{G} = \rho_g \log\frac{G_t}{G} + \epsilon_{g,t+1} \tag{40}$$

$$\log\frac{MS_{t+1}}{MS} = \rho_{ms} \log\frac{MS_t}{MS} + \epsilon_{ms,t+1} \tag{41}$$

$$\log\frac{UIP_{t+1}}{UIP} = \rho_{UIP} \log\frac{UIP_t}{UIP} + \epsilon_{uip,t+1} \tag{42}$$

There are now two ways to close the model. First, as is standard for models of the SOE, we can assume that processes for foreign variables $R^*_{n,t}$, Π^*_t, C^*_t, I^*_t, and Λ^*_t are exogenous and independent. Then assuming AR(1) processes for these as well the model is closed with

$$\log(1+R^*_{n,t})/(1+R^*_n) = \rho^*_r \log(1+R^*_{n,t-1})/(1+R^*_n) + \epsilon^*_{r,t+1} \tag{43}$$

$$\log\frac{\Pi^*_{t+1}}{\Pi^*} = \rho^*_\pi \log\frac{\Pi^*_t}{\Pi^*} + \epsilon^*_{\pi,t+1} \tag{44}$$

$$\log\frac{C^*_{t+1}}{C^*} = \rho^*_c \log\frac{C^*_t}{C^*} + \epsilon^*_{c,t+1} \tag{45}$$

$$\log\frac{I^*_{t+1}}{I^*} = \rho^*_I \log\frac{I^*_t}{I^*} + \epsilon^*_{i,t+1} \tag{46}$$

$$\log\frac{\Lambda^*_{t+1}}{\Lambda^*} = \rho^*_\Lambda \log\frac{\Lambda^*_t}{\Lambda^*} + \epsilon^*_{\lambda,t+1} \tag{47}$$

The second more satisfactory approach is to acknowledge that the foreign variables are interdependent and part of a model driven by the same form of shocks and policy rules as for the SOE. This model can be the closed economy baseline model fitted to World or US data.

3 An Open Economy NK Model with Financial Frictions

We now introduce two financial frictions to the SOE: liquidity-constrained "rule of thumb" consumers and a financial accelerator for firms. The inclusion of these features is particularly relevant, not only because it acknowledges powerful transmission mechanisms of shocks in emerging economies, but it also helps to conceptualize and understand events such as the 2008 global financial crisis and subsequent economic slowdown. Carlstrom and Fuerst (1997), Bernanke et al. (1999) and Gertler et al. (2003), for example, stress the importance of financial frictions in the amplification of both real and nominal shocks to the economy, namely in the form of the financial accelerator, linking the cost of borrowing and firms' net worth.

Consider first the existence of liquidity-constrained consumers. Suppose that a proportion λ of consumers are credit constrained and have no income from monopolistic retail firms. They must consume out of wage income and their consumption is given by

$$C_{1,t} = \frac{W_t h_t}{P_t} \tag{48}$$

The remaining Ricardian consumers are modeled as in Appendix A and consume $C_{2,t}$. Total consumption is then

$$C_t = \lambda C_{1,t} + (1 - \lambda) C_{2,t} \tag{49}$$

Note that, when taking the model to estimation, we reparameterize and define now a parameter λ_{C_1}, which measures the share of consumption consumed by the liquidity-constrained consumers, such that $\lambda_{C_1} = \lambda \frac{C_1}{C} = 1 - (1 - \lambda)\frac{C_2}{C}$.

This model assumes that Ricardian and liquidity-constrained consumers work the same hours h_t. Following Gali et al. (2004) we now relax this assumption. Liquidity-constrained consumers now choose $C_{1,t}$ and $L_{1,t} = 1 - h_{1,t}$ to maximize $\Lambda_1(C_{1,t}, L_{1,t})$ subject to

$$C_{1,t} = \frac{W_t h_{1,t}}{P_t} \tag{50}$$

The first-order conditions are now the same for both types

$$\frac{\Lambda_{L_1,t}}{\Lambda_{C_1,t}} = \frac{\Lambda_{L_2,t}}{\Lambda_{C_2,t}} = \frac{W_t}{P_t} \tag{51}$$

Together with (50) and the functional form $\Lambda_{1,t} = \Lambda(C_{1,t}, L_{1,t}) = \frac{(C_{1,t}^{(1-\rho)} L_{1,t}^{\rho})^{1-\sigma} - 1}{1-\sigma}$ this leads to the first-order condition for the liquidity-constrained consumers

$$\frac{\rho(1 - L_{1,t})}{(1 - \rho)L_{1,t}} = 1 \quad \Rightarrow \quad L_{1,t} = 1 - h_{1,t} = \rho \tag{52}$$

In other words, hours worked by liquidity-constrained consumers are constant. Aggregate hours are now

$$h_t = \lambda h_{1,t} + (1 - \lambda) h_{2,t} \tag{53}$$

We can model the risk premium rigorously and financial stress by introducing a financial accelerator. The first ingredient of financial frictions in the open economy is liability dollarization. Wholesale firms borrow from home and foreign financial intermediaries in both currencies, with exogenously given proportion[3] of the former given by $\varphi \in [0, 1]$, so that this expected cost is

$$\Theta_t \varphi E_t \left[(1 + R_{n,t}) \frac{P_{C,t}}{P_{C,t+1}} \right] + \Theta_t (1 - \varphi) E_t \left[(1 + R^*_{n,t}) \frac{P^*_{C,t}}{P^*_{C,t+1}} \frac{RER_{C,t+1}}{RER_{C,t}} \right]$$
$$= \Theta_t \left[\varphi E_t \left[(1 + R_{t+1}) \right] + (1 - \varphi) E_t \left[(1 + R^*_{t+1}) \frac{RER_{C,t+1}}{RER_{C,t}} \right] \right] \quad (54)$$

If $\varphi = 1$ or if UIP holds this becomes $(1 + \Theta_t) E_t \left[1 + R_{t+1} \right]$. In (54), $RER_{C,t} \equiv \frac{P^*_{C,t} S_t}{P_{C,t}}$ is the real exchange rate, $R_t \equiv \left[(1 + R_{n,t-1}) \frac{P_{t-1}}{P_t} \right] - 1$ is the ex post real interest rate over $[t - 1, t]$ and $\Theta_t \geq 0$ is the external finance premium.

The second ingredient is an external finance premium Θ_t such that when the firm equates the expected return with the expected cost of borrowing, we have

$$E_t[1 + R_{k,t+1}] = E_t \left[\Theta_{t+1} \left(\varphi E_t \left[(1 + R_{t+1}) \right] + (1 - \varphi) E_t \left((1 + R^*_{t+1}) \frac{RER_{C,t+1}}{RER_{C,t}} \right) \right) \right] \quad (55)$$

where

$$\Theta_t = s \left(\frac{N_t}{Q_{t-1} K_t} \right)^{-\chi} \; ; \; s'(\cdot) < 0 \quad (56)$$

In (56), N_t is net worth and $Q_{t-1} K_t - N_t$ is the external financing requirement. Thus $\frac{Q_{t-1} K_t - N_t}{N_t}$ is the leverage ratio and thus (55) and (56) state that the cost of capital is an increasing function of this ratio. Bernanke et al. (1999), in a costly verification model, show that the optimal financial contract between a risk-neutral intermediary and entrepreneur takes the form of a risk premium given by (56). Thus the risk premium is an increasing function of leverage of the firm. Following these authors, in the general equilibrium we ignore monitoring costs.

Assume that entrepreneurs exit with a given probability $1 - \xi_e$. Then the net worth accumulates according to

$$N_{t+1} = \xi_e V_t + (1 - \xi_e) D^e_t \quad (57)$$

where D^e_t are exogenous transfer, consistent with a balanced growth path steady state, from exiting to newly entering entrepreneurs continuing, and V_t, the net value carried over from the previous period, is given by

[3]We do not attempt to endogenize the decision of firms to partially borrow foreign currency; this lies outside the scope of this paper.

$$V_t = (1 + R_{k,t})Q_{t-1}K_t - \Theta_t \left[\varphi(1 + R_t) + (1 - \varphi)(1 + R_t^*) \frac{RER_{C,t}}{RER_{C,t-1}} \right] (Q_{t-1}K_t - N_t) \tag{58}$$

where $R_{k,t}$ is the ex post return given by

$$1 + R_{k,t} = \frac{(1 - \alpha)\frac{P_t^W}{P_t}\frac{Y_t^W}{K_t} + (1 - \delta)Q_t}{Q_{t-1}} \tag{59}$$

Demand for capital is then given by

$$E_t[1 + R_{k,t+1}] = \frac{E_t\left[(1 - \alpha)\frac{P_{t+1}^W}{P_{t+1}}\frac{Y_{t+1}^W}{K_{t+1}} + (1 - \delta)Q_{t+1}\right]}{Q_t} \tag{60}$$

Finally, exiting entrepreneurs consume the residual equity so that their consumption

$$C_t^e = \frac{1 - \xi_e}{\xi_e} N_t \tag{61}$$

must be added to total consumption. The full model is summarized in Appendices C and D with the closed economy baseline in A and B as a special case.[4]

4 Incomplete Exchange Rate Pass-Through

We now provide a more general setup in which a fixed proportion θ of retailers set export prices $P_{H,t}^{*p}$ in the home currency (producer currency pricers, PCP) and a proportion $1 - \theta$ set export prices $P_{H,t}^{*\ell}$ in the dollars (local currency pricers, LCP). Then the price of exports in foreign currency is given by

$$P_{H,t}^* = \theta P_{H,t}^{*p} + (1 - \theta)P_{H,t}^{*\ell} \tag{62}$$

Putting $\theta = 0$ gets us back to the previous model with complete exchange rate pass-through.

[4]The closed economy model with financial frictions is a special case when $\varphi = 1$.

4.1 PCP Exporters

Assume that there is a probability of $1 - \xi_H$ at each period that the price of each good f is set optimally to $\hat{P}_{H,t}(f)$. If the price is not reoptimized, then it is held constant.[5] For each producer f the objective is at time t to choose $\hat{P}_{H,t}(f)$ to maximize discounted profits

$$E_t \sum_{k=0}^{\infty} \xi_H^k D_{t,t+k} Y_{t+k}(f) \left[\hat{P}_{H,t}(f) - P_{H,t+k}\mathrm{MC}_{t+k}\right]$$

where $D_{t,t+k}$ is the discount factor over the interval $[t, t+k]$, subject to a common[6] downward sloping demand from domestic consumers and foreign importers of elasticity ζ and $MC_t = \frac{P^W_{H,t}}{P_{H,t}}$ are marginal costs. The solution to this is

$$E_t \sum_{k=0}^{\infty} \xi_H^k D_{t,t+k} Y_{t+k}(f) \left[\hat{P}_{Ht}(f) - \frac{\zeta}{(\zeta - 1)} P_{H,t+k}\mathrm{MC}_{t+k}\right] = 0 \qquad (63)$$

and by the law of large numbers the evolution of the price index is given by

$$P^{1-\zeta}_{H,t+1} = \xi_H \left(P_{H,t}\right)^{1-\zeta} + (1 - \xi_H)(\hat{P}_{H,t+1}(f))^{1-\zeta} \qquad (64)$$

Monopolistic profits as a proportion of GDP are given by

$$\frac{\Gamma_t}{P_{H,t}Y_t} \equiv \frac{P_{H,t}Y_t - P^W_{H,t}Y^W_t}{P_{H,t}Y_t} = 1 - \mathrm{MC}_t\left(1 + \frac{F}{Y}\right) \qquad (65)$$

For good f imported by the home country from PCP foreign firms the price $P^p_{F,t}(f)$, set by retailers, is given by $P^p_{F,t}(f) = S_t P^*_{F,t}(f)$. Similarly, $P^{*\,p}_{H,t}(f) = \frac{P_{H,t}(f)}{S_t}$.

4.2 LCP Exporters

Price setting in export markets by domestic LCP exporters follows in a very similar fashion to domestic pricing. The optimal price in units of domestic currency is $\hat{P}^{*\,\ell}_{H,t} S_t$, costs are as for domestically marketed goods so (63) and (64) become

[5] Thus we can interpret $\frac{1}{1-\xi_H}$ as the average duration for which prices are left unchanged..

[6] Recall that we have imposed a symmetry condition $\zeta = \zeta^*$ at this point, i.e., the elasticity of substitution between differentiated goods produced in any one bloc is the same for consumers in both blocs.

Table 1 Summary of notation for prices

Origin of good	Domestic market	Export market (PCP)	Export market (LCP)
Home	P_H	$P_H^{*\,p} = \frac{P_H}{S_t}$	$P_H^{*\,\ell} \neq \frac{P_H}{S_t}$
Foreign	P_F^*	$P_F^p = S_t P_F^*$	Nonexistent

$$E_t \sum_{k=0}^{\infty} \xi_H^k D_{t,t+k} Y_{t+k}^*(f) \left[\hat{P}_{H,t}(f)^{*\,\ell} S_{t+k} - \frac{\zeta}{(\zeta-1)} P_{H,t+k} \mathrm{MC}_{t+k} \right] = 0 \tag{66}$$

and by the law of large numbers the evolution of the price index is given by

$$(P_{H,t+1}^{*\,\ell})^{1-\zeta} = \xi_H (P_{H,t}^{*\,\ell})^{1-\zeta} + (1-\xi_H)(\hat{P}_{H,t+1}^{*\,\ell}(f))^{1-\zeta} \tag{67}$$

Foreign exporters from the large ROW bloc are PCPers so we have

$$P_{F,t} = S_t P_{F,t}^* \tag{68}$$

Table 1 summarizes the notation used.

To obtain the nonlinear dynamics for LCPers, rewrite (66) as

$$E_t \sum_{k=0}^{\infty} \xi_H^k D_{t,t+k} Y_{t+k}^*(f) S_{t+k} \left[\hat{P}_{H,t}(f)^{*\,\ell} - \frac{\zeta}{(\zeta-1)} P_{H,t+k}^{*\,\ell} \mathrm{MC}_{t+k}^{\ell} \right] = 0 \tag{69}$$

where

$$MC_t^{\ell} \equiv \frac{MC_t P_{H,t}}{S_t P_{H,t}^{*\,\ell}} \tag{70}$$

As before define the terms of trade for the home bloc (import/export prices in one currency) as $\mathcal{T}_t \equiv \frac{P_{F,t}}{P_{H,t}}$. Define the terms of trade for the foreign bloc as $\mathcal{T}_t^* \equiv \frac{P_{H,t}^*}{P_{F,t}^*}$. With PCPers only the law of one price holds and $\mathcal{T}_t^* = \frac{S_t P_{H,t}^*}{S_t P_{F,t}^*} = \frac{P_{H,t}}{P_{F,t}} = \frac{1}{\mathcal{T}_t}$, but with LCPers this no longer is the case. Now we have that

$$\mathcal{T}_t^* \equiv \frac{P_{H,t}^*}{P_{F,t}^*} = \frac{\theta P_{H,t}^{*\,p} + (1-\theta) P_{H,t}^{*\,\ell}}{P_{F,t}^*} = \frac{\theta \frac{P_{H,t}}{S_t} + (1-\theta) P_{H,t}^{*\,\ell}}{\frac{P_{F,t}}{S_t}} \tag{71}$$

It follows that

$$\mathcal{T}_t \mathcal{T}_t^* = \theta + (1-\theta) \frac{S_t P_{H,t}^{*\,\ell}}{P_{H,t}} \tag{72}$$

and hence from (70) and (72)

$$MC_t^{\ell} = \frac{(1-\theta)MC_t}{\mathcal{T}_t\mathcal{T}_t^* - \theta} \tag{73}$$

The system is completed with

$$\Pi_{H,t}^* = \theta\Pi_{H,t}^{*p} + (1-\theta)\Pi_{H,t}^{*\ell} \tag{74}$$

From $S_t P_{H,t}^{*p} = P_{H,t}$ and $RER_t \equiv \frac{S_t P_t^*}{P_t}$ we have that

$$\Pi_{H,t}^{*p} = \frac{RER_{t-1}\Pi_{H,t}\Pi_t^*}{RER_t\Pi_t} \tag{75}$$

Exporters from the foreign bloc are PCPers so $S_t P_{F,t}^* = P_{F,t}$. Therefore by analogy with (75), we have

$$\Pi_{F,t} = \frac{RER_t}{RER_{t-1}}\frac{\Pi_t}{\Pi_t^*}\Pi_{F,t}^* \tag{76}$$

and

$$\Pi_t = \left[\mathrm{w}(\Pi_{H,t})^{1-\mu} + (1-\mathrm{w})(\Pi_{F,t})^{1-\mu}\right]^{\frac{1}{1-\mu}} \tag{77}$$

From the definitions of $\mathcal{T}_t$ and $\mathcal{T}_t^*$ we have that

$$\frac{\mathcal{T}_t}{\mathcal{T}_{t-1}} = \frac{\Pi_{F,t}}{\Pi_{H,t}} \tag{78}$$

$$\frac{\mathcal{T}_t^*}{\mathcal{T}_{t-1}^*} = \frac{\Pi_{H,t}^*}{\Pi_{F,t}^*} \tag{79}$$

$$H_t^{\ell} - \xi_H\beta E_t[(\Pi_{H,t+1}^{*\ell})^{\zeta-1}H_{t+1}^{\ell}] = Y_t^* S_t U_{C,t} \tag{80}$$

$$J_t^{\ell} - \xi_H\beta E_t[(\Pi_{H,t+1}^{*\ell})^{\zeta}J_{t+1}^{\ell}] = \frac{1}{1-\frac{1}{\zeta}}MS_t\, Y_t^* S_t U_{C,t} MC_t^{\ell} \tag{81}$$

$$1 = \xi_H(\Pi_{H,t}^{*\ell})^{\zeta-1} + (1-\xi_H)\left(\frac{J_t^{\ell}}{H_t^{\ell}}\right)^{1-\zeta} \tag{82}$$

Equations (73)–(82) give us the new equations to describe imperfect exchange rate pass-through. As $\theta \to 1$ we get back to the previous model with complete exchange rate pass-through.

5 The Equilibrium, Fiscal Policy, and Foreign Asset Accumulation

In equilibrium, goods markets, money markets, and the bond market all clear. Equating the supply and demand of the home consumer good and assuming that government expenditure, taken as exogenous, goes exclusively on home goods, we obtain[7]

$$Y_t = C_{H,t} + C^e_{H,t} + I_{H,t} + \frac{1-\nu}{\nu}\left[C^*_{H,t} + C^{e*}_{H,t} + I^*_{H,t}\right] + G_t \tag{83}$$

Fiscal policy is rudimentary: a balanced government budget constraint is given by

$$P_{H,t}G_t = T_t + M_{H,t} - M_{H,t-1} \tag{84}$$

Adjustments to the taxes, T_t, in response to shocks to government spending away from the steady state are assumed to be nondistortionary.

Let $\sum_{h=1}^{\nu} B_{F,t}(h) = \nu B_{F,t}$ be the net holdings by the household sector of foreign bonds. Summing over the household budget constraints (including entrepreneurs and capital producers), noting that net holdings of domestic bonds are zero (since home bonds are not held by foreign households), and subtracting (84), we arrive at the accumulation of net foreign assets:

$$\begin{aligned} P^*_{B,t}S_tB_{F,t} + S_tM_{F,t} &= S_tB_{F,t-1} + S_tM_{F,t-1} + W_tL_t + \Gamma_t + (1-\xi_e)P_tV_t \\ &\quad + P_tQ_t(1 - S(X_t))I_t - P_tC_t - P_tC^e_t - P_{I,t}I_t - P_{H,t}G_t \\ &\equiv S_tB_{F,t-1} + S_tM_{F,t-1} + TB_t \end{aligned} \tag{85}$$

where the trade balance, TB_t, is given by the national accounting identity

$$P_{H,t}Y_t = P_tC_t + P_tC^e_t + P_{I,t}I_t + P_{H,t}G_t + TB_t \tag{86}$$

This completes the model. Given nominal interest rates $R_{n,t}$, $R^*_{n,t}$ the money supply is fixed by the central banks to accommodate money demand. By Walras' Law, we can dispense with the bond market equilibrium condition. Then the equilibrium is defined at $t = 0$ as stochastic sequences C_t, C^e_t, $C_{H,t}$, $C_{F,t}$, $P_{H,t}$, $P_{F,t}$, P_t, $M_{H,t}$, $M_{F,t}$, $B_{H,t}$, $B_{F,t}$, W_t, Y_t, L_t, $P^0_{H,t}$, P^I_t, K_t, I_t, Q_t, V_t, foreign counterparts C^*_t, etc., RER_t, and S_t, given the monetary instruments $R_{n,t}$, $R^*_{n,t}$ and exogenous processes.

[7]Note that all aggregates, Y_t, $C_{H,t}$, etc., are expressed in per capita (household) terms.

6 The Workings of the Financial Frictions

The SOE model makes explicit the operating mechanism of liability dollarization. This feature increases the susceptibility to external shocks since a potential depreciation can substantially inflate debt service costs, due to currency mismatches (i.e., debts are denominated in foreign currency when the value of production is denominated in domestic currency), and thus increase rollover risk. In other words, borrowers in this model may find that both interest and exchange rate fluctuations have large effect on their real net worth positions (see (57) and (58)), and so, through balance sheet constraints that affect investment spending, have much more serious macroeconomic consequences than for richer industrial economics.

To understand the precise mechanism through which the various financial frictions and dollarization magnify the shocks, and affect the other variables in the economy, we need first to take a step back and illustrate some of the mechanisms driving the real exchange rate, and the behavior of net worth of the wholesale firms sector. Solving forward in time linearization of the modified UIP condition it is straightforward to see that the real exchange rate is a sum of future expected real interest rate differentials with the ROW plus a term proportional to the sum of future expected net liabilities plus a sum of expected future shocks, $\epsilon_{UIP,t}$. The real exchange will depreciate if the sum of expected future interest rate differentials are positive and/or the sum of expected future net liabilities are positive and/or a positive shock to the risk premium, $\epsilon_{UIP,t}$, occurs.

Also crucial to the understanding of the effects of the financial accelerator and liability dollarization is the behavior of the net worth of the wholesale sector. Again in (58) we can see that net worth increases with the ex post return on capital, and decreases with the financial accelerator risk premium and the ex post costs of capital in home currency and dollars: $\varphi(1 + R_t) + (1 - \varphi)(1 + R_t^*)\frac{RER_{C,t}}{RER_{C,t-1}}$. Note that $\frac{RER_{C,t}}{RER_{C,t-1}}$ is the real depreciation of the home currency, so net worth falls if Tobins Q falls and if some borrowing is in dollars ($\varphi < 1$). We see also that a *depreciation* of the real exchange rate brings about a further drop in net worth. However, an *appreciation* of the real exchange rate will offset the drop in net worth. Output falls through two channels: first, a drop in Tobins Q and a subsequent fall in investment demand and, second, through a reduction in consumption by entrepreneurs. For the analysis in the following sections, we parameterize the model according to two alternatives, Model no FF as the baseline open economy model (no frictions/dollarization) and Model FF that includes all the financial frictions discussed above and liability dollarization, assuming that firms borrow a fraction of their financing requirements $1 - \varphi \in [0, 1]$ in dollars.

7 Posterior Estimation

We now present estimates of the model variants for the Indian economy. We linearize about a zero inflation balanced growth steady state. Next, we briefly describe the estimation methods used in this section.

7.1 Bayesian Methods

Bayesian estimation entails obtaining the posterior distribution of the model's parameters, say θ, conditional on the data. Using Bayes' theorem, the posterior distribution is obtained as

$$p(\theta|Y^T) = \frac{L(Y^T|\theta)p(\theta)}{\int L(Y^T|\theta)p(\theta)d\theta} \tag{87}$$

where $p(\theta)$ denotes the prior density of the parameter vector θ, $L(Y^T|\theta)$ is the likelihood of the sample Y^T with T observations (evaluated with the Kalman filter) and $\int L(Y^T|\theta)p(\theta)d\theta$ is the marginal likelihood. Since there is no closed form analytical expression for the posterior, this must be simulated.

One of the main advantages of adopting a Bayesian approach is that it facilitates a formal comparison of different models through their posterior marginal likelihoods, computed using the Geweke (1999) modified harmonic mean estimator. For a given model $m_i \in M$ and common data set, the marginal likelihood is obtained by integrating out vector θ,

$$L\left(Y^T|m_i\right) = \int_\Theta L\left(Y^T|\theta, m_i\right) p\left(\theta|m_i\right) d\theta \tag{88}$$

where $p_i\left(\theta|m_i\right)$ is the prior density for model m_i, and $L\left(Y^T|m_i\right)$ is the data density for model m_i given parameter vector θ. To compare models (say, m_i and m_j) we calculate the posterior odds ratio which is the ratio of their posterior model probabilities (or Bayes Factor when the prior odds ratio, $\frac{p(m_i)}{p(m_j)}$, is set to unity):

$$PO_{i,j} = \frac{p(m_i|Y^T)}{p(m_j|Y^T)} = \frac{L(Y^T|m_i)p(m_i)}{L(Y^T|m_j)p(m_j)} \tag{89}$$

$$BF_{i,j} = \frac{L(Y^T|m_i)}{L(Y^T|m_j)} = \frac{\exp(LL(Y^T|m_i))}{\exp(LL(Y^T|m_j))} \tag{90}$$

in terms of the log-likelihoods. Components (89) and (90) provide a framework for comparing alternative and potentially misspecified models based on their marginal likelihood. Such comparisons are important in the assessment of rival models, as the model which attains the highest odds outperforms its rivals and is therefore favored.

Given Bayes factors, we can easily compute the model probabilities $p_1, p_2, \ldots, p_n$ for n models. Since $\sum_{i=1}^{n} p_i = 1$ we have that $\frac{1}{p_1} = \sum_{i=2}^{n} BF_{i,1}$, from which p_1 is obtained. Then $p_i = p_1 BF(i, 1)$ gives the remaining model probabilities.

7.2 Data, Priors, and Calibration

To estimate the system, we use five macroeconomic observables at quarterly frequency. We use measures of real GDP, real investment, the inflation rate, the nominal interest rate, and the real exchange rate. All data are taken from the International Financial Statistics and RBI database and the sample period is 1996:1–2008:4. The inflation rate is calculated on the Wholesale Price Index (WPI), which includes food, fuel, and manufacturing indices.[8] The interest rate is measured by the 91-day Treasury Bill rate, in order to capture the combined effect of the RBI policy rates and liquidity changes brought about by the Bank sterilization interventions (see Bhattacharya et al. (2010)). A time series for investment is only available at the annual frequency. Thus, we use the interpolation techniques suggested by Litterman (1983) to obtain quarterly data based on the Index of Industrial Production (IIP) for capital goods.[9] For GDP, data is available from 1996:4 onwards, so we interpolate the first few initial periods from annual data, using the IIP. Finally, We use the trade-weighted real effective exchange rate as a proxy for the real exchange rate.

Since the variables in the model are measured as deviations from a constant steady state, the GDP and investment series are detrended against a linear quadratic trend in order to obtain approximately stationary data.[10] Real variables are measured in logarithmic deviations from the respective trends, in percentage points, while inflation and the nominal interest rate are demeaned and expressed as quarterly rates. The corresponding measurement equations are:

[8]The WPI rather than the CPI was officially used by the RBI until 2014 (i.e., at the time we produced the paper), mainly because it was the broader measure and there were four different CPI measures, depending on the type of worker.

[9]The Bayesian system estimation techniques used in our study can easily handle variables measured with imprecision, by introducing stochastic measurement errors. Exploratory analysis revealed that measurement errors are a negligible source of uncertainty in our estimated models and we therefore focus on estimation results without measurement errors.

[10]Employing the Hodrick–Prescott filter instead delivers time series with similar behavior and estimation results are qualitatively, and quantitatively, very close.

Table 2 Calibrated parameters

Calibrated parameter	Symbol	Value for India
Discount factor	β	0.9863
Depreciation rate	δ	0.069
Risk premium—scaling	k_B	1.00
Financial accelerator risk premium	Θ	1.01
Imported investment share	is_{import}	0.15
Imported consumption share	cs_{import}	0.10
Exported investment share	is_{export}	0.02
Exported consumption share	cs_{export}	0.23

$$\begin{bmatrix} GDP_t \\ INV_t \\ log(WPI_t - WPI_{t-1}) \\ TBill_t/4 \\ REER_t \end{bmatrix} = \begin{bmatrix} log\left(\frac{Y_t}{Y}\right) \\ log\left(\frac{I_t}{I}\right) \\ log\left(\frac{\Pi_t}{\Pi}\right) \\ log\left(\frac{1+R_{n,t}}{1+R_n}\right) \\ log\left(\frac{REER_t}{REER}\right) \end{bmatrix} \tag{91}$$

In order to implement Bayesian estimation, it is first necessary to define prior distributions for the parameters. A few structural parameters are kept fixed in the estimation procedure, in accordance with the usual practice in the literature (see Table 2). This is done so that the calibrated parameters reflect steady-state values of the observed variables. For instance, β is set at 0.9823, corresponding to an interest rate of 7 % (matching its sample mean), while $\delta = 0.025$ is a common choice for the depreciation rate. In turn, the investment adjustment cost parameter ϕ_X is set at 2.

The choice of priors for the estimated parameters is usually determined by the theoretical implications of the model and evidence from previous studies. However, as noted in the introduction, estimated DSGE models for emerging economies, and India in particular, are scarce, though one might infer potential priors by comparing the features and stylized facts of developed and developing economies. In most cases, we use the same priors used in our earlier study (see Gabriel et al. 2012).

In general, inverse gamma distributions are used as priors when nonnegativity constraints are necessary, and beta distributions for fractions or probabilities. Normal distributions are used when more informative priors seem to be necessary. In some cases, we use same prior means as in previous studies (Levin et al. (2006); Smets and Wouters (2003); Smets and Wouters (2007), for example), but choose larger standard deviations, thus imposing less informative priors and allowing for the data to determine the parameters' location. The first four columns of Table 3 provide an overview of the priors used for each model variant. For consistency and comparability, all priors are the same across different specifications.

The risk aversion parameter σ allows significant room for maneuver, with a normal prior defined with a mean of 2 and standard deviation of 0.5. The beta prior density for ϱ is centered in the midpoint of the unit interval with a standard deviation of 0.2, while the Calvo-pricing parameter ξ has a mean of 0.75 and standard deviation of 0.1 as in Smets and Wouters (2007), implying a contract length of 4 quarters. The labor share α has a normal prior with mean 0.8 (approximately its steady-state value[11]), while ζ has a mean of 7 with a standard deviation of 0.5.

For the policy parameters, priors were chosen so that a large domain is covered, reflecting the lack of knowledge of the RBI reaction function. We choose beta distributions for the parameters that should be constrained between 0 and 1, namely the smoothing coefficient ρ (centered around 0.75 with a standard deviation of 0.1) and the forward–backward-looking parameters φ and τ, with a mean of 0.5 and a standard deviation of 0.2, a relatively diffuse prior. The feedback parameters θ and ϕ have normal priors with a mean of 2 and a standard error of 1, thus covering a relatively large parameter space.

The shock processes are the likeliest elements to differ from previous studies based on the developing economies. Adolfson et al. (2008), for example, argue for choosing larger prior means for shock processes when analyzing a small open developed economy (Sweden). In the case of India, it is natural to expect significantly larger swings in the macro observables and the prior means for the standard errors are therefore set at 3 (3.5 for the risk premium shock, higher than the US), using an inverse gamma distribution.

7.3 Posterior Estimates

The joint posterior distribution of the estimated parameters is obtained in two steps. First, the posterior mode and the Hessian matrix are obtained via standard numerical optimization routines. The Hessian matrix is then used in the Metropolis–Hastings algorithm to generate a sample from the posterior distribution. Two parallel chains are used in the MCMC-MH algorithm and in all the estimations reported in this paper, the univariate diagnostic statistics produced by Dynare indicate convergence by comparing between and within moments of multiple chains (Brooks and Gelman 1998).

Thus, 100,000 random draws (though the first 30 % “burn-in” observations are discarded) from the posterior density are obtained via the MCMC-Metropolis–Hastings algorithm (MH), with the variance–covariance matrix of the perturbation term in the algorithm being adjusted in order to obtain reasonable acceptance rates

[11] We chose not to calibrate α to its steady-state value and instead freely estimate this parameter. The proximity of the estimated values for α will provide additional indications regarding the quality of the fit for each model.

(between 20–30 %).[12] Table 3, reports posterior means of all estimated parameters, along with the approximate 95 % confidence intervals based on the approximate posterior standard deviation obtained from the inverse Hessian at the posterior mode.

Table 3 reports the estimation results for the standard SOE with no financial frictions (No FF) and for a model incorporating a financial accelerator mechanism and liability dollarization (FF), assuming a policy rule that feedbacks on inflation and the nominal exchange rate (Eq. (28)). In this rule the responses to both inflation deviations and exchange rate movements are direct, reflecting an open economy interest rate rule that predominantly tracks variability of the two potential targets, as we discussed in Sect. 1.[13] The two bottom lines of Table 3 report the log marginal likelihood of the two models under study. A striking result is the substantial improvement in fit achieved by the model with financial frictions over the simpler SOE model. Indeed, the difference in the log-likelihoods is remarkable, lending unequivocal support to the FF model.

The posterior estimates and confidence intervals for the two models are presented in the right-most column of Table 3. These results are plausible and are generally similar to those of Gabriel et al. (2012). One interesting aspect revealed by these estimates is that prices are estimated to be a lot stickier when financial frictions are absent, while under the second model, firms adjust prices quite frequently, between 1 and 3 quarters, implying only mild price stickiness. A similar result is obtained for consumption habits, with an estimated lower habit persistence for the FF model.

As in Gabriel et al. (2012), both estimated models undershoot α, suggesting a labor share around two-thirds. Structural parameters like σ and ζ deviate little from their prior means, in fact the posterior distributions overlap with the prior ones, which might suggest that the data is not very informative about these parameters. ϱ, on the other hand, is pinned down with better precision at around 0.3, much lower than the prior mean of 0.8. Estimates of μ are very imprecise and not significantly different from zero, which may suggest some identification problems. Our estimation delivers, based on the posterior estimates of λ_{C1}, a relatively low share of liquidity-constrained consumers in the Indian economy. Around 38 % of the households is liquidity constrained. These households do not trade on asset markets and consume entirely their disposable income each period. Although this figure seems low for a country where 27.5 % of the population live below the poverty line this is in line with the finding in Gabriel et al. (2012), which finds that $\lambda = 0.30$, and may present some important implications to the fiscal policy making in India.

The estimated parameters capturing the policy response to inflation suggest that the RBI appears to be quite aggressive in preempting inflationary pressures, with θ_{ph} close to 3. However, the response for fluctuations in the exchange rate is estimated to be quite feeble and not statistically different from zero. On the other hand, the degree of policy inertia is similar to that obtained in Gabriel et al. (2012), with ρ estimated above 0.85.

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[12] See Schorfheide (2000) for more details.

[13] Mallick (2011) estimates a structural VAR with the exchange rate and provides evidence of exchange rate targeting by the RBI.

Table 3 Priors and posterior estimates

Parameter	Notation	Prior distribution			Posterior distribution$^{\diamond}$	
		Density	Mean	S.D/df	No FF	FF
Investment adjustment	ϕ_i	Normal	4.00	1.50	3.50 [1.60:5.47]	3.89 [1.71:5.84]
Risk aversion	σ	Normal	2.00	0.50	2.27 [1.53:2.96]	2.25 [1.19:3.08]
Consumption habit	h_C	Beta	0.60	0.20	0.81 [0.60:0.97]	0.63 [0.12:0.98]
Calvo prices	ξ	Beta	0.75	0.15	0.83 [0.77:0.90]	0.69 [0.56:0.83]
Labor share	α	Normal	0.68	0.10	0.66 [0.63:0.69]	0.63 [0.58:0.68]
Preference parameter	ϱ	Beta	0.80	0.20	0.09 [0.04:0.14]	0.27 [0.10:0.44]
Substitution elas. (H/F goods)	μ	Normal	1.50	0.50	0.50 [−0.25:1.26]	1.04 [0.02:1.89]
Investment substitution elas.	ρ_I	Inv. gamma	0.25	2.00	0.094 [0.056:0.133]	0.118 [0.061:0.177]
Risk premium elas.	χ_B	Inv. gamma	0.05	2.00	0.044 [0.013:0.084]	0.037 [0.013:0.064]
Substitution elas. (varieties)	ζ	Normal	7.00	0.50	7.07 [6.30:7.95]	7.11 [6.28:7.94]
Financial frictions						
Ext. finance premium elas. (F)	χ	Inv. gamma	0.03	4.00	–	0.025 [0.006:0.046]
Inverse of leverage (F)	n_k	Beta	0.50	0.15	–	0.49 [0.35:0.65]
Entrepreneurs survival rate (F)	ξ_e	Beta	0.93	0.05	–	0.88 [0.80:0.97]
Degree of liability dollarization	φ	Beta	0.50	0.10	–	0.22 [0.05:0.38]
Proportion of RT consumption	λ_{C1}	Beta	0.10	0.05	–	0.08$^{✠}$ [0.01:0.18]
Interest rate rule						
Interest rate smoothing	ρ	Beta	0.65	0.10	0.85 [0.73:0.99]	0.88 [0.77:0.99]
Feedback from exp. inflation	θ_{ph}	Normal	2.00	1.00	2.91 [1.60:3.98]	2.68 [1.58:3.74]
Feedback from exchange rate	θ_{sh}	Normal	0.50	0.25	0.11 [0.00:0.21]	0.17 [0.01:0.29]

(continued)

Table 3 (continued)

Parameter	Notation	Prior distribution			Posterior distribution◇	
		Density	Mean	S.D/df	No FF	FF
AR(1) coefficient						
Technology	ρ_A	Beta	0.5	0.10	0.38 [0.19:0.58]	0.51 [0.26:0.76]
Government spending	ρ_G	Beta	0.50	0.10	0.91 [0.84:0.97]	0.77 [0.52:0.94]
Price markup	ρ_{MS}	Beta	0.65	0.10	0.96 [0.92:0.99]	0.64 [0.34:0.94]
UIP	ρ_{uip}	Beta	0.65	0.10	0.73 [0.50:0.94]	0.87 [0.78:0.98]
Foreign interest rate	ρ_r	Beta	0.50	0.10	0.48 [0.17:0.81]	0.65 [0.40:0.87]
Foreign inflation rate	ρ_{pie}	Beta	0.65	0.10	0.52 [0.23:0.82]	0.67 [0.38:0.91]
Foreign consumption	ρ_c	Beta	0.65	0.10	0.65 [0.35:0.96]	0.78 [0.51:0.95]
Foreign investment	ρ_i	Beta	0.50	0.10	0.51 [0.18:0.83]	0.50 [0.17:0.82]
Foreign MUC	ρ_{muc}	Beta	0.65	0.10	0.72 [0.50:0.97]	0.73 [0.49:0.98]
Standard deviation of AR(1) innovations/I.I.D. shocks						
Technology	$sd(\epsilon_A)$	Inv. gamma	2.00	3.00	4.03 [2.28:5.76]	3.11 [1.57:4.99]
Government spending	$sd(\epsilon_G)$	Inv. gamma	2.00	3.00	16.04 [12.42:19.62]	8.54 [0.53:18.57]
Price markup	$sd(\epsilon_{MS})$	Inv. gamma	2.00	3.00	8.97 [5.54:12.44]	1.84 [0.58:3.44]
UIP	$sd(\epsilon_{UIP})$	Inv. gamma	2.00	3.00	1.32 [0.66:1.95]	1.29 [0.67:1.93]
Monetary policy	$sd(\epsilon_r)$	Inv. gamma	2.00	3.00	1.12 [0.82:1.39]	1.10 [0.82:1.35]
Foreign interest rate	$sd(\epsilon_{re})$	Inv. gamma	2.00	3.00	1.87 [0.58:3.36]	2.19 [0.58:3.90]
Foreign inflation rate	$sd(\epsilon_{pie})$	Inv. gamma	2.00	3.00	1.56 [0.52:2.72]	1.57 [0.63:2.64]
Foreign consumption	$sd(\epsilon_c)$	Inv. gamma	2.00	3.00	1.58 [0.55:2.56]	8.20 [0.61:14.19]
Foreign investment	$sd(\epsilon_i)$	Inv. gamma	2.00	3.00	2.04 [0.56:4.17]	1.98 [0.59:3.91]
Foreign MUC	$sd(\epsilon_{muc})$	Inv. gamma	2.00	3.00	2.16 [0.57:4.20]	1.51 [0.56:2.56]
LL					–529.07	–511.50

◇*Notes* we report posterior means and 95 % probability intervals (in parentheses) based on the output of the Metropolis–Hastings algorithm. Sample period: 1996:I to 2008:IV

✠ λ is derived as follows: $\frac{C_2}{C} = \frac{C_2^*}{C^*} = 1.5$, then $\lambda_{C_1} = \lambda \frac{C_1}{C} = 1 - (1 - \lambda)\frac{C_2}{C}$

The estimation of the shock processes shows some persistence, but less so that results for developed economies such as the US and the Euro Area. Interestingly, the external shocks are even less persistent. Second, the estimated standard deviations are larger than the values commonly found for developed economies, in accordance with the macro volatility-stylized facts typically associated with emerging economies. Most strikingly, the standard errors associated with the government spending and price markup shocks reach very large values for the No FF model. Results for the FF model are less pronounced, although in this case, estimations pick up a large standard deviation coming from foreign consumption. The remaining standard deviations are somewhat below the specified priors.

8 Empirical Applications

Having shown the model estimates and the assessment of relative model fit between the two alternative variants, we now use them to investigate a number of key macroeconomic issues in India. The model favored in the space of competing models may still be poor (potentially misspecified) in capturing the important dynamics in the data. To further evaluate the absolute performance of one particular model against data, it is necessary to compare the model's implied characteristics with those of the actual data. Also in this section, we address the following questions: (i) can the models capture the underlying characteristics of the actual data? (ii) what are the impacts of the structural shocks on the main macroeconomic time series?

8.1 Standard Moment Criteria

To assess the contributions of assuming different specifications in our estimated models, i.e., Models with and without financial frictions (FF), we compute some selected second moments and present the results in this subsection. Table 4 presents the second moments implied by the above estimations and compares with those in the actual data. In particular, we compute these model-implied statistics by solving the models at the posterior means obtained from estimation. The results of the model's second moments are compared with the second moments in the actual data to evaluate the models' empirical performance.

In terms of the standard deviations, almost all models generate relative high volatility compared to the actual data (except for the interest rate). Both model variants can successfully replicate the stylized fact that investment is more volatile than output. Inflation volatility is practically unchanged owing to the higher responsiveness (and volatility) of the interest rate. Overall, the estimated model with FF is able to reproduce acceptable volatility for the main variables of the DSGE model. The inflation volatilities implied by the model with no FF is close to that of the data. In line with the Bayesian model comparison, the NK model with financial frictions fits the data better in terms of implied volatilities of output, investment, real exchange rate and interest rate, getting closer to the data in this dimension. Note that our "better" model with FF clearly outperforms its rival in capturing the volatilities of output and investment and does well at matching the interest rate volatility in the data.

Table 4 also reports the cross-correlations of the five observable variables vis-a-vis output. All models perform successfully in generating the positive contemporaneous correlations observed in the data (the only exception is the predicted correlation between output and inflation generated by the model without financial frictions). It is worth noting that our "preferred" model, NK model with FF, does well at capturing the contemporaneous cross-correlation of the inflation rate and output, suggesting that the financial accelerator and liquidity-constrained consumption help fitting the Indian data in this dimension.

The NK model with FF outperforms its counterpart at capturing the autocorrelations (order = 1) of all variables apart from the interest rate. Using this model, output is more autocorrelated while inflation seems to be less autocorrelated than those in the data at order 1. Also note, as suggested by Castillo et al. (2013), that the "preferred" model does a better job at matching the data autocorrelations in terms of the real exchange rate inertia and this is generated by the endogenous persistence induced by partial liability dollarization. In other words, the additional Phillips curve that arises from the dollarization mechanism seems to be supported by the data. This provides additional evidence explaining why the inclusion of liability dollarization helps a model to outperform rivals. Nevertheless, the NK FF model, in general, is able to capture the main features of the data in most dimensions and strengthens the argument that the presence of financial friction mechanisms is supported by the data.

Table 4 Selected second moments$^{\diamond}$

	Output	Inflation	Interest rate	Investment	Exchange rate
Standard deviation					
Data	1.50	0.97	1.93	6.15	3.56
Model no FF	6.58	**1.60**	1.72	17.74	6.71
Model FF	**2.67**	1.75	**1.80**	**10.84**	**6.23**
Cross-correlation with output					
Data	1.00	0.11	0.26	0.57	0.05
Model no FF	1.00	–0.08	**0.18**	0.84	0.82
Model FF	1.00	**0.19**	0.12	**0.49**	**0.16**
Autocorrelations (order = 1)					
Data	0.59	0.13	0.83	0.91	0.65
Model no FF	0.97	0.27	**0.84**	0.99	0.95
Model FF	**0.83**	**0.23**	0.86	**0.97**	**0.92**

$^{\diamond}$All the second moments are theoretical moments computed from the model solutions (order of approximation = 1). The results are based on the models' posterior distribution

8.2 Autocorrelation Functions

To further illustrate how the estimated models capture the data statistics, we plot the unconditional autocorrelations of the actual data and those of the endogenous variables generated by the model variants in Fig. 1. In general, all models match reasonably well the autocorrelations of output, interest rate and investment shown in the data within a shorter period horizon. The data report that these three variables are positively and very significantly autocorrelated over short horizons. At lags of one-two quarters, both of the estimated models are able to generate the observed autocorrelations of interest rate and investment as noted above. Output, investment, and the real exchange rate are more autocorrelated in both models than in the data, but the NK model with FF gets closer to the data toward the end of sample period. When it comes to matching inflation, all models exhibit the shortcoming of the inability of predicting the dynamics in the data.

Of particular interest is that, when assuming the absence of financial frictions, the implied autocorrelograms produced by the NK model fit very well the observed autocorrelation of interest rate, while the NK FF model generates slightly more sluggishness and is less able to match the autocorrelation observed in the data as the period horizon increases. However, the performance of the two models tends to converge toward the end of the sample period. Perhaps the main message to emerge

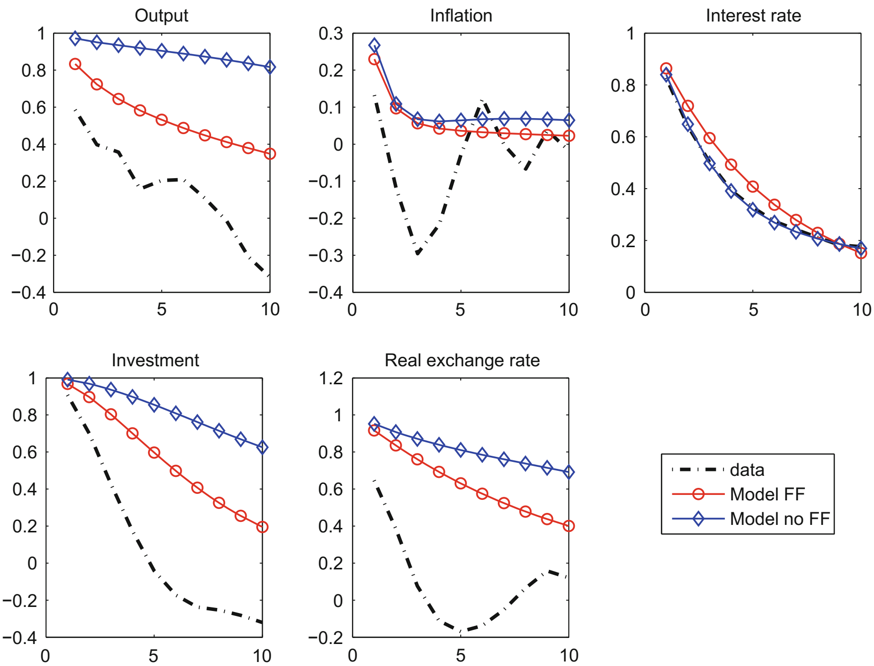

Fig. 1 Autocorrelations of observables in the actual data and in the estimated models

from this RBC type of model validity exercise is that it can be misleading to assess model fit using a selective choice of second moment comparisons. LL comparisons provide the most comprehensive form of assessment that will still leave trade-offs in terms of fitting some second moments well, at the expense of others. The NK model incorporating FF outperforms in terms of getting closer to the autocorrelation observed in the Indian GDP, investment and real exchange rate. Overall, the results in this exercise generally show again that the estimated DSGE models are able to capture the some important features of Indian data and the presence of financial frictions helps improve the model fit to data.

8.3 Impulse Response Analysis

In this section we study (the estimated posterior) impulse responses for two selected shocks: a domestic technology shock (a_t) and a shock to the country's external risk premium ($\epsilon_{UIP,t}$). The aim of this exercise is twofold. First, we are interested in comparing the transmission of the two key internal and external shocks when the accelerator mechanism is "turned on" and "turned off". This way, we assess the impact of imposing the financial accelerator, dollarization, and the credit-constrained consumption on different model dynamics. Second, we investigate the importance of shocks to the endogenous variables of interests in order to gain a better understanding of the innovation and forecasting uncertainties and, thus, the model uncertainties faced by monetary policymakers. This exercise is performed for our models with and without the financial frictions. The endogenous variables of interest are the observable variables in the estimation and each response is for a 20-period (5 years) horizon.

Figures 2 and 3 plot the mean responses corresponding to a positive one standard deviation of the shocks' innovation. The impulse response functions show the percentage deviation of variables from their steady state. A technology (TFP) shock a_t has a positive impact on output, investment, real exchange rate, and the terms of trade and implies an immediate fall in inflation, real wage, and interest rate. Nevertheless, the effect dies out relatively rapidly (about 1 year) when affecting output, real exchange rate, the terms of trade and the price level. This shock appears to be fairly persistent when affecting investment, as confirmed by the AR(1) coefficient estimate.

The plots also suggest that a positive technology shock in India acts as a labor demand shifter: higher productivity shrinks labor demand, pushing marginal cost down, lowers prices and interest rate, but its effect on prices is not persistent: inflation returns to preshock levels after about 1 year. When all firms experience a decline in their marginal cost as a result of a shock in technology, they will adjust prices downward only partially in the short run. In addition, a technology shock also depreciates the currency in response to the lowering of the interest rate, thereby increasing the terms of trade, which improves goods' competitiveness. Output also jumps upwards in response to the lower future expected real interest rate.

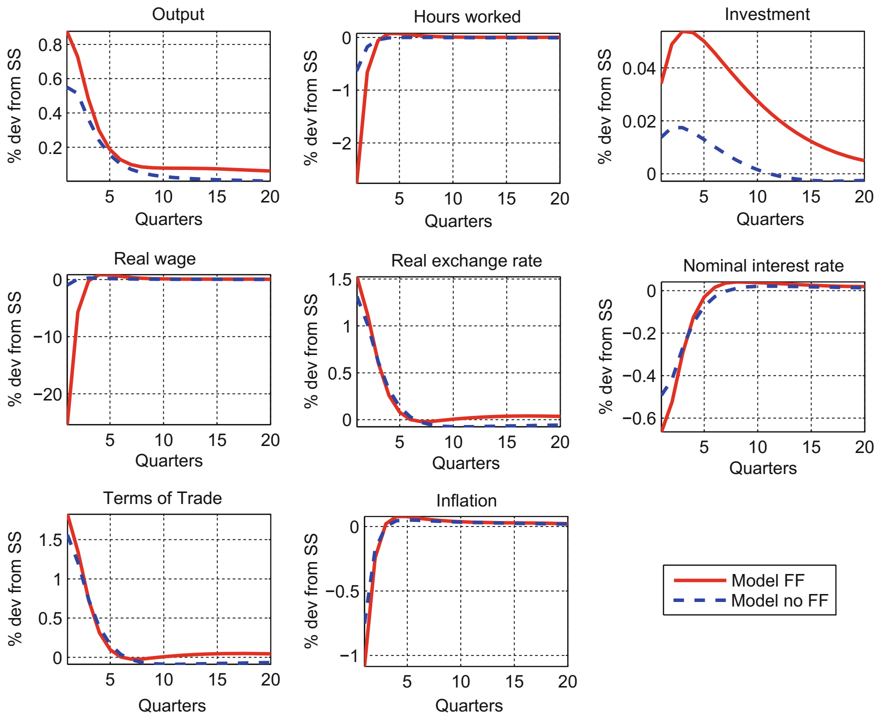

Fig. 2 Estimated impulse responses to a positive productivity shock

Consider now the labor market and the behavior of the real wage. With sticky prices, the increase in demand for output is less than the productivity increase; so the demand for labor falls, shifting the demand curve in (real wage, quantity) space inward. This puts an initial downward pressure on the real wage. On the supply side of the labor market, since the marginal utility of consumption for the household falls as consumption rises, there is an increase in leisure (i.e., a reduction in hours), shifting the supply-of-labor curve outward, thus tending to raise the real wage. The demand effect dominates, and we find that the real wage falls on impact of the productivity improvement. This finding is in line with the closed economy model analysis in Gabriel et al. (2012). With the credit frictions in place a productivity shock translates into a larger change in the wage if workers are more credit constrained because of more inelastic labor supply from such workers.

We find that the addition of financial market frictions in India does not substantially affect the postshock behaviors of inflation exchange rate and terms of trade. However, there are amplifications of the output, employment, investment, nominal interest rate and real wage responses in the presence of the financial accelerator. The amplification seems to be much more substantial for the real wage, employment and investment responses. This result is found to be generally consistent with those from

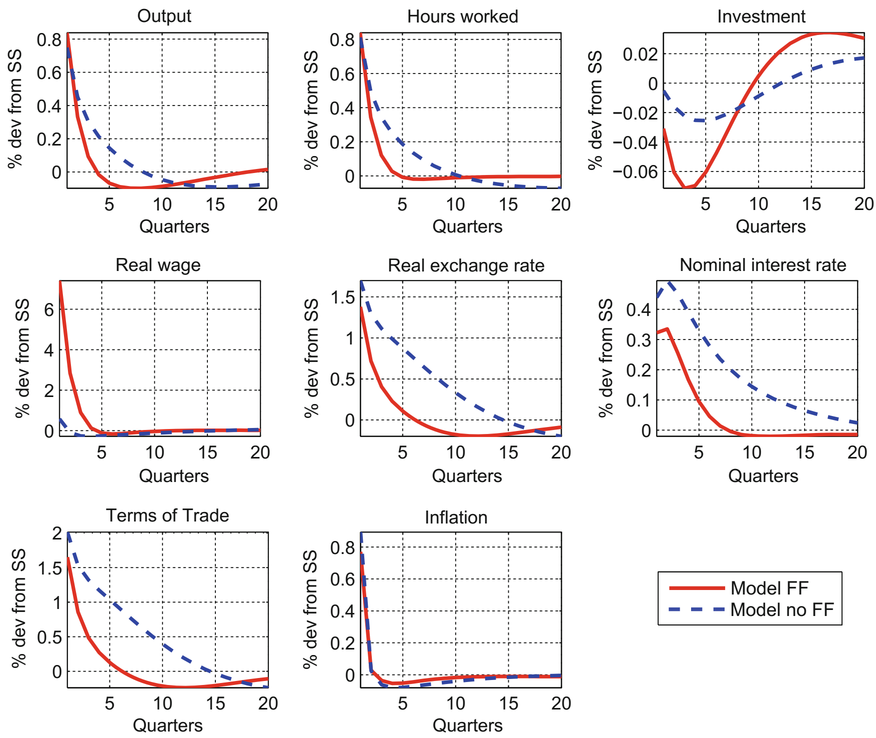

Fig. 3 Estimated impulse responses to a positive UIP shock

Bernanke et al. (1999)'s simulations with a monetary policy shock. When there is an unanticipated positive shock in factor productivity, the demand for capital is stimulated, which in turn raises investment and the price of capital. The increase in asset prices pushes up net worth, forcing down the external finance premium and this, as a result, helps to further stimulate private investment. The decline in inflation, however, is relatively marginal with a financial accelerator.

In Fig. 3, we evaluate the responses from a one standard deviation increase in the domestic country external risk premium. Most responses are consistent with the findings of Bernanke et al. (1999), using calibrated models. In particular, the models with and without FF predict that a positive risk premium shock immediately depreciates the real exchange rate. As expected, there is an immediate drop in investment because the increase in the cost of capital drives Tobin's Q down. The initial fall in net worth is exacerbated rather than attenuated by balance sheet effects, and the external risk premium rises by more. Investment further falls with the effects of the financial frictions. The nominal interest rate jumps on impact and the interest rate differential relative to abroad is rapidly closed and the exchange rate depreciation is short-lived because of the monetary policy tightening. Indeed, we expect to observe an interest rate increase when there is an increase in the external borrowing premium.

Almost all the responses are short-lived, as suggested by the parameter estimates. The immediate implication is that, through the modified interest-exchange rate UIP channel, the monetary policy can trigger a further balance sheet effect that has the effect of returning net worth back to its steady state faster with the effects of FF, following the exchange rate appreciation, and this way bring investment and hence output faster back to equilibrium. Most significantly, we find that in the model with FF the presence of the financial accelerator and dollarization magnifies the effects of a shock to the country's external risk premium on investment, the real wage, and nominal interest rate. There is a long-stabilizing effect as investment and output are "accelerated" faster back to potential.

Overall, the results from the estimated posterior impulse responses following unanticipated shocks confirm the findings discussed above, that there is substantial evidence in the data to support the presence of a financial accelerator mechanism and the various other financial frictions. More precisely, the inclusion of the accelerator along with the dollarized borrowers affects the transmission mechanism of monetary policy and significantly magnifies the effects of both internal and external shocks on most of the key macroeconomic variables in the estimated economy. Nonetheless, it produces only a relatively modest initial impact on output following a UIP shock and this contradicts to the findings from Gertler et al. (2003)'s model simulation. The mild response perhaps implies some distinct compositional effects to components of output from various frictions. Given that financial frictions tend to impact more directly fluctuations in investment via capital perhaps there are offsetting effects among the individual output components, coming from various frictions (e.g., a delayed response of consumption). In Fig. 3, the initial rise of output falls sharply following the fall in investment demand. With the frictions operative the contraction in output is nearly doubled at longer horizons.

9 Policy Discussions with Financial Imperfections

The RBI's proposed stabilization objective combined with the change of its nominal anchor to headline CPI inflation under the FIT framework have strong implications for policy making/transmission in the presence of financial frictions. For example, imperfect access to financial markets implies that the demand of credit-constrained consumers is insensitive to interest rate movements. Because their demand depends only on real wages, relative price changes, through the effects on real wages, also influence aggregate demand. This has implications on the effectiveness of monetary policy, and inflation targets as a nominal anchor that helps stabilize inflationary expectations in an uncertain future. Currency mismatch due to liability dollarization may be reduced by stabilized low inflation (Mishkin 2006). With the features that are especially relevant to India and other emerging economies, there are more important challenges to FIT in emerging economies: weak public sector financial management and inflation control, getting compounded by low policy credibility and degree of central bank independence, can lead to sudden stops of capital inflows thus making emerging economies such as India vulnerable to financial crises (Calvo and Mishkin 2003). The transmission of policy operation to inflation and aggregate demand may be affected by weak financial sector institutions and markets. Transition to FIT is complicated in emerging economies and should be combined with reforms of improving institutional framework and prudential supervision of the financial system. The interesting results from the IRF analysis show that some movements including output are more persistent when the financial frictions are present. This extra inertial in output suggests that agents are more responsive to current financial conditions. This, consequently, requires active behaviors of policy that respond to financial conditions. When markets are subject to significant financial imperfections, monetary policy at the RBI needs to be rather aggressive to stablize/prevent persistent fluctuations. Our results in terms of monetary policy predict aggressive expected inflation targeting stance which seems to be consistent with the behavior of the monetary authorities.

There are also welfare outcomes to the monetary policy frameworks of inflation stabilization objective with financial frictions. Since we find that the various forms of financial imperfections are significant amplifier of the effects of financial stress in the Indian macroeconomy, the policy questions here are (a) how do financial frictions affect the conduct of monetary policy? (b) because of extensive liability dollarization, should the exchange rate play a special role in monetary policy? There is a growing body of literature that compares alternative monetary policy regimes by their ability to stabilize emerging economies when faced with external shocks and financial frictions. In Batini et al. (2010a), the paper sets out the two-bloc SOE model calibrated using Indian/US data and studies the effectiveness of macroeconomic policy under two monetary interest rate regimes: domestic Inflation targeting with a floating exchange rate and a managed exchange rate. The main result is that flexible exchange rate regimes outperform a pegging one. In Batini et al. (2010b), the model with FF is further calibrated to India and other emerging economies. An important feature of their work is the introduction of a zero lower bound into the construction of policy rules and they compare these regimes with the optimal policy. The paper first reaffirms the finding in the literature that financial frictions, especially when coupled with liability dollarization, severely increase the costs of a pegging regime. It also recommends that central banks with these frictions should not explicitly target the exchange rate; nor should they implicitly do so by choosing a CPI inflation target. With frictions, the zero lower bound constraint on the nominal interest rate makes simple Taylor-type rules perform much worse in terms of stabilization performance than fully optimal monetary policy. The main message is that monetary policymakers should consider adopting the "twin pillars" of flexible exchange rate and inflation targeting, as opposed to their more traditional use of active exchange rate management, to accommodate fluctuations in capital inflows and anchor the inflation rate, and that future research should examine alternative simple rules that mimic the fully optimal rule more closely.

Before the financial crisis of 2008 there was another main approach in the literature to modeling the interaction between banking distress and the real economy. This was modeled as "Collateral Constraints", going back to Kiyotaki and Moore (2007) and was subsequently developed and incorporated into a DSGE model by Brozoza-Brzezina et al. (2013). In this setting agents face endogenous credit limits determined by the value of collateralized assets. Collateral constraints always bind but default never occurs. In the financial accelerator scenario the propagation and amplification come from the fluctuation of agents' net worth while in the collateral constraint scenario from fluctuations in asset prices. The significance of such credit frictions, which are particularly relevant for emerging markets such as India, presents implications for monetary policy and housing prices (see, for example, Aoki and Vlieghe (2004) and Iacoviello (2005)). From 2008 onward the literature on financial frictions and macroeconomic fluctuations has expanded considerably and focused both on improving the existing approaches and on developing new theories to model the interactions between the financial sector and the real economy focusing mainly on how monetary policy should react to financial crisis. Cúrdia and Woodford (2010) extend the financial accelerator approach to investigate the implications of time-varying interest rate spreads for the conduct of monetary policy. Adrian and Shin (2009) analyze how balance sheet quantities of market-based financial intermediaries are important macroeconomic state variables for the conduct of monetary policy. Gertler and Karadi (2011) and Gertler and Kiyotaki (2012) extend the financial accelerator approach to analyze the conduct of "Unconventional" Monetary Policy.

10 Conclusions and Future Research

Overall, the estimated models reveal some useful insights. By extending our analysis to a small open economy framework, we now include important sources of fluctuations. Moreover, the introduction of financial frictions in the form of liquidity-constrained consumers, a financial accelerator mechanism and liability dollarization are not only realistic, but also conducive to a better empirical performance. Indeed, model fit is significantly improved, thus providing a more consistent explanation for the fluctuations exhibited by the data. This intensifies the exposure of a SOE to internal and external shocks in a manner consistent with the stylized facts discussed in Sect. 1.

The results correctly predict that the Indian economy is subject to more volatile shocks and that prices appear to be relatively flexible for India. In terms of monetary policy, an aggressive expected inflation targeting stance seems to be consistent with the behavior of the monetary authorities. Overall, these results suggest that a great deal of volatility is is being transmitted by the demand side of the economy. One possible explanation is that all sorts of exogenous uncertainty, and potential misspecifications (particularly on the demand side) are being picked up by these shock processes. Note that we do not explicitly model fiscal policy and we are not using observables for the foreign sector. This suggests that careful modeling of fiscal policy might be required to understand this result better.

Nevertheless, there are limitations to our study and a number of directions for future research. First, we believe that in the case of emerging economies, the role of trends in the data requires special attention. Andrle (2008), for example, argues that assumptions on trending behavior should be explicitly modeled, rather than side-stepped by means of an ad hoc filtering procedure. Alternatively, one can take an agnostic view regarding detrending in DSGE models by following the one-step approach recently suggested by Ferroni (2011), in which filtering parameters are jointly estimated with structural parameters, thus allowing for formal statistical comparisons among different detrending procedures.

Second, there is some discrepancy in matching some moments between the model and data. Figure 1 highlights the inability of the model to satisfactorily account for the observed autocorrelations in investment, output and real exchange rate, whereas Table 4 shows that the model over predicts volatilities of all variables except the interest rate. As discussed, part of this could be a result of misspecification of the trend when the data is detrended. This could also be due to the influence of the priors used in the estimation. The latest development in this area is employing endogenous priors in DSGE estimations, in which the priors are selected endogenously based on presamples to optimize the model's ability in matching the moments of the endogenous variables (see Christiano et al. (2011), Del Negro and Schorfheide (2008) and Chin et al. (2015)). Perhaps the main message to emerge from this RBC type of model validity exercise in this paper is that it can be misleading to assess model fit using a selective choice of second moment comparisons. Likelihood comparisons provide the most comprehensive form of assessment that will still leave trade-offs in terms of fitting some second moments well, at the expense of others. An alternative way of validating the model performance is to follow Del Negro and Schorfheide (2004) and Del Negro et al. (2007) and to compare the DSGE model with a hybrid model that is a combination of an unrestricted VAR and the VAR implied by the estimated DSGE model (DSGE priors). These DSGE-VAR routines can also be used to test model misspecification in a more formal way as the empirical performance of a DSGE-VAR depends on the tightness of the DSGE prior and is used as a benchmark for validation.

Third, several recent papers have documented the importance of the cost channel of monetary policy transmission, in which nominal interest rate fluctuations affect the cost of financing working capital, impacting on firms marginal cost and pricing decisions. This monetary friction could be incorporated and tested for its empirical relevance, as an additional friction in our Indian SOE model. Employment frictions in the labor market, wage stickiness, and other form of financial frictions discussed in the previous section may be the other features worth testing in the current model. A formal comparison with all these approaches would be of some interest.

Finally, it would also be interesting to learn to what extent the different shocks are important in accounting for fluctuations in the Indian economy. Which are the main frictions and driving forces of business cycle dynamics in this small open economy? The analysis can be done by parameterizing the model according to alternative variants, ordered by increasing degrees of frictions and extending the estimation results to compute variance decompositions. Again this suggests directions for future research.

A A Closed Economy Model

This section develops a standard New Keynesian (NK) DSGE model without any features we associate with emerging economies. To give us a preliminary insight into what is different about an emerging economy such as India. Every NK DSGE model has at its core a real business cycle model, describing the intertemporal problems facing consumers and firms and defining what would happen in the absence of the various Keynesian frictions. We first define a single-period utility for the representative agent in terms of consumption, C_t, and leisure, L_t, as

$$\Lambda_t = \Lambda(C_t, L_t) = \frac{((C_t - h_C C_{t-1})^{(1-\varrho)} L_t^{\varrho})^{1-\sigma} - 1}{1-\sigma} \tag{A.1}$$

In this utility function $\sigma \geq 1$ is a risk aversion parameter which is also the inverse of the intertemporal rate of substitution. h_C is a habit parameter for private consumption C_t.[14] The parameter $\varrho \in (0, 1)$ defines the relative weight households place on consumption and this form of utility is compatible with a balanced growth steady state for for all $\sigma \geq 1$.[15] For later use, we write down the marginal utilities of consumption and leisure as, respectively,

$$\Lambda_{C,t} = (1-\varrho)(C_t - h_C C_{t-1})^{(1-\varrho)(1-\sigma)-1} L_t^{\varrho(1-\sigma)} \tag{A.2}$$

$$\Lambda_{L,t} = -\varrho(C_t - h_C C_{t-1})^{(1-\varrho)(1-\sigma)} L_t^{\varrho(1-\sigma)-1} \tag{A.3}$$

The value function at time t of the representative household is given by

$$\Omega_t = E_t \left[\sum_{s=0}^{\infty} \beta^s \Lambda(C_{t+s}, L_{t+s}) \right] \tag{A.4}$$

where β is the discount factor. In a stochastic environment, the household's problem at time t is to choose state-contingent plans for consumption $\{C_t\}$, leisure, $\{L_t\}$ and holdings of financial savings to maximize Ω_t given its budget constraint in period t

$$B_{t+1} = B_t(1 + R_t) + W_t h_t - C_t \tag{A.5}$$

[14] An alternative preference specification is the Jaimovich–Rebelo preferences (Jaimovich and Rebelo 2009), that allows for flexible parameterization of the strength of wealth effects on the labor supply decision. The preference takes the following form and habit evolves according to $H_t = C_t^{\kappa} H_{t-1}^{1-\kappa}$. In the case with the wealth elasticity of labor supply $\kappa = 0$ there is no wealth effect on labor supply. This flexible specification links agents' habits with their consumption decisions and can account for the high volatility of wage and consumption relative to output that characterizes developing countries. This feature may be important to study the effect of income on labor supply for emerging markets like India in adverse financial conditions: rising interest rate can induce larger short run wealth effects on labor supply despite of a significant drop in wages.

[15] See Barro and Sala-i-Martin (2004), Chap. 9.

where B_t is the net stock of real financial assets at the beginning of period t, W_t is the real wage rate, and R_t is the real interest rate paid on assets held at the beginning of period t. Hours worked are $h_t = 1 - L_t$ and the total amount of time available for work or leisure is normalized at unity. Government spending is financed by lump-sum nondistortionary taxes throughout. The first-order conditions for this optimization problem are

$$\Lambda_{C,t} = \beta E_t \left[(1 + R_{t+1}) \Lambda_{C,t+1} \right] \tag{A.6}$$

$$\frac{\Lambda_{L,t}}{\Lambda_{C,t}} = W_t \tag{A.7}$$

Equation (A.6) is the Euler consumption function: it equates the current marginal utility of consumption with the discounted marginal of consumption of a basket of goods in period $t + 1$ enhanced by the interest on savings. Thus, the household is indifferent as between consuming 1 unit of income today or $1 + R_{t+1}$ units in the next period. Equation (A.7) equates the marginal rate of substitution between consumption and leisure with the real wage, the relative price of leisure. This completes the household component of the RBC model.

Turning to the production side, we assume that output Y_t is produced using hours, h_t and beginning-of-period capital K_t with a Cobb–Douglas production function

$$Y_t = F(A_t, h_t, K_t) = (A_t h_t)^{\alpha} K_t^{1-\alpha} \tag{A.8}$$

where A_t is a technology parameter and Y_t, h_t, and K_t are all in per capita (household) units. Assume first that capital can adjust instantly without investment costs. Then equating the marginal product of labor with the real wage and the marginal product of capital with the cost of capital (given by the real interest rate plus the depreciation rate, $R_t + \delta$), we have

$$F_{h,t} = \alpha \frac{Y_t}{h_t} = W_t \tag{A.9}$$

$$F_{K,t} = (1 - \alpha) \frac{Y_t}{K_t} = R_t + \delta \tag{A.10}$$

Let investment in period t be I_t. Then capital accumulates according to

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{A.11}$$

The RBC model is then completed with an output equilibrium equating supply and demand

$$Y_t = C_t + I_t + G_t \tag{A.12}$$

where G_t is government spending on services assumed to be formed out of the economy's single good and by a financial market equilibrium. In this model, the only asset accumulated by households as a whole is capital, so the latter equilibrium is simply $B_t = K_t$. Substituting into the household budget constraint (A.5) and using the first-order conditions (A.9) and (A.10), and (A.11) we end up with the output equilibrium condition (A.12). In other words, equilibrium in the two factor markets and the output market implies equilibrium in the remaining financial market, which is simply a statement of Walras' Law.

Now let us introduce investment costs. It is convenient to introduce capital producing firms that at time t convert I_t of output into $(1 - S(X_t))I_t$ of new capital sold at a real price Q_t and at a cost (that was absent before) of $S(X_t)$. Here, $X_t \equiv \frac{I_t}{I_{t-1}}$ and the function $S(\cdot)$ satisfies $S', S'' \geq 0$; $S(1+g) = S'(1+g) = 0$. Thus, investment costs are convex and disappear along in the balanced growth steady state. They then maximize expected discounted profits

$$E_t \sum_{k=0}^{\infty} D_{t,t+k} \left[Q_{t+k}(1 - S\left(I_{t+k}/I_{t+k-1}\right))I_{t+k} - I_{t+k}\right]$$

where $D_{t,t+k} \equiv \beta \frac{\Lambda_{C,t+k}}{\Lambda_{C,t}}$ is the real stochastic discount rate and

$$K_{t+1} = (1-\delta)K_t + (1 - S(X_t))I_t \tag{A.13}$$

This results in the first-order condition

$$Q_t(1 - S(X_t) - X_t S'(X_t)) + E_t\left[\frac{1}{(1+R_{t+1})} Q_{t+1} S'(X_{t+1}) \frac{I_{t+1}^2}{I_t^2}\right] = 1 \tag{A.14}$$

Demand for capital by firms must satisfy

$$E_t[(1+R_{t+1})RPS_{t+1}] = \frac{E_t\left[(1-\alpha)\frac{P_{t+1}^W Y_{t+1}}{K_{t+1}} + (1-\delta)Q_{t+1}\right]}{Q_t} \tag{A.15}$$

In (A.15) the right-hand side is the gross return to holding a unit of capital in from t to $t+1$. The left-hand side is the gross return from holding bonds, the opportunity cost of capital and includes an exogenous risk premium shock RPS_t, which, for now, we leave unmodeled. We complete the setup with investment costs by defining the functional form

$$S(X) = \phi_X (X_t - (1+g))^2 \tag{A.16}$$

where g is the balanced growth rate. The RBC model we have set out defines a equilibrium in output, Y_t, consumption C_t, investment I_t, capital stock K_t and factor prices, W_t for labor and R_t for capital, and the price of capital Q_t, given exogenous processes for technology A_t, government spending G_t and the risk premium shock RPS_t.

The NK framework combines the DSGE characteristics of RBC models with frictions such as monopolistic competition—in which firms produce differentiated goods and are price setters, instead of Walrasian determination of prices—and nominal rigidities, in which firms face constraints on the frequency with which they are able to adjust their prices. Therefore, we now introduce a *retail sector* that uses a homogeneous wholesale good to produce a basket of differentiated goods for consumption

$$C_t = \left(\int_0^1 C_t(m)^{(\zeta-1)/\zeta} dk \right)^{\zeta/(\zeta-1)} \tag{A.17}$$

where ζ is the elasticity of substitution. This implies a set of demand equations for each intermediate good m with price $P_t(m)$ of the form

$$C_t(m) = \left(\frac{P_t(m)}{P_t} \right)^{-\zeta} C_t \tag{A.18}$$

where $P_t = \left[\int_0^1 P_t(m)^{1-\zeta} dm \right]^{\frac{1}{1-\zeta}}$. P_t is the aggregate price index.

Conversion of good m from a homogeneous output requires a cost $cY_t^W(m)$ where wholesale production uses the production technology (A.8). Thus

$$Y_t(m) = (1-c)Y_t^W(m) \tag{A.19}$$

$$Y_t^W = (A_t h_t)^{\alpha} K_t^{1-\alpha} \tag{A.20}$$

To introduce price stickiness, we assume that there is a probability of $1-\xi$ at each period that the price of each intermediate good m is set optimally to $P_t^0(m)$. If the price is not reoptimized, then it is held fixed.[16] For each intermediate producer m the objective is at time t to choose $\{P_t^0(m)\}$ to maximize discounted profits

$$E_t \sum_{k=0}^{\infty} \xi^k D_{t,t+k} Y_{t+k}(m) \left[P_t^0(m) - P_{t+k} MC_{t+k} \right] \tag{A.21}$$

subject to (A.18), where $D_{t,t+k}$ is now the nominal stochastic discount factor over the interval $[t, t+k]$. The solution to this is

$$E_t \sum_{k=0}^{\infty} \xi^k D_{t,t+k} Y_{t+k}(m) \left[P_t^0(m) - \frac{1}{(1-1/\zeta)} P_{t+k} MC_{t+k} MS_{t+k} \right] = 0 \tag{A.22}$$

In (A.22) we have introduced a markup shock MS_t to the steady-state markup $\frac{1}{(1-1/\zeta)}$. By the law of large numbers, the evolution of the price index is given by

[16]Thus we can interpret $\frac{1}{1-\xi}$ as the average duration for which prices are left unchanged.

$$P_{t+1}^{1-\zeta} = \xi P_t^{1-\zeta} + (1-\xi)(P_{t+1}^0)^{1-\zeta} \tag{A.23}$$

In setting up the model for simulation and estimation, it is useful to represent the price dynamics as difference equations. Using the fact that for any summation $S_t \equiv \sum_{k=0}^{\infty} \beta^k X_{t+k}$, we can write

$$\begin{aligned} S_t &= X_t + \sum_{k=1}^{\infty} \beta^k X_{t+k} = X_t + \sum_{k'=0}^{\infty} \beta^{k'+1} X_{t+k'+1} \text{ putting } k' = k+1 \\ &= X_t + \beta S_{t+1} \end{aligned} \tag{A.24}$$

and defining here the nominal discount factor by $D_{t,t+k} \equiv \beta \frac{\Lambda_{C,t+k}/P_{t+k}}{\Lambda_{C,t}/P_t}$, inflation dynamics are given by

$$\frac{P_t^0}{P_t} = \frac{H_t}{J_t} \tag{A.25}$$

$$H_t - \xi \beta E_t[\Pi_{t+1}^{\zeta-1} H_{t+1}] = Y_t \Lambda_{C,t} \tag{A.26}$$

$$J_t - \xi \beta E_t[\Pi_{t+1}^{\zeta} J_{t+1}] = \left(\frac{1}{1-\frac{1}{\zeta}} \right) Y_t \Lambda_{C,t} MC_t MS_t \tag{A.27}$$

$$\Pi_t : \quad 1 = \xi \Pi_t^{\zeta-1} + (1-\xi) \left(\frac{J_t}{H_t} \right)^{1-\zeta} \tag{A.28}$$

Real marginal costs are no longer fixed and are given by

$$MC_t = \frac{P_t^W}{P_t} \tag{A.29}$$

Nominal and real interest rates are related by the Fischer equation

$$E_t[1 + R_{t+1}] = E_t \left[\frac{1 + R_{n,t}}{\Pi_{t+1}} \right] \tag{A.30}$$

where the nominal interest rate is a policy variable, typically given in the literature by a standard Taylor-type rule:

$$\log \left(\frac{1+R_{n,t}}{1+R_n} \right) = \rho \log \left(\frac{1+R_{n,t-1}}{1+R_n} \right) + \theta_\pi \log \left(\frac{\Pi_t}{\Pi} \right) + \theta_y \log \left(\frac{Y_t}{Y} \right) \tag{A.31}$$

In fact, we will model monetary policy in a more general way by formulating a Calvo-type forward/backward interest rate rule in inflation targets as in Levine et al. (2007) and Gabriel et al. (2009). This is defined by

$$\log\left(\frac{1+R_{n,t}}{1+R_n}\right) = \rho\log\left(\frac{1+R_{n,t-1}}{1+R_n}\right) + \theta_\pi \log\frac{\Theta_t}{\Theta} + \phi_\pi \log\frac{\Phi_t}{\Phi} + \theta_y \log\left(\frac{Y_t}{Y}\right) + \epsilon_{MPS,t} \tag{A.32}$$

where $\epsilon_{MPS,t}$ is a monetary policy shock and

$$\log\Phi_t = \log\Pi_t + \tau\log\Phi_{t-1} \tag{A.33}$$

$$\varphi E_t[\log\Theta_{t+1}] = \log\Theta_t - (1-\varphi)\log(\Pi_t) \tag{A.34}$$

The Calvo rule can be interpreted as a feedback from expected inflation (the $\theta\log\frac{\Theta_t}{\Theta}$ term) and past inflation (the $\phi\log\frac{\Phi_t}{\Phi}$ term) that continues at any one period with probabilities φ and τ, switching off with probabilities $1-\varphi$ and $1-\tau$. The probability of the rule lasting for h periods is $(1-\varphi)\varphi^h$, hence the mean forecast horizon is $(1-\varphi)\sum_{h=1}^{\infty} h\varphi^h = \varphi/(1-\varphi)$. With $\varphi = 0.5$, for example, we would have a Taylor rule with one-period lead in inflation ($h = 1$). Similarly, τ can be interpreted as the degree of backward-lookingness of the monetary authority.

This rule can also be seen as a special case of a Taylor-type rule that targets h-step-ahead (back) expected rates of inflation and past inflation rates (with $h = 1, 2, \ldots, \infty$)

$$i_t = \rho i_{t-1} + \theta_0\pi_t + \theta_1 E_t\pi_{t+1} + \theta_2 E_t\pi_{t+2} + \cdots + \gamma_1\pi_{t-1} + \gamma_2\pi_{t-2} + \cdots, \tag{A.35}$$

albeit one that imposes a specific structure on the θ_i's and γ_i's (i.e., a weighted average of future and past variables with geometrically declining weights). This has an intuitive appeal and interpretation, reflecting monetary policy in an uncertain environment: the more distant the h-step-ahead forecast, the less reliable it becomes, hence the less weight it receives. In turn, past inflation has a typical Koyck-lag structure.

Note that we are approximating the behavior of the central bank with an instrument rule, rather than assuming that the monetary authority optimizes a specific loss function. Despite the lack of a substantial body of evidence for the Indian case, the forward/backward-looking Calvo-type formulation can be useful to analyze the RBI's interest rate setting behavior. Bhattacharya et al. (2010), using VAR methods, find monetary policy in India to have weak transmission channels. On the other hand, however, Virmani (2004) reports on the potential forward/backward-looking behavior of the RBI using instrumental rules, suggesting that a backward-looking rule explains the data well. Our proposal nests both types of behavior and can therefore shed light on their relative importance.

The structural shock processes in log-linearized form are assumed to follow AR(1) processes

$$\log A_t - \log\bar{A}_t = \rho_A(\log A_{t-1} - \log\bar{A}_{t-1}) + \epsilon_{A,t}$$
$$\log G_t - \log\bar{G}_t = \rho_G(\log G_{t-1} - \log\bar{G}_{t-1}) + \epsilon_{G,t}$$
$$\log MS_t - \log MS = \rho_{MS}(\log MS_{t-1} - \log MS) + \epsilon_{MS,t}$$

$$\log RPS_t - \log RPS = \rho_{RPS}(\log RPS_{t-1} - \log RPS) + \epsilon_{RPS,t}$$

where $MS = RPS = 1$ in the steady state (so $\log MS = \log RPS = 0$), while the monetary policy shock $\epsilon_{MPS,t}$ is assumed to be i.i.d with zero mean. This completes the specification of the benchmark NK model.

B Summary of Closed Economy Model

The following summarizes the dynamic model for the closed economy which applies to the foreign bloc. Note that the baseline model in Appendix A puts $\lambda = 0$ and shuts down the financial accelerator.

$$\begin{aligned}
\Lambda_{2,t} &= \Lambda(C_{2,t}, L_t) = \frac{(C_{2,t}^{(1-\varrho)} L_{2,t}^{\varrho})^{1-\sigma} - 1}{1-\sigma} \\
\Lambda_{C_2,t} &= (1-\varrho) C_{2,t}^{(1-\varrho)(1-\sigma)-1} (1-h_{2,t})^{\varrho(1-\sigma)}) \\
\Lambda_{L_2,t} &= \varrho C_{2,t}^{(1-\varrho)(1-\sigma)} L_{2,t}^{\varrho(1-\sigma)-1} \\
\Lambda_{C_2,t} &= \beta E_t \left[(1+R_{t+1}) \Lambda_{C_2,t+1} \right] \\
\frac{\Lambda_{L_2,t}}{\Lambda_{C_2,t}} &= \frac{W_t}{P_t} \\
L_{2,t} &\equiv 1 - h_{2,t} \\
h_{1,t} &= 1 - \rho \\
C_{1,t} &= \frac{W_t h_{1,t}}{P_t} \\
h_t &= \lambda h_{1,t} + (1-\lambda) h_{2,t} \\
C_t^e &= \frac{1-\xi_e}{\xi_e} N_t \\
C_t &= \lambda C_{1,t} + (1-\lambda) C_{2,t} + C_t^e \\
Y_t^W &= F(A_t, h_t, K_t) = (A_t h_t)^\alpha K_t^{1-\alpha} \\
Y_t &= (1-c) Y_t^W \\
\frac{P_t^W}{P_t} F_{h,t} &= \frac{P_t^W}{P_t} \frac{\alpha Y_t^W}{h_t} = \frac{W_t}{P_t} \\
P_t &= \frac{1}{1-\frac{1}{\zeta}} P_t^W \\
K_{t+1} &= (1-\delta) K_t + (1 - S(X_t)) I_t \\
X_t &\equiv \frac{I_t}{I_{t-1}}
\end{aligned}$$

$$
\begin{aligned}
Q_t(1 - S(X_t) - X_t S'(X_t)) + E_t \left[\frac{1}{(1+R_{t+1})} Q_{t+1} S'(Z_{t+1}) \frac{I_{t+1}^2}{I_t^2} \right] &= 1 \\
E_t[(1+R_{t+1})\Theta_{t+1}] &= E_t[1 + R_{k,t+1}] \\
1 + R_{k,t} &= \frac{(1-\alpha_I)\frac{P_t^W}{P_t}\frac{Y_t^W}{K_t} + (1-\delta)Q_t}{Q_{t-1}} \\
\Theta_t &= s\left(\frac{N_t}{Q_{t-1}K_t}\right) RP_t = k\left(\frac{N_t}{Q_{t-1}K_t}\right)^{-\chi} RPS_t \\
N_{t+1} &= \xi_e V_t + (1-\xi_e) D_t^e \\
D_t^e &= \bar{D}_t^e \text{ (BGP steady state)} \\
V_t &= (1+R_{k,t})Q_{t-1}K_t - \Theta_t(1+R_t)(Q_{t-1}K_t - N_t) \\
S(X_t) &= \phi_X(X_t - (1+g))^2 \\
Y_t &= C_t + G_t + I_t \\
H_t - \xi\beta E_t[\Pi_{t+1}^{\zeta-1} H_{t+1}] &= Y_t \Lambda_{C,t} \\
J_t - \xi\beta E_t[\Pi_{t+1}^{\zeta} J_{t+1}] &= \left(\frac{1}{1-\frac{1}{\zeta}}\right) Y_t \Lambda_{C,t} MS_t MC_t \\
1 &= \xi \Pi_t^{\zeta-1} + (1-\xi)\left(\frac{J_t}{H_t}\right)^{1-\zeta} \\
MC_t &= \frac{P_t^W}{P_t} \\
1 + R_t &= \frac{1 + R_{n,t-1}}{\Pi_t} \\
\log A_t - \log \bar{A}_t &= \rho_A(\log A_{t-1} - \log \bar{A}_{t-1}) + \epsilon_{A,t} \\
\log G_t - \log \bar{G}_t &= \rho_G(\log G_{t-1} - \log \bar{G}_{t-1}) + \epsilon_{G,t} \\
\log MS_t - \log MS &= \rho_{MS}(\log MS_{t-1} - \log MS) + \epsilon_{MS,t} \\
\log RPS_t - \log RPS &= \rho_{RPS}(\log RPS_{t-1} - \log RPS) + \epsilon_{RPS,t} \\
\log\left(\frac{1+R_{n,t}}{1+R_n}\right) &= \rho \log\left(\frac{1+R_{n,t-1}}{1+R_n}\right) + \theta \log \frac{\Theta_t}{\Theta} + \phi \log \frac{\Phi_t}{\Phi} + \epsilon_{MPS,t} \\
\log \Phi_t &= \log \Pi_t + \tau \log \Phi_{t-1} \\
\varphi E_t[\log \Theta_{t+1}] &= \log \Theta_t - (1-\varphi)\log(\Pi_t)
\end{aligned}
$$

The steady state is given by the following:

$$
\bar{N}_t = \frac{(1-\xi_e)\bar{D}_t}{(1-\xi_e(1+R_k))} \tag{B.36}
$$

$$1 + R_k = (1 + R)\ s\left(\frac{\bar{N}_t}{\bar{K}_t}\right) \tag{B.37}$$

$$\frac{\bar{K}_t}{\bar{Y}_t^W} = \frac{1 - \alpha}{R_k + \delta} \tag{B.38}$$

Choose a functional form

$$s\left(\frac{\bar{N}_t}{Q\bar{K}_t}\right) = k\left(\frac{\bar{N}_t}{Q\bar{K}_t}\right)^{-\chi}$$

We obtain χ from econometric studies and we have data on the risk premium $\Theta = \frac{1+R_k}{1+R}$ and leverage (= borrowing/net worth)

$$\ell = \frac{QK - N}{N} = \frac{QK}{N} - 1 = \frac{1}{n_k} - 1$$

defining $n_k \equiv \frac{N}{QK}$. Then we can set the scaling parameter k from (B.37) as

$$k = \Theta n_k^{\chi}$$

Then in the baseline steady state used to calibrate parameters, we put $\bar{N}_t = n_k \bar{K}_t$ and calibrate $\bar{D}^e$ from (B.36). The nonzero-inflation steady state and the calibrated k are given by

$$\begin{aligned}
1 + R &= \frac{(1 + g)^{1+(\sigma-1)(1-\varrho)}}{\beta} \\
1 + R_n &= \Pi(1 + R) \\
Q &= 1 \\
\bar{Y}_t &= (1 - c)(h_t\bar{A}_t)^{\alpha}\bar{K}_t^{1-\alpha} \\
\frac{\varrho\bar{C}_{2,t}}{(1 - \varrho)(1 - h)} &= \bar{W}_t \\
\bar{C}_{1,t} &= \bar{W}_t h \\
\frac{\alpha P^W \bar{Y}_t^W}{Ph} &= \bar{W}_t \\
\frac{\bar{K}_t}{\bar{Y}_t^W} &= \frac{1 - \alpha}{R_k + \delta} \\
1 + R_k &= (1 + R)\Theta \\
\Theta &= k\, n_k^{-\chi} = k\left(\frac{\bar{N}_t}{Q\bar{K}_t}\right)^{-\chi} \\
\bar{I}_t &= (\delta + g)\bar{K}_t
\end{aligned}$$

$$\bar{Y}_t = \bar{C}_t + \bar{I}_t + \bar{G}_t$$
$$1 = \frac{1}{1-\frac{1}{\zeta}}\frac{P^W}{P}$$
$$\bar{N}_t = n_k \bar{K}_t = \frac{(1-\xi_e)\bar{D}^e_t}{(1-\xi_e(1+R_k))} \text{ (determines } \bar{D}^e_t)$$

C Summary of Standard Open Economy Model

For the small open economy as $\nu \to 0$ and $\mathrm{w}^*_C \to 1$, from (5) we have that $\frac{1-\nu}{\nu}(1 - \mathrm{w}^*_C) \to 1 - \omega^*_C$. Similarly, $\frac{1-\nu}{\nu}(1 - \mathrm{w}^*_I) \to 1 - \omega^*_I$.

$$\Lambda_{C,t}: \quad \frac{1}{1+R_{n,t}} = \beta E_t\left[\frac{\Lambda_{C,t+1}}{\Lambda_{C,t}\Pi_{t+1}}\right] \tag{C.39}$$
$$\frac{W_t}{P_{C,t}} = \frac{\Lambda_{L,t}}{\Lambda_{C,t}} = -\frac{\Lambda_{h,t}}{\Lambda_{C,t}} \tag{C.40}$$
$$C_{2,t}: \quad \Lambda_{C,t} = (1-\varrho)C_{2,t}^{(1-\varrho)(1-\sigma)-1}(1-h_t)^{\varrho(1-\sigma)} \tag{C.41}$$
$$\lambda_{h,t} = -C_{2,t}^{(1-\varrho)(1-\sigma)}\varrho(1-h_t)^{\varrho(1-\sigma)-1} \tag{C.42}$$
$$C_{1,t} = \frac{W_t h_t}{P_{C,t}} \tag{C.43}$$
$$C_t = \lambda C_{1,t} + (1-\lambda)C_{2,t} \tag{C.44}$$
$$\left(\frac{P_{F,t}}{P_{C,t}}\right): \quad 1 = \left[\mathrm{w}_C\left(\frac{P_{H,t}}{P_{C,t}}\right)^{1-\mu_C} + (1-\mathrm{w}_C)\left(\frac{P_{F,t}}{P_{C,t}}\right)^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} \tag{C.45}$$
$$\frac{P_{H,t}}{P_{C,t}} = \frac{1}{[\mathrm{w}_C + (1-\mathrm{w}_C)\mathcal{T}_t^{1-\mu_C}]^{\frac{1}{1-\mu_C}}} \tag{C.46}$$
$$\text{where } \mathcal{T}_t \equiv \frac{P_{F,t}}{P_{H,t}}$$
$$C_{F,t} = \mathrm{w}_C\left(\frac{P_{H,t}}{P_{C,t}}\right)^{-\mu_C} C_t \tag{C.47}$$
$$C_{F,t} = (1-\mathrm{w}_C)\left(\frac{P_{F,t}}{P_{C,t}}\right)^{-\mu_C} C_t \tag{C.48}$$
$$C_{H,t}{}^* = (1-\omega^*_C)\left(\frac{P_{H,t}}{P_{C,t}RER_{C,t}}\right)^{-\mu^*_C} C_t{}^* \tag{C.49}$$
$$H_t: \quad H_t - \xi_H\beta E_t[\Pi_{H,t+1}^{\zeta-1}H_{t+1}] = Y_t\Lambda_{C,t} \tag{C.50}$$
$$J_t: \quad J_t - \xi_H\beta E_t[\Pi_{H,t+1}^{\zeta}J_{t+1}] = \frac{1}{1-\frac{1}{\zeta}}MS_tY_t\Lambda_{C,t}MC_t \tag{C.51}$$

$$\Pi_{H,t}: \quad 1 = \xi_H \Pi_{H,t}^{\zeta-1} + (1-\xi_H)\left(\frac{J_t}{H_t}\right)^{1-\zeta} \tag{C.52}$$

$$MC_t = \frac{P_{H,t}^W}{P_{H,t}} = \frac{P_{H,t}^W/P_{C,t}}{P_{H,t}/P_{C,t}} = \frac{\frac{W_t}{P_{C,t}} h_t}{\alpha Y_t \frac{P_{H,t}}{P_{C,t}}} \tag{C.53}$$

$$h_t: \quad Y_t^W = (A_t h_t)^\alpha K_t^{1-\alpha} \tag{C.54}$$

$$Y_t = (1-c)Y_t^W \tag{C.55}$$

$$\frac{P_{H,t}^W}{P_{C,t}}: \quad \frac{P_{H,t}^W}{P_{C,t}} = MC_t \frac{P_{H,t}}{P_{C,t}} \tag{C.56}$$

$$Q_t: E_t\left[1+R_{t+1}\right] = \frac{E_t\left[\frac{P_{H,t+1}^W}{P_{t+1}}(1-\alpha)\frac{Y_{t+1}}{K_{t+1}} + (1-\delta)Q_{t+1}\right]}{Q_t} \tag{C.57}$$

$$R_t: \quad 1+R_t = \frac{1+R_{n,t-1}}{1+\Pi_t} \tag{C.58}$$

$$K_{t+1} = (1-\delta)K_t + (1-S(X_t))I_t$$

$$S', S'' \geq 0; \; S(1+g) = S'(1+g) = 0 \tag{C.59}$$

$$X_t = \frac{I_t}{I_{t-1}} \tag{C.60}$$

$$S(X_t) = \frac{\phi_I}{2}(X_t - (1+g))^2 \tag{C.61}$$

$$I_t: \quad \frac{P_{I,t}}{P_{C,t}} = Q_t(1 - S(X_t) - X_t S'(X_t)) + E_t\left[\frac{Q_{t+1}S'(X_{t+1})}{(1+R_{t+1})}\frac{I_{t+1}^2}{I_t^2}\right] \tag{C.62}$$

$$I_{H,t} = \mathrm{w}_I\left(\frac{P_{H,t}/P_{C,t}}{P_{I,t}/P_{C,t}}\right)^{-\mu_I} I_t \tag{C.63}$$

$$I_{F,t} = (1-\mathrm{w}_I)\left(\frac{P_{F,t}/P_{C,t}}{P_{I,t}/P_{C,t}}\right)^{-\mu_I} I_t \tag{C.64}$$

$$I_{H,t}^* = (1-\omega_I^*)\left(\frac{P_{H,t}/P_{C,t}}{P_{I,t}/P_{C,t}RER_{I,t}}\right)^{-\rho_I^*} I_t^* \tag{C.65}$$

$$\frac{P_{I,t}}{P_{C,t}} = \left[\mathrm{w}_I\left(\frac{P_{H,t}}{P_{C,t}}\right)^{1-\mu_I} + (1-\mathrm{w}_I)\left(\frac{P_{F,t}}{P_{C,t}}\right)^{1-\mu_I}\right]^{\frac{1}{1-\mu_I}} \tag{C.66}$$

$$Y_t: \quad Y_t = C_{H,t} + I_{H,t} + C_{H,t}^* + I_{H,t}^* + G_t \tag{C.67}$$

$$\frac{S_t}{S_{t-1}} = \frac{RER_{C,t}\,\Pi_t}{RER_{C,t-1}\,\Pi_t^*} \tag{C.68}$$

$$\Pi_{F,t}: \quad \frac{\mathcal{T}_t}{\mathcal{T}_{t-1}} = \frac{\Pi_{F,t}}{\Pi_{H,t}} \tag{C.69}$$

$$\mathcal{T}_t: \quad RER_{C,t} = \frac{1}{\left[1-\mathrm{w}_C + \mathrm{w}_C\mathcal{T}_t^{\mu_C-1}\right]^{\frac{1}{1-\mu_C}}} \tag{C.70}$$

$$RER_{I,t} = \frac{1}{\left[1-\mathrm{w}_I + \mathrm{w}_I\mathcal{T}_t^{\mu_I-1}\right]^{\frac{1}{1-\mu_I}}} \tag{C.71}$$

$$\Pi_t = [\mathrm{w}_C(\Pi_{H,t})^{1-\mu_C} + (1-\mathrm{w}_C)(\Pi_{F,t})^{1-\mu_C}]^{\frac{1}{1-\mu_C}} \tag{C.72}$$

$$\log(1+R_{n,t})/(1+R_n) = \rho_r \log(1+R_{n,t-1})/(1+R_n) + (1-\rho_r)(\theta_\pi E_t[\log\Pi_{t+1}]/\Pi$$

$$+\theta_s \log S_t/S) + \epsilon_{r,t+1} \tag{C.73}$$

$$RER^r_t = \frac{\Lambda^*_{C,t}}{\Lambda_{C,t}} \tag{C.74}$$

$$1 + R^*_t = \frac{1 + R^*_{n,t-1}}{1 + \Pi^*_t} \tag{C.75}$$

$$\frac{1}{(1 + R^*_{n,t})\phi(\frac{S_t B^*_{F,t}}{P_{H,t} Y_t})} S_t B^*_{F,t} = S_t B^*_{F,t-1} + TB_t \tag{C.76}$$

$$\phi(\frac{S_t B^*_{F,t}}{P_{H,t} Y_t}) = \exp\left(\frac{\phi_B S_t B^*_{F,t}}{P_{H,t} Y_t}\right);\ \phi_B < 0 \tag{C.77}$$

$$TB_t = P_{H,t} Y_t - P_{C,t} C_t - P_{I,t} I_t - P_{H,t} G_t \tag{C.78}$$

Then the real exchange rate is given by

$$RER_{C,t} = RER^d_t RER^r_t \tag{C.79}$$

$$RER^d_t\ :\ 0 = \quad E_t\left[\frac{\Lambda_{C,t+1}}{\Lambda_{C,t}} \frac{RER^r_{t+1}}{RER^r_t} \frac{1}{\Pi^*_{t+1}} \left(\frac{1}{\phi(\frac{S_t B^*_{F,t}}{P_{H,t} Y_t}) \exp(\epsilon_{UIP,t+1})} - \frac{RER^d_{t+1}}{RER^d_t}\right)\right]$$

Shocks:

$$\log \frac{A_{t+1}}{A} = \rho_a \log \frac{A_t}{A} + \epsilon_{a,t+1} \tag{C.80}$$

$$\log \frac{G_{t+1}}{G} = \rho_g \log \frac{G_t}{G} + \epsilon_{g,t+1} \tag{C.81}$$

$$\log \frac{MS_{t+1}}{MS} = \rho_{ms} \log \frac{MS_t}{MS} + \epsilon_{ms,t+1} \tag{C.82}$$

$$\log \frac{UIP_{t+1}}{UIP} = \rho_{UIP} \log \frac{UIP_t}{UIP} + \epsilon_{uip,t+1} \tag{C.83}$$

If the ROW is not modeled explicitly we close the model with exogenous AR(1) shocks

$$\log(1 + R^*_{n,t})/(1 + R^*_n) = \rho^*_r \log(1 + R^*_{n,t-1})/(1 + R^*_n) + \epsilon^*_{r,t+1} \tag{C.84}$$

$$\log \frac{\Pi^*_{t+1}}{\Pi^*} = \rho^*_\pi \log \frac{\Pi^*_t}{\Pi^*} + \epsilon^*_{\pi,t+1} \tag{C.85}$$

$$\log \frac{C^*_{t+1}}{C^*} = \rho^*_c \log \frac{C^*_t}{C^*} + \epsilon^*_{c,t+1} \tag{C.86}$$

$$\log \frac{I^*_{t+1}}{I^*} = \rho^*_i \log \frac{I^*_t}{I^*} + \epsilon^*_{i,t+1} \tag{C.87}$$

$$\log \frac{\Lambda^*_{t+1}}{\Lambda^*} = \rho^*_\Lambda \log \frac{\Lambda^*_t}{\Lambda^*} + \epsilon^*_{\lambda,t+1} \tag{C.88}$$

Otherwise $R^*_{n,t}$, Π^*_t, C^*_t and I^*_t are modeled as before. First, assume zero growth in the steady state: $g = g^* = 0$ and nonnegative inflation. Then we have

$$R_n: \quad 1 + R_n = (1 + R^*_n)\phi\left(\frac{SB}{P}\right) \tag{C.89}$$

$$\frac{W}{P} = -\frac{U_L}{U_C} \tag{C.90}$$

$$U_C = (1-\varrho)C_2^{(1-\varrho)(1-\sigma)-1}(1-L)^{\varrho(1-\sigma)} \tag{C.91}$$

$$U_L = -C_2^{(1-\varrho)(1-\sigma)}\varrho(1-L)^{\varrho(1-\sigma)-1} \tag{C.92}$$

$$C_1 = \frac{WL}{P_C} \tag{C.93}$$

$$C = \lambda C_1 + (1-\lambda)C_2 \tag{C.94}$$

$$P_F/P_C: \quad 1 = \left[\mathrm{w}_C\left(\frac{P_H}{P_C}\right)^{1-\mu_C} + (1-\mathrm{w}_C)\left(\frac{P_F}{P_C}\right)^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} \tag{C.95}$$

$$\frac{P_H}{P_C} = \frac{1}{[\mathrm{w}_C + (1-\mathrm{w}_C)\mathcal{T}^{1-\mu_C}]^{\frac{1}{1-\mu_C}}} \tag{C.96}$$

$$C_H = \mathrm{w}_C\left(\frac{P_H}{P_C}\right)^{-\mu_C} C \tag{C.97}$$

$$C_F = (1-\mathrm{w}_C)\left(\frac{P_F}{P_C}\right)^{-\mu_C} C \tag{C.98}$$

$$C_H{}^* = (1-\omega^*_C)\left(\frac{P_H}{P_C RER_C}\right)^{-\mu^*_C} C^* \tag{C.99}$$

$$H(1-\xi_H\beta) = YU_C \tag{C.100}$$

$$J(1-\xi_H\beta) = \frac{1}{1-\frac{1}{\zeta}} YU_C MC \tag{C.101}$$

$$MC: \quad H = J \tag{C.102}$$

$$MC = 1 - \frac{1}{\zeta} = \frac{C_2}{\alpha Y\frac{P_H}{P_C}} \tag{C.103}$$

$$Y = (1-c)(AL)^\alpha K^{1-\alpha} \tag{C.104}$$

$$\frac{P^W_H}{P_C} = MC\frac{P_H}{P_C} \tag{C.105}$$

$$K = \frac{(1-\alpha)MC\frac{P_H}{P_C}Y}{(R+\delta)Q} \tag{C.106}$$

$$1 + R = \frac{1+R_n}{\Pi} \tag{C.107}$$

$$I = (g+\delta)K \tag{C.108}$$

$$X = 1 \tag{C.109}$$

$$S(X) = S'(X) = 0 \tag{C.110}$$

$$Q = \frac{P_I}{P_C} \tag{C.111}$$

$$I_H = \mathrm{w}_I \left(\frac{P_H/P_C}{P_I/P_C}\right)^{-\mu_I} I \tag{C.112}$$

$$I_F = (1-\mathrm{w}_I)\left(\frac{P_F/P_C}{P_I/P_C}\right)^{-\mu_I} I \tag{C.113}$$

$$I_H^* = (1-\omega_I^*)\left(\frac{P_H}{PRER}\right)^{-\mu_I^*} I^* \tag{C.114}$$

$$\frac{P_I}{P_C} = \left[\mathrm{w}_I \left(\frac{P_H}{P_C}\right)^{1-\mu_I} + (1-\mathrm{w}_I)\left(\frac{P_F}{P_C}\right)^{1-\mu_I}\right]^{\frac{1}{1-\mu_I}} \tag{C.115}$$

$$Y = C_H + I_H + EX_C + EX_I + G_t \tag{C.116}$$

$$EX_C = C_{H,t}^* = (1-\omega_{C,t}^*)\left(\frac{P_H}{P_C RER_C}\right)^{-\mu_C^*} C^* \tag{C.117}$$

$$EX_I = I_{H,t}^* = (1-\omega_{I,t}^*)\left(\frac{P_H}{P_I RER_I}\right)^{-\mu_I^*} I^* \tag{C.118}$$

$$RER_C = \frac{1}{\left[1-\mathrm{w}_{+}\mathrm{w}_C \mathcal{T}^{\mu_C-1}\right]^{\frac{1}{1-\mu_C}}} \tag{C.119}$$

$$RER_I = \frac{1}{\left[1-\mathrm{w}_I + \mathrm{w}_I \mathcal{T}^{\mu_I-1}\right]^{\frac{1}{1-\mu_I}}} \tag{C.120}$$

$$R_n^* : \quad 1 = \beta(1+R_n^*) \tag{C.121}$$

$$1+R^* = \frac{1+R_n^*}{\Pi^*} \tag{C.122}$$

The model is complete if we pin down the steady state of the foreign assets or equivalently the trade balance (TB). In other words, there is a unique model associated with any choice of the long-run assets of our SOE.[17] The trade balance is

$$TB = P_H Y - P_C C - P_I I - P_H G = \underbrace{P_H EX_C - (P_C C - P_H C_H)}_{\text{Net Exports of C-goods}} + \underbrace{P_H EX_I - (P_I I - P_H I_H)}_{\text{Net Exports of I-goods}} \tag{C.123}$$

using (C.116), for some choice of TB, say zero.

The problem now is that we need to force the nonlinear model to this steady state even when the latter may not be completely accurate. A way of doing this is to add a term $\theta_{tb} \log(TB_t/TB)$ to the Taylor rule with a very small $\theta_{tb} > 0$ so that when there is a trade surplus the rule makes the nominal exchange rate appreciate slightly.

Finally, we calibrate ω_C and ω_I using trade data. From (C.123) we have

[17] The same point applies to government debt when we introduce fiscal policy.

$$cs_{imp} \equiv \frac{\text{C-imports}}{\text{GDP}} = \frac{C_F}{Y} = c_y(1 - \mathrm{w}_C)\left(\frac{P_F}{P_C}\right)^{-\mu_C} \tag{C.124}$$

$$is_{imp} \equiv \frac{\text{I-imports}}{\text{GDP}} = \frac{I_F}{Y} = i_y(1 - \mathrm{w}_I)\left(\frac{P_F}{P_I}\right)^{-\mu_I} \tag{C.125}$$

$$cs_{exp} \equiv \frac{\text{C-exports}}{\text{GDP}} = (1 - \omega_C^*)\left(\frac{P_H}{P_C RER_C}\right)^{-\mu_C^*} c_y^* \frac{Y^*}{Y} = \frac{C_H^*}{Y} \tag{C.126}$$

$$is_{exp} \equiv \frac{\text{I-exports}}{\text{GDP}} = (1 - \omega_I^*)\left(\frac{P_H}{P_I RER_I}\right)^{-\mu_I^*} i_y^* \frac{Y^*}{Y} = \frac{I_H^*}{Y} \tag{C.127}$$

Hence using data for shares cs_{imp}, is_{imp}, cs_{exp} and is_{exp}, we can calibrate ω_C and ω_I. Use data for India: $cs_{imp} = 0.10$, $is_{imp} = 0.15$, $cs_{exp} = 0.23$, and $is_{exp} = 0.02$ for $TB = 0$. With balanced steady-state growth, the balanced growth steady-state path of the model economy with or without investment costs is given by $Q = 1$ and

$$\frac{\bar{\Lambda}_{C,t+1}}{\bar{\Lambda}_{C,t}} \equiv 1 + g_{\Lambda_C} = \left[\frac{\bar{C}_{t+1}}{\bar{C}_t}\right]^{(1-\varrho)(1-\sigma)-1} = (1+g)^{((1-\varrho)(1-\sigma)-1)} \tag{C.128}$$

Thus from (C.39)

$$1 + R = \frac{(1+g)^{1+(\sigma-1)(1-\varrho)}}{\beta} \tag{C.129}$$

Similarly for the foreign bloc

$$1 + R^* = \frac{(1+g^*)^{1+(\sigma^*-1)(1-\varrho^*)}}{\beta^*} \tag{C.130}$$

It is then possible to have different preferences, inflation and growth rates provided

$$\frac{1+R_n}{1+R_n^*} = \phi\left(\frac{SB}{P}\right) = \frac{\Pi(1+R)}{\Pi^*(1+R^*)} = \frac{\Pi\beta^*}{\Pi^*\beta}\frac{(1+g)^{1+(\sigma-1)(1-\varrho)}}{(1+g^*)^{1+(\sigma^*-1)(1-\varrho^*)}} \tag{C.131}$$

which pins down the assets in the steady state.

D Summary of Open Economy Model with Financial Frictions: Complete Exchange Rate Pass-Through

Note that there are already two financial frictions in the previous model: Ricardian households pay a risk premium for their international borrowing there are liquidity-constrained households. To complete the model we add a financial accelerator consisting of

$$E_t[1 + R_{k,t+1}] = E_t\left[\Theta_{t+1}\left(\varphi E_t\left[(1 + R_{t+1})\right] + (1 - \varphi)E_t\left((1 + R^*_{t+1})\frac{RER_{C,t+1}}{RER_{C,t}}\right)\right)\right] \tag{D.132}$$

$$\Theta_t = k\left(\frac{N_t}{Q_{t-1}K_t}\right)^{-\chi} \tag{D.133}$$

$$N_{t+1} = \xi_e V_t + (1 - \xi_e)D^e_t \tag{D.134}$$

$$V_t = (1 + R_{k,t})Q_{t-1}K_t - \Theta_t\left[\varphi(1 + R_t) + (1 - \varphi)(1 + R^*_t)\frac{RER_{C,t}}{RER_{C,t-1}}\right](Q_{t-1}K_t - N_t) \tag{D.135}$$

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Finance and Credit in a Model of Monetary Policy

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JEL Classifications: E43 · E44 · E47 · E58

1 Introduction

The global financial crisis has promoted an explosion of work by macroeconomists in both advanced and emerging countries developing microfounded models with financial frictions. Such frictions tend to lead to time-varying endogenous wedges between different sets of market interest rates in which changes in money or credit supply may impact and change both aggregate demand and potential output levels.[1] In this paper, we will show how microfounded models can be extended to encompass financial frictions, without necessarily sacrificing internal coherence, and also

[1]See Chadha and Holly (2011) for a treatment of a number of partial equilibrium and general equilibrium modeling approaches that try to understand nonconventional monetary policies. Although there is a growing literature, a workhorse model has not yet been developed.

We are grateful for helpful conversations and comments from Philip Arestis, Chetan Ghate, Mike Joyce, Ken Kletzer, Jack Meaning, James Warren and participants at the BIS-OECD Workshop Panel on Policy Interaction: Fiscal Policy, Monetary Policy and Debt Interaction, the Reserve Bank of India. We also thanks Luisa Corrado, Germana Corrado, Sean Holly, Philip Tuner, Alex Waters and Fabrizio Zampolli for permission to draw on joint work. Any remaining errors are our own.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_16

consider the implications for monetary policy in India.[2] Naturally, when we consider India financial frictions pervade economic analysis: (i) external financing constraints may effect the demand for foreign exchange reserves; (ii) the informal sector may be segmented from financial issues;[3] (iii) consumers and firms may face collateral constraints; (iv) banks and other financial intermediaries may face some form of "repression"; and (v) the government seems likely to face inelastic demand for debt denominated in domestic or, even, foreign currency.[4] Rather than addressing each of these frictions, we shall concentrate on considering the implications of collateral constraints in a model of loan production by commercial banks and examine the extent to which this friction complicates the choice faced by monetary policy makers.

The long global economic expansion from the early 1990s to late 2008 was a period in which finance became both content and proud, perhaps through benign neglect.[5] Financial engineering and innovation created new bridges from savers to borrowers within countries and internationally and it seemed to many that credit markets were well-oiled by the financial sector and financial spreads became increasingly compressed.[6] In parallel, in the workhorse models of this period, the typical rigidities were simply those of sticky prices and monopolistic competition, which generated deviations from the flex-price equilibrium in response to exogenous shocks. Accordingly, the output gap and the inflation rate became a sufficient pair of statistics to monitor the economy.[7] In a forward-looking model agents simply had to know enough to understand that the monetary authorities would act on the short-term real rate to close any expected output gap in expectation and thus any deviation from the stated inflation target. Control of this real interest rate by the central bank was all that was required in order to achieve stability. financial factors were excluded by design from having any amplification impact in the standard model.[8]

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[2]The call for more work on the monetary-financial nexus was made by Hammond et al. (2009). This paper forms part of an answer.

[3]See Khan and Thomas (2014) on this important point. Note that if some markets are segmented financially then policy may have work harder to influence or act on those markets on which it has some (limited) influence.

[4]The agenda involves writing down general equilibrium models built from the principles of household optimization that match key stylised facts of the business cycle behavior. The model can then be solved under various forms of stabilization policies under which the welfare of the household can be assessed and in which the Lucas critique is respected. Gabriel et al. (2012, 2016) support the need to include financial frictions in their estimated DSGE models of first a closed and then an open economy.

[5]In 1925 prior to making the decision to return to an overvalued gold standard, Churchill had called for industry to be more content and finance less proud. By 2007, finance, it seemed to many, had it all.

[6]With the development of many new credit instruments and the increasing levels of leverage of financial institutions, it seemed that markets were being completed.

[7]Ironically at the same time, many of the price rigidities were being nicely ironed out by an explosion in production from China.

[8]In Chadha et al. (2013b), we show how money and financial factors were excluded by design from having any amplification impact in the standard model.

But the prescriptions of the workhorse microfounded model did not help us understand the policy initiatives developed in the crisis. Monetary policy became constrained at the zero lower bound and this led to the rediscovery of importance of open market operations, or balance sheet policies, as a way of influencing interest rates beyond the normal policy horizon. It was well known that fiscal policy operated to help aggregate demand in a recession but here it was called up also to recapitalise banks. This extra function as a fiscal 'backstop' meant that any concern about borrowing limits would not only frustrate countercyclical policy because escalating market determined interest rates would bear down on activity but potentially leave the financial sector highly vulnerable to further shocks. Furthermore the fragility of the role of commercial banks as maturity transformers was revealed and the systemic lack liquidity in the event of risk aversion exposed. Balance sheet operations expanded the size and composition of the central bank balance sheet and reduced the duration of financial markets' bond holdings and increase liquidity. These operations involve the issuance of short-term debt-fiscal instruments (interest rate bearing reserves or T-Bills). So as well as helping to reduce long-term rates by signaling lower rates or by offsetting risk premia, these monetary-fiscal operations hedged liquidity risk. In some sense, advanced country central banks stumbled toward these solutions and need to develop models to help us understand the extent to which they should remain part of the policymaker toolkit in advanced or emerging economies.

For an emerging economy, these operations by advanced economies had a twofold implication of first making it less clear that these economies should necessarily continue to liberalize financial markets and second, imparted a wave of capital inflows seeking higher yields than were typically available in the advanced economies. Although we retain a closed economy structure we can use the model to understand the implications of the kinds of driving forces that increase the availability of money and credit with our model of loans production.[9] India started a process of financial liberalization in the early 1990s in parallel with the long economic expansion in the advanced economies. And we are interested in understanding how an emerging economy should set policy in light of the relaxation of financial repression, which implies a move to market determined interest rates, and as a consequence of lessons learnt from the financial exuberance in advanced economies.

Using a microfounded model calibrated to the Indian economy, we examine the efficacy of a standard active interest rate reaction function of the type adopted by advanced economies in the decade leading up to the financial crisis. In our model the commercial banking sector provides loans on the basis of posted collateral, the value of which is heavily procyclical, which leads to countercyclical lending spreads that tend to amplify the economic cycle. We find that the economy exhibits less volatility if commercial banks can vary (or choose) their reserve–deposit ratio over the business cycle. By paying attention to the provision of central bank money (or reserves), the policymaker can militate against the commercial banks seeking to offset the costs

[9]See Mohanty and Rishabh (2016) in this volume for an analysis of open economy issues facing emerging economies. We maintain that the key issue is always the scale and cost of the supply of loanable funds whether from local sources or from abroad.

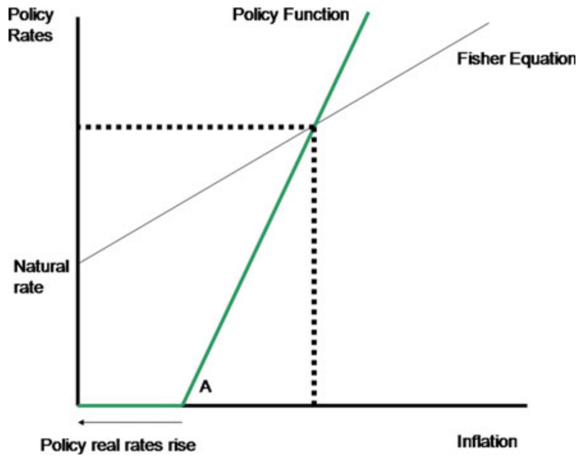

Fig. 1 The Simple NK framework

a fixed reserve–deposit ratio by varying market interest rates more than they would otherwise. Time variation in the reserve–deposit ratio acts as a time-varying subsidy (or tax) on lending. An augmented policy rule that feeds back from various market spreads, or so-called financial conditions, may offer an alternate path.

In the next section we present a brief overview of the simple rules debate and how financial premia impact on the economy. Section 3 then discusses the external finance premia and its introduction into macro models. In Sect. 4 we outline a model of financial frictions and consider the monetary policy problem. Section 5 offers the main calibrated and simulated results. The final section concludes with some thoughts on financial frictions.

2 Standard Sticky Price Monetary Policy

Let us remind ourselves about the policy prescriptions that emerged from the monopolistically competitive sticky price version of a DSGE model. Then we shall turn to the basic insight offered by the existence of a financial wedge and provide some intuition on the likely consequences for policymaking. This framework seems close to that which the RBI seems to want to adopt a framework for thinking about monetary policy in the presence of financial frictions.[10]

2.1 Simple Monetary Policy

In the simple linearised New Keynesian model (see Fig. 1). The policy reaction function simply has to react by more than any given change in inflation so that the

[10]See IMF Article IV consultations (e.g. 2015) on the Indian monetary policy problem.

(economy-wide) real interest rate acts to bear down on any output gap and drive inflation back to its target. This linear model is subject to a number of well-known control problems: (i) changes in the natural rate (the intercept), which cannot be easily measured, will lead to monetary impulses from nominal rates that imply an incorrect real rate of interest; (ii) measuring the output gap and then forecasting the change in the inflation that is implied is very difficult in real time; (iii) with no constellation asset prices in the model, we are left hoping that use of a single policy rate leads to clearing in credit markets that does not leave the economy in a fragile state; and (iv) finally if rates were to fall to zero and deflationary pressures continued to escalate, real rates would rise and the economy would be in serious danger of not being able to be stabilized around the normal target.

The need for microfoundations for financial frictions is thus motivated by each of these objections. The natural rate can be interpreted as that reflecting monetary and financial conditions elsewhere, so that, for example, if the financial sector is expanding at a fast rate, the natural rate rises. The operation of the financial sector may impact on both measured potential supply and current demand and thus make any kind of output gap calculation almost impossible. Money market clearing in a host of short-term and long-term financial markets will determine the set of interest rates that are relevant for the consumption and investment decisions and these may not be strictly proportional to the short run policy rate at all times—in the language of finance, they may be disconnected. Finally, if the policy rate hits the lower zero bound, we may need to think about operating on other asset and bond prices in order to gain some traction on the monetary transmission mechanism.[11]

2.2 Financial Wedges

There is no workhorse model for understanding all types of financial frictions. But Hall (2009) provides a useful taxonomy. He reminds us that an increase in any financial friction will tend to increase the interest rate wedge between those who provide capital and the cost of capital paid by firms. Let us consider a static standard Cobb–Douglas production sector with driving forces that may include government purchases and efficiency. In such a model another driving force might be a tax on the difference between payments to the capital factor and the price of capital. An increase in such a wedge will tend to depress output and employment, and the converse will hold true with reductions in the wedge tending to create a boom. The story is akin to that arising from the Diamond–Mirrlees analysis of the inefficiency of taxing an intermediate product, with capital playing the role of an intermediate product.

The legs of the argument are that an increase in financial frictions acts to increase the price of capital and so reduce its demand. Because of the economy-wide resource constraint this will increase both the output–capital ratio and the consumption–

[11] In our model developed in detail later we can assess (i) and (ii) but elsewhere we have studied (ii) and (iv).

capital ratio accordingly. Through the Cobb–Douglas production function the labor–capital ratio rises along with output–capital and induces a fall in real wages. The household balances its demand for goods consumption against the supply of hours worked and this allows us to solve for the optimal level of capital, which is lower than prior to the financial frictions shock. The lower level of capital induces a fall in output. The argument goes through in the opposite direction with a fall in the size of financial frictions increasing output. Indeed under this kind of analysis financial frictions are embedded in the supply side of the economy and may be particularly hard to understand in NK models, which concentrates on demand and cost-push shocks in the production of goods. Though qualitatively, changes in the financial wedge seem to have a similar effect to a payroll tax, which places a wedge between wages received by workers and paid by employees. Hall (2009) finds that a 6 % increase in the financial spread can induce a recession that size of that experienced by many advanced economies after the start of the financial crisis.

2.3 Flex-Price Model

Chari et al. (2007) argue forcefully that financial frictions do not only inhabit the wedge between the rental price of capital and return to capital, arguing that frictions in the financing of inputs may provide an important explanation for changes in the observed wedge between aggregate inputs and outputs, so-called efficiency. They suggested a now widely applied technique for decomposing aggregate fluctuations into four time-varying wedges: efficiency (including input financing), investment (the markup on the price of capital), labor (the markup on labor inputs), and government consumption. The point of departure is consumer maximization of utility given the choice of consumption and labor into which wedges are placed

$$\max_{c_t l_t} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t) N_t, \tag{1}$$

subject to a flow budget constraint

$$c_t + (1 + \tau_{xt}) x_t = (1 - \tau_{lt}) w_t l_t + r_t k_t + T_t, \tag{2}$$

where c_t is consumption at time t, x_t is investment, τ_{xt} and τ_{lt} are the time-varying tax rates (or wedges) on investment and labor, w_t is the wage rate, r_t is the real interest rate T_t are lump-sum taxes, N_t is population, β is the discount factor, and k_t is the capital stock. Firms maximize profits.

$$\max_{k_t, l_t} A_t F(K_t, (1 + \gamma)^t l_t) - w_t l_t - r_t k_t, \tag{3}$$

where A_t represents the efficiency wedge (between aggregate inputs and outputs) and like standard real business cycle models this parameter is exogenously determined from the model the parameter $(1+\gamma)$ is the rate of labor-augmenting technical progress. The law of motion of capital is given by;

$$(1 + \lambda)k_{t+1} = (1 - \delta)k_t + x_t, \tag{4}$$

where $(1 + \lambda)$ is the growth rate of the population which is a constant and δ is the depreciation rate. The equilibrium conditions of the economy are as follows, with first the resource constraint:

$$c_t + x_t + g_t = y_t, \tag{5}$$

$$y_t = A_t F(K_t, (1 + \gamma)^t l_t), \tag{6}$$

$$-\frac{U_{lt}}{U_{ct}} = (1 - \tau_{lt})A_t(1 + \gamma)^t F_{lt}, \tag{7}$$

$$U_{ct}(1 + \tau_{xt}) = \beta E_t U_{ct+1} \left[A_{t+1}F_{kt+1} + (1 - \delta)(1 + \tau_{xt+1})\right]. \tag{8}$$

The wedges thus can be described as the following, the parameter A_t is the efficiency wedge at time t, and captures any distortion that may cause the representative firm to allocate resources more efficiently. The labor wedge is described by $(1 - \tau_{lt})$ and captures any effects which separate the marginal product of labor (rhs of 7) from the marginal rate of substitution between consumption and labor (lhs of 7). The investment wedge is given by $\frac{1}{(1+\tau_{xt})}$ which captures anything which separates the intertemporal rate of substitution in consumption from the asset pricing kernel. It is important to note that the wedges do not pick out a single type of distortion within the wedge rather they capture all possible distortions that may affect labor, investment and efficiency, with government expenditure operating as something of a residual.

In most studies of business cycle accounting, it is found that the efficiency and labor wedges account for most of measured business cycle fluctuations, see Kehoe and Prescott (2002). Indeed in their examination of the BRIC economics, Chakraborty and Otsu (2013) largely concur but do find a significant role for the investment wedge in India during the 2000s. It is therefore not clear whether under some parameterizations of these models the investment wedge may have a larger role to play than initially thought or whether this framework systematically overestimates the role played by efficiency wedges, echoing the RBC literature of the 1980s. Even if that is the case, it might be that changes input financing might help us understand changes in measured economy-wide efficiency.

2.4 The Recent Deep Recession

The kind of analysis outlined in the previous section tends to lead to the conclusion that in response to changes in financial frictions, consumption and investment ought to move in opposite directions as the economy switches from capital to labor. But what we consistently find in many economies is that consumption and investment move together quite markedly, especially in the recent recessions across the advanced economies, which most commentators think were closely related to revelation of large-scale external financial frictions. This means that we need to find microfoundations for frictions that drive consumption and investment in the same direction over the business cycle. In fact the problem is even worse. Chadha and Warren (2012) took a model in which an external financial premium was driven negatively by asset prices (in the spirit of Bernanke et al. 1999) and allowed the relative magnitude of asset prices to increase markedly relative to productivity and various demand shocks. Taking data from the model simulated with all these shocks, they examined the evolution of output without each of four possible wedges, or shocks: investment (*aka* financial), labor or efficiency (or productivity) and/or government. And when they accounted for the causes of the business cycle in the data produced by this model, in the fashion of Chari et al. (2007), they found that it was when the efficiency/productivity wedge was removed that the model performed the worst.

In other words the shock driving the external finance premium looks like a productivity or efficiency wedge because it drives consumption and investment in the same direction. It is therefore important in our model that we do employ a setup where consumption and investment co-move positively.[12] This finding means that financial frictions may tend look like a supply shock in a macro-model, or in the language of CKM an input financing shock. As far as the early part of the twenty-first century was concerned therefore, the apparent fall in financial frictions would have been observationally equivalent to an increase in productivity and would simply have led to the central bank stoking up more demand to meet its inflation target. The problem was, of course, that the financial frictions were about to return with a vengeance.

3 The External Finance Premia

To help illustrate the implications of financial frictions for demand, Fig. 2 (from Chadha et al. 2010) traces the impact of the external finance premia on activity, as measured by consumption. In this representation the central bank, in the top right-hand side quadrant, sets the policy rate and supplies central bank money on demand in response to any shifts in money demand. The banking system chooses the quantity

[12]In the model have two types of frictions in the investment decision. First, loans for investment are subject to a costly production function and secondly we also have some costs in the actual investment function. Both are required to have consumption and investment co-move positively.

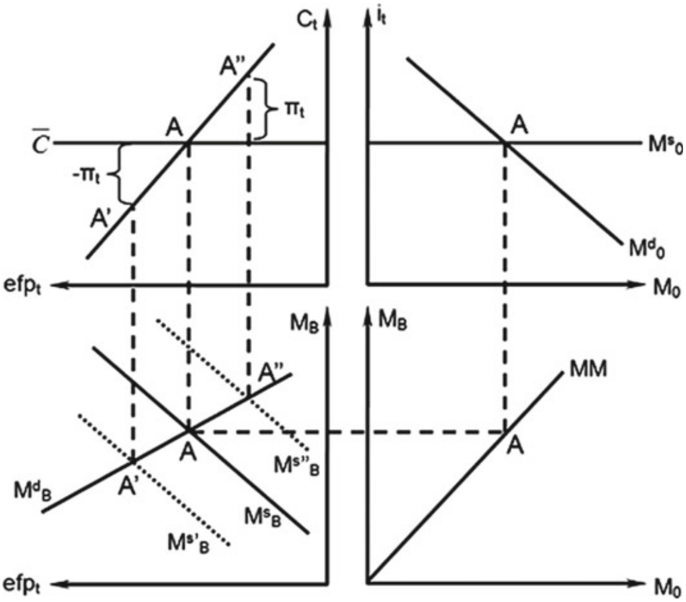

Fig. 2 Money, EFP and demand

of broad money that it wants to create from the MM curve, which can be thought of as an optimizing decision. There need not be a fixed multiple of broad but the final choice of the financial system implies a particular multiplier. The demand for broad money falls in the EFP and the supply increases to set a level of demand at *A*, which is consistent with a given level of broad and narrow money, as well as the prevailing policy rate. But any exogenous shifts in the supply of broad money will thus change the external finance premium and the level of output to *A*' or *A*". Thus broad money and the level of activity can be quite distinct from the policy rate or the quantity of central bank money. And, if the lending function, relates to some measure of the financial friction, we might be moving closer to a story in which expenditure components that rely on bank lending may covary over the business cycle and be linked directly to the supply of loans. What we would like to have, in terms of microeconomic foundations, is a consumption (and investment) path that is not only tilted by the policy rate but also affected by the quantity of credit offered.

3.1 Open Market Operations and Money

If the policy rate is fixed or bounded at the lower zero bound, policy makers may wish to introduce forms of open market operations to influence market interest rates further along the maturity spectrum.[13] And so generally speaking, new initiatives such as quantitative easing are really just an extended open market operation involving the unsterilised swap of central bank money for privately held assets. The key difference is that the duration of the swap is both intended to be long term and of uncertain length. An open market operation, if unsterilised, leads to an increase in the quantity of base or outside money. This money represents claims on the public sector and will not be neutral with respect to any given expenditure plans if there is a real balance effect that induces a fall interest rates. This is because the increase in money changes the price of claims on the public sector. If, however, the private sector fully discounts the present value of taxes that will need to be paid to meet these obligations then these bonds will not represent net wealth and the operation will be neutral. The debate on the efficacy of such operations hinged on the question of whether the supply of outside money changes the wealth position of the private sector (see Gale 1982).

But the analysis of such operations lays outside the remit the workhorse New Keynesian (NK) Model in which the evolution of monetary aggregates, which are simply a veil by which real planned transactions were effected, provided no additional feedback to the state of the economy. These models, as already explained, are highly tractable and were used to develop simple, precise policy prescriptions, even at the lower zero bound of Bank rate, by influencing expectations of the duration of any given level of Bank rate in order to induce exchange rate depreciations or positive inflation shocks and so close any given sequence of output gaps in expectation. In these models, open market operations were neutral because at the lower zero bound money and bonds become perfect substitutes and any swap of one for the other does not change the wealth position of the private sector. In fact, in these models QE-type policies are simply forms of commitment strategies that provide signals about the long-term intentions of the central bank to hit a given inflation target.

The NK argument that monetary policy can only work through the management of expectations is not a universal result as it relies on particular assumptions. In these models, financial markets are complete in which a representative agent can spring into life and financial wealth is allocated over an infinite life. Idiosyncratic risk in these economies can be hedged and asset prices depend on state-contingent payoffs. In this case, the price of financial assets is not influenced by changes in their net supply, as demand is perfectly elastic. It seems quite possible though that demand curves for assets, particularly which are issued in large quantities, may become downward sloping, in which case changes in net supply can affect their relative prices.[14] This possibility then means that the relative supply of money or credit can influence market interest rates and so impact directly on expenditure paths without having to rely on pure signaling effects.

In Chadha et al. (2013a), we explored the advantages to the representative household from using money as an indicator, particularly when it covaries negatively with market interest rates, EFP. This is because when the money supply process is domi-

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[13] The discussion in this section follows closely that of Breedon et al. (2012).

[14] See Chadha et al. (2013b) for the implications for US bond yields from supply effects.

nated by supply shocks, the EFP and money supply tend to move in opposite directions. And this will tend to setup output and inflation variances that may be missed by a simple feedback rule related to standard inflation targeting practice. We examined an illustrative calculation in a model of money supply via a loans production function, in which the economy is better stabilized when the correlation between money and interest rates is driven to zero, that is when the information content from money supply is exploited by the policy maker. As a by-product, we can understand why money may not have much information for activity in an economy when the central bank has acted to stabilize activity well. We need then to consider how money, inside or outside the private sector can be created and for what reason it is held.

The Chadha–Corrado model, is an extension of the Goodfriend and McCallum (2007), in which credit constrained consumers require loans from a commercial bank in order to effect their planned consumption paths. The bank employs a loans production technology with arguments in the value of collateral and the employment of workers who monitor loans and also has to respect a liquidity constraint in deciding on the optimal levels of the reserve–deposit ratio. The commercial bank's liabilities can thus be funded by a mix of interest rate paying reserves and external finance premium paying loans. Chadha and Corrado (2012) and Chadha et al. (2012) find that in this framework, banks can use reserves as a buffer against costly changes in monitoring costs and so can choose to alleviate some of the countercyclical variation in the external finance premium. So we examine the implications from increasing the reserve ratio by some 7 % in this model.

The fall in output following a large negative demand shock is, in this case, can be some 15 %. After which inflation falls by around 6 % with real wages and employment both falling by something more than 20 % and in this case the increase in monitoring effort by commercial banks puts upward pressure on the external finance premium. The increased issuance of bonds by the government, which tries to stabilize output also pushed up liquidity premia on bonds. In the two cases where the reserve–deposit ratio is not fixed but chosen endogenously by commercial banks, the contractionary shock leads to an increase in demand for reserves, which are supplied perfectly elastically by the central bank. This increase in reserves, analogous to an increase in the central bank balance sheet, acts to limit the increase in the costs of loans supply, because banks hold reserves *ex ante* against potential problems with loans. Liquid reserves offset some of the upward shock to interest rates spreads and can mitigate around 30–40 % of the shock in this model. There has been some work examining the impact of QE by the Fed on India, for example Banerjee and Basu (2016) who concentrate on the spillover effects for India via a terms of trade and UIP channel. Clearly overseas economies may impact shocks on India. But we though are more interested in the analysis of the appropriate domestic monetary policy options for India, which may include active interest rates, as well as some role for the expansion or contraction of the central bank balance sheet.

4 A DSGE Model of Money and Banking

In this section, we will examine a DSGE model that differs from the 'plain vanilla' New Keynesian case by having more than one interest rate. A plain vanilla model would have as its New Keynesian core a forward-looking household and firm, optimizing their profit and consumption stream, subject to sticky prices and with central bank operations conducted under an active interest rate rule. In this model, we shall in addition have one or more interest rates impact on aggregate demand and these will have some additional traction on the economy. We shall keep my exposition of the microfoundation devices to a minimum and encourage reading of the original papers for further details. The creation of models with more than one interest rate means that the short-term interest rate performs as an approximate control device at all times and an especially problematic one when the zero lower bound, or some other constraint, acts to constrain the interest rate path. The model is a variant of Goodfriend and McCallum (2007) developed by Chadha and Corrado (2012), consumers are deposit constrained and banks choose a mix of lending and reserves holding to meet a given level of deposit demand. We also allow investment in this version of the model, which is allocated through the same loan production function and incurs some costs in implementation. Banks produce loans for consumption and investment using a combination of the value of collateral, monitoring workers and also have preference for liquid reserves. Reserves act as a cushion against hiring and firing of monitoring workers and thus can attenuate movements in the external finance premium, which is essentially the marginal costs of loans supply.

4.1 A Model of Money and Banking

The model is a (Calvo-Yun) monopolistically competitive economy with sticky prices and four main agents; households, who can work either in the goods producing sector or in the banking sector monitoring loan quality and produces wholesale goods and retail goods, banks, who meet consumer deposit demand via reserves and a loans production function, and the monetary authority. Households divide their time between working in goods or loan production and leisure. They consume up to the value of their deposits, invest on behalf of the firm they own, take on loans and hold other assets of bonds and capital. Commercial banks hold reserves and create loans to equal the quantity of deposits held by households. The government issues bonds and backs interest rate payments with lump-sum taxation on households—we do not develop an active version of fiscal policy here and simply assume some steady-state level of public debt. The central bank holds some of the outstanding stock of bonds and used that to back its issuance of reserves, or central bank money. Figure 3 sets out the relationships between these three sectors in this model.

Private Sector		Government	
Assets	**Liabilities**	**Assets**	**Liabilities**
Deposits D	Loans L	Tax T	Bonds B
Bonds γB	Tax T		
Capital K	Capital K		

Posted for loan production

Commercial Banks		Central Bank	
Assets	**Liabilities**	**Assets**	**Liabilities**
Reserves r	Deposits D	Bonds $(1-\gamma)B$	Reserves r
Loans L			

Fig. 3 The flow of funds

4.2 Households and Firms

The household plan are constrained by the quantity of deposits in the representative commercial bank. The households decide on their consumption, investment (as owners of the firm) and labor supply to production sector and banking sector during period t. Households demand deposits because the consumption and investment decision is made at the beginning of period t and income is determined (realized) at the end of period t. Banks therefore lend to fund consumption and investment. Throughout we assume that there are one-period deposits, loans, and government bonds.

The household maximizes the expected present value of its expected utility, U_t:

$$\max U_t = E_0 \sum_{k=0}^{\infty} \beta^t [\phi log(c_t) + (1-\phi) log(1 - n_t^s - m_t^s)] \tag{9}$$

where c_t is consumption expenditures in period t, n_t^s is supply of labor to the production of goods, m_t^s is labor monitoring work in the banking sector subject to the following three constraints.

The household budget constraint (Lagrangian multiplier, λ_t) acts on flow income. The household source of funds comprises: (i) deposits and bonds from previous period, (ii) wages from their labor, (iii) sales of physical capital, and (iv) sales of goods. Households use their funds for (i) holding deposits, (ii) purchasing bonds and capital, (iii) paying for wages, and taxes, and (iv) paying for their consumption expenditures.

$$\frac{D_{t-1}}{P_t} + \frac{B_t}{P_t} + q_t(1-\delta)K_t + w_t(n_t^s + m_t^s) + y_t\left(\frac{P_t^W}{P_t}\right)^{1-\epsilon}$$
$$= \frac{D_t}{P_t^A} + \frac{B_{t+1}}{P_t(1+R_t^B)} + q_tK_{t+1} + w_t(n_t + m_t) + tax_t + c_t \qquad (10)$$

where q_t is the real price of capital, K_t is the capital at start of t, D_t is households' deposits, P_t^W is wholesale good price, P_t is the aggregate price index, n_t^s is the labor supplied to the firms by households, m_t^s is the labor supplied to banking sector, w_t is the real wage rate, n_t and m_t is the labor demanded by firms and banking sector. R_t^D is nominal deposit interest rate, R_t^B is nominal interest rate on government bonds purchased in t and redeemed in $t+1$, ϵ is the elasticity of differentiated goods, tax_t is the real lump-sum tax payment.

In addition, households have the constraint that deposits are held in advance (Lagrangian multiplier, μ_t). Household consumption and investment during the period t is constrained to the quantity of deposits:

$$y_t = c_t + I_t = \frac{v_tD_t}{P_t} \qquad (11)$$

where v_t is the velocity of deposit circulation, D_t is deposits. The impact of velocity changes will be introduced later as a measure of financial inclusion (Khan and Thomas 2014).

4.3 Firms

4.3.1 Wholesale Goods Producer

As is standard in New Keynesian models, we adopt both a constant returns to scale Cobb–Douglas production function and assume that the wholesale goods producer operates under monopolistic competition and seeks to minimize the costs of production posts prices subject to Calvo pricing. The Cobb–Douglas production is subject to labor-augmenting efficiency shocks, $A1_t$, with shares of capital and labor given by η and $1-\eta$, respectively.

Firms decide the amount of production they wish to supply and the demand for labor by meeting the sales equal to net production (Lagrangian multiplier: ξ_t):

$$K_t^\eta(A1_tn_t)^{1-\eta} = y_t\left(\frac{P_t^W}{P_t}\right)^{-\epsilon} \qquad (12)$$

By clearing the household and production sector, we can define the equilibrium in the labor market and in goods market.

$$\frac{1-\phi}{1-n_t^s-m_t^s}=w_t\lambda_t \tag{13}$$

$$w_t=\frac{\xi_t}{\lambda_t}(1-\eta)\frac{y_t}{n_t} \tag{14}$$

And we employ a standard law of motion for capital considering an investment adjustment cost, $S(\cdot)$ in this model:

$$K_{t+1}=(1-\delta)K_t+\left[1-S\left(\frac{I_t}{I_{t-1}}\right)\right]I_t \tag{15}$$

where $S\left(\frac{I_t}{I_{t-1}}\right)=\frac{s}{2}\left(\frac{I_t}{I_{t-1}}-(1+\varrho)\right)^2$, $S(1+\varrho)=S'(1+\varrho)=0$, $S''(1+\varrho)=s>0$, ϱ is a trend growth rate.

4.3.2 Final Good Producer (Retailer)

Final goods are produced using a variety of intermediate goods, which allows us to derive the standard New Keynesian Phillips curve. To which we append both backward and forward-looking behavior to capture the behavior of price setters in rule of thumb settings. The derivation of the price of goods results from the Calvo pricing mechanism:

$$\sum_{s=0}^{\infty}\theta^s E_t\left[\Lambda_{t,s}Y_{t,t+s}\left(\frac{P_t^f}{P_{t-1}}-\mathrm{X}_\psi \mathrm{mc_t}\pi_{\mathrm{t-1,t+s}}\right)\right]=0 \tag{16}$$

where only $1-\theta$ share of firms can reset their price per period, P_t^f is forward-looking firm optimal price (resetting price), $\Lambda_{t,s}=\beta^s\left(\frac{c_{t+s}}{c_t}\right)^{-1}\left(\frac{P_t}{P_{t+s}}\right)$ is the households' stochastic discount factor, $X_\psi=1/mc$ is desired markup. mc_t is real marginal cost, and $\pi_{t-1,t+s}=\frac{P_{t+s}}{P_{t-1}}$. The aggregate price level is thus given by:

$$P_t=\theta P_{t-1}+(1-\theta)\bar{P}_t^*, \tag{17}$$

where $\bar{P}_t^*$ is an index of prices set in period t based on the forward-looking and backward-looking price setting behavior such that

$$\bar{P}_t^*=\omega P_t^b+(1-\omega)P_t^f, \tag{18}$$

where P_t^b is the price set by the backward-looking rule of thumb ($P_t^b=\bar{P}_{t-1}^*+\pi_{t-1}$), P_t^f is the fraction of the price set by on a forward-looking basis, and ω measures the degree of backward-looking price setting behavior. Hybrid New Keynesian Phillips

Curve is given by

$$\pi_t = \kappa mc_t + \gamma_f E_t(\pi_{t+1}) + \gamma_b \pi_{t-1}. \tag{19}$$

4.4 Government Sector

The government faces a per period government budget constraint in which any excess of government expenditure will be financed by the issuance of bonds and central bank money. The government issues bonds to the household or supplies reserves to commercial banks at differentiated interest rates. We will use two version of our model: one in which the issuance of reserves does not bear interest $\left(R_t^{IB} = 0\right)$ and remains a fixed fraction of the overall level of deposits, secondly, where there is some interest paid on reserves $\left(R_t^{IB} = R_t > 0\right)$ and as a consequence, the commercial bank optimizes on the fraction of deposits held as reserves.

$$g_t - tax_t = \frac{r_t}{P_t(1 + R_t^{IB})} - \frac{r_{t-1}}{P_t} + \frac{B_{t+1}}{P_t(1 + R_t^B)} - \frac{B_t}{P_t} = 0 \tag{20}$$

where g_t is the government expenditures, tax_t is the tax receipt, B_t is government bond, r_t is banks' reserves, R_t^{IB} is supposed to be equal to policy rate, R_t. For simplicity, we will also use. $re_t = \frac{r_t}{P_t(1+R_t^{IB})}$ and $b_{t+1} = \frac{B_{t+1}}{P_t(1+R_t^B)}$. There are in effect two types of government liabilities, reserves which attract the policy rate (akin to T-bills) or zero interest rate (akin to currency) or bonds which attract the benchmark interest rate minus their liquidity service yield. The reserves are held by banks as part of their assets and bonds are held by households and may be posted as collateral in order to obtain loans.

4.5 Banking Sector

4.5.1 The Demand and Supply of Deposits

The commercial bank balance sheet is given by:

$$L_t + r_t = D_t \tag{21}$$

where L_t is nominal loans, r_t is nominal reserves, D_t is nominal deposits at the end of t. The household has a demand for deposits, as a deposit-in-advance constraint, which is given by:

$$c_t + I_t = \frac{v_t D_t}{P_t}. \tag{22}$$

and the derived demand for deposits (broad money) can be written as:

$$D_t^d = \frac{P_t y_t}{v_t}. \tag{23}$$

The commercial bank supply for deposits can be expressed from bank balance sheet constraint

$$D_t^s = \frac{L_t}{1 - rr_t}, \tag{24}$$

where $rr_t = \frac{r_t}{D_t}$ is the reserve–deposit ratio.

4.5.2 Loan Production and the Broad Liquidity Constraint

The commercial bank meets the demand for households deposits by producing loans. Assuming that there are information frictions in lending markets (e.g., asymmetric information), we assume that loans are created by Cobb–Douglas loans production function with inputs of collateral and bank monitoring (or screening) effort.

$$\frac{L_t}{P_t} = F\,\underbrace{(b_{t+1} + A3_t k q_t K_{t+1})}_{\text{collateral}}{}^{\alpha}(A2_t m_t)^{1-\alpha} \qquad 0 < \alpha < 1 \tag{25}$$

Collateral comprises (real) government bonds b_{t+1} $(= \frac{B_{t+1}}{P_t(1+R_t^B)})$ and capital K_{t+1} posted by households which is inferior as collateral relative to bonds, q_t, is the price of capital, K_{t+1} is capital at end of t, k is an inferiority of capital as collateral relative to bonds, $A3_t$ is collateral shock (asset price shock). The second argument in the production function comprises m_t, which is employment in loan monitoring and $A2_t$, which is a monitoring productivity shock. The coefficient, F measures the efficiency with which inputs are turned in loans.

By placing the loans production function into the deposit supply, we can express a broad liquidity constraint as a function of the DIA condition, the bank balance sheet and the loan production function

$$y_t = v_t \frac{F(b_{t+1} + A3_t k q_t K_{t+1})^{\alpha}(A2_t m_t)^{1-\alpha}}{1 - rr_t} \qquad 0 < \alpha < 1. \tag{26}$$

We can derive the equilibrium of the labor demand in banking sector

$$w_t = \frac{\mu_t}{\lambda_t} \frac{(1-\alpha) y_t}{m_t}$$

4.5.3 Reserves

The commercial bank can either hold a fixed fraction of its overall deposit as reserves or be allowed to vary the ratio in an optimised manner. Following Chadha and Corrado (2012) banks seek to maximize total returns within period subject to the returns from loans, L_t, which are lent out at the interest rate of R_t^L, the cost or return of obtaining reserves, $R_t r_t$, and the payment of deposit interest, $R_t^D D_t$, to deposits

$$\max_{r_t} \Pi_t = R_t^L \underbrace{(D_t - r_t)}_{L_t} + R_t^{IB} r_t - R_t^D D_t \tag{27}$$

$$s.t. \quad C_t^r = \frac{1}{2} R_t^T (\bar{r} - r_t)^2 + \tau_t (\bar{r} - r_t) \tag{28}$$

Commercial bank profits are also subject to a side constraint motivated by concerns over reserve management. We assume that banks have an exogenous target for the level of reserves, $\bar{r}$, perhaps set by custom and practice or by legislation.[15] We assume that any deviation from this target imposes two costs on the bank. The first is symmetric and derives from the bank's desire to smooth the path of reserves and avoid any sharp swings in its asset position as these may signal mismanagement and result in reputational loss. In the model the cost of such deviations from target is the uncollateralised interest rate, R_t^T. This is because if $r_t < \bar{r}$, the commercial bank will fund its shortfall at the penalty rate, and if $r_t > \bar{r}$ the commercial bank will have missed the opportunity to lend out those reserves at the same penalty rate and thus incurs the opportunity cost, R_t^T.

The second term relates to the need of commercial banks to hold a certain level of reserves to meet its desired reserve target in any given period. Whilst exogenous in this framework, this target is most likely driven by the level of required reserves set by the regulator Basel (2010), although banks may set a target in excess of this minimum limit if they have heightened precautionary motives for holdings safe, liquid assets, such as central bank reserves. Therefore, the second term can be thought of as an exogenous shift in the ex ante probability of a reserve shortfall or analogously an shift in the demand for reserves. Solving with respect to reserves, and assuming the interest on reserves model, the optimal, profit-maximizing level of reserves gives us the commercial bank demand curve and can be written as

$$r_t = \bar{r} + \left[\frac{R_t^{IB} - R_t^L}{R_t^T} \right] + \frac{\tau_t}{R_t^T}. \tag{29}$$

It is a positive function of the probability, τ_t of the commercial bank being short its obligated level of reserves, $\bar{r}$, and positive in R_t^{IB}, and negative in, R_t^L, which is

[15] In practice, most major economies have a minimum level of required reserves relative to depositis. Our long-run target for India is set at 20 %.

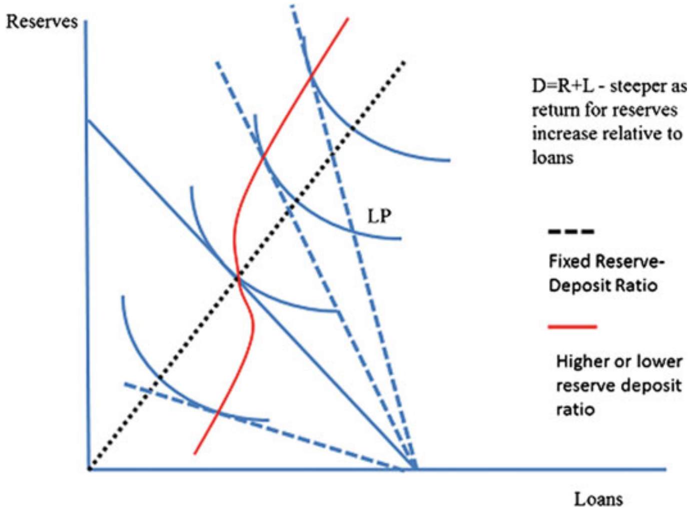

Fig. 4 Commercial bank's demand for reserves

respectively the return on reserves and the opportunity cost of reserves, i.e., the loan rate. We therefore emphasize that the relative cost and returns of the two mechanisms of meeting deposit demand change, so do the bank's optimal quantities of each.

Figure 4 illustrates the implications of changing the return on reserves for the commercial bank choice of reserve–deposit ratio. For a given quantity of deposits, which corresponds to a given fraction of lending and reserves, each asset yields a overall return at its interest rate. If the ratio of reserves to deposits is fixed then for a higher or lower level of deposits the bank's asset allocation will lie on the black expansion path. But if there are changes in the return on reserves, the slope of the isoquant line will change and the composition of the optimal portfolio will change. If the bank does not change the composition of its assets, it will not be maximizing profits. In general equilibrium, the bank will then have an incentive to change its loan rates and this will tend to inject volatility into the economy.

4.6 Market Interest Rates

The model produces a variety of market interest rates that are determined by the implicit service yield from each type of loan contract (See Table 1). As in Goodfriend and McCallum (2007) we start with a benchmark riskless interest rate that introduces a one-period default-free security that provides no collateral services to its holders. This benchmark rate bears a shadow 'total' return that represents the pure intertemporal rate of interest, which (=risk adjusted pecuniary + service yields on other assets) must be matched by other assets. That is, the bank would be willing to

Table 1 Market interest rates

Interest rate	Equation
Benchmark interest rate	$R_t^T = \beta E_t\left(\frac{\lambda_t P_{t+1}}{\lambda_{t+1} P_t}\right) - 1$
External finance premium	$EFP_t = \frac{v_t m_t w_t}{(1-\alpha)(1-rr_t)y_t} = \frac{\mu_t v_t}{\lambda_t(1-rr_t)}$
Liquidity service yield on bond	$LSY_t^B = \frac{\mu_t}{\lambda_t}\Omega_t$
Liquidity service yield on capital	$LSY_t^K = k \times A3_t LSY_t^B$
Policy rate	$R_t = \rho R_{t-1} + (1-\rho)(\phi_\pi \pi_t + \phi_y y_t + \phi_f f_t)$
Deposit rate	$R_t^D = (1 - rr_t)R_t$
Loan rate	$R_t^L = R_t + CEFP_t$
Bond rate	$R_t^B = R_t^T - LSY_t^B$

loan funds to the household, if it incurred all necessary costs to match the benchmark rate R_t^T.

From the perspective of household optimization problem, the benchmark riskless interest rate R_t^T is defined as:

$$1 + R_t^T = \beta E_t \frac{\lambda_t P_{t+1}}{\lambda_{t+1} P_t}. \tag{30}$$

The interest rate on bonds R_t^B is lower than R_t^T due to the liquidity service yield (LSY_t^B) on bonds. (by $\frac{\partial \mathcal{L}}{\partial B_{t+1}} = 0$)

$$R_t^T - R_t^B = \frac{\mu_t}{\lambda_t}\Omega_t = LSY_t^B, \tag{31}$$

where $\frac{\mu_t}{\lambda_t} = \frac{\phi}{c_t} - 1$, measures the households' marginal utility relative to households shadow value of funds while Ω_t is the marginal value of bond-collateralised lending.

The marginal value of bond for collateralised lending (Ω_t) is given by

$$\frac{\partial y_t}{\partial b_{t+1}} = \frac{\alpha y_t}{b_{t+1} + A3_t k q_t K_{t+1}} \tag{32}$$

The liquidity service yield on capital (LSY_t^K) is

$$LSY_t^K = k \times LSY_t^B, \tag{33}$$

where k is an inferiority of capital as collateral relative to bonds.

4.7 External Finance Premium

Here, we assume that the collateral costs are borne by the bank. The commercial bank can obtain (borrow) funds in the interbank market at interbank rate, or policy rate, R_t^{IB}. The external finance premium, EFP_t, can be regarded as the gap between the uncollateralised loan rate R_t^T and the cost of loanable funds R_t^{IB}. This external finance premium reflects the real marginal cost of loan production. From the cost-minimizing optimal mix of factor inputs, the real marginal cost of loan production, mcl_t, is the factor price (w_t) divided by the marginal product of monitoring work in the loan production (mpm_t). Note that workers whether they work in goods production or monitoring are paid the same wage.

$$mcl_t = \frac{w_t}{mpm_t} \tag{34}$$

$$mpm_t = (1-\alpha)\frac{L_t}{P_t m_t} = (1-\alpha)\frac{(1-rr_t)D_t}{P_t m_t} = (1-\alpha)\frac{(1-rr)y_t}{V_t m_t} \tag{35}$$

$$UEFP_t = mcl_t = \frac{w_t v_t m_t}{(1-\alpha)(1-rr)y_t} = \frac{\mu_t}{\lambda_t}\frac{v_t}{(1-rr_t)} \tag{36}$$

$$CEFP_t = (1-\alpha)UEFP_t = \frac{w_t v_t m_t}{(1-rr)y_t} = \frac{\mu_t}{\lambda_t}\frac{v_t(1-\alpha)}{(1-rr_t)} \tag{37}$$

The EFP_t reflects the real marginal cost of loan production and has two forms: uncollateralised, $UEFP_t$, and collaterised, $CEFP_t$. In effect, the uncollateralised loan rate is equated to R_t^T as it comprises the policy rate and the premium.

We can show that the external finance premium interacts with both the demand (c_t+I_t) and supply factor of money (D_t) and bank balance sheet condition (rr_t). Most loans are collateralised with assets (government bonds and capital) and therefore the loan rate (R_t^L) is lower than the benchmark rate R_t^T by the liquidity service yield from assets.

The deposit rate is simply

$$R_t^D = R_t^{IB}(1-rr_t) \tag{38}$$

so that as the ratio of reserves to deposits rises as the commercial bank pays a lower return to depositors.

4.8 Monetary Policy and Fiscal Policy

We suppose that the central bank changes its policy rate (interbank rate) in response to inflation and output in standard fashion.

$$\widehat{R}_t^{IB} = \rho\widehat{R}_{t-1}^{IB} + (1-\rho)(\phi_\pi\widehat{\pi}_t + \phi_y\widehat{y}_t + \phi_f\widehat{f}_t) \tag{39}$$

Under the standard interest rate reaction function, $\phi_f = 0$. But in a later simulation we will assess what happens when the policy maker feeds back from financial conditions, which we proxy by

$$\widehat{f}_t = \left(\frac{L_t}{P_t} - efp_t \right),$$

where a demand for more loans from optimal increases in investment or consumption will tend to lead to a limited response by the policy maker because loans and the external finance premium will rise together. But when the financial sector itself changes the extent of its activity by shifting its supply, then loans and the external finance premium will move negatively and so there will be a strong response by the policy maker.

We characterize fiscal policy as simply a stationary target for the government bond to GDP ratio, boy_t

$$\widehat{boy}_t = a6_t = \rho_{boy} \widehat{boy}_{t-1} + \epsilon_t^{boy}.$$

5 Results

We calibrate this model to Indian data and solve using standard techniques. The model is solved under three separate scenarios. A standard NK model with government debt stable and an active interest rate but with no explicit monitoring of financial conditions. The alternate solution retains the active interest rate rule but also allows the commercial bank to vary its demand for reserves and the central bank to meet that demand. The third solution allows the central bank to respond to supply shocks in bank lending under either of a fixed or variable reserves regime with an augmented interest rate reaction function. We examine a number of impulse responses of key endogenous state variables to the model's shocks under the two solutions, as well as an example of the data generated from the two basic cases. Then we assess the moments of the model and approximate the welfare of the household (Figs. 5 and 6).

5.1 Calibration

Table 2 reports the values for the parameters and Table 4 the steady-state values of relevant variables.[16] Following Goodfriend and McCallum (2007) we choose the consumption weight in utility, ϕ, of 0.4 mark available time in either goods or banking services production. labor share is 0.6 from Gabriel et al. (2012). We also set the

[16]The equations for the steady-state equations are listed in the technical appendix.

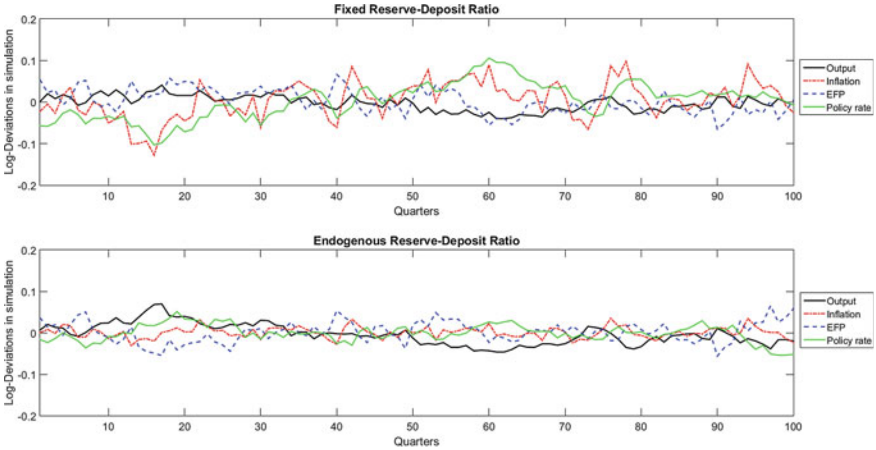

Fig. 5 Simulation of series of HP filtered key variables under the benchmark scenario, *Note* The series show the middle segment of a simulation of 5,000 data points from a benchmark calibration. The simulated data are HP filtered ($\lambda = 1600$)

Fig. 6 Simulation of series of HP filtered key variables under the banking dominant scenario, *Note* The series show the middle segment of a simulation of 5,000 data points from a calibration where the standard deviation of banking shocks is 5 times higher than in the benchmark calibration. The simulated data are HP filtered ($\lambda = 1600$)

relative share of capital and labor in goods production η to be 0.4. We choose the elasticity of substitution of differentiated goods, ϵ, to be equal to 6. The discount factor, β, is set to 0.98 which is close to the canonical quarterly value while the markup coefficient in the Phillips curve, κ, is set to 0.24 (Goyal 2014). The depreciation rate, δ, is set to be equal to 0.025 while the trend growth rate, ϱ, is set to 0.125 which cor-

Table 2 Parameter calibration

Parameter	Description	Value
β	0.98	Discount factor
κ	0.24	Philips curve slope
α	0.7	Collateral weight in loan production
$1-\alpha$	0.3	Monitoring weight in loan production
ϕ	0.4	Consumption weight in utility
η	0.4	Capital weight in firm's production
δ	0.025	Depreciation rate of capital
s	4	Elasticity of investment adjustment cost
ϱ	0.0125	Trend growth rate
ϵ	6	Elasticity of substitution of differentiated goods
F	3.9	Efficiency in loan production
k	0.2	Inferiority of capital as collateral
ρ	0.8	Interest rate smoothing in Taylor rule
ϕ_π	1.5	Response to inflation gap in Taylor rule
ϕ_y	0.5	Response to output gap in Taylor rule
ϕ_f	0–1.5	Response to financial condition in Taylor rule

responds to 5 % per year. The steady-state value of bond holding level relative to GDP, b, is set to 0.75 as of the third quarter of 2005.[17]

The deep parameters linked to money and banking are defined as follows. Ratio of Nominal GDP to M3 in India has averaged 1.7 since 1990. The fractional reserve requirement, rr, is set at 0.2, which is just below the RBI's statutory liquidity ratio of just over 20 %. This leaves us three key deep parameters to manipulate which may influence the rest of the steady-state variables. Interestingly these are three financial variables and so are of particular interest to our debate on policies. α is the Cobb–Douglas weight of collateral in loan production. This is the degree to which banks base their lending on collateral as opposed to monitoring work or information based lending. The benchmark calibration of 0.7 is taken from Calomirism (2015). k, is the degree to which capital is less efficient as collateral than bonds as it entails higher costs to the bank in order to check its physical condition and market price. It is also less liquid should default occur and the collateral be called upon to repay the value of the loan. We set this parameter to 0.2 which follows Goodfriend and McCallum (2007). F, can be thought of as total factor productivity in loan production, or a measure of the efficiency with which banks use the factors of production to produce loans.[18] We end up with a 5.6 % per year average real short-term rate; a 2.3 % average

[17]The steady state of the transfer level, the Lagrangian of the production constraint and base money depend on the above parameters. The steady state of the marginal cost is $mc = \frac{\epsilon-1}{\epsilon}$.

[18]Some authors have also described it as a measure of credit conditions within the economy. The rationale for this seems plausible as when credit conditions are tight, banks will require more collateral and will employ more monitoring work to provide the same amount of loans to the economy.

collateralized external finance premium that is broadly in line with the average spread of the prime rate over the policy rate and with some 4mn employed in banks from labor force of over 500 mn, so let us choose something around 1% for the share of employment in banking, we choose 1.3 %.[19] The steady-state value this yields is $F = 3.9$.

With these parameter values we see that the steady state of labor input, n, is 0.35 which is close to 1/3 as required. As the steady states are computed at zero inflation we can interpret all the rates as real rates. The benchmark rate, R^T, is 13 % per annum. The interbank rate, R^{IB}, is 5.6 % and the government bond rate, R^B, is 9.8 % per annum. Finally the collateralized external finance premium is 2.3 % per annum which is in line with the average spread of the prime rate over the policy rate in the emerging economies (Table 3).

5.2 Solution Method

The benchmark model has 27 endogenous variables $\{c, n, y, m, w, K, I, q, P, \pi, \pi_{t-1}, mc, H, b, \Omega, EFP, R^T, R^B, R^{IB}, R^L, R^D, \lambda, \mu, \xi, T, r, re\}$, 9 lagged variables $\{P_{-1}, H_{-1}, c_{-1}, b_{-1}, re_{-1}, R^B_{-1}, y_{-1,} K_{-1,} I_{-1}\}$ and eight exogenous shocks $\{a1, a2, a3, a4, a5, a6, a7, a8\}$, see Table 4. Equation (83) through (108), 9 lagged identities construct the model to be solved by King and Watson (1998) algorithm. For the simulation we consider contemporaneous shocks to $a1, \ldots, a8$. To obtain the simulated series we have produced 5,000 draws from a normal distribution, discard the first 250 and considered the middle 100. For the impulse response analysis and simulation exercise we consider the real and financial shocks described in Table 4, which reports the volatility and persistence parameters chosen for the calibration and simulation exercise. These are standard parameters in the literature. The model is then solved using the solution methods of King and Watson (1998) to derive the impulse responses of the endogenous variables to different shocks, to obtain asymptotic variance and covariances of the variables and to simulate the data. This system of linear difference equations can be expressed as a singular dynamic system of the following form

$$\check{\mathbf{A}} E_t \mathbf{y}_{t+1} = \check{\mathbf{B}} y_t + \check{\mathbf{C}} \varepsilon_t \qquad \forall t \geq 0, \tag{40}$$

where $\mathbf{y}_t$ is the vector of endogenous variables comprising both predetermined and nonpredetermined variables including policy rules for the nominal interest rate, ε_t is a vector of exogenous forcing variables, and $\check{\mathbf{A}}, \check{\mathbf{B}}$ and $\check{\mathbf{C}}$ are matrices of fixed, time-invariant, coefficients. E_t is the expectations operator conditional on information available at time t. King and Watson (1998) demonstrate that if a solution exists

[19]http://www.slideshare.net/iimjobs/india-banking-sector-report-april-2014 from Reserve Bank of India (2014).

Table 3 Steady states

Variable	Value	Description
y	0.9505	Output
c	0.6948	Consumption
I	0.2557	Investment
K	6.9035	Capital
m	0.0045	Employment in banking sector
n	0.3463	Employment in goods producing sector
w	1.6469	Real wage
λ	0.5611	Shadow value of consumption
μ	0.0146	Shadow value of DIA constraint
Ω	0.3178	Marginal value of consumption
v	0.588	Velocity
c/y	0.73	Consumption to GDP
I/y	0.27	Investment to GDP
K/y	7.26	Capital to GDP
$boy(= b/y)$	0.75	Bond to GDP
rr	0.2	Reserve to deposit ratio
L	1.2932	Loans
LSY^B	3.3%	Liquidity service yield (Bonds)
LSY^K	0.7%	Liquidity service yield (Capital)
EFP	7.6 %	Uncollateralized external finance premium
$CEFP$	2.3 %	Collateralised external finance premium
R^T	13.1 %	Risk free rate
R^{IB}	5.6 %	Interbank rate
R^L	7.9 %	Loan rate
R^B	9.8 %	Bond rate

Note Market interest rates and service yields are annualized

and is unique then we may write any such solution in state-space form as follows

$$\begin{aligned} \mathbf{y}_t &= \mathbf{\Pi s}_t \\ \mathbf{s}_t &= \mathbf{M s}_{t-1} + \mathbf{G e}_t, \end{aligned} \tag{41}$$

where the $\mathbf{s}_t$ matrix includes the state variables of the model (predetermined variables along with exogenous variables), $\mathbf{e}_t$ is a vector of shocks to the state variables and $\mathbf{\Pi}$, $\mathbf{M}$, and $\mathbf{G}$ are coefficient matrices. There are eight shocks in $\mathbf{G}$ and the variance–covariance as well as the autocorrelation matrices associated with these shocks are described in Table 4. The impulse responses of this system are given by

Table 4 Properties of exogenous shocks

Shock	Persistence	Standard deviation (%)
Productivity	0.95	1.0
Monitoring	0.5	1.0
Collateral	0.5	1.0
Monetary policy	0	1.0
Markup	0.7	1.0
Bond holdings	0.7	1.0
Velocity	0.5	1.0
Liquidity	0.33	1.0

$$\begin{aligned} E_t\mathbf{y}_{t+k} - E_{t-1}\mathbf{y}_{t+k} &= \mathbf{\Pi}\left(E_t\mathbf{s}_{t+k} - E_{t-1}\mathbf{s}_{t+k}\right) \\ &= \mathbf{M}^k\mathbf{G}\mathbf{e}_t. \end{aligned} \tag{42}$$

And the variance of the states, $\mathbf{V}_{ss}$, is given by

$$vec\left(\mathbf{V}_{ss}\right) = (\mathbf{I} - \mathbf{M} \otimes \mathbf{M})^{-1}\, vec\left(\mathbf{G}\mathbf{V}_{ee}\mathbf{G}^T\right). \tag{43}$$

5.3 *Impulse Response Functions*

Figures 7, 8, 9 and 10 shows the endogenous responses of key state variables to four of the eight shocks we have considered in the model.[20] In response to an increase in productivity, a fixed reserve–deposit ratio leads to a greater increase in the EFP, which acts to lead to lower output and inflation than when reserves are allowed to increase and the increase in the EFP is attenuated. In the latter case, output increases by more and inflation falls by less. Figure 8 shows the impact of an increase in the productivity of bank loan production, which acts like an aggregate demand shock-raising output and inflation. When the reserve ratio is allowed to move, the commercial bank does not shed as much labor in loans production and this means that the external finance premium does not fall as much, acting again to attenuate the impact on output and inflation. Figure 9 shows the impact of a collateral, or asset price shock, and because it is an argument in the loans production function, it has a very similar impact to the efficiency of loan production—having higher value collateral allows the bank to shed expensive monitoring labor and drive down the EFP—but this effect will be limited if central bank meets the demand for reserves instead. Finally, with a positive monetary policy shock, the commercial bank may choose to hold more reserves and this will tend to limit the impact on the external finance premium.

[20]The other four shock IRFs are available on request.

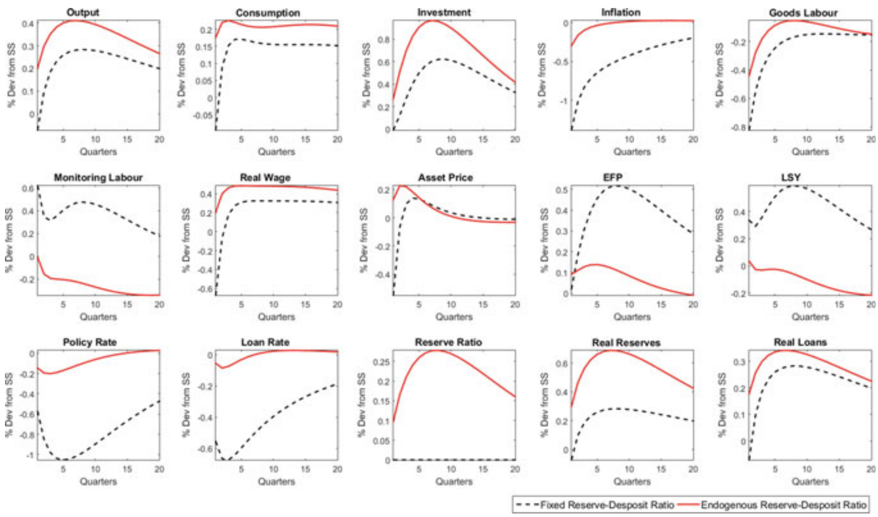

Fig. 7 Impulse response to a positive productivity shock (+1 %)

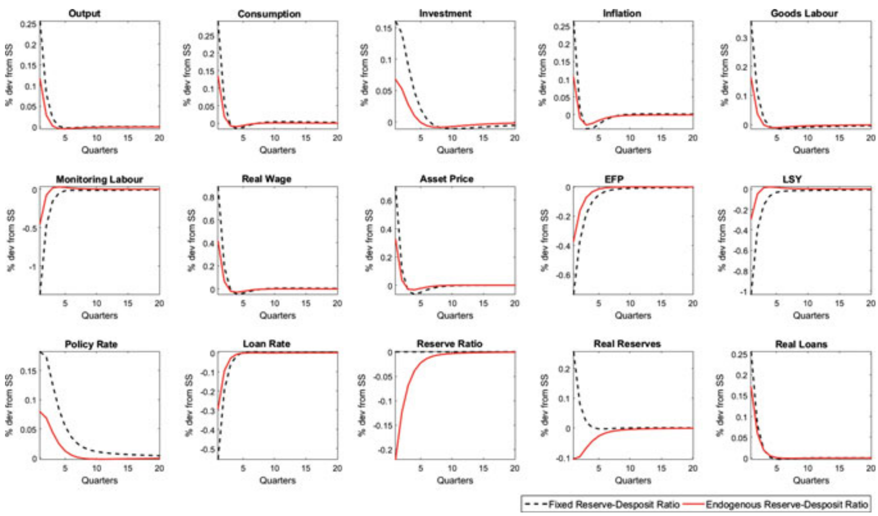

Fig. 8 Impulse response to a positive banking productivity shock (+1 %)

We should treat variation in the reserve–deposit ratio, as the counterpart to changes in the size of the central bank balance sheet over the business cycle and this seems quite clearly to act in a stabilizing manner compared to an interest rate rule alone. Even though we have a closed economy model, clearly the Reserve Bank of India could expand or contract its balance sheet with respect to domestic and/or foreign assets.

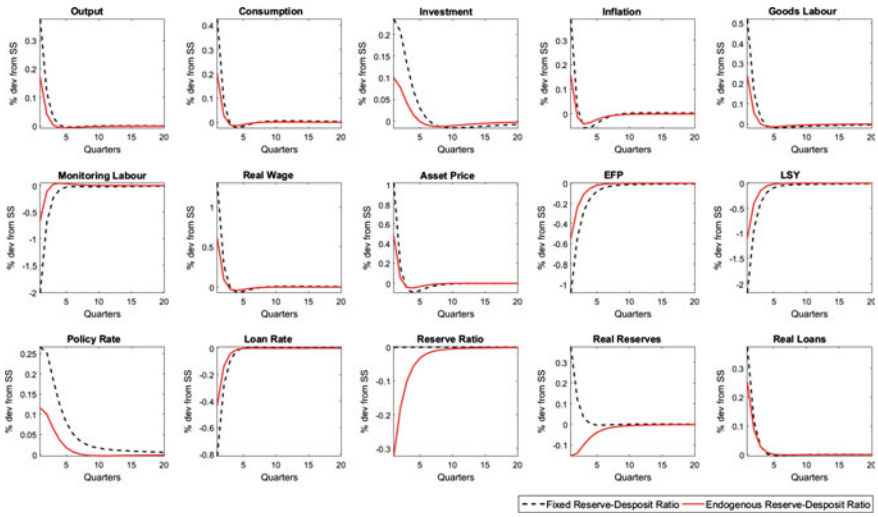

Fig. 9 Impulse response to a positive collateral shock (+1 %)

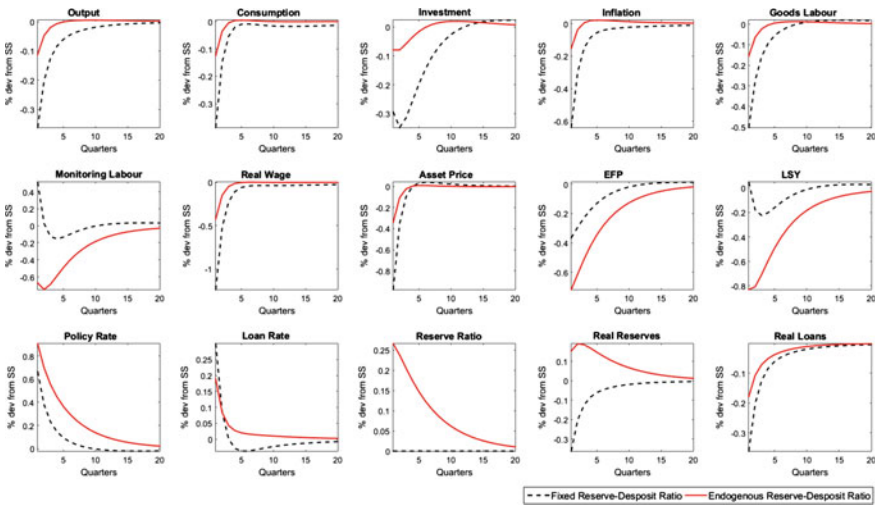

Fig. 10 Impulse response to a positive policy rate shock (+1 %)

5.4 Table of Moments and Welfare

Having calibrated and simulated the model, we show in Table 5 the moments from the model where there is a fixed reserve ratio and where we allow commercial banks and the central bank to set the appropriate level of reserves. In this model, consumption and investment move with the business cycle, albeit where investment is signif-

Table 5 Moments of simulated series from the model

	Fixed reserve ratio		Endogenous reserve ratio	
Variables	S.D (%)	$Corr(i, y)$	S.D (%)	$Corr(i, y)$
Output	1.01	1.00	1.20	1.00
Consumption	1.01	0.95	0.92	0.89
Investment	1.44	0.79	2.50	0.89
Inflation	3.07	0.24	1.15	−0.03
Employment in goods sector	1.55	0.81	1.59	0.83
Employment in monitoring	4.96	−0.73	4.74	−0.76
Real wages	3.14	0.95	2.92	0.92
Asset price	2.46	0.91	2.27	0.80
External finance premium	2.46	−0.43	2.12	−0.49
Liquidity service yield	4.37	−0.64	3.95	−0.68
Policy interest rate	2.15	−0.27	1.32	0.07
Loan interest rate	2.15	−0.76	1.52	−0.62
Real deposits	0.94	0.43	1.20	0.62
Reserve ratio	0.00	0.00	1.07	0.61

Note S.D. and *Corr* denote the asymptotic standard deviation, and contemporaneously cross-correlation between the relevant variable and output from the filtered second moments obtained from the model

icantly more volatile than consumption, as we would expect. Note that asset prices are procyclical and market interest rates are countercyclical. The latter results suggests that the amplification effect of asset prices leading to lower market interest rates dominates any attenuation effect whereby increased demand for loans in an upswing places upward pressure on market interest rates. With endogenous reserves, inflation becomes less volatile and broadly acyclical. Note also that under this regime, real wages, asset prices, and the external finance premium become significantly less volatile.

5.5 *Welfare Analysis*

Having discussed in the previous section why variance in the reserve–deposit ratio can improve welfare over the cycle we seek to strengthen this result by quantifying its impact on the representative household. To do this we carry out some more stringent welfare analysis by deriving a welfare loss function from a second-order approximation to utility.

5.5.1 Deriving The Welfare Loss Function

The welfare approximation derived from the canonical New Keynesian model finds that welfare of the representative household only depends on the variance of output and inflation (Galí 2008). The use of the approximation allows us to quantify precisely the welfare rankings arising from each of our policy rules, possibly allowing some normative statements. Thus, we derive a quadratic loss function using a second-order Taylor approximation to utility using the labor demand function, marginal cost function and sales-production constraint to substitute for household consumption.[21] Once reordered and simplified we are left with a loss function with relevant terms in the variances of consumption, inflation, wages, employment in the goods sector and the marginal cost.

$$U_t - U = -\frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t L_t + O3 \tag{44}$$

$$\text{with } L_t = \frac{1}{2}\left[\begin{array}{c} \sigma_c^2 + \frac{\theta}{\chi}\left[\frac{\frac{n}{c}-\frac{w}{c}}{1-\eta}\right]\sigma_\pi^2 - \\ \frac{w}{c}\sigma_w^2 - \frac{n}{c}\sigma_n^2 + \frac{mc}{c}\sigma_{mc}^2 \end{array}\right],$$

where $\chi = \frac{(1-\epsilon)(1-\beta\epsilon)}{\epsilon}\frac{1-\eta}{1+\eta(\epsilon-1)}$. Given that $\frac{w}{c} > 0$ *and* $\frac{n}{c} > 0$, more flexible wages and employment improves welfare, whilst $\frac{mc}{c} > 0$ *and* $\frac{\epsilon}{\chi}\left[\frac{\frac{n}{c}-\frac{w}{c}}{1-\eta}\right] > 0$, so more stable marginal cost, consumption, and inflation improves welfare.

The results of the welfare analysis given in Table 6 are stark. Compared to a fixed reserve ratio, allowing commercial banks to choose their ratio of reserves to deposits is welfare-enhancing for the representative household under a normal regime or one where banking shocks dominate, e.g., after a reform in or liberalization of the banking system.[22] Rather than allowing reserves to be endogenous, using an augmented rule by responding to the difference between credit and financial spreads also seems to improve welfare, by reducing losses, relative to a standard interest rate reaction function. But an augmented rule has little advantage when reserves are endogenous unless banking shocks dominate, and then perhaps to a small degree. Augmenting the interest rate reaction function by responding to financial conditions does also seem to improve performance both when reserves are fixed and when banking shocks dominate. We conclude that relative to the standard interest rate reaction function,

[21] The additive nature of our household's utility function allows us to take a Taylor expansion of each term and substitute it back into the original function. The labor demand function is then rearranged for monitoring work, a second-order expansion taken and substitution made. This process is then repeated for the marginal cost equation. Following Galí (2008) we substitute the resulting linear term in goods sector employment for a second-order term in inflation using the sales equal net production constraint.

[22] A referee suggested rightly that we rerun these calculations for different choices of deep parameters, but we have undertaken this kind of analysis elsewhere using advanced country calibrations and obtained qualitatively similar results.

Table 6 Approximated welfare loss

		Benchmark scenario		Banking dominant scenario	
	Parameter on EFP	Fixed	Endogenous	Fixed	Endogenous
Standard rule	$\phi_f = 0$	1.8290	0.1616	2.6589	0.2593
Augmented rule	$\phi_f = 0.25$	1.7235	0.1643	2.2224	0.2510
	$\phi_f = 0.5$	1.6251	0.1674	1.9156	0.2430
	$\phi_f = 0.75$	1.5337	0.1708	1.7640	0.2361
	$\phi_f = 1$	1.4577	0.1744	1.7995	0.2309

Note Banking dominant scenario denotes the case where the standard deviation of banking shocks is 5 times higher than in the benchmark calibration

the modeling of financial frictions implies that more sophisticated monetary policy actions may be required than a standard active interest rate rule. We have not undertaken a full-blown optimality analysis, and leave that to future work, but suspect these kinds of results will continue to obtain were that undertaken. Remember that our results simply imply that the mix of commercial bank assets and the size of the central bank balance sheet are likely to matter for representative household welfare in a world of financial frictions.

6 Conclusion

Modern macroeconomics has been frequently criticized for its apparent inability to model financial questions. From the equity premium puzzle to the dominance of the representative agent, questions of risk and asymmetric information seem to have been side-stepped in our need to match aggregate behavior with recourse to shocks rather than structure. The global financial crisis has provided a concrete incentive to develop models with financial frictions. To some extent and with a limited departure from neoclassical microfoundations, it seems possible to introduce structures that allow financial developments to feedback substantively into agent decision rules.[23] Indeed Kletzer (2014), after his careful summary of India's financial and monetary environment, calls for more analysis of the bank lending and asset price channel and accordingly this is to what we turn in this chapter.

In the model developed in this chapter, the set of interest rate premia that lead to market clearing in money and credit markets are closely linked to bank behavior and to the evolution of asset prices. In advanced economies, these models were developed as a by-product of the need to understand nonconventional monetary policy with either preferences for assets of different maturities or loan productions functions

[23] We do though need more work to help those financially excluded to benefit from financial intermediation, see Chakravarty and Pal (2013).

or bank capital to understand the evolution of financial frictions.[24] In an emerging economy such as India, which is moving toward greater levels of financialization, the normative results in these models may help prevent the kind of enduring financial crisis being played out in the advanced world. Our results suggest that in the presence of substantive financial frictions, monetary policy makers have to pay attention to financial conditions as well as output and inflation when setting policy rates and also consider carefully the correct response to liquidity shortfalls and changes in velocity, when assessing the appropriate size of the central bank balance sheet and the mix of assets held by commercial banks.[25]

7 Appendix

7.1 First-Order Condition

7.1.1 Households and Banking Sector

$$c_t : \qquad \frac{\phi}{c_t} - \lambda_t - \mu_t = 0 \tag{45}$$

$$B_{t+1} : \qquad \frac{\mu_t}{\lambda_t}\Omega_t - 1 + \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} (1 + R_t^B) \right) = 0 \tag{46}$$

$$K_{t+1} : \qquad \frac{\mu_t}{\lambda_t} kA3_t q_t \Omega_t - q_t + \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{\xi_{t+1}}{\lambda_{t+1}} \eta \left(\frac{K_{t+1}}{A1_{t+1} n_{t+1}} \right)^{(\eta-1)} + \frac{\lambda_{t+1}}{\lambda_t} q_{t+1}(1-\delta) \right) = 0 \tag{47}$$

where $\frac{\mu_t}{\lambda_t} = \frac{\phi}{c_t \lambda_t} - 1$ measures households' marginal utility relative to shadow value of funds. $\Omega_t = \frac{\partial y_t}{\partial b_{t+1}} = \frac{\alpha y_t}{b_{t+1} + A3_t k q_t K_{t+1}}$ is marginal value of bonds as collateral.

$$I_t : \qquad -\lambda_t + \lambda_t q_t (1 - S(\frac{I_t}{I_{t-1}}) - S'(\frac{I_t}{I_{t-1}})\frac{I_t}{I_{t-1}}) + \beta \lambda_{t+1} q_{t+1} S'(\frac{I_{t+1}}{I_t}) \left(\frac{I_{t+1}}{I_t} \right)^2 - \mu_t = 0$$

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[24]See Caglar et al. (2011) for a summary and papers by Harrison (2011) as well as Gertler and Karadi (2011) for the baseline papers. Also see Kim and Aum (2011) for results on the Korean economy.

[25]The RBI published some of its views in 2015 in a roadmap report to which our paper can be thought to be complementary.

$$n_t^s, m_t^s : \qquad \frac{1-\phi}{1-n_t^s-m_t^s} = w_t\lambda_t \tag{48}$$

$$m_t : \qquad w_t = \frac{\mu_t}{\lambda_t}(1-\alpha)\frac{y_t}{m_t} \tag{49}$$

7.1.2 Firms (Wholesale Good Producing Firm and Retailer)

$$n_t : w_t = \frac{\xi_t}{\lambda_t}(1-\eta)\frac{y_t}{n_t} \tag{50}$$

$$mc_t = \frac{\epsilon-1}{\epsilon}\frac{\xi_t}{\lambda_t}$$

$$P_t^f : \sum_{s=0}^{\infty}\theta^s E_t\left[\Lambda_{t,s}Y_{t,t+s}\left(\frac{P_t^f}{P_{t-1}} - \mathrm{X}_\psi \mathrm{mc_t}\pi_{\mathrm{t-1,t+s}}\right)\right] = 0 \tag{51}$$

where P_t^f is forward-looking firms' optimal price (resetting price), $\Lambda_{t,s} = \beta^s\left(\frac{c_{t+s}}{c_t}\right)^{-1}\left(\frac{P_t}{P_{t+s}}\right)$ is the households' stochastic discount factor, $X_\psi = 1/mc$ is desired markup. mc_t is real marginal cost, $\pi_{t-1,t+s} = \frac{P_{t+s}}{P_{t-1}}$.

Aggregate price level is given by

$$P_t : \qquad P_t = \theta P_{t-1} + (1-\theta)\bar{P}_t^* \tag{52}$$

where $\bar{P}_t^*$ is an index of prices set in period t based on the forward-looking and backward-looking price setting behavior such that

$$\bar{P}_t^* = \omega P_t^b + (1-\omega)P_t^f \tag{53}$$

where P_t^b is the price set by the backward-looking rule of thumb ($P_t^b = \bar{P}_{t-1}^* + \pi_{t-1}$), P_t^f is the price set by forward-looking firms, and ω is the degree of backward-lookingness and $1-\omega$ is forward-lookingness.

Hybrid New Keynesian Philips Curve is given by

$$\widehat{\pi}_t = \kappa\widehat{mc}_t + \gamma_f E_t(\widehat{\pi}_{t+1}) + \gamma_b\widehat{\pi}_{t-1} + a5_t \tag{54}$$

7.2 Market Clearing

Resource Constraint

$$y_t = c_t + I_t \tag{55}$$

Financial Market (Deposits)

$$D_t^s = D_t^d = \frac{P_t y_t}{v_t} \tag{56}$$

Balanced Government Budget

$$T_t = g_t - tax_t = \frac{B_{t+1}}{P_t(1 + R_t^B)} - \frac{B_t}{P_t^A} - \frac{r_t}{P_t} R_t^{IB} \tag{57}$$

7.3 Steady States

For the productivity and monitoring shocks we assume a trend growth rate equal to $A2_t = A1_t = (1 + \varrho)^t$. In steady state $q = 1$, $A2 = A1 = (1 + \varrho)$, λ shrinks at rate ϱ so $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+\varrho}$. There is no inflation so $P = 1$ while capital grows at rate ϱ in steady state. We use the constant steady-state bonds to output ($boy = \frac{\mathrm{B}}{(1+R^B)y}$). That is, we assume that the fiscal authority's policy is set in order to stabilize boy_t at an exogenous policy-determined value.

7.3.1 The Core Steady States

The following 10 equations give the steady-state value for $y, c, I, K, m, n, w, \lambda, \mu, \Omega$:

$$y = c + I \tag{58}$$

$$1 = \frac{vF}{1 - rr}\left(boy + \frac{kK}{y}\right)^{\alpha}\left(\frac{m}{y}\right)^{1-\alpha} \tag{59}$$

$$\Omega = \frac{\alpha}{\left(boy + \frac{kK}{y}\right)} \tag{60}$$

$$\frac{1 - \phi}{1 - n - m} = w\lambda \tag{61}$$

$$w = \frac{\mu}{\lambda}\frac{(1-\alpha)y}{m} \tag{62}$$

$$w = \frac{\epsilon - 1}{\epsilon}(1-\eta)\left(\frac{K}{n(1+\varrho)}\right)^{\eta} \tag{63}$$

$$\frac{\mu}{\lambda}k\Omega - 1 + \beta\left[\frac{1-\delta}{1+\varrho} + \eta\frac{\epsilon - 1}{\epsilon}\left(\frac{K}{n(1+\varrho)}\right)^{\eta-1}\right] = 0 \tag{64}$$

$$\frac{1}{mc} = \left(\frac{K}{y(1+\varrho)}\right)^{\eta}\left(\frac{n}{y}\right)^{(1-\eta)} \tag{65}$$

$$I = \frac{\rho + \delta}{1+\varrho}K \tag{66}$$

$$\frac{\mu}{\lambda} = \frac{\phi}{c\lambda} - 1 \tag{67}$$

7.3.2 Other Variables

$$D = \frac{y}{v} \tag{68}$$

$$r = rrD = rr\frac{y}{v} \tag{69}$$

$$L = (1-rr)D = (1-rr)\frac{y}{v} \tag{70}$$

$$T = g - tax = b - b(1+R^B) - rR^{IB} \tag{71}$$

$$b = boy \times y \tag{72}$$

$$R^T - R^B = LSY^B = \Omega \tag{73}$$

$$LSY^K = k \times LSY^K \tag{74}$$

$$EFP = \frac{vmw}{(1-\alpha)(1-rr)y} = \frac{\mu}{\lambda}\frac{v}{(1-rr)} \tag{75}$$

$$CEFP = (1-\alpha) \times EFP = \frac{vmw}{(1-rr)y} = (1-\alpha)\frac{\mu}{\lambda}\frac{v}{(1-rr)} \tag{76}$$

$$\tau = R^L - R^{IB} \tag{77}$$

Accordingly spreads between interest rates can be written as follows:

$$R^T = \frac{1+\varrho}{\beta} - 1 \tag{78}$$

$$R = R^T - EFP \tag{79}$$

$$R^L = R^{IB} + CEFP \tag{80}$$

$$R^B = R^T - LSY^B \tag{81}$$

$$R^D = R(1-rr) \tag{82}$$

7.4 Log-linearization

Consumption

$$c_t = -c(\lambda\lambda_t + \mu\mu_t) \tag{83}$$

Supply of labor

$$w_t = \frac{n}{1-n-m}n_t + \frac{m}{1-n-m}m_t - \lambda_t \tag{84}$$

Demand for labor in the goods sector

$$w_t = mc_t + y_t - n_t \tag{85}$$

Demand for monitoring work

$$w_t = \mu_t - \lambda_t + y_t - m_t \tag{86}$$

Broad liquidity problem

$$y_t = v_t + rr_t + (1-\alpha)(a2_t + m_t) + \alpha\left(\frac{b}{boy+kK}b_{t+1} + \frac{kK}{boy+kK}(a3_t + q_t + K_{t+1})\right)$$

where $boy = \frac{B}{P(1+R^B)y}$ and $b_{t+1} = \frac{B_{t+1}}{P_t(1+R_t^B)} = boy_t + y_t$
Marginal value of bond as collateral

$$\Omega_t = \frac{kK}{boy + kK/y}(y_t - q_t - K_{t+1} - a3_t) + \frac{b}{boy + kK/y} b_{t+1} \tag{87}$$

Asset price

$$\begin{aligned}\left(1 - k\Omega\frac{\mu}{\lambda}\right) q_t =& \frac{\beta}{1+\varrho}\left(1 - \delta + \eta mc\left(\frac{K}{n(1+\varrho)}\right)^{\eta-1}\right)(E_t\lambda_{t+1} - \lambda_t) \\ &+ \frac{\beta}{1+\varrho}(1-\delta)E_t q_{t+1} + k\Omega\frac{\mu}{\lambda}(\mu_t - \lambda_t + \Omega_t + a3_t) \\ &+ \frac{\beta}{1+\varrho}\eta mc\left(\frac{K}{n(1+\varrho)}\right)^{\eta-1} E_t\left(mc_{t+1} + (1-\eta)(n_{t+1} + a1_{t+1})\right)\end{aligned}$$

Deposit-in-advance constraint (DIA)

$$P_t + y_t = D_t + v_t \tag{88}$$

production function

$$y_t = \eta K_t + (1-\eta)(a1_t + n_t) \tag{89}$$

Goods Market Clearing Condition

$$y_t = \frac{c}{y}c_t + \frac{I}{y}I_t \tag{90}$$

Law of Motion of Capital

$$K_{t+1} = \frac{1-\delta}{1+\varrho}K_t + \frac{\varrho+\delta}{1+\varrho}I_t \tag{91}$$

Investment

$$q_t = (1+\varrho)^2 s\left[(I_t - I_{t-1}) - \beta\left(E_t(I_{t+1}) - I_t\right)\right] + \frac{\mu}{\lambda}\mu_t \tag{92}$$

Inflation

$$\pi_t = p_t - p_{t-1} \tag{93}$$

Philips curve

$$\pi_t = \gamma_b\pi_{t-1} + \gamma_f E_t(\pi_{t+1}) + \kappa mc_t + a5_t \tag{94}$$

Government Budget Constraint

$$TT_t = b\left(b_{t+1} - b_t - R^B(b_t + R_t^B)\right) - rR^{IB}(r_t + R_t^{IB}) \tag{95}$$

Riskless Interest Rate (Benchmark Interest Rate)

$$R_t^T = \lambda_t - E_t(\lambda_{t+1}) + E_t(\pi_{t+1}) \tag{96}$$

Liquidity Service Yield (LSY_t)

$$R_t^T - R_t^B = \mu_t - \lambda_t + \Omega_t \tag{97}$$

External Finance Premium (EFP_t)

$$EFP_t = v_t + w_t + m_t - y_t + rr_t = \mu_t - \lambda_t + v_t + rr_t \tag{98}$$

Interbank Interest Rate (Policy Rate)

$$R_t^{IB} = R_t^T - EFP_t \tag{99}$$

Loan Interest Rate

$$R_t^L = R_t^{IB} + (C)EFP_t \tag{100}$$

Bond Interest Rate

$$R_t^B = R_t^T - LSY_t^B \tag{101}$$

Deposit Interest Rate

$$R_t^D = R_t^{IB} - \frac{rr}{1 - rr} rr_t \tag{102}$$

Monetary Policy Rule (Taylor Rule)

$$R_t = \rho R_{t-1} + (1 - \rho)(\phi_\pi \pi_t + \phi_y mc_t + \phi_f f_t) + a4_t \tag{103}$$

OMO Policy Rule (Fiscal Policy Rule)

$$boy_t = a6_t = \rho_{boy} boy_{t-1} + \epsilon_t^{boy} \tag{104}$$

Velocity

$$v_t = a7_t \tag{105}$$

Liquidity Preference

$$\tau_t = a8_t \tag{106}$$

Endogenous Reserves

$$r_t = \frac{1}{rR^T}\left(R^{IB}R_t^{IB} - R^L R_t^L + \tau\tau_t\right) \tag{107}$$

Loans

$$L_t = D_t - \frac{1}{1-rr}rr_t \tag{108}$$

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Indian Economy During the Era of Quantitative Easing: A Dynamic Stochastic General Equilibrium Perspective

Shesadri Banerjee and Parantap Basu

1 Introduction

The world economy went through major upheavals since the outbreak of the global financial crisis (2007–2009). Given the scale and depth of this crisis experienced in different parts of the world, unprecedented policy interventions were triggered by central banks of advanced countries led by the Federal Reserve. Due to severe liquidity shortages faced by the banks, Federal Reserve Board resorted to the unconventional measures to inject liquidity involving nontraditional asset purchases, widely known as Quantitative Easing (QE hereafter). These assets largely consisted of agency debt, mortgage-backed securities and Treasury securities. The end result of this operation was a sharp decline in short term policy rate in the US nearly hitting the zero lower bound.

QE was launched in the US in three phases. Following the collapse of Lehman Brothers in September 2008, in the first phase, large-scale asset purchases (LSAP) of agency debt, mortgage-backed securities, and Treasury securities were undertaken. The second phase, which started from October 2010, experienced massive purchases of Treasury securities. The third phase of QE that started from September 2011 involved sterilized acquisition of long-term bonds financed by selling some of its

This work is an extension of the NCAER project (working paper no 109) generously funded by the Think Tank Initiative of the Canadian International Development Research Center. Yong-dae Lee and Ajaya Sahoo are gratefully acknowledged for their competent and timely research assistance.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_17

short term bonds accompanied by LSAP.[1] The trend of QE was interrupted in May 2013 when the Fed signaled its intention to unwind its unconventional monetary policy. On May 22, 2013, Chairman Ben Bernanke first spoke of the possibility of the Fed tapering off its security purchases. Interesting? while QE in the US has ended, the European Central Bank has launched a new program of quantitative easing since January 22, 2015.

The impacts of QE on emerging market economies (EME) have become increasingly controversial and pivotal in the current policy debates. It is argued that QE sets off a global search for yield by investors and leads to mispricing of the domestic assets in EMEs (Mishra et al. 2014). An influential strand of literature views that phasing out of QE would be detrimental for EMEs and could lead to major economic downturn due to macroeconomic imbalances and weak financial sector (Basu et al. 2014; Eichengreen and Gupta 2014; Rajan 2014). Emerging economies are concerned about the negative spillover effects of QE on their capital flows, exchange rates, and asset prices. Raghuram Rajan, the governor of the Reserve Bank of India, argued that this phasing out may give rise to excess volatility in the global financial markets and could lead to harmful spillover effects (Rajan 2014). While it is generally accepted in literature that QE was effective in lowering long-term yield rates in the US and in stimulating economic activity (Lavigne et al. 2014), there is mixed evidence of its international spillover effects. A stream of empirical literature has emerged to investigate the spillover effects of QE using mostly the event study methodology (Basu et al. 2014; Mishra et al. 2014; Rai and Suchanek 2014), counterfactual experiments (Barroso et al. 2013), and atheoretical VAR and VECM approaches (Tillmann 2014). However, hardly any effort is being made in literature to model the effects of QE and its phasing out on EMEs using a Dynamic Stochastic General Equilibrium (DSGE) framework from an open economy perspective. Our paper, precisely, aims to do this in the context of the Indian economy.

In this paper, we set up a Small Open Economy (SOE) DSGE model to understand the effects of QE on an emerging market economy like India. The paper does not intend to draw details of the unwinding mechanism of QE as it is already addressed in existing literature. Instead, it conceptualizes QE impulse in the form of a temporary negative shock to short term foreign policy rate consistent with the stationarity property of a standard SOE-DSGE model. The tapering out phase of QE is formulated by a mean reverting process for the foreign interest rate. The pass-through effect of QE shock sets in to the domestic economy via the linkage between external and

[1]By the end of phase 1 of QE, the Fed had injected $2.1 trillion into the US economy. During November 2010, Fed started the second round with a purchase of $600 billion worth of Treasury securities along with an added investment of $250–300 billion in treasuries from the profits of previous investments. In phase 3, the initial budget was $40 billion/month, which was raised to $85 billion by December 2012. *Source* www.macroeconomicanalysis.com.

internal terms of trade. The consequent reallocation of inter-sectoral resources finally translates into the dynamics of output and inflation. To the best of our knowledge, none of the extant DSGE applications to the Indian macroeconomy have studied the implications of QE through this terms of trade transmission channel described in our model.

Our model builds on Basu and Thoenissen (2011) where the home country is linked to the rest of the world through tradeable intermediate goods. The model has standard frictions of a typical small open economy like India which include: (i) aggregate habit persistence as in Abel (1990), (ii) investment adjustment cost as in Christiano et al. (2005), (iii) home bias in consumption and investment as in Baekus et al. (1994), (iv) imperfect capital mobility in terms of transaction cost of foreign asset holding as in Benigno (2009), (v) nominal frictions in terms of staggered price setting as in Calvo (1983), and (vi) financial frictions in terms of the existence of "rule-of-thumb" consumers. Monetary policy is modeled by the forward looking inflation targeting Taylor rule. We incorporate both domestic and foreign policy shocks in our model. The former includes fiscal and monetary policy shocks. Foreign interest rate shock is the only external shock in our model perceived as a QE shock which is the central focus of the paper.

A bulk of the literature on QE has explored and examined new channels through which it can impact the macroeconomic variables, such as portfolio rebalancing (Butt et al. 2014; Joyce et al. 2014), macroprudential linkages with banking frictions (Gertler and Karadi 2011), asset price channel (Ranaldo and Rossi 2010; Fratzscher et al. 2013), market segmentation (Gagnon et al. 2011), liquidity channel (Christensen and Gillan (2013)), signaling channel (Bauer and Rudebusch 2014), and others. In contrast to this newly growing literature, our model relies on the traditional channel of the uncovered interest parity (UIP) condition for transmission of a QE shock. The UIP assumption is motivated by the stylized facts reported in Sect. 2. The quarterly data (2004–2005:Q4 to 2014–2015:Q2) reveal statistically significant correlation between interest rate differential (between RBI Repo rate and Federal Fund's rate) and home currency depreciation for both raw data and data filtered for the business cycle component. This comovement has intensified during the QE episodes (2009–2010:Q1 to 2013–2014:Q2). Further, the behavior of external terms of trade in India during the QE period motivates us to model the linkage between UIP and external terms of trade and investigate the traditional UIP channel to study the pass-through effects of the US interest rate shock following QE.[2]

Propagation mechanism of QE shock works as follows. A lower foreign interest rate makes the home currency depreciate via uncovered interest parity condition. Since the home country sets its export price in foreign currency due to the wide-

[2]One may still debate about the validity of UIP condition in the context of India due to the prevalence of currency and capital controls. However, these controls already started loosening with the advent of financial reforms in India. Given that the focus of our paper is on QE and post-QE era when financial and currency reforms are in full swing in India, UIP is a reasonable approximation which is further reinforced by the data support that we provide in the paper.

spread use of pricing-to-market, home intermediate goods producers experience an increase in its cash flow and find it profitable to supply more exportables in the international market. This increase in intermediate goods production drives up the real marginal cost. Since the home intermediate goods producers use a staggered pricing rule, this rise in marginal cost translates into a higher relative price of home-produced intermediate goods with respect to CPI. This immediately results in a lower terms of trade via the composite CPI which is a weighted average of prices of home and foreign-produced intermediate goods. This favorable tilt in terms of trade lowers our net export. A higher real marginal cost drives up the real wage and rental price of capital which promote labor supply and investment. It also heightens domestic inflation to which the home central bank responds positively by raising the interest rate via a Taylor rule. Home interest rate thus moves in the opposite direction of foreign rate which is a pattern consistent with the stylized facts presented in the next section.

We also analyze the macroeconomic effects of a taper talk of QE. The QE taper is modeled as a "news" effect of a future rise in foreign interest rate. Such a "news" is perceived by the market as a future appreciation of the home currency which lowers the expected relative price of exportable because the price of exportable is set in foreign currency. This encourages the home producers initially cut back export giving rise to a large drop in net export. As home producers lower the production of exportable, it drives down the real marginal cost which feeds into a deflationary spell via the home price setting function. The central bank cuts interest rate to respond to low inflation which makes the home currency appreciation materialize. The terms of trade first declines and then rises as the QE taper materializes reflecting the observed pattern.

The impulse responses of a QE shock and also a news shock of QE tapering based on our stylized DSGE model are broadly consistent with the key macroeconomic developments in India during the QE period: GDP rises, inflation gathers momentum and in response to this, the central bank raises the interest rate while foreign policy rate hits the zero lower bound. Due to a favorable terms of trade effect, the current account deteriorates which means net capital outflow. Then a subsequent taper talk of QE reverses the courses of the terms of trade, inflation, and the net export.

On the domestic fiscal front, deficit to GDP ratio rose broadly during the time when QE taper talk started. Using our model-based impulse responses, we also investigate how a positive fiscal deficit shock impacts the economy. The impulse response analysis reveals that a positive fiscal spending shock boosts home policy rate and makes the home currency depreciate. These two effects are rather similar to the effect of a negative foreign interest rate shock. In contrast, GDP drops in response to such a fiscal shock which reflects the negative effect of terms of trade on export demand.

This chapter is organized as follows. In Sect. 2, we present the backdrop of domestic macroeconomic conditions during QE and its adjacent periods in India for contextualization of our DSGE model. We lay out the model in Sect. 3. Section 4 reports the model simulation results. Section 5 concludes.

2 India During the Era of Quantitative Easing

In this section, we provide an overview of the quantitative and qualitative features of some major macroeconomic variables of India during the period of unconventional monetary policies followed by the US federal reserve. We take a balanced sample spanning over the period of 2004–2005:Q4 to 2014–2015:Q2 and split the same into three subperiods to inspect behavioral patterns of the relevant variables. The subperiods are as follows: pre-QE period (2004–2005:Q4 to 2008–2009:Q4), QE episode (2009–2010:Q1 to 2013–2014:Q2), and post-QE episode (2013–2014:Q3 to 2014–2015:Q2).[3] The choice of subperiods is consistent with Park et al. (2014). The time paths of year on year (y-o-y %) growth rates of macroeconomic variables are plotted in Panel A (Chart 1–4) and Panel B (Chart 5–8). The QE phase is highlighted in each chart of each panel. The average growth rates of key variables are documented in Table 1.[4]

2.1 A Sketch of Domestic Macroeconomic Scenario

2.1.1 Macroeconomic Landscape During Pre-QE and QE Periods

Prior to the global financial crisis, Indian economy was going through a moderately stable period of high growth in GDP, private consumption and investment with gradually rising trend of inflation (Charts 1 and 2 in Panel A). The growth environment was well complemented by financial sector reforming measures, rule-based fiscal policy and forward looking monetary policy. Policy rates of India and the US were showing comovements (Chart 3 in Panel A) and their differential was low. The Indian Rupee (INR) appreciated in value accompanied by a rise in foreign exchange reserve (Chart 4 in Panel A and Chart 7 in Panel B). Although, current account deficit and gross fiscal deficit to GDP ratio were undergoing some fluctuations, external debt to GDP ratio was rising in a relatively stable manner.

With the onset of the financial crisis, there was a rapid reversal of trends of several of these macroeconomic aggregates. Initially, India was insulated to the global crisis due to its limited exposure to illiquid securitized assets. However, the deceleration in growth, consumption and investment started to set in from 2009:Q2 onwards

[3]Note that we refer the years as the fiscal years in India. A fiscal year starts from the month of April of a particular year to the end of March of the forthcoming year. So, when we mention our sample period as 2004–2005:Q4 to 2014–2015:Q2, it implies that the observations are taken from January 2005 to September 2014.

[4]Data sources of the respective macroeconomic variables are provided in Data Appendix. All series are available at a quarterly frequency. Nominal series were converted to real using the GDP deflator with 2004–2005 as the base year.

(Chart 1 and Chart 2 in Panel A). It is argued that the economy was affected significantly through real, financial, and confidence channels, and the economic downturn was triggered from contagion effect of the crisis due to greater degree of trade and financial integration of domestic economy with the external sector.[5]

As the crisis unfolded, the US Federal Reserve and other major central banks deployed unconventional monetary policy measures to provide monetary accommodation. The process was set off with the US quantitative easing. The RBI also adopted various conventional and unconventional measures to protect the domestic economy from contagion and spillover of such balance sheet policy of the central banks of advanced countries which included augmenting domestic and foreign exchange liquidity. The Government of India also supported the economy by intermittent fiscal stimulus packages, as shown by spikes in fiscal deficit to GDP ratio (Chart 6 in Panel B), reversing the earlier efforts of fiscal consolidation. The domestic economy showed signs of slow recovery from late 2011 while inflation started calming down.

2.1.2 Comparing Movements of Policy Rates in India and US

An intriguing feature of the policy rate movement is that during QE episode RBI Repo rate sharply drifted away from US Federal Funds rate while the rates in other emerging countries primarily followed the lead of US Federal Funds rate (Basu et al. 2015). The reason for this going-against-the-wind behavior of the Indian Repo rate is the rising concern of RBI for inflation. In the process of recovery, inflation also picked up and was aggravated by a spurt in global commodity prices (particularly oil price). As a result, the Reserve Bank had to shift its policy focus from accommodative to tight monetary policy which is evident from the sharp rise in policy rate since 2010. Parallel to this, fiscal policy was also tightened as evident from the spike in deficit to GDP ratio in 2010. From the mid of 2011–2012 to the end of 2012–2013, the economy suffered several supply side shocks which include food and global commodity prices, infrastructure bottlenecks, input costs for industrial production which slowed down output growth and made inflation soar.[6] On the external front, current account deficit (CAD) widened and the Indian rupee sharply depreciated. The widening differential between India and the US short term policy interest rates was also followed by a rise of terms of trade,[7] fiscal deficit to GDP ratio with some fluctuations, external debt to GDP ratio, volatility of foreign direct and portfolio investments.

[5]See the RBI Speeches given by Subbarao 2009 and Mohanty 2013.

[6]*Source* https://www.rbi.org.in/scripts/AnnualReportPublications.aspx?Id=1039.

[7]The terms of trade is measured as the ratio of unit value of importable to unit value of exportable.

Panel: A

Chart:1

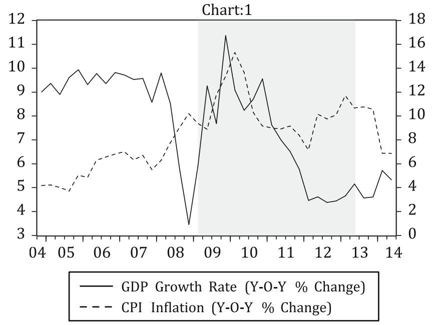


Chart:2

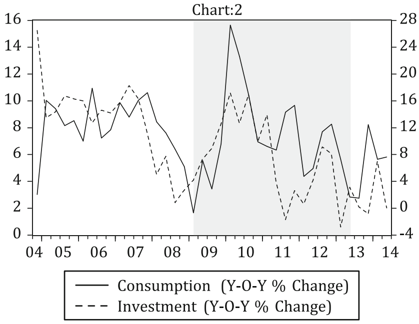


Chart:3

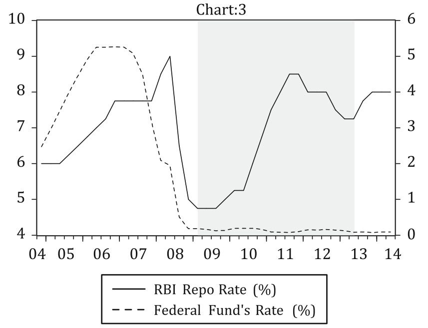
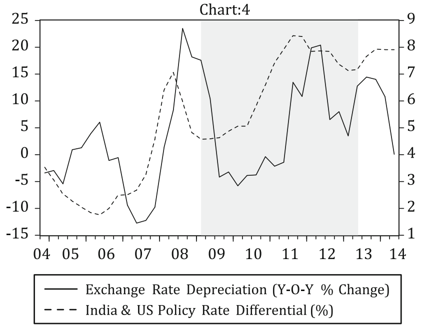


Chart:4



Panel: B

Chart:5

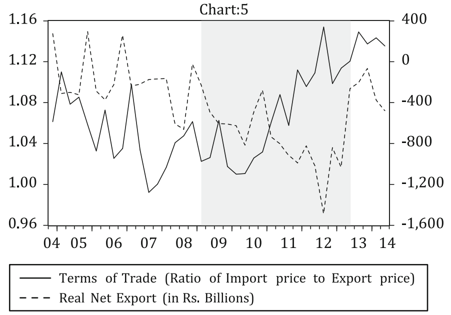


Chart:6

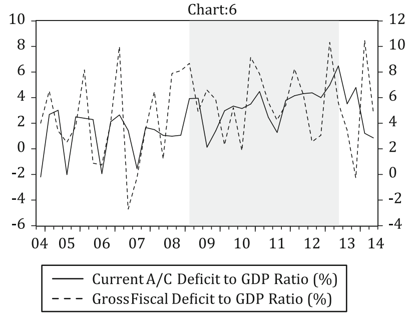


Chart:7

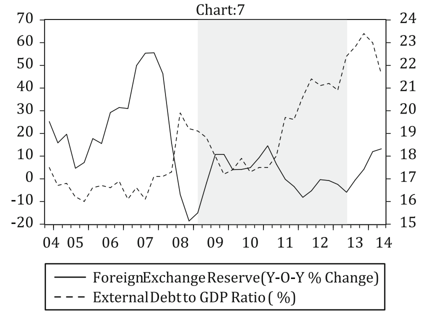
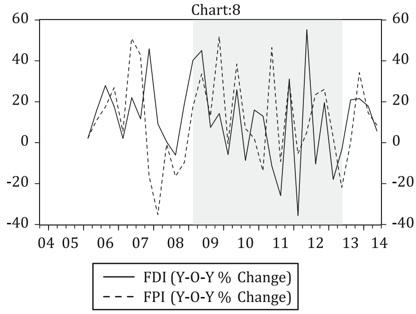


Chart:8



2.1.3 Post-QE Episode: Taper Tantrum and Policy Response of RBI

It is not clear how the tapering of Fed's asset purchases affected the Indian economy. Although the Fed Chairman made this tapering quite explicit during the second quarter of 2013, financial markets anticipated the phasing out of QE longtime before. Around this period, as pointed by Khan (February 2015) in his speech, foreign investors were concerned about the high current account deficit, moderation in growth, high fiscal deficit, high inflation and policy uncertainty in India. There was tightening of liquidity and higher volatility in all market segments along with a sharp decline in stock prices. For example, during the period between May 22, 2013 and August 30, 2013, the Indian Rupee depreciated by 15.5 % against the US Dollar, 14.1 % against Brazilian Real and 6.9 % against South African Rand. Portfolio capital inflows which were buoyant till the third week of May 2013 began retreating as US yield rose and yield spread trimmed down considerably.

In order to control the taper tantrum, the Reserve Bank of India intervened to curb excessive volatility in foreign exchange market and resorted to a mix of policy measures including foreign exchange market intervention, monetary tightening through reduction in banks' access to overnight Liquidity Adjustment Facility (LAF), increase in Marginal Standing Facility (MSF) rate and increase in daily minimum Cash Reserve Ratio (CRR) maintenance requirements. In addition, other policy measures were also adopted such as gold import restrictions, special dollar swap window for PSU oil companies, special concessional swap window for attracting FCNR deposits, increase in overseas borrowing limit of banks, disallowing banks from carrying proprietary trading in currency futures/exchange traded options. Further, foreign indirect investment limit in government debt was enhanced by 5 billion US dollar to 30 billion US dollar in June 2013 to attract greater inflows. Banks mobilized about 34 billion US dollar under FCNR scheme and Offshore Foreign Currency Borrowings for augmenting the foreign exchange reserves of the country. To ease pressures on rising CAD and to discourage import of gold, quantitative as well as other restrictions were placed on gold imports in consultation with the Government of India. Additionally, to encourage longer term foreign currency inflows, the external commercial borrowing mechanism was liberalized. Limits on foreign direct investments in some sectors were relaxed.[8]

2.1.4 Quantitative Features of Key Macroeconomic Aggregates

Table 1 summarizes the quantitative features of a few key macroeconomic aggregates for three subperiods. It is noteworthy from the table that on the real front, except for investment which showed a sharp decline, the Indian economy did not show any major departure from its baseline trend during the QE period. Economic growth decelerated a marginally (a decline of 2 %) and then settled down at 5 % growth rate while private consumption became a bit sloth. On the other hand, fluctuations of

[8]Source RBI Speeches–https://www.rbi.org.in/Scripts/BS_ViewSpeeches.aspx.

Table 1 Average growth rates of key macroeconomic variables

Variables	Pre-QE period	QE period	Post-QE period
GDP	8.8	6.9	5.1
Consumption	8.2	7.2	5.6
Investment	13.1	7.3	1.6
CPI Inflation	6.1	10.4	8.8
Exchange rate depreciation	0.4	5.5	9.8
Repo rate	1.0	1.4	0.13
CAD to GDP Ratio	1.3	3.6	1.2

nominal variables are noteworthy. Inflation rate rose to double digit level during the QE era although it came down a bit during the post-QE era. The rupee value also showed remarkable decline, on an average, by 5.5 % and nearly by 10 % during QE and in the post-QE era, respectively. The current account deteriorated but returned to normalcy during the post-QE period.

2.2 *Empirical Support of Uncovered Interest Rate Parity Condition*

In a world with no cross border restrictions on capital movement, a basic arbitrage condition is the uncovered interest parity condition (UIP). A higher home nominal interest rate triggers capital inflow in search for yield which will be quickly eliminated by an offsetting depreciation of the home currency. The UIP condition is criticized in the literature due to its empirical failure (Isard 2006). In the context of India, UIP condition remarkably holds up during the QE period. Figure 1 plots Indian and US policy rate differential and the rate of depreciation of home currency for the business cycle component. Table 2 presents the correlation between interest rate differential and expected rate of depreciation of the home currency for raw data as well as for band-pass filtered data at the business cycle frequency.[9] The correlation is robustly positive and stronger after 2007.

Table 3 presents gross capital inflow during the post-QE periods. Both foreign direct and portfolio investments (FDI and FPI) steadily increased in India over the years despite recurrent year-to-year fluctuations as seen in Panel B, Chart 8. Thus, notwithstanding its empirical limitations, UIP is a reasonable baseline approxima-

[9]We attempt to obtain maximum possible number of observations in a balanced sample for all the variables (i.e., for RBI repo rate, Federal Fund's rate, and nominal exchange rate) and it is possible to trace back up to second quarter of 2000–2001. The business cycle component is extracted from policy rate differential and exchange rate depreciation using Christiano–Fitzgerald asymmetric filter for the periodicity between 6 to 32 quarters. The statistical significance of correlation coefficients are assigned by '*' for 10 %, '**' for 5 % and '***' for 1 % level.

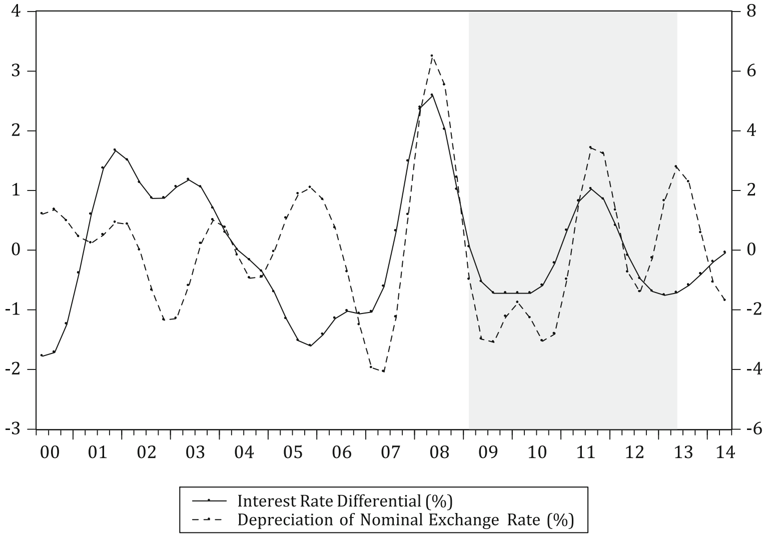


Fig. 1 Interest rate differential and exchange rate depreciation over business cycle

Table 2 Correlation between interest rate differential and exchange rate depreciation

Case	2000–'01:Q2 to 2014–'15:Q2	2009–'10:Q1 to 2013–'14:Q2	2009–'10:Q2 to 2013–'14:Q3
Raw data	0.32**	0.48**	0.44*
Business cycle component	0.38***	0.48**	0.52**

Table 3 Gross capital flow as percentage of GDP

Years	FDI	FPI
2005–'06	33.3	29.5
2007–'08	54.1	34.0
2009–'10	69.7	35.2
2011–'12	72.7	38.9
2013–'14	77.9	42.4

tion of interest rate and exchange rate movements for the Indian economy following the impact effect of a shock. The case for UIP is particularly strong during the QE period when India went through increasing financial openness as seen by FDI and FPI inflows.

With these stylized facts of the Indian economy during the pre-QE, QE, and post-QE era as a broad guideline, we develop a small open economy DSGE model in the next section. The aim of our modeling is not to replicate all the empirical regularities reported here although the model predicts some of the key impact effects of the QE shocks.

3 The Model

The model environment is in line with Basu and Thoenissen (2011) and Banerjee and Basu (2014, 2015), and features the framework of a small open economy with incomplete financial markets. Each country produces one tradable intermediate good which is used in the home and foreign consumption as well as investment goods basket. The specifications of consumption and investment goods are similar to Baekus et al. (1994), Heathcote and Perri (2002), Thoenissen (2011), Basu and Thoenissen (2011). In the modeling framework, we incorporate various frictions and shocks, as proposed in Kollmann (2002), Smets and Wouters (2003), and Christiano et al. (2005), to address the business cycle characteristics of a developing economy like India. Frictions are considered in the form of external habit formation in consumption, investment adjustment costs, transaction costs of foreign bond holding, and staggered price setting of intermediate goods producing firms. Aggregate dynamics of the model are driven by five shocks, such as, total factor productivity (TFP), investment specific technology (IST), monetary and fiscal policy shocks, and foreign interest rate shocks. Given the objective of this chapter, our focus is on the transmission of foreign interest rate shock to home economy.

3.1 Description of the Model Economy

The representative household owns the physical capital stock, rents capital to the intermediate goods firms, and supplies labor. The household enters into a period t with its proceeds from wage income, rental income, profit from the ownership of firms, and interest income from domestic and foreign bond holding. The household disburses its income at date t for final consumption goods, investment in physical capital, and purchase of new bonds (domestic as well as foreign).

Firms are structured into two layers, one is final goods producing firm and the other is intermediate goods producing firm. Final goods firms produce two types of goods, namely, consumption goods and investment goods which are not internationally traded. In contrast, intermediate goods firms produce tradeable goods which are used for processing final consumption and investment goods. These intermediate goods firms produce differentiated variety of goods. As a result, each such producer wields some monopoly power of price setting. The nexus of final and intermediate goods producing firms is motivated by Kollmann (2002) and Basu and Thoenissen (2011).

The government finances an exogenous stream of fiscal spending of final goods by a combination of lump-sum taxes and domestic borrowing. The monetary authority follows a forward looking interest rate rule to respond to inflation and business cycle conditions.

3.2 Representative Household

The home economy consists of a continuum of agents over the unit interval. A fraction λ of consumers (with suffix 1) are forward looking and the remaining $(1-\lambda)$ are rule-of-thumb consumers (with suffix 2). Forward looking consumers maximize the following present value of its lifetime expected utility subject to standard flow budget constraints.

$$E_0 \sum_{t=0}^{\infty} \beta^t V[(C_t^1 - \gamma_c C_{t-1}), L_t^1)], \tag{1}$$

where E_0 = the conditional expectation at date t, β = preference-based discount factor, with $0 < \beta < 1$. Aggregate habit formation means that the consumer derives utility from current consumption, C_t after adjusting for the previous period's aggregate level of consumption, C_{t-1} and suffers disutility from supplying labor, L_t. The instantaneous utility function is additively separable in consumption and labor and is given by:

$$V(.) = \left[\frac{1}{1-\sigma_c}\left(C_t^1 - \gamma_c C_{t-1}\right)^{1-\sigma_c} - \frac{1}{1+\sigma_l}\left(L_t^1\right)^{1+\sigma_l}\right], \tag{2}$$

where σ_c is the inverse of the elasticity of substitution in consumption and σ_l is the reciprocal of the Frisch labor supply elasticity.

Residents of the home country trade two nominal riskless bonds of one period maturity denominated in the domestic and foreign currency, respectively. In both countries, residents issue these bonds to finance their consumption expenditures. Following Benigno (2009), we assume that home bonds are only traded nationally but foreign residents can allocate their wealth in foreign bonds denominated in the foreign currency. This asymmetry in the financial market structure allows us to include the feature of capital control faced by a developing country like India. Since only one riskless foreign currency denominated bond is traded internationally, the international financial market is incomplete. Further, the home households face a transaction cost when they take a position in the foreign bond market. This cost depends on the net foreign asset position of the home economy as in Benigno (2009).

The forward looking household accumulates capital by purchasing investment goods (X_t) at a price $P_{x,t}$ using the investment technology:

$$K_{t+1} = (1-\delta)K_t + [1 - S(X_t/X_{t-1})]X_t, \tag{3}$$

where δ = the rate of depreciation of the capital stock and $S(.)$ captures investment adjustment costs as proposed by Christiano et al. (2005). We assume that $S(1) = S'(1) = 0$ and $S''(1) = \varkappa > 0$. The implication is that adjustment cost disappears in the long run.

The representative home resident thus faces the following flow budget constraint:

$$P_t C_t^1 + P_{x,t} X_t + \frac{B_{H,t}}{\left(1 + i_t\right)} + \frac{\xi_t B_{F,t}}{\left(1 + i_t^*\right) \Theta\left(\frac{\xi_t B_{Ft}}{P_t}\right)} = W_t L_t + R_{k,t} K_t + B_{H,t-1} + \xi_t B_{F,t-1} + \Omega_t^d - T_t, \tag{4}$$

where P_t = consumer price level, W_t = nominal wage, $B_{H,t}$, and $B_{F,t}$ are the individual's holdings of domestic and foreign nominal riskless bonds denominated in the local currency, i_t = the home country nominal interest rate, i_t^* = foreign country nominal interest rate, and ξ_t = nominal exchange rate expressed as the price of one unit of foreign currency in terms of home currency. The household supplies labor and rents capital to the domestic intermediate goods firms and receives wage and rental income as, $W_t L_t$ and $R_{k,t} K_t$, respectively. The term, $\Omega_t^{d,j}$ is the profit income of the household from the domestic intermediate goods firms. Since home agents own all domestic intermediate firms, the equity holding within these firms is evenly distributed among domestic agents. Positive profit arises from the ownership of monopolistic intermediate goods firms only while competitive retail firms earn zero supernormal profits.

The cost function $\Theta(.)$ drives a wedge between the returns on home and foreign bonds. This implies that the home country borrows from the foreign country at a premium while lends at a discount. As in Benigno (2009), the spread between borrowing and lending rates depends on the net foreign asset position of the home economy. Profits from this activity in the foreign asset market are distributed equally among foreign residents. In the steady state this spread is zero. The cost function $\Theta(.)$ is unity only when the net foreign asset position is at its steady-state level, i.e., $B_{F,t} = \overline{B}$ while it is a differentiable decreasing function in the neighborhood of $\overline{B}$.

Household's first order conditions are:

$$C_t^1 : (C_t^1 - \gamma_c C_{t-1})^{-\sigma_c} - \lambda_t P_t = 0 \tag{5}$$

$$L_t^1 : -L_t^{1\sigma_L} + \lambda_t P_t (W_t / P_t) = 0 \tag{6}$$

$$K_{t+1} : -\mu_t + E_t \mu_{t+1}(1 - \delta) + E_t \lambda_{t+1} P_{t+1}(R_{kt+1}/P_{t+1}) = 0 \tag{7}$$

$$\begin{aligned} X_t : \mu_t &\left[(1 - s(X_t/X_{t-1})) - s'(X_t/X_{t-1})(X_t/X_{t-1})\right] \\ &+ E_t \mu_{t+1} s'(X_{t+1}/X_t)(X_{t+1}/X_t)^2 - \lambda_t P_t (P_{x,t}/P_t) = 0 \end{aligned} \tag{8}$$

$$B_{H,t+1} : -\lambda_t . \frac{1}{1 + i_t} + E_t \lambda_{t+1} = 0 \tag{9}$$

$$B_{F,t+1} : \frac{-\xi_t \lambda_t}{\left(1 + i_t^*\right) \Theta\left(\frac{\xi_t B_{F,t}^j}{P_t}\right)} + E_t \xi_{t+1} \lambda_{t+1} = 0, \tag{10}$$

where λ_t and μ_t are the corresponding Lagarange multipliers for the nominal flow budget constraint (4) and the capital accumulation technology (3), respectively.

The marginal Tobin's Q (the opportunity cost of investment in terms of foregoing consumption), is: $q_t = \mu_t / P_t \lambda_t$, and the Euler equation (8) can be rewritten as:

$$q_t \left[(1 - s(X_t/X_{t-1})) - s'(X_t/X_{t-1})(X_t/X_{t-1})\right] + E_t q_{t+1} s'(X_{t+1}/X_t)(X_{t+1}/X_t)^2 m_{t+1} = P_{xt}/P_t, \tag{11}$$

where m_{t+1} is the stochastic discount factor equal to $\beta(C_{t+1}^1 - \gamma_c C_t)^{-\sigma_c}/(C_t^1 - \gamma_c C_{t-1})^{-\sigma_c}$ and Eq. (7) can be written as:

$$q_t = E_t q_{t+1}(1 - \delta) m_{t+1} + E_t m_{t+1}(R_{kt+1}/P_{t+1}) \tag{12}$$

We assume that all individuals belonging to the same country have the same level of initial wealth. This assumption, together with the fact that all individuals face the same labor demand and own an equal share of all firms, imply that within the same country all individuals face the same budget constraint. Thus, they choose identical paths for consumption.

3.3 Rule-of-Thumb Consumers

As in Gali et al. (2005), we bring limited asset market participation by introducing a fraction $(1 - \lambda)$ of rule-of-thumb households who do not have any access to asset markets and thus are not forward looking. Their first order condition only satisfies the static efficiency condition as follows:

$$L_t^{2\sigma_L} = (C_t^2 - \gamma_c C_{t-1})^{-\sigma_c} (W_t/P_t) \tag{13}$$

They also consume their current income and do not save or invest. In other words,

$$C_t^2 = \frac{W_t}{P_t} . L_t^2 \tag{14}$$

The aggregate consumption demand is given by

$$C_t = \lambda C_t^1 + (1 - \lambda) C_t^2 \tag{15}$$

The aggregate labor supply is given by

$$L_t = \lambda L_t^1 + (1 - \lambda) L_t^2 \tag{16}$$

3.4 *Final Goods Producing Firms*

3.4.1 Consumption Goods Sector

Competitive distributors bundle up home and foreign intermediate consumption goods ($C_{H,t}$ and $C_{F,t}$) to deliver final consumption goods (C_t) to the household. They use the following CES technology for packaging these two goods.

$$C_t = \left[v^{\frac{1}{\theta}} C_{H,t}^{\frac{\theta-1}{\theta}} + (1 - v)^{\frac{1}{\theta}} C_{F,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{17}$$

where θ = the elasticity of intra-temporal elasticity of substitution between home and foreign-produced consumption goods and v = the home bias in consumption.

Home and foreign consumption goods are made up of a continuum of intermediate goods in the unit interval based on the following CES technology:

$$C_{H,t} = \left[\int_0^1 C_{H,t}^{\frac{\varepsilon-1}{\varepsilon}}(i) di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{18}$$

$$C_{F,t} = \left[\int_0^1 C_{F,t}^{\frac{\varepsilon-1}{\varepsilon}}(i) di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{19}$$

The following input demand functions for the home economy stem from the final consumption goods producers[10]:

$$C_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\varepsilon} v \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} C_t$$

$$C_{F,t}(i) = \left(\frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\varepsilon} (1 - v) \left(\frac{P_{F,t}}{P_t} \right)^{-\theta} C_t \tag{20}$$

Corresponding to the previous demand functions, the consumer price index (CPI) is defined as

$$P_t = [v P_{H,t}^{1-\theta} + (1 - v) P_{F,t}^{1-\theta}]^{1/(1-\theta)} \tag{21}$$

[10] Similar conditions hold for foreign producers.

while

$$P_{H,t} = \left[\int_0^1 P_{H,t}^{1-\varepsilon}(i)di \right]^{\frac{1}{1-\varepsilon}} \tag{22}$$

and

$$P_{F,t} = \left[\int_0^1 P_{F,t}^{1-\varepsilon}(i)di \right]^{\frac{1}{1-\varepsilon}} \tag{23}$$

$P_{H,t}$ and $P_{F,t}$ are determined by the price setting behavior of the domestic and foreign intermediate goods firms specified later.

3.4.2 Investment Goods Sector

In an analogous manner, final investment goods (X_t) are produced by packaging home and foreign-produced intermediate goods ($X_{H,t}$ and $X_{F,t}$):

$$X_t = Z_{x,t} \left[\varphi^{\frac{1}{\tau}} X_{H,t}^{\frac{\tau-1}{\tau}} + (1-\varphi)^{\frac{1}{\tau}} X_{F,t}^{\frac{\tau-1}{\tau}} \right]^{\frac{\tau}{\tau-1}}, \tag{24}$$

where φ = home bias in investment and τ = elasticity of substitution between home and foreign intermediate inputs, $Z_{x,t}$ = investment specific technology shock (IST) that appears in the investment goods production function as a total factor productivity (TFP) term as in Basu and Thoenissen (2011).

$$X_{H,t} = \left[\int_0^1 X_{H,t}^{\frac{\varepsilon-1}{\varepsilon}}(i)di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{25}$$

$$X_{F,t} = \left[\int_0^1 X_{F,t}^{\frac{\varepsilon-1}{\varepsilon}}(i)di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{26}$$

Cost minimization by these investment goods firms give rise to the following input demand functions:

$$X_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\varepsilon} \varphi \left(\frac{P_{H,t}}{P_{x,t}} \right)^{-\tau} X_t \tag{27}$$

$$X_{F,t}(i) = \left(\frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\varepsilon} (1-\varphi) \left(\frac{P_{F,t}}{P_{x,t}} \right)^{-\tau} X_t \tag{28}$$

where the investment goods price index (or the producer price index, PPI) is given by:

$$P_{x,t} = \left[\varphi P_{H,t}^{1-\tau} + (1-\varphi)P_{F,t}^{1-\tau}\right]^{1/(1-\tau)} \tag{29}$$

The PPI is a function of the home and foreign-produced intermediate goods prices. Due to different substitution elasticities and different degrees of consumption and investment home biases, it differs from the CPI.

3.4.3 Completing the Price Nexus

Based on (21) and (29), the price indices for consumption and investment goods are given by

$$P_t = P_{H,t}\left[\nu + (1-\nu)(P_{F,t}/P_{H,t})^{1-\theta}\right]^{1/(1-\theta)} \tag{30}$$

$$P_{x,t} = P_{H,t}\left[\varphi + (1-\varphi)(P_{F,t}/P_{H,t})^{1-\tau}\right]^{1/(1-\tau)}(1/Z_{x,t})$$

Thus, the relative price of investment (i.e., PPI/CPI) or the internal terms of trade is:

$$\frac{P_{x,t}}{P_t} = \frac{\left[\varphi + (1-\varphi)(P_{F,t}/P_{H,t})^{1-\tau}\right]^{1/(1-\tau)}}{\left[\nu + (1-\nu)(P_{F,t}/P_{H,t})^{1-\theta}\right]^{1/(1-\theta)}} \cdot \frac{1}{Z_{xt}} \tag{31}$$

The external terms of trade $P_{F,t}/P_{H,t}$ can create a wedge between the internal terms of trade $(P_{x,t}/P_t)$ and the IST shock, $Z_{x,t}$ as in Basu and Thoenissen (2011).

3.5 *Intermediate Goods Producing Firms*

Home intermediate goods firms produce tradable intermediate goods by renting capital and hiring labor from home households using the following constant returns to scale production function (Kollmann 2002):

$$Y_t(i) = A_t K_t(i)^{\alpha} L_t(i)^{1-\alpha}, \tag{32}$$

where A_t = the total factor productivity (TFP). The cost minimization implies

$$\frac{K_t(i)}{L_t(i)} = (1-\alpha)\alpha^{-1}\frac{W_t}{R_{k,t}}, \tag{33}$$

where W_t and $R_{k,t}$ are the nominal wage and nominal rental price plus depreciation cost. The nominal marginal cost is:

$$MC_t = \frac{1}{A_t} R_{k,t}^{\alpha} W_t^{1-\alpha} \alpha^{-\alpha} (1-\alpha)^{\alpha-1} \tag{34}$$

The real marginal cost (denoted as mc_t) looks symmetric as in (34) and can be written as:

$$mc_t = \frac{1}{A_t} r_{k,t}^{\alpha} w_t^{1-\alpha} \alpha^{-\alpha} (1-\alpha)^{\alpha-1}, \tag{35}$$

where $r_{k,t}$ and w_t are real rental price and real wage.

3.6 Home and Foreign Demands

The aggregate home and foreign demands for home tradable intermediate goods are given by

$$Y_{H,t} = C_{H,t} + X_{H,t} \tag{36}$$

$$Y_{H,t}^{*} = C_{H,t}^{*} + X_{H,t}^{*} \tag{37}$$

Using (18), (27), (36) and integrating across all firms (ignoring the price dispersion term in a first order approximation), the aggregate home demand for intermediate goods can be written more compactly as

$$Y_{H,t} = \nu \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} C_t + \varphi \left(\frac{P_{H,t}}{P_{x,t}} \right)^{-\tau} X_t$$

Based on the assumption that the home country charges the price of its exportable in terms of foreign currency after indexing it for foreign inflation, we get the aggregate foreign demand for home intermediate goods using (37)[11]:

$$Y_{H,t}^{*} = \lambda_1 \nu^{*} \left(\frac{\xi_t P_{H,t}^{*}}{P_t} . rx_t^{-1} \right)^{-\theta^{*}} + \lambda_2 \varphi^{*} \left(\frac{\xi_t P_{H,t}^{*}}{P_t} . rx_t^{-1} \right)^{-\tau^{*}} \tag{38}$$

[11] Such a pricing behavior of exportable is validated by the widespread pricing-to-market behavior.

where rx_t is the real exchange rate defined as $\xi_t P_t^* / P_t$. We normalize the aggregate foreign demand Y_t^* to unity, which means that λ_1 and λ_2 are fractions of foreign GDP devoted to consumption and investment, respectively.[12]

3.7 Price Setting Equations

As the intermediate goods firms produce differentiated goods, they are monopolistic price setters. Price setting is staggered as in Calvo (1983). These firms set $P_{H,t}$ after receiving a price signal that γ_p fraction of firms will keep the price unchanged in the next period. They also take the demand functions of their intermediate goods as given.

The profit of the home intermediate goods firms is given by

$$\Omega_t^d(P_{H,t}, P_{H,t}^*) = \left[(P_{H,t}(i) Y_{H,t}(i) + P_{H,t}^*(i) Y_{H,t}^*(i) - \Psi(Y_{H,t}(i) + Y_{H,t}^*(i)) \right], \qquad (39)$$

where $\Psi(.)$ is the nominal cost of production.

Under the assumption of identical nominal frictions, the dynamics of prices across two segmented markets can be written as:

$$P_{H,t} = \left[\gamma_p \left(P_{H,t-1} \Pi \right)^{1-\varepsilon} + \left(1 - \gamma_p \right) \left(\widetilde{P}_{H,t} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \qquad (40)$$

$$P_{H,t}^* = \left[\gamma_p \left(P_{H,t-1}^* \Pi^* \right)^{1-\varepsilon^*} + \left(1 - \gamma_p \right) \left(\widetilde{P}_{H,t}^* \right)^{1-\varepsilon^*} \right]^{\frac{1}{1-\varepsilon^*}}, \qquad (41)$$

where '$\sim$' stands for the optimal price and Π and Π^* are steady-state home and foreign inflation rates.

The home price is determined by the following price setting problem :

$$\widetilde{P}_{H,t} = \arg\max_{\varrho_t} \sum_{k=0}^{\infty} \beta^k \gamma_p^k D_{t,t+k} E_t \left[\Pi^k \varrho_t \left(\frac{\Pi^k \varrho_t}{P_{H,t+k}} \right)^{-\varepsilon} Y_{H,t+k} - \Psi(Y_{t+k}) \right] \qquad (42)$$

[12] To see how one gets (38), use the fact that $\frac{P_{H,t}^*}{P_t^*} = \frac{\xi_t P_{H,t}^*}{P_t}.rx_t^{-1}$ and $\frac{P_{H,t}^*}{P_{x,t}^*} = \frac{\xi_t P_{H,t}^*}{P_t}.rx_t^{-1}.\frac{P_t^*}{P_{xt}^*}$. Next note that $\frac{P_{x,t}^*}{P_t^*} = \frac{\left[\varphi^* + (1-\varphi^*)(P_{F,t}^*/P_{H,t}^*)^{1-\tau^*}\right]^{1/(1-\tau^*)}}{\left[\nu^* + (1-\nu^*)(P_{F,t}^*/P_{H,t}^*)^{1-\theta^*}\right]^{1/(1-\theta^*)}} \cdot \frac{1}{Z_{x,t}^*}$. In our calibration we assume that $\tau^* = \theta^*$ and $\nu^* = \varphi^*$ as the baseline, which means $\frac{P_{x,t}^*}{P_t^*} = \frac{1}{Z_{x,t}^*}$ where $Z_{x,t}^*$ is the foreign IST shock which we assume away by normalizing to unity.

where $D_{t,t+k}$ is the inflation adjusted stochastic discount factor equal to $(V_{1,t+k}/V_{1,t})$. (P_t/P_{t+k}) with the subscript of $V(.,.)$ representing the partial derivative with respect to the first argument of the utility function in Eq. (2).

Since prices are nonstationary, the domestic prices are deflated by CPI. This helps us to write the optimal price in a standard form as:

$$\frac{\widetilde{P}_{H,t}}{P_t} = \frac{(\varepsilon/(\varepsilon-1))E_t \sum_{k=0}^{\infty}(\beta^k \gamma_p^k D_{t,t+k} mc_{t+k} Y_{H,t+k}}{E_t \sum_{k=0}^{\infty} \beta^k \gamma_p^k D_{t,t+k} Y_{H,t+k}}, \tag{43}$$

which can be written in the following recursive form at the steady state where $Y_{H,t}$ is time invariant[13]:

$$\frac{\widetilde{P}_{H,t}}{P_t} = \frac{\varepsilon}{\varepsilon-1} F_t^{-1} mc_t + (1 - F_t^{-1}) E_t \frac{\widetilde{P}_{H,t+1}}{P_{t+1}} \tag{44}$$

where

$$F_t = Y_{H,t}^{-1} E_t \sum_{k=0}^{\infty} \beta^k \gamma_p^k D_{t,t+k} Y_{H,t+k} \Pi_{t+k} \tag{45}$$

The price setting problem for the export price is analogous to the domestic prices except that it takes account of the fact that the home country sets its export price in foreign currency indexing it against foreign steady-state inflation rate Π^* as in Kollmann (2002). It is given by[14]

$$\widetilde{P}_{H,t}^* = \arg\max_{\varkappa_t} \sum_{k=0}^{\infty} \beta^k \gamma_p^k D_{t,t+k} E_t \left[\xi_{t+k} \Pi^{*^k} \varkappa_t \left(\frac{\varkappa_t \Pi^{*^k}}{P_{t+k}} \right)^{-\varepsilon^*} Y_{H,t+k}^* - \Psi(Y_{t+k}) \right] \tag{46}$$

The optimal export price can be written analogously as[15]

$$\frac{\xi_t \widetilde{P}_{H,t}^*}{P_t} = \frac{(\varepsilon^*/(\varepsilon^*-1))E_t \sum_{k=0}^{\infty} \beta^k \gamma_p^k D_{t,t+k} mc_{t+k} Y_{H,t+k}^* \Pi_{t+k}}{E_t \sum_{k=0}^{\infty} (\gamma_p \Pi^{*-\varepsilon^*})^k D_{t,t+k} Y_{H,t+k}^* \Pi_{t+k}} \tag{47}$$

which gives rise to the following recursive representation of the relative export price with respect to the home CPI:

$$\frac{\widetilde{P}_{H,t}^* \xi_t}{P_t} = \frac{\varepsilon^*}{\varepsilon^*-1} F_t^{*-1} mc_t + \Pi^{*\varepsilon^*} (1 - F_t^{*-1}) E_t \frac{\widetilde{P}_{H,t+1}^* \xi_{t+1}}{P_{t+1}}, \tag{48}$$

[13]Details of the derivation of (44) are available from the authors upon request.

[14]In a world of law of one price (LOOP), the foreign terms of trade is identical to home terms of trade and thus, the export price setting equation becomes redundant. However, we do not assume LOOP in our model as in Kollmann (2002).

[15]The details of the derivation of (48) are available upon request from the authors.

where

$$F_t^* = Y_{H,t}^{*-1} E_t \sum_{k=0}^{\infty} \beta^k \gamma_p^k \Pi^{*^{-k\epsilon^*}} D_{t,t+k} Y_{H,t+k}^* \Pi_{t+k} \tag{49}$$

Not surprisingly, the relative domestic and export prices, (44) and (48), depend positively on the current and anticipated real marginal cost via the staggered price setting rules.

3.8 Fiscal Policy

Home government consumes G_t amount of final consumption goods and finances the same by lump-sum taxes T_t and borrowing. All such bonds are held domestically. Therefore, the government budget constraint takes the form of

$$P_t G_t - T_t = \frac{B_{H,t+1}}{1+i_t} - B_{H,t} \tag{50}$$

Government spending G_t is the single fiscal policy tool which is formulated as the following process:

$$\ln G_t - \ln \bar{G} = \rho_G (\ln G_{t-1} - \ln \bar{G}) + \xi_{G,t}, \tag{51}$$

where $\bar{G}$ is the steady-state government spending, $\rho_G \in (0,1)$ is the persistence of fiscal spending, $\xi_{G,t}$ is the fiscal policy white noise shock.

3.9 Real Exchange Rate

The real exchange rate is defined as the ratio of foreign to home CPI ($\xi_t P_t^*/P_t$). It is straightforward to verify the following identity for the real exchange rate (call it RX_t)[16]:

$$RX_t = \left(\frac{P_{t-1}}{P_t}\right)\left(\frac{P_t^*}{P_{t-1}^*}\right)\left(\frac{\xi_t}{\xi_{t-1}}\right) RX_{t-1}$$

Assuming that the foreign inflation rate is constant, the loglinear version of the real exchange rate process is given by

[16]The second author is grateful to Yongdae Lee to point out this useful identity.

$$\widehat{RX_t} = \widehat{\frac{\xi_t}{\xi_{t-1}}} - \widehat{\frac{P_t}{P_{t-1}}} + \widehat{RX_{t-1}} \tag{52}$$

Thus, real exchange rate fluctuates around its PPP level following the relationship (52).

3.10 Home Monetary Policy

The central bank coordinates with the fiscal policy by setting a policy rate (i_t) and auctions off $\{B_{H,t}\}$ sequence of bonds at this mandated interest rate. This short term policy rate sequence follows a standard Taylor rule and is specified as follows.[17]

$$\widehat{i_t} = \phi_i \widehat{i_{t-1}} + (1 - \phi_i) \left[\phi_\pi E_t \{\widehat{\pi}_{t+1}\} + \phi_y \widehat{y}_{H,t}\right] + \xi_t^m, \tag{53}$$

where '$\sim$' represents the proportional deviation from the steady state, ϕ_i is the interest rate smoothing parameter, ϕ_π and ϕ_y are the policy response to expected inflation $\widehat{\pi}_{t+1}$ and output gap, $\widehat{y}_{H,t}$. We assume that the home monetary authority is solely concerned about the domestic inflation and output fluctuations in designing its own monetary policy.[18]

3.11 Market Equilibrium

The solution to our model satisfies the following market equilibrium conditions which must hold for the home and foreign country

1. Market clearing condition for the home-produced intermediate goods is

$$Y_t = Y_{H,t} + Y_{H,t}^* \tag{54}$$

2. Market clearing condition for foreign-produced intermediate goods is

$$Y_t^* = Y_{F,t} + Y_{F,t}^* \tag{55}$$

[17] We follow Kollmann (2002) in formulating the interest rate rule as a function of $\widehat{y}_{H,t}$ (which is the deviation of y_{Ht} from the steady state). $\widehat{y}_{H,t}$ is analogous to output gap in a standard new Keynesian model.

[18] One may debate whether during the QE phase, the RBI explicitly followed the lead given by major player such as Federal Reserve or ECB in formulating its own monetary policy. There is no clear evidence that it was the case. In fact data (as seen Fig. 2) suggest that Indian Repo rate diverged from US Federal Funds rate since 2009 which is contrary to such a posited leader–follower relationship. We thus assume that the home central bank basically follows a traditional forward looking Taylor rule.

3. Bond Market clears:

$$\frac{\xi_t B_{F,t}}{P_t(1+i_t^*)\Theta\left(\frac{\xi_t B_{F,t}}{P_t}\right)} - \frac{\xi_t B_{F,t-1}}{P_t} = \frac{\xi_t P^*_{H,t}}{P_t} Y^*_{H,t} - \frac{P_{F,t}}{P_t} Y_{Ft} \tag{56}$$

4. $\{B_{H,t}\}$ satisfies the government budget constraint (50).

Note that the first equality in (56) shows the current account balance. The right hand side is home country's net export.

3.12 *National Income Accounting*

We next verify whether the Walras law holds for the aggregate economy. Aggregating the flow budget constraints of all home households, we obtain :

$$P_t C_t + P_{x,t} X_t + \frac{B_{H,t+1}}{(1+i_t)} + \frac{\xi_t B_{F,t}}{(1+i_t^*)\Theta\left(\frac{\xi_t B_{F,t}}{P_t}\right)}$$
$$= B_{H,t} + \xi_t B_{F,t-1} + W_t L_t + R_{k,t} K_t + \Omega_t^d - T_t$$

Next, we substitute the bond market clearing condition (56) to get

$$P_t C_t + P_{x,t} X_t + \frac{B_{Ht+1}}{\left(1+i_t\right)} - B_{Ht} + P^*_{H,t}\xi_t Y^*_{H,t} - P_{F,t} Y_{F,t} = W_t L_t + R_{k,t} K_t + \Omega_t^d - T_t \tag{57}$$

The aggregate profit is given by

$$\Omega_t^d = P_{H,t} Y_t - W_t L_t - R_{k,t} K_t, \tag{58}$$

which after plugging into (57) provides:

$$P_t C_t + P_{x,t} X_t + \frac{B_{H,t+1}}{\left(1+i_t\right)} - B_{H,t} + P^*_{H,t}\xi_t Y^*_{H,t} - P_{F,t}(C_{F,t} + X_{F,t}) = P_{H,t} Y_t - T_t \tag{59}$$

Finally, substituting the government budget constraint, we get rid of the tax term to obtain:

$$P_t C_t + P_{x,t} X_t + P_t G_t + P^*_{H,t}\xi_t Y^*_{H,t} - P_{F,t} Y_{F,t} = P_{H,t} Y_t \tag{60}$$

Note that $(P^*_{H,t}\xi_t Y^*_{H,t} - P_{F,t} Y_{F,t})$ is the home country's net export. Thus, the national income identity holds.

3.13 Modified Uncovered Interest Parity Condition

The modified UIP condition follows from (9) and (10),

$$\frac{1+i_t}{1+i_t^*} = E_t \frac{\xi_{t+1}}{\xi_t} \Theta \left(\frac{\xi_t B_{F,t}}{P_t} \right) \tag{61}$$

The bond holding cost function $\Theta(.)$ drives a wedge between home and foreign bond returns. The modified UIP condition is an essential building block of our model. The stylized facts reported in the earlier section provides strong empirical support to the application of UIP.

4 Model Simulation

In this section, we only focus on the effects of QE shock and taper talk along with the fiscal spending shock that occurred during adjacent periods of QE. The effects of other shocks are not analyzed to keep the focus on relevant shocks driving economy during the QE period.

Motivated by a persistent decline in the US federal funds rate during the QE era reported in Sect. 2, we model the quantitative easing shock as a negative shock in foreign interest rate with a slow recovery. A positive eight quarter ahead "news" shock is added to foreign interest rate to represent the "taper talk".[19] In other words, foreign interest rate is modeled as:

$$\widehat{i_t^*} = \phi_i^* \widehat{i_{t-1}^*} - (\xi_t^{*m} - \xi_{t-8}^{*m}), \tag{62}$$

where ϕ_i^* is the phasing out parameter and ξ_t^{*m} is a white noise term. The baseline parameterization of the model is shown in Tables 4 and 5. There are four additional shocks in the model namely, TFP (A_t), IST ($Z_{x,t}$), fiscal spending (G_t), and home monetary policy (i_t) which are kept in the background. Most of the baseline parameters are close to the values chosen as in Banerjee and Basu (2015). We assume a higher home bias in investment than consumption on par with Banerjee and Basu (2015). The rationale for choosing a low value for the nominal rigidity parameter γ_p in the context of India is also explained in Banerjee and Basu (2015). The steady-state inflation rates for home and foreign countries are fixed at 3 % to 2 %, respectively, which means a steady-state depreciation rate of 1 % for the home currency.[20] The phasing out parameter ϕ_i^* is fixed at 0.86 based on an AR(1) estimation of the historical

[19] An eight-quarter lag is arbitrarily chosen assuming that the market foresees the tapering of QE about 2 years ahead. Changing this lag to four quarters makes no difference to the impulse response analysis except that the actual taper materializes after four quarters instead of eight quarters.

[20] Setting a higher steady-state inflation rate for the home country does not change the impulse response properties of the model.

Table 4 Baseline parameterization

β	σ_c	σ_L	γ_c	γ_p	ε	ε^*	θ	ν	φ	ν^*	φ^*	τ	α	λ
0.98	2	0	0.6	0.22	6	6	2	0.7	0.8	0.8	0.8	2	0.3	0.3

Table 5 Baseline parameterization (contd)

δ	$S''(1)$	ϕ_i	ϕ_π	ϕ_y	ϕ_i^*	$\Theta'(\bar{b}_f).\bar{c}$	λ_1	λ_2	Π	Π^*
0.1	2.5	0.81	1.64	0.5	0.86	0.001	0.67	0.24	1.03	1.02

annual Federal Funds rate for the period 1956–2012. The risk aversion parameter σ_c is fixed at 2 which is in line with the estimate of Levine and Pearlman(2011). There is no readily available estimate of the proportion of rule-of-thumb consumers $(1-\lambda)$ for the Indian economy. Gali et al. (2005) use $\lambda = 0.5$. Given the existence of a vast informal sector in India, we set a greater value of $1-\lambda$ equal to 0.7. Changing λ in this vicinity has negligible effect on the impulse response analysis that we report later.[21]—Tables 4 and 5 summarize the baseline parameter values.

4.1 Effect of a QE Shock

Figure 2 plots the impulse response functions (IRF) of relevant macroeconomic aggregates followed by a one standard deviation negative shock in foreign interest rate from its steady-state value. This decline in foreign interest rate is motivated by the sharp drop in US federal funds rate from its baseline value of 5 % since 2007 (Fig. 1). Given the domestic interest rate, such a decline in foreign interest rate makes the home currency depreciate via the UIP condition (61). Since home producers of intermediate goods set the export price in foreign currency, the depreciation of home currency raises the optimal relative price of exportable $(\widetilde{P}^*_{H,t}\xi_t/P_t)$ in (48). Intermediate goods producers, therefore, experience a rise in export revenue from the sale of intermediate goods abroad. This encourages them to expand the intermediate goods output for the export market. The immediate effect of this output expansion is a rise in the real marginal cost mc_t in Eq. (48) which in turn boosts the optimal relative home price of tradable $(\widetilde{P}_{H,t}/P_t)$ via the staggered price setting rule (44). This immediately translates into a lower terms of trade $(P_{F,t}/P_{H,t})$ via the price aggregator (21). Given that $\tau = \theta$ and $\nu < \varphi$, a lower external terms of trade translates into a higher rela-

[21] As in any standard DSGE model, the impulse response analysis depends on the choice of parameters values. The key model parameter values are carefully chosen in line with the extant literature. Some parameter values (e.g., λ) are not available in the Indian context. We performed some sensitivity analysis (e.g., alternative home biases in consumption and investment) and found that the key impulse results are reasonably robust. The details of this sensitivity analysis is not presented for the sake of brevity.

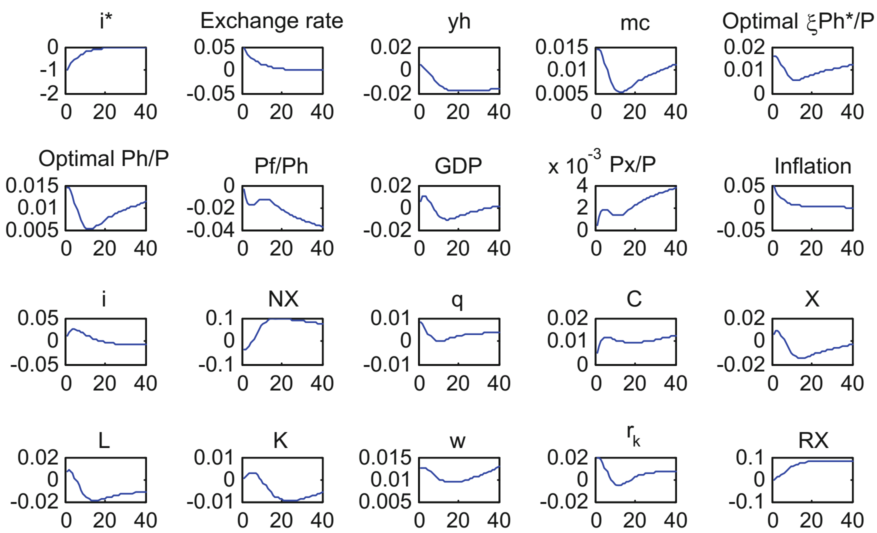


Fig. 2 Effect of a QE shock

tive price of investment goods ($P_{x,t}/P$) via (31). The real exchange rate depreciates following its law of motion (52).

A favorable tilt in the external terms of trade lowers our net export. Rise in $\widetilde{P}_{H,t}/P_t$ fuels domestic inflation via the price aggregator (40). The home central bank reacts to it by raising nominal interest rate based on the Taylor rule (53). Thus, home interest rate moves in opposite direction to the change in foreign rate which is consistent with the stylized facts reported earlier.

On the factor markets, a higher real marginal cost translates into a higher real wage and rental price of capital via (35). Agents respond to this by supplying more labor and investing more in physical capital which raises the Tobin's Q. Higher wage and rental income create positive income effect which boosts household consumption. The impact effect of a QE on GDP is positive which reflects the spurt in home intermediate goods production but it is quantitatively very small and is quickly reversed because of the sharp decline in net exports.

4.2 *Effect of a QE Taper Talk*

We model the effect of a QE taper talk as a "news" effect which is envisaged as an expected rise in foreign interest rate eight quarters ahead which means a positive shock to ξ_{t-8}. Figure 3 plots the impulse response of "news" that foreign interest rate will rise. Market anticipates an appreciation of home currency which translates into a lower expected relative price of exportable via the price setting function. The

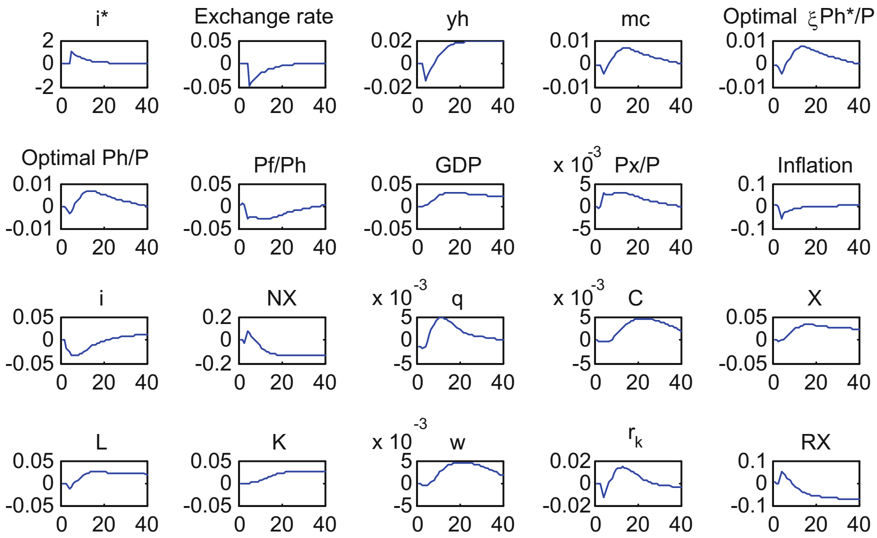


Fig. 3 Effect of a QE taper talk

real effect of such taper talk works opposite to the effect a negative QE shock discussed in the earlier section. Intermediate goods producers react to this "news" by cutting back tradable intermediate goods production ($Y_{H,t}$). This lowers the real marginal cost, *mc* and then, it translates into a lower inflation immediately via the price aggregator. The central bank lowers its interest rate in response to low inflation via the Taylor rule before exchange rate actually appreciates. The anticipation of appreciation of home currency becomes a reality after eight quarters via the uncovered interest parity condition. However, following this episode of appreciation, the home currency depreciates again as the foreign interest rate reverts to its mean.

Given that the nominal exchange rate is not altered for eight quarters, a lower domestic inflation raises the real exchange rate (*RX*) which translates into a higher optimal export price ($\xi_t P^*_{H,t}/P_t$). This boosts real marginal costs and raises P_H/P via the price setting function. The terms of trade P_F/P_H moves in the opposite direction to P_H/P following the price aggregator (30). A higher relative price of home goods shows up as an increase in GDP (see Eq. 60). The current account shows swings in response to this news effect due to conflicting movements of different relative prices. Not surprisingly, Tobin's Q mimics the pattern of the real marginal cost. The rest of the effects are similar as before.

The bottom line of this impulse responses to QE taper news is that there are sudden reversals in the behavior of some key macroeconomic aggregates such as the nominal exchange rate, net exports and Tobin's Q due to the *expectations effect*. For example, the terms of trade initially declines but then as soon as the tapering is realized after eight quarters, it reverses its course. The same also happens for CPI inflation. There is initial deflation and then inflation picks up its momentum. The financial market summarized by Tobin's Q shows a similar reversal. Taper talk thus possibly gives rise to more volatility in these key macroeconomic aggregates.[22]

4.3 Effect of a Fiscal Spending Shock

As discussed in Sect. 2, on the domestic front a noteworthy development is the rise in fiscal deficit particularly during the period of taper talk and subsequent taper tantrum. Motivated by this stylized fact, we analyze the effect of a positive government spending shock on relevant macroeconomic variables. Figure 4 plots impulse responses of a serially correlated (setting $\rho_G = 0.75$) one standard deviation shock in fiscal spending (G). The effect on the aggregate economy is broadly similar to the effect of a negative foreign interest rate shock. A blip in government spending by escalating the fiscal deficit raises the home interest rate. This makes the home currency to depreciate via the UIP condition. Home intermediate goods production rises along the similar channel described earlier. However, GDP drops which reflects a pronounced negative effect of terms of trade on export demand. Current account also experiences a deep decline as the terms of trade moves in favor of the home country. These two latter effects sharply contrast with the effects of a QE shock. The

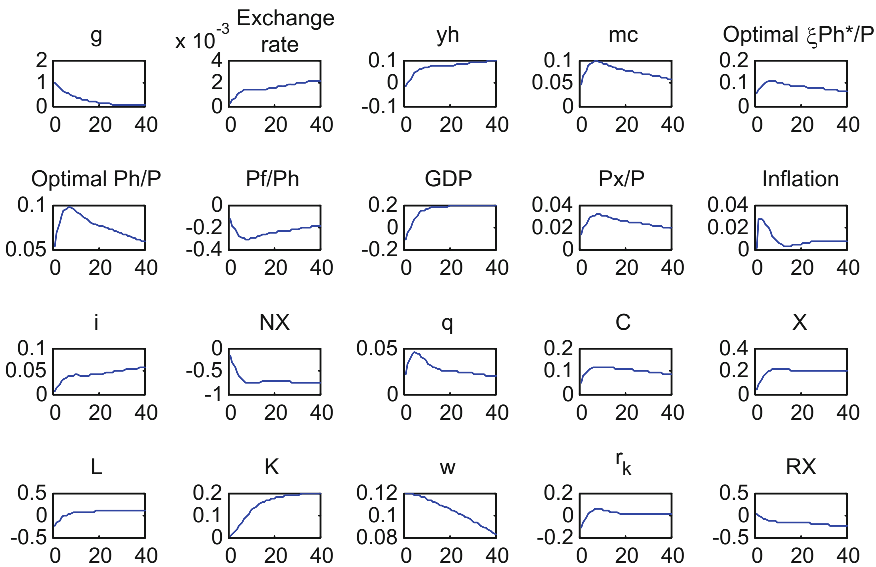


Fig. 4 Effect of a fiscal spending shock

[22]We use the term volatility in the sense of sudden change in the track. Evidently, we are not addressing issue of volatility spillover which requires serious modeling of the second-order effects of QE shocks. This is beyond the scope of this chapter.

real exchange rate, however, shows very little fluctuations in response to such fiscal shock.

4.4 Summarizing IRF Analysis and Connecting to Stylized Facts

A negative foreign interest rate shock (QE shock) has the following impact effects which have some bearing on the stylized facts reported earlier: (i) home currency depreciates, (ii) terms of trade declines, (iii) current account deteriorates, (iv) GDP falls momentarily and then shows rise, and (v) home policy rate diverges from foreign policy rate. These features are broadly consistent with the stylized facts reported in Panels A and B. The relevant economic aggregates showed similar patterns from the start of 2009 following the QE shock. However, one has to be cautious in concluding whether these features are necessarily engendered by a QE shock alone. During this period, fiscal deficit also rose and a positive fiscal spending shock also generates some similar impact effects particularly on home interest rate and exchange rate. The taper talks about QE reversed some of these trends. However, it is difficult to draw a definitive conclusion about the effect of taper talks because it is not known when the market anticipated the tapering phase of QE.

5 Conclusion

The aim of this paper is to develop a stylized DSGE framework to understand the effect of QE in a small open economy like India. This exercise is motivated by some broad stylized facts about the behavior of key macroeconomic aggregates. What is novel in this chapter is that, it highlights the effect of QE on the Indian macroeconomy via the external terms of trade channel. Our model predicts that a QE innovation raises the real marginal cost of production in the home country because intermediate goods producers experience a favorable terms of trade effect and step up their production. This higher real marginal cost translates into inflation through the standard new Keynesian Phillips curve channel. The home central bank raises interest rates to respond to inflation which explains the pervasive stylized fact that home and foreign interest rates move in opposite directions after a few periods of QE innovation.

We also model the tapering of QE (taper talk) as a “news” about future increases in foreign interest rate. Such a news effect creates market anticipation and expectation about a future appreciation of the home nominal interest rate which impacts the terms of trade positively as observed in the data. Our DSGE model predicts that such “news” could give rise to greater volatility in terms of a sudden change in the time paths of key macroeconomic variables.

The issue still remains whether the macroeconomic fluctuations of the Indian economy during QE and post-QE period was governed by the foreign interest rate shock alone. Our impulse response analysis suggests that the effect of QE shock on real GDP is rather minimal and the effects are broadly similar to a fiscal spending shock. It is still difficult to draw any definitive conclusion from the present model due to its highly stylized nature and the nonavailability of high frequency data for real economic aggregates. In a companion paper (Banerjee and Basu 2015), we find that the aggregate effect of foreign interest rate shocks is minimal and aggregate fluctuations are more governed by investment specific technology shocks during the post-liberalization period. Our present model also abstracts from many complications such as tax distortions, informal labor market, banking, and credit market frictions. We also believe that banking frictions, as in Gertler and Karadi (2011), are less important for India because of its highly regulated banking industry and this is why we assumed it away in our model. Credit market frictions in terms of a lending–borrowing spread and informal labor market can be introduced but it is unlikely to alter the main punchline of the paper.

6 Data Appendix

We have plotted a set of macroeconomic variables in Panel A and B to depict the key features of the Indian economy during pre-QE period, QE period, and post-QE period spanning over 2004–'05:Q4 to 2014–'15:Q2. In the following table, we present the data sources of the respective variables.

Variable	Source
GDP Growth	National Accounts Statistics
GDP Deflator	International Financial Statistics
CPI Inflation	St. Louise FRED Database
Private Consumption	National Accounts Statistics
Private Investment	National Accounts Statistics
RBI Repo rate	Database of Indian Economy, RBI
Federal Fund's rate	St. Louise FRED Database
Depreciation of Nominal Exchange rate	Website of Exchangerate.com
Terms of Trade	International Financial Statistics
Real Net Export	Database of Indian Economy, RBI
Current A/C Deficit to GDP Ratio	Database of Indian Economy, RBI
Gross Fiscal Deficit to GDP Ratio	Database of Indian Economy, RBI
External Debt to GDP Ratio	Database of Indian Economy, RBI
Foreign Exchange Reserve	Database of Indian Economy, RBI
Foreign Direct Investment (FDI)	Database of Indian Economy, RBI
Foreign Portfolio Investment (FPI)	Database of Indian Economy, RBI

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Part VI
Future Challenges

The Past and Future of Inflation Targeting: Implications for Emerging-Market and Developing Economies

Klaus Schmidt-Hebbel and Martín Carrasco

1 Introduction

Inflation Targeting (IT) was born in 1989 with the Reserve Bank of New Zealand (RBNZ) Act and started by the RBNZ in January 1990. At the time of its birth, this new monetary framework had no name. 25 years later, IT has spread world-wide through advanced economies (AEs) and, in particular, through emerging-market and developing economies (EMDEs). As of April 2015, central bank of 36 countries have an IT framework in place.[1]

What is IT? A monetary policy framework focused on price stability as the main policy goal reflected by an explicit numerical inflation target, pursued by a monetary authority endowed with operational and instrument independence, which conducts policy in a transparent way and is accountable for its actions and results to political authorities and the public. In fact, the four key attributes of IT can be summarized as: policy independence, an explicit target for inflation, transparency, and accountability (Kamber et al. 2015; Walsh 2015).

We thank Ken Kletzer for very useful comments on a first draft.

[1]We follow the IMF regarding both the classification of economies into AEs and EMDEs, and the IT country list (IMF 2015).

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_18

In what sense is IT different from best monetary practice in other monetary regimes, in particular those where nominal anchors are either money growth or the exchange rate? First, under IT the target is obviously a measure of inflation (the ultimate goal of price stability), as opposed to money or exchange rate targeting (which are intermediate policy goals for all monetary authorities that pursue price stability). Second, because attainment of an inflation target is in principle more elusive to central bank than controlling money growth or the exchange rate, IT requires higher degrees of monetary policy independence, transparency, and accountability than those observed in alternative monetary regimes. Third, considering the key role of inflation expectations for the path of future inflation, IT central bank focus more strongly on different measures of inflation expectations and forecasts in setting policy than other central bank. The paramount role of the inflation forecast as intermediate policy objective under IT has led some researchers to redefine IT as inflation forecast targeting (Svensson 1997).

While the main goal of IT is inflation, it is not the only objective of monetary policy under IT. While pursuing price stability, the monetary authority does so by also attempting to reduce output volatility and ensure financial stability. Therefore, the conduct of policy is focused on attaining the inflation objective over the medium term—over an explicit policy horizon—and not in the very short term. This approach is termed flexible IT and is the way central bank have gradually chosen to implement IT, in opposition to strict IT.[2]

This paper is about the past and the future of IT, with a focus on policy lessons and implications for EMDEs. Section 2 reviews the world experience in adopting and developing the IT regime, focusing on pre-conditions, the likelihood of having IT in place, the transition toward full-fledged IT, and the evolution of the IT framework. Then, Sect. 3 reviews selectively the wide international evidence on monetary policy and macroeconomic performance under IT. The IT regime was put to several tests, shortly before and then during and after the Global Financial Crisis —the results are analyzed in Sect. 4. The next section draws the lessons from the experience of IT in EMDEs and identifies their key future policy challenges. Concluding remarks close the paper.

[2]The foundation of flexible IT is illustrated best by legal acts related to IT in New Zealand. The assigned policy objective for the Reserve Bank of New Zealand (RBNZ) was established in clause 8 of the RBNZ Act of December 1989: "The primary function of the Bank is to formulate and implement monetary policy directed to the economic objective of achieving and maintaining stability in the general level of prices." The flexible part of IT is reflected a decade later by the 1999 Policy Target Agreement between the Government of New Zealand and the RBNZ: "In pursuing its price stability objective, the Bank shall implement monetary policy in a sustainable, consistent and transparent manner and shall seek to avoid unnecessary instability in output, interest rates and the exchange rate" (Grimes 2013; Walsh 2015).

2 Adopting and Developing IT

After New Zealand's adoption of IT in 1990, this new monetary regime started slowly to spread around the world. 11 AEs and 25 EMDEs have IT in place in 2015. The gradually growing number of IT countries, reflected in Fig. 1, includes both stationary and converging inflation targeters (ITers), as well as full-fledged and partial ITers—important distinctions that we discuss below.

Which are the main pre-requisites that an economy and its central bank should satisfy before adopting IT? What triggers formal adoption of an inflation target in practice? Which is the difference between partial and full-fledged IT? Has the frontier best practice of IT changed over the last 25 years? We address these questions next.

2.1 Pre-conditions for Successful IT

In the 1990s, it was often thought that IT could only be successfully implemented in countries with high levels of institutional development and macroeconomic stability, and where central bank satisfied the highest standards regarding independence and conduct of monetary policy (Masson et al. 1997). Strict attainment of such conditions would have restricted IT adoption mostly to AEs. However, already in the late 1990s IT had been adopted by more EMDEs than AEs.

To identify pre-conditions for IT, it is useful to start with the key features of IT: (i) price stability is explicitly and publicly stated as the main goal of monetary

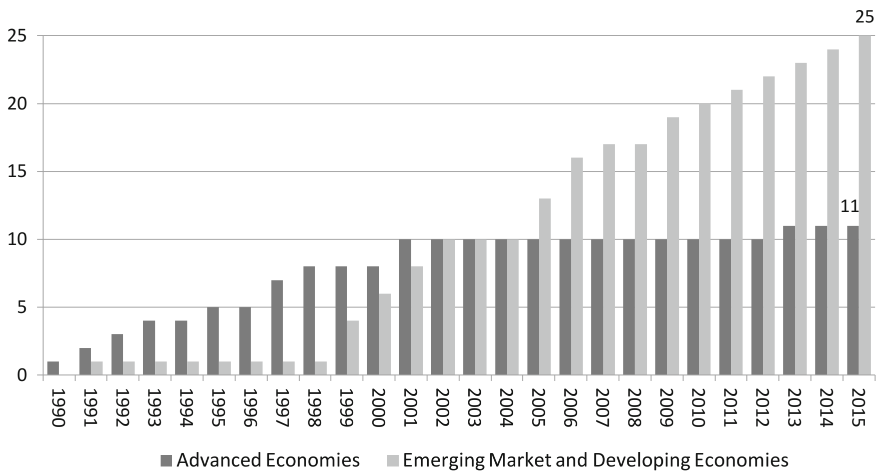

Fig. 1 Number of IT countries, 1989–2015. *Source* Hammond (2012) and central bank webpages

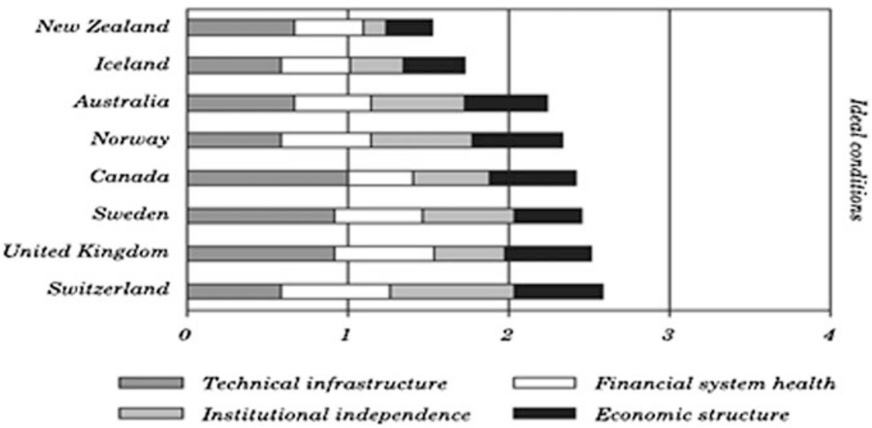

Fig. 2 Preconditions at the time of inflation targeting adoption in advanced economies. *Source* Batini and Laxton (2007)

policy, (ii) a quantitative target for inflation is publicly announced; (iii) conduct of monetary policy is based on a wide set of information, including inflation forecasts; (iv) monetary policy is conducted in a highly transparent way; and (v) the monetary authority complies with high standards of public accountability regarding the conduct of policy and its results. Based on the latter five features, Batini and Laxton (2007) identify four broad categories of pre-conditions for successful IT: (a) central bank institutional independence, (b) well-developed central bank infrastructure, (c) developed economic structure, and (d) a healthy financial system. Then the authors identify specific variables for each category and provide annual measures for 21 ITers, before and after their adoption of IT.[3]

Their findings are surprising. No IT country and its corresponding central bank satisfied to any significant extent the four pre-conditions at the time of IT adoption. Out of a maximum score of 4 points (when meeting all pre-conditions fully), AEs scored on average 2.3 points and EMDEs 1.6 points (Figs. 2 and 3). Individual country scores at the time of IT adoption ranged between 1.2 points (The Philippines) and 2.6 points (Switzerland). Generally, the later IT is adopted, the more pre-conditions are satisfied, suggesting that IT central bank learn by importing IT policy frameworks from earlier IT adopters. Moreover, all countries continued improving on their IT pre-conditions for many years after they started IT. This suggests that countries could start IT well before satisfying theoretical

[3]The variables in each category are: (i) for institutional independence: full legal independence, goal independence, and operational independence; (ii) for well-developed central bank infrastructure: technical infrastructure, data availability, and systematic inflation forecasting and modeling capabilities; (iii) for developed economic structure: full price deregulation, no excess sensitivity of inflation to commodity prices and the exchange rate, low dollarization, and low trade openness; (iv) healthy financial system: six measures of banking and capital market development.

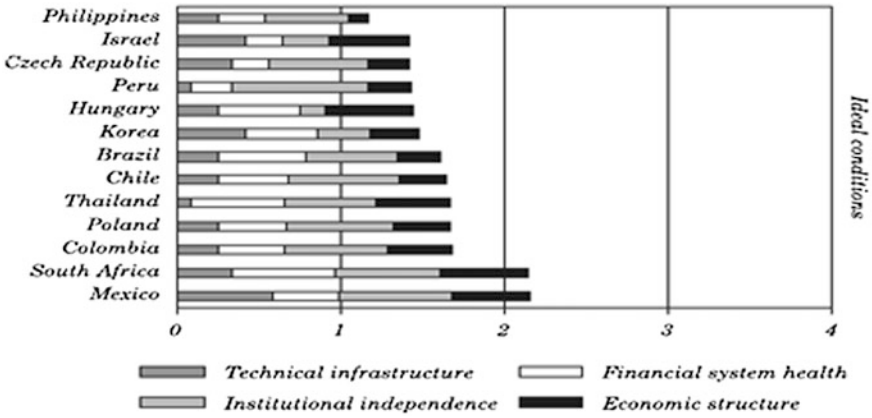

Fig. 3 Preconditions at the time of inflation targeting adoption in emerging market and developing countries. *Source* Batini and Laxton (2007)

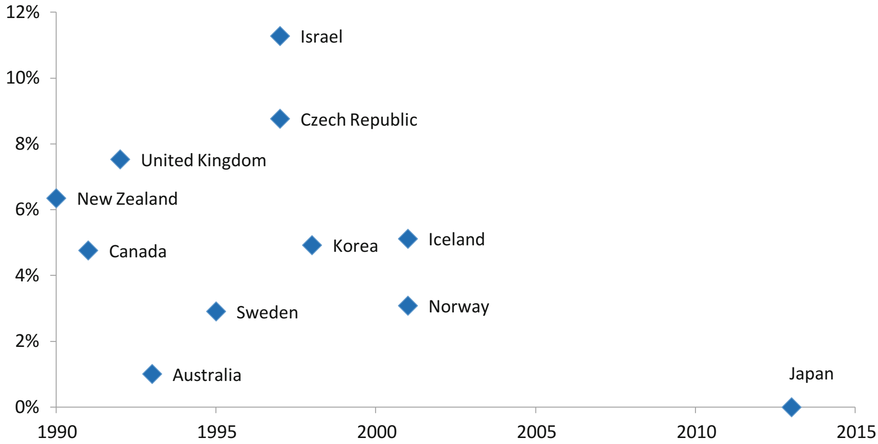

Fig. 4 Initial inflation levels and inflation-targeting adoption years in 11 advanced economies. *Source* Hammond (2012) and central bank webpages

pre-conditions. While there is still lack of research that links satisfaction of pre-conditions to the subsequent success of IT, it seems that non-satisfaction of pre-conditions has not hampered IT success. However, central bank efforts toward improving significantly their institutional and policy framework after IT adoption also suggest that they view such upgrades as key for their long-term policy success. Hence theoretical pre-conditions for IT have proven to be de facto post-conditions required for gradual strengthening of the IT framework (Figs. 4 and 5).

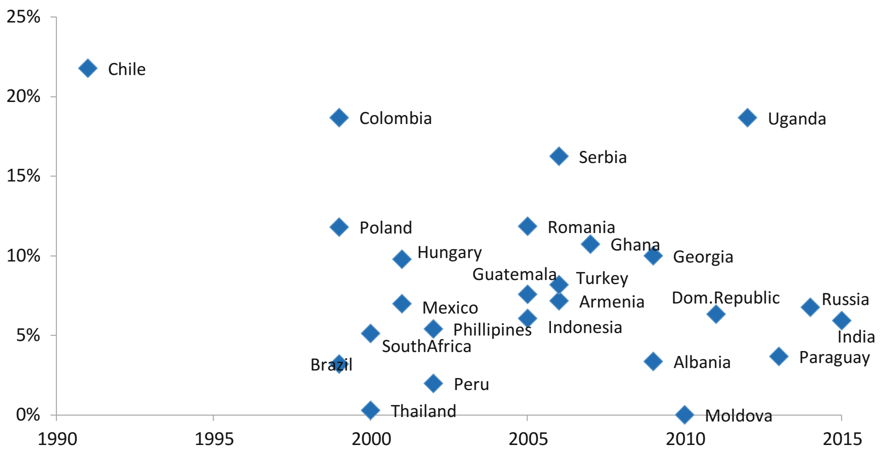

Fig. 5 Initial inflation levels and inflation-targeting adoption years in 25 emerging market and developing countries. *Source* Hammond (2012) and central bank webpages

2.2 *On the Likelihood of Having an IT Regime in Place*

The issue of IT pre-conditions is closely linked to the question about which institutional and macroeconomic features are observed when central bank adopt IT and hold to it over time. Hence, which conditions raise the likelihood of having an IT framework in place?

Gerlach and Schnabel (2000) performed probit regressions on a small cross-section country sample, finding evidence for the role of inflation, credibility measures, trade openness, and terms of trade shocks in shaping the likelihood of IT. Mishkin and Schmidt-Hebbel (2002) also estimate a probit model, applied to a larger cross-country sample, identifying the influence of several pre-condition variables (inflation, fiscal position, proxies of alternative monetary regimes, central bank independence and credibility) and trade openness in shaping the likelihood of IT. Carare and Stone (2006) estimate a cross-country probit model on a larger cross-country sample, adding measures of fiscal and financial pre-conditions, and per capita GDP, to some variables used in the preceding studies. Hu (2006) is the first study to consider the time dimension of having IT in place, by using a panel data set (comprised by 66 countries and covering the period 1980–2000) to estimate a probit pooled-data model (without controlling for country effects) for the IT regime. In addition to some of the variables considered in the previous studies, he finds evidence that the exchange rate regime, external debt, and GDP growth contribute to the likelihood of having IT in place.

A more recent study extends the existing empirical literature on the likelihood of having IT in place by using a large panel data sample of 98 countries extending from 1975 to 2005 (Calderón and Schmidt-Hebbel 2008).[4] The base-line results, which are robust to alternative specifications and econometric methods, are reproduced here in Table 1. They imply the following.

Five important key pre-condition variables are generally highly significant (and exhibit expected signs) in shaping the likelihood of IT: the level of inflation (with negative sign; a proxy of lack of stabilization progress), the government budget balance (positive sign; a proxy of the absence of fiscal dominance), a measure of financial development (positive sign; a proxy of the absence of financial dominance), an inflexible exchange-rate regime (negative sign; reflecting presence of a competing exchange-rate anchor), and GDP per capita (positive sign; a proxy of central bank capability of conducting monetary policy effectively and independently). Other significant IT likelihood determinants are trade openness (positive sign; a measure of reform progress generally) and a regional dummy variable for Latin America (positive; reflecting early spreading of IT in this region).

2.3 Convergence Toward Full-Fledged IT

The preceding evidence suggests that countries and central bank with IT in place are more likely than others to satisfy several institutional, macroeconomic, and financial conditions. At the same time, macroeconomic conditions in IT countries and the features of the IT framework adopted by their central bank continue improving well after the regime adoption year.

Many countries—most of them EMDEs—adopted IT early on, at a time when they did not satisfy the conditions of a full-fledged IT framework. For example, Chile, Colombia, and Israel adopted a system of partial IT in the 1990s without giving up their exchange-rate anchor. For several years—until the late 1990s or early 2000s—these countries had in place both inflation targets and exchange-rate bands. Facing frequent policy tensions arising from inconsistent inflation and exchange-rate targets and the corresponding lack of full monetary independence, they adopted eventually a floating exchange rate regime, which is a key condition of full-fledged IT. Other IT central bank, like those of Brazil (until today) and the UK (until 1998), lack full legal independence, which may affect their operational independence and policy performance.

[4]This paper expands the existing literature in five ways: allowing for a broader specification that encompasses a wide set of potential determinants of the likelihood of IT; using a large dataset for a treatment group comprised by all IT countries and a large control group of non-IT countries, with three decades of annual data; for robustness checks, applying different panel-data estimation techniques for discrete-choice dependent variables, comprising pooled data estimators for logit and probit models, the conditional logit estimator for fixed effects, and logit and probit estimators for random effects; conducting robustness checks of the preferred specification by testing its validity for different country and time sub-samples; and subjecting the preferred specification to alternative measures of our treatment group, varying IT starting dates.

Table 1 Likelihood of having an inflation-targeting regime in place. Dependent variable: dummy variable for having an IT regime in place (1 = yes; 0 = no). Estimation methods: Discrete-choice logit panel-data models. Sample: 1975–2005 (annual data 1975–2005)

Fixed effects logit			Random effects logit					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inflation	−130.026***	−117.311***	−35.392***	−36.295***	−43.349***	−36.421***	−39.508***	−33.487***
	(2.95)	(3.18)	(5.10)	(5.46)	(6.13)	(5.88)	(6.63)	(6.46)
Government budget balance	−25.066	–	19.307 **	20.685**	15.040**	17.909**	–	–
	(1.45)	–	(2.07)	(2.31)	(1.98)	(2.53)	–	–
Financial development	19.372***	16.881***	0.775	–	3.299***	3.186***	2.633***	2.677***
	(3.07)	(3.39)	(0.55)	–	(3.19)	(3.40)	(2.99)	(3.22)
Exchange rate regime	−20.320***	−17.824***	−4.958***	−5.068***	−4.978***	−4.464***	−3.990***	−3.655***
	(3.03)	(3.22)	(5.27)	(5.54)	(7.04)	(7.20)	(7.74)	(7.49)
GDP per capita	104.027***	90.130***	5.042***	5 249***	4.605***	3 478***	4.822***	3.829***
	(3.19)	(356)	(478)	(5 25)	(508)	(349)	(5.90)	(419)
Trade openness	46.763***	42.343***	1.156	–	2.289**	0.837	3185***	2.134**
	(2.83)	(3.03)	(0.82)	–	(2.06)	(0.68)	(4.01)	(2.53)
Money growth volatility	–	–	−0.142	−0.126	–	–	–	–
	–	–	(0.44)	(0.39)		–	–	–
Terms of trade volatility	–	–	1.760	0.959	–	–	–	–
	–	–	(0.28)	(0.15)	–	–	–	–
Dummy LAC	–	–	6.986***	6.741***	7.789***	–	7.433***	–
	–	–	(3.84)	(4.11)	(4.63)		(4.85)	–
Constant	–	–	−45.403***	−45.517***	−43.798***	−30.343***	−47.961***	−36.263***
	–	–	(5.01)	(5.27)	(5.68)	(3.44)	(7.01)	(4.57)
Observations	491	554	1143	1163	1854	1854	2305	2305
Number 1 of countries	19	24	71	71	76	76	98	98

(continued)

Table 1 (continued)

Fixed effects logit			Random effects logit					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Countries with the IT regime	19	24	19	19	19	19	24	24
Countries without the IT regime (control group)	0	0	52	52	57	57	74	74
LR statistic	450.19	499.19	76.03	75.10	126.91	126.90	177.77	161.95
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note Absolute value of z statistics in parentheses
** significant at 10 %; ** significant at 5 %; *** significant at 1 %*
Source Calderón and Schmidt-Hebbel (2008)

Another dimension that implies a deviation from full-fledged IT is when countries adopt annual inflation targets in their transition from moderate-to-low inflation levels. Figure 1 reflects that a majority of countries adopted IT when their initial inflation rates were well above long-term stationary target levels in the range of 1–3 %. Many of these "inflation-converging ITers" adopted annual (or sometimes multi-annual) inflation targets that were revised regularly, typically downwards. The list of countries includes a few AEs (New Zealand, Israel, Korea) and many EMDEs that started IT at relatively high levels of inflation (including Chile, Colombia, Poland, Hungary, Mexico, Philippines, Romania, Guatemala, Indonesia, Serbia, Armenia, Turkey, and Ghana among others). The latest IT adopter, India, started IT in 2015 with an initial target set at 8 %.

Inflation-converging ITers adopted IT as a stabilization tool to bring inflation down toward long-term low stationary levels. However, variable annual inflation targets limit severely the conduct of monetary policy during the transition toward low stationary targets and inflation levels. The next section discusses their performance in reducing inflation and inflation expectations.

2.4 *Evolution of the IT Framework*

Another relevant issue is about the evolving best practice of full-fledged IT over the last 25 years. Even for countries that practiced frontier or full-fledged IT as understood at the start of IT (including New Zealand, Canada, and the UK in the early 1990s), has the meaning and content of IT changed for them and for all other ITers over the course of the last quarter century?

The answer is yes. The world evidence suggests that best practice IT has changed since it was started by New Zealand in 1990. This evolution has taken place in four dimensions: institutional features of the conduct of monetary policy, specific features of the inflation target, technical capabilities, and acceptance of flexible inflation targeting.

Changes in institutional features have been observed regarding independence, transparency, and accountability of central bank. The central role of operational independence in the conduct of monetary policy—conditioned by the absence of fiscal dominance—has been strengthened since the 1990s. Moreover, the lack of legal independence of some central bank has probably hindered their attainment of full operational independence.

A growing understanding of the key importance of high levels of policy transparency has been reflected in major improvements in IT central bank. In their first years many IT central bank—particularly those in EMDEs in the 1990s—were opaque in their communications with markets and the general public. As documented by Batini and Laxton (2007) and discussed more generally below, IT central bank have upgraded significantly transparency of their IT regime, their data, models and forecasts, and their internal discussion regarding policy decisions over the last 25 years. This has come together with improvements in accountability of

Table 2 Selective features of the inflation-targeting framework in 36 IT countries, 2015

Country	IT adoption year	Transparency: publication of minutes	Accountability: parliamentary hearings	2015 inflation target	Target horizon
Albania	2009	Yes	Yes	3 % ± 1 pp	Medium term
Armenia	2006	Yes	Yes	4 % ± 1.5 pp	Medium term
Australia	1993	Yes	Yes	2–3 %	Medium term
Brazil	1999	Yes	Yes	4.5 % ± 2 pp	Yearly target
Canada	1991	No	Yes	2 % (mid-point of 1–3 %)	Six-eight quarters
Chile	1991	Yes	Yes	3 % ± 1 pp	Around 2 years
Colombia	1999	Yes	Yes	2–4 %	Medium term
Czech Republic	1997	Yes	No	2 % ± 1 pp	Medium term
Dominican Republic	2011	Yes	Yes	4 % ± 1 pp	Medium term
Georgia	2009	Yes	Yes	5 %	Medium term
Ghana	2007	No	No	8 % ± 2 pp	18–24 months
Guatemala	2005	Yes	Yes	4 % ± 1 pp	End of year
Hungary	2001	Yes	Yes	3 % ± 1 pp	Medium term
Iceland	2001	Yes	Yes	2.50 %	On average
India	2015	Yes	Yes	4 % ± 2 pp	Medium term
Indonesia	2005	No	No	4 % ± 1 pp	Medium term
Israel	1997	Yes	Yes	1–3 %	Within two years
Japan	2013	Yes	Yes	2 %	Approx. 2 years as soon as possible
Korea	1998	Yes	Yes	3 % ± 0.5 pp	Three years
Mexico	2001	Yes	Yes	3 % ± 1 pp	Medium term
Moldova	2010	Yes	Yes	5 % ± 1.5 pp	Medium term
New Zealand	1990	No	Yes	2 % ± 1 pp	Medium term
Norway	2001	No	Yes	2.5 %	Medium term
Paraguay	2013	Yes	Yes	4.5 %	Medium term
Peru	2002	No	Yes	2 % ± 1 pp	At all times
Philippines	2002	Yes	No	4 % ± 1 pp	Medium term
Poland	1999	Yes	No	2.5 % ± 1 pp	Medium term
Romania	2005	No	No	3 % ± 1 pp	Medium term
Russia	2014	Yes	Yes	4 %	Medium term
Serbia	2006	No	No	4 % ± 1.5 pp	Medium term
South Africa	2000	No	Yes	3–6 %	On a continuous basis

(continued)

Table 2 (continued)

Country	IT adoption year	Transparency: publication of minutes	Accountability: parliamentary hearings	2015 inflation target	Target horizon
Sweden	1995	Yes	Yes	2 %	Normally 2 years
Thailand	2000	Yes	No	2.5 % ± 1.5 pp	Eight quarters
Turkey	2006	Yes	Yes	5 % ± 2 pp	Multiyear
Uganda	2012	Yes	Yes	5 % ± 2 pp	Medium term
United Kingdom	1992	Yes	Yes	2 %	At all times

Sources and Note information in Hammond (2012) updated to more countries and to current information published in central bank webpages

the policy conduct by IT central bank, both regarding political bodies (government and parliament) and the general public.

The last quarter century has also seen convergence toward specific features of the inflation target. While some AEs had initially adopted inflation targets based on a core inflation measure, today all ITers use the headline CPI as their target measure —for reasons that range from high-frequency data availability to relevance as a country's dominant inflation measure.

Numerical mid-points of inflation targets are today between 1 and 3 % in AEs (Table 2). There are several EMDEs with current target mid-points at or above 4 %, including India, which set its first inflation target at 8 % in 2015. EMDE target levels above 4 % are typically transition targets toward lower long-term stationary levels. Considering only stationary target ITers, EMDEs have converged toward inflation target mid-points that vary between 2 and 3 %, only slightly above average target mid-points in AEs. Communicating in different ways their tolerance to inflation deviations, central bank use either point targets, point targets with tolerance bands or target ranges. A majority of central bank have in place one of these options, with a typical deviation of 1 pp. from the target mid-point.

Hence best-practice IT has evolved to a relative narrow choice of stationary inflation target mid-points (defined at 2, 2.5, or 3 %), with a small tolerance to inflation deviations that averages 1 pp. This represents the likely medium term policy objective for the dozen IT EMDEs that are still on their path toward convergence to lower stationary target and inflation levels.

A major evolution of IT over time has taken place regarding central bank technical capabilities in processing data, developing models, and generating forecasts. This progress has come together with global strengthening of data processing capabilities, the development of dynamic stochastic general-equilibrium (DSGE) models, and the capability of using the DSGE models (in conjunction with complementary smaller models) as central bank workhorses for generating forecasts for macroeconomic variables and their own policy rates. No such capabilities existed when IT was adopted by some AEs and EMDEs in the early 1990s. Certainly such progress is not limited to IT central bank. However, the specific need for accurate forecasts of inflation for their publication in the form of fan charts in regular inflation reports has put particular pressure on IT central bank to build up their in-house capabilities for model development and forecasting. These technical capacities are much more developed in each and every IT central bank today than in the 1990s, and they are on average more developed today in IT central bank than in non-IT central bank.

Since the 1990s the IT regime has evolved toward explicit acknowledgment that it implies flexible IT, as opposed to strict IT. Mervyn King (1997) famously described strict IT as an approach reflecting policy preferences of an "inflation-nutter" central banker. Svensson (2010) makes the contrast more explicit: "Flexible IT means that monetary policy aims at stabilizing both inflation around the inflation target and the real economy, whereas strict inflation targeting aims at stabilizing inflation only, without regard to the stability of the real economy."

What does flexible IT imply in practice? Price stability is not the only objective of the monetary authority that pursues flexible IT. However, in lexicographic terms, price stability comes first, while output (and possibly financial) stability comes second. As discussed below, this implies that, in addition to price stability, output stability (and possibly financial stability) is included as an argument in policy reaction functions of IT central bank.

Therefore temporary inflation deviations from targets are tolerated as long as their degree of persistence is limited. This leads IT central bank to state explicitly their policy horizon, i.e., the time period at which they expect—for which they forecast—that inflation will return to the target level, conditional on the current policy rate and its future path. IT central bank differ regarding how specific their stated policy horizons are. While circa half of 36 ITers specify generic horizons like "medium term," "on average" or "at all times," the other half commits to explicit horizons that vary between 1 and 3 years and are on average 2 years (Table 2).

3 Evidence on Monetary Policy and Macroeconomic Performance Under IT

Are ITers different from NITers regarding central bank independence, transparency, and accountability? Which is the distribution of inflation targets across ITers and do targets change over time? Which are the differences in inflation deviations from targets across ITers and what explains them? Do IT central bank attach a larger weight to inflation than to output stabilization? Is long-term inflation lower in IT countries? Does IT anchor better inflation expectations? How does monetary policy efficiency in ITers compare to NITers?

3.1 Central Bank Independence, Transparency, and Accountability

Central bank independence—to be free from fiscal and political pressures that create conflicts with central bank objectives—is a key condition for successful conduct of central bank policies. Independence of a monetary institution is a wide concept that ranges from central bank legal independence to institutional features of selection and duration of board members and to operational independence in the conduct of monetary, exchange rate, and financial policies. A key condition for central bank monetary independence is the absence of fiscal dominance, i.e., legal prohibition of central bank financing of government budgets and related fiscal or quasi-fiscal operations.

The first cross-country measures of central bank independence, based on 16 criteria, were developed for a world sample by Cukierman et al. (1992). Jácome and Vásquez (2008) broaden these measures for Latin America and the Caribbean. The most comprehensive dataset for several central bank independence measures that is available to date is Dincer and Eichengreen's (2014) for 89 countries over 1998–2010. In their ranking, IT central bank do not fare very well in comparison to non-IT central bank. The highest ranked ITers are Sweden and Hungary (placed 8 and 9, respectively) and the lowest ranked are South Africa and India (placed 86 and 89, respectively) (Table 3). It comes as a surprise that IT central bank do not rank better on average than non-IT central bank in terms of statutory measures of independence. It is likely that the conduct of monetary policy by IT central bank exhibits larger de facto independence than what is reflected by available statutory measures. However, to ensure long-term autonomy in the conduct of their policies, many IT countries face the challenge of giving a greater degree of legal and statutory independence to their central bank.

High degrees of transparency are essential to modern central banking, for reasons that range from political legitimacy to accountability and to monetary policy efficiency (Dincer and Eichengreen 2014).[5]

How important is transparency for central bankers? Two early surveys of central bankers provide useful answers to this question. From a 1998 survey of 94 central bank in the world, Fry et al. (2000) report that 74 % of central bank consider transparency a "vital" or "very important" component of their monetary policy framework. Based on a separate survey of 88 central bank, Blinder (2000) finds that transparency is considered a very important factor in establishing or maintaining credibility.

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[5]Dincer and Eichengreen (2014) present a wealth of data on central bank independence and transparency, for 120 central bank until 2010, and report regression results to relate fundamentals to the two latter measures, as well as their impact on inflation and inflation volatility. However, they do not report descriptive or empirical results for central bank by different monetary regimes, like IT.

Table 3 Ranking of central bank independence and transparency of IT countries in world ranking, 2010

Country	Transparency ranking	Independence ranking
Sweden	1	8
New Zealand	2	72
Hungary	3	9
Czech Republic	4	24
United Kingdom	4	79
Israel	6	40
Canada	7	50
Australia	7	83
Iceland	11	14
Japan	11	62
Norway	14	46
Philippines	14	68
Turkey	14	29
Indonesia	17	11
Poland	17	58
Thailand	17	74
Armenia	21	7
Brazil	21	nd
Chile	21	16
Korea	21	65
Peru	21	32
South Africa	21	86
Moldova	27	17
Albania	27	27
Romania	30	5
Georgia	30	36
Colombia	34	69
Ghana	34	nd
Guatemala	34	nd
Mexico	43	26
Russia	80	28
Uganda	80	70
India	80	89
Dominican Republic	nd	nd
Paraguay	nd	nd
Serbia	nd	nd

Source Dincer and Eichengreen (2014): Table 8, CBIW measure for independence; Table 1 for transparency
Note Dincer and Eichengreen's rankings of independence are for 89 countries and of transparency for 120 countries

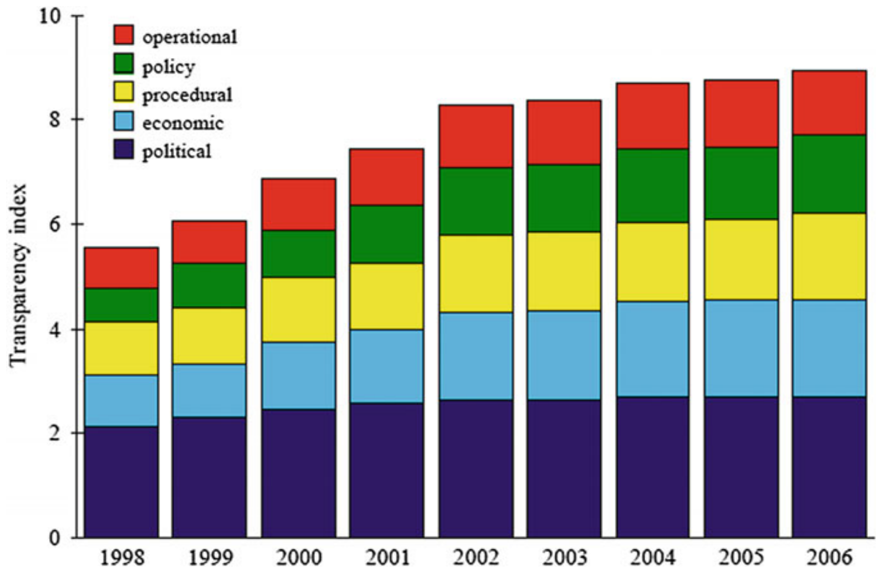

Fig. 6 Average transparency of inflation-targeting central bank, 1998–2006. *Note* The aggregate central-bank transparency index comprises five dimensions of transparency: political, economic, procedural, policy, and operational. *Source* Geraats (2009)

Eijffinger and Geraats (2006) propose a central bank transparency index based on five criteria: political transparency (policy objectives), economic transparency (data, models, and forecasts), procedural transparency (release of minutes and votes), policy transparency (announcement and explanation of decisions), and operational transparency (implementation of decisions). Eijffinger and Geraats (2006) and Geraats (2009) provide measures of transparency for 100 central bank using annual data for 1998–2006 that reflect IT's comparative strength. The 21 IT central bank in the world sample have raised their levels of transparency in all five dimensions during a short time span (Fig. 6). IT central bank display higher levels of overall transparency compared to central bank that have in place exchange-rate targets, monetary targets or other monetary regimes, and the differences between ITers and NITers have increased over time (Fig. 7).

The results by Geraats (2009) for up to 2006 are confirmed by the transparency data published by Dincer and Eichengreen (2014) for 2010: transparency is highest among IT central bank (Table 3). In fact, the 11 most transparent central bank in the world are those of the 11 countries that comprise the universe of AEs that practice IT today.

Transparency is a key component of accountability of independent central bank. With independence of monetary institutions led by unelected government officials comes their duty to account for their decisions about policy regimes and policy

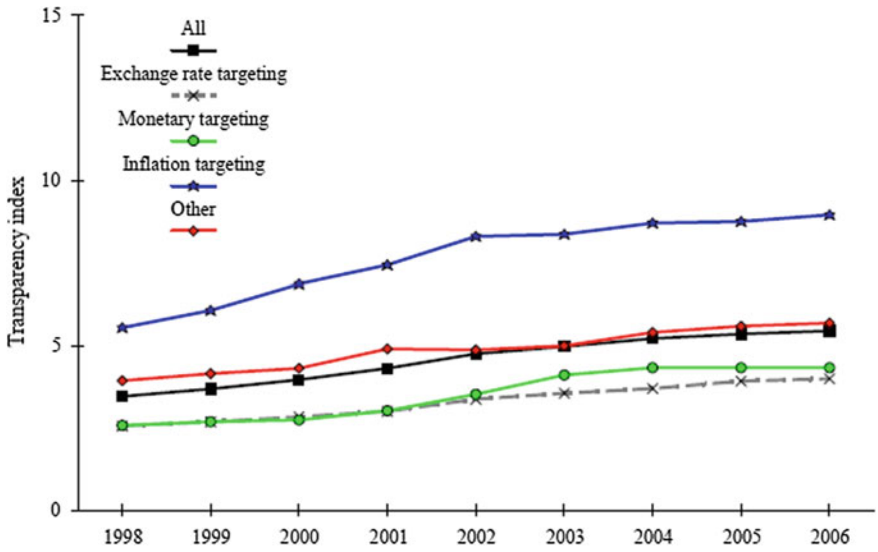

Fig. 7 Average central bank transparency by monetary policy regimes, 1998–2006. *Note* central bank are classified according to their monetary policy regimes: exchange rate targeting, monetary targeting, inflation targeting, and other. *Source* Geraats (2009)

decisions. Central bank accountability goes beyond transparency. In addition to providing public access to all relevant policy inputs and outputs on their web pages, central bank are required to satisfy formal acts of accountability. Such acts include regular parliamentary hearings, press releases or press conferences after policy decisions are made, publication of minutes of policy meetings, publication of votes by policy committee members, and publication of regular inflation or monetary policy reports. Many IT central bank lead the world in most of the previous measures of transparency and accountability.

Table 2 lists two important measures of transparency and accountability for the world's 36 IT central bank in 2015. These selective measures show some variance across ITers. On transparency, the minutes of monetary policymaking meetings are published by 75 % of all ITers; 9 IT central bank do not publish them. On accountability, 28 IT central bank do appear before parliament to provide testimony on monetary policy; 8 do not. All 36 IT countries publish regular inflation reports.

We conclude from this evidence that IT central bank overall do not satisfy high standards regarding legal and statutory independence, compared to other central bank. However, most of them represent the world's highest standards regarding transparency and accountability.

3.2 Targets and Inflation Deviations from Targets

Inflation target mid-points among the 36 ITers range from 2 % in most AEs to 5 % or above in several EMDEs (Table 2). This cross-country variation reflects a combination of country-specific features, as illustrated by the history of targets set by 27 IT countries until 2013 (Figs. 8 and 9). First, as noted above, among

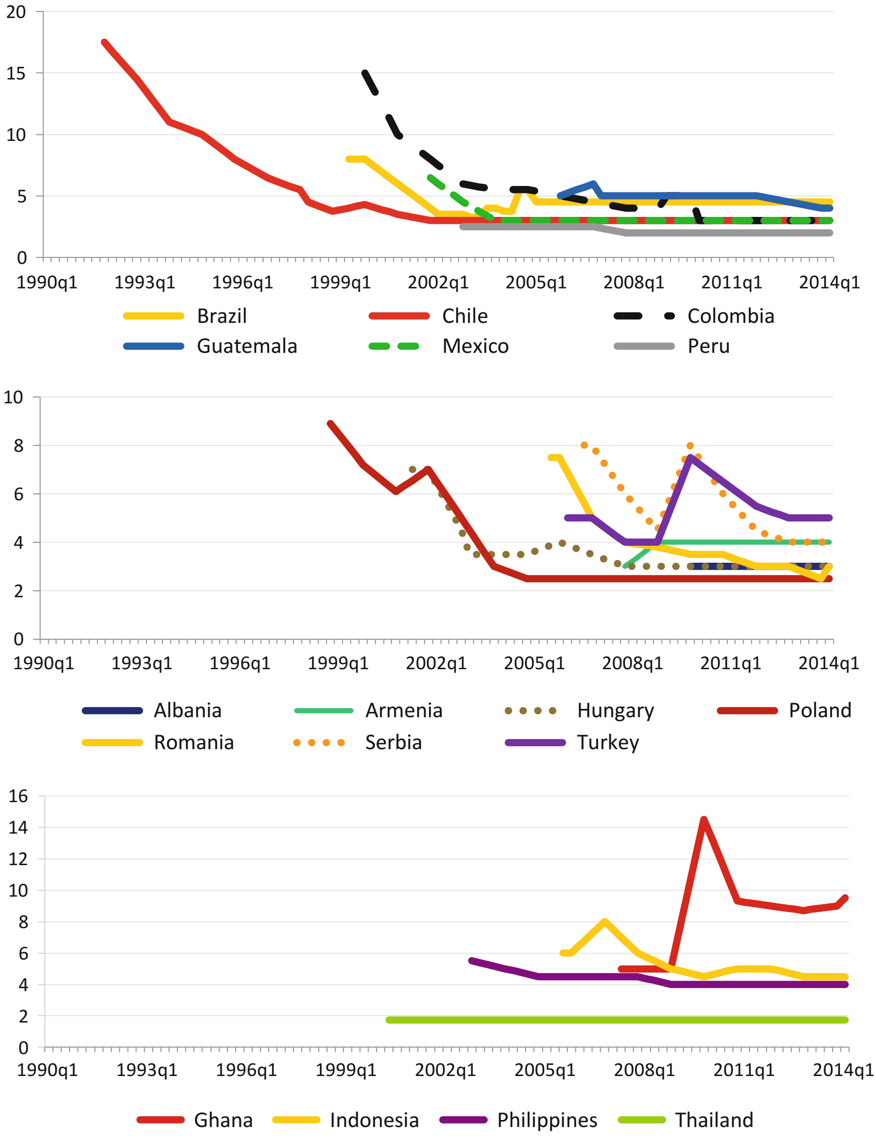

Fig. 8 History of inflation targets in 17 IT emerging and developing economies, from IT Start to 2014. *Source* Authors' calculations

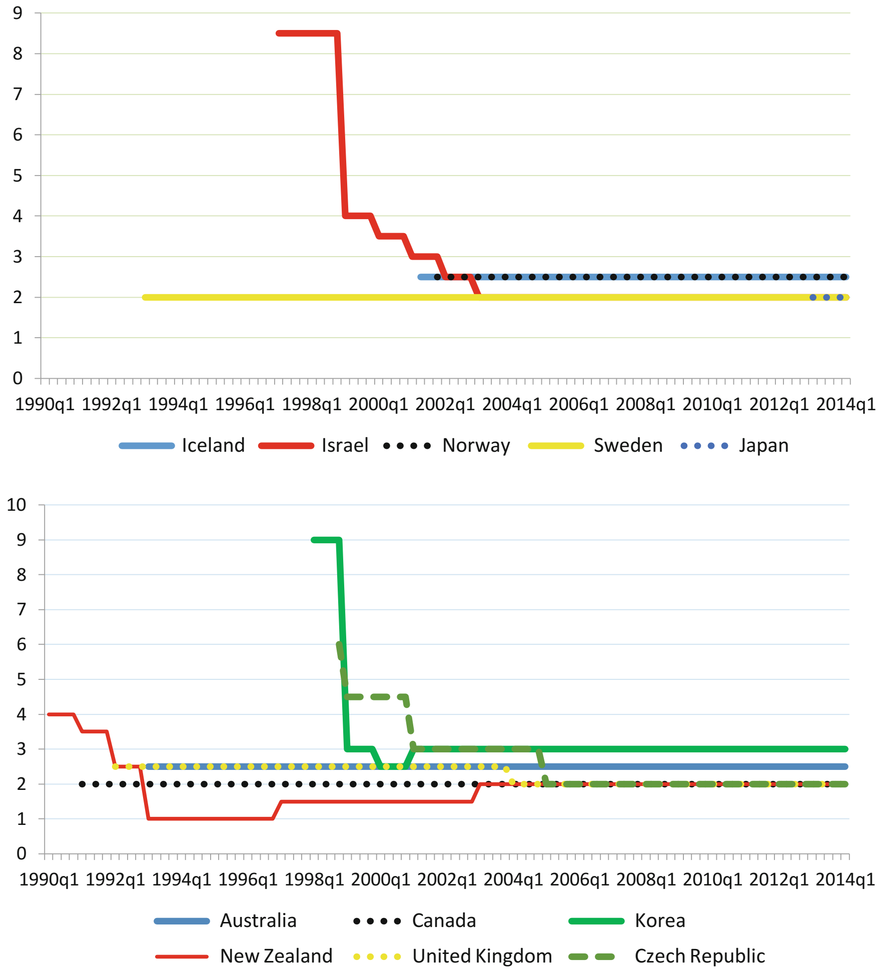

Fig. 9 History of inflation targets in 11 IT advanced economies, from IT Start to 2014. *Source* Authors' calculations

countries with stationary targets, target levels are slightly higher in EMDEs than in AEs. Second, some countries modified their already low targets shortly after starting IT (Peru, UK). Third, as of 2015, circa 12 EMDEs are on their convergence toward lower stationary targets—particularly those that have adopted IT in recent years. Finally, several EMDEs adjusted upwards their target levels in response to the large inflation shocks in 2007–2008 (Ghana, Serbia, Turkey). We conclude that cross-country target variance is much smaller in 2015 than one or two decades ago. Over time most ITers converge toward target mid-points in the range of 2–3 %.

There is a large dispersion of quarterly inflation deviations from target levels in 27 countries in 1990–2013, both across countries and over time. World inflation shocks in 2006–2007 and their subsequent reversion during the 2008–2009 Global Financial Crisis cause large inflation deviations that are common to most ITers. Idiosyncratic country shocks and recessions show up in large inflation deviations in particular country episodes (including Korea 1999, Brazil 2003, Indonesia 2005, and Iceland 2009).

As a summary indicator of deviations, we compute the country average absolute deviation from the quarterly inflation rate deviations from target levels for 28 IT countries, depicted from their corresponding IT start through 2014 (Figs. 10 and 11).

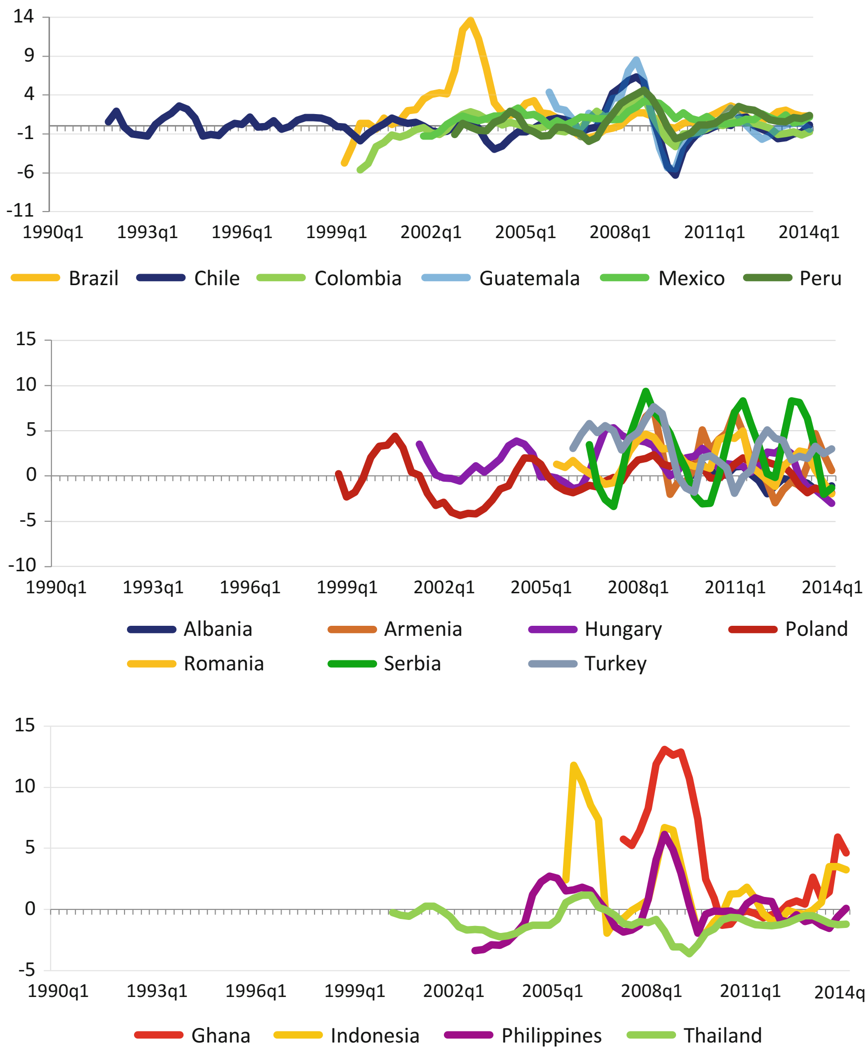

Fig. 10 History of inflation deviations from targets in 17 IT emerging and developing economies, from IT Start to 2014. *Source* Authors' calculations

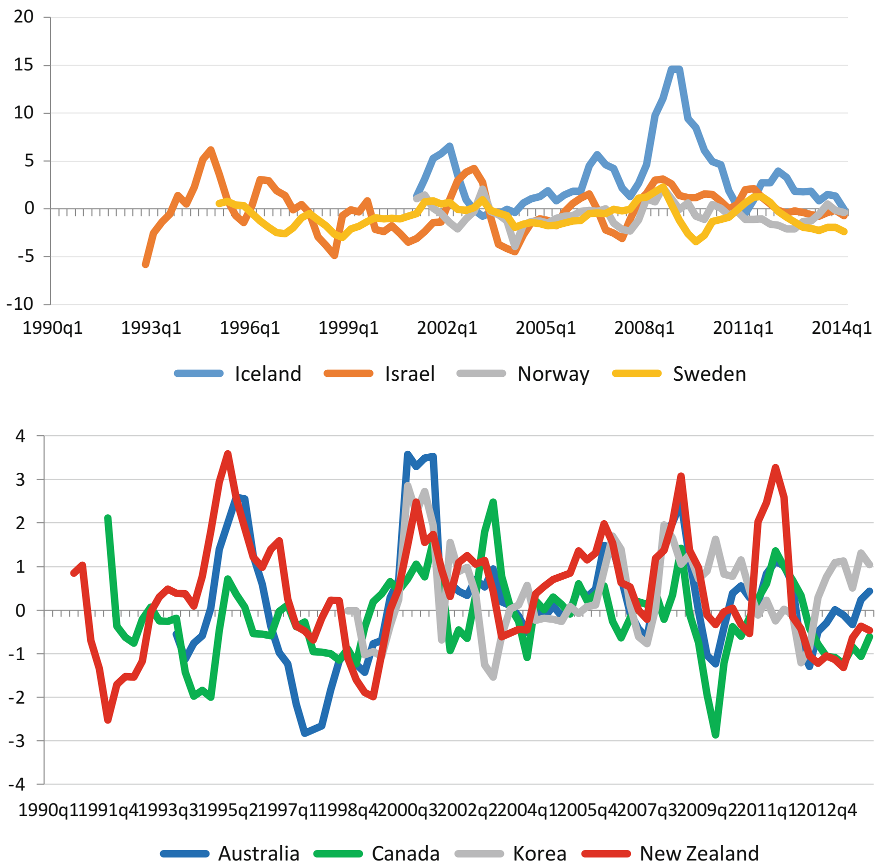

Fig. 11 History of inflation deviations from targets in eight IT advanced economies, from IT Start to 2014. *Source* Authors' calculations

Average absolute deviations range across countries from a low of 0.8 % to a high of 4.3 %. Inflation deviations from targets tend to be larger in countries more sensitive to inflation shocks and where average inflation and target levels are higher. The average absolute inflation deviation from target levels over the full IT period is 2.09 % in EMDEs, which (unsurprisingly) is significantly higher than the average 1.34 % observed in AEs (Fig. 12).

Note that the average absolute inflation deviation across all EMDEs includes many country experiences of higher inflation targets and inflation rates than those of AEs. Moreover, considering the lags in monetary transmission, the need of weighting inflation and output in the policymaker's objective function under flexible IT, and the standard length of the monetary policy horizon (typically 2–3 years, which exceeds significantly the 1-year horizon of annual targets), it is remarkable

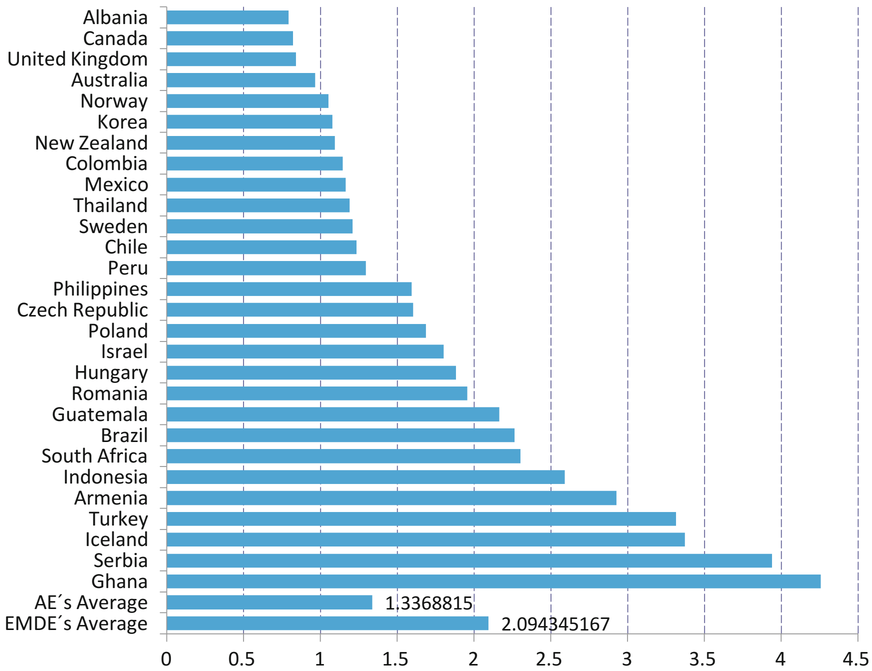

Fig. 12 Average absolute inflation deviations from targets in 28 inflation-targeting countries, from IT Start to 2013. *Source* Authors' calculations

how successful many inflation-transition ITers are in their convergence to low stationary targets and inflation levels.

Panel data evidence on the determinants of absolute inflation deviations from inflation targets shows that, controlling for oil price and exchange rate shocks, deviations are smaller when central bank independence is higher and the country's credit rating is higher (Albagli and Schmidt-Hebbel 2008). Central bank independence and country credit ratings are likely to contribute to a better anchoring of inflation expectations, hence lowering inflation deviations from targets.

3.3 Monetary Policy Conduct and Policy Rules

ITers are not inflation nutters. However, do ITers put a larger weight on inflation than on output (or financial variables) in the conduct of monetary policy?

Cecchetti and Ehrmann (1999) address this question, based on a model that derives a Taylor-type policy function from a central bank objective function that minimizes losses from inflation and output deviations. Using data from 23 countries from the 1980s and 1990s (nine of which became ITers in the 1990s), the authors test if their central bank became more averse to inflation volatility. Their evidence shows that in all countries, whether they targeted inflation or not, aversion to inflation variability increased during the decade of the 1990s, which is consistent with the world's Great Moderation period. The nine ITers became significantly more averse to inflation volatility after they adopted IT and their aversion increased by more than that of NITers.

More recent evidence reported by Bleich et al. (2012) shows that the introduction of IT has significantly shifted reaction functions of central bank toward inflation stabilization.

Muñoz and Schmidt-Hebbel (2013) specify a generalized Taylor equation that nests backward- and forward-looking inflation and activity variables in setting policy rates. The model is applied to a world panel of real-time monthly 1994–2011 data for 28 advanced and emerging economies, of which 20 are ITers. The evidence for 2002–2011 shows that IT central bank react both to past inflation and to inflation forecasts and the reaction to inflation forecasts is almost four times as large as to past inflation (Table 4). In contrast, NITers do not react to past inflation and

Table 4 Monetary policy in inflation and non-inflation targeting countries, 1994–2011 and 2002–2011. Dependent variable: Monetary policy rate. Estimation methods: Instrumental variable fixed effects. Sample: 1994–2011 (monthly data)

Sample dependent variable variables	(1)	(2)	(3)	(4)
	IT countries		Non-IT countries	
	1994–2011	2002–2011	1994–2011	2002–2011
	mpr_t			
mpr_{t-1}	0.953***	0.956***	0.964***	0.944***
	(0.006)	(0.007)	(0.008)	(0.013)
$Inflation_{t-3,\ t-1}$	0.018***	0.013***	0.005*	0.003
	(0.003)	(0.003)	(0.003)	(0.002)
$Unemployment_{t-4,\ t-2}$	−0.024***	−0.024***	−0.005	−0.004
	(0.006)	(0.008)	(0.004)	(0.004)
Inflation $forec_{t,\ t+11}$	0.023**	0.050***	0.034**	0.035**
	(0.009)	(0.013)	(0.016)	(0.017)
GDP growth $forec_{t,\ t+11}$	0.001	−0.006	0.029***	0.034***
	(0.009)	(0.010)	(0.010)	(0.011)
Observations	2,668	2,153	1,275	895
Number of countries	20	20	8	8
Country Fe	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes

We instrument the lag of monetary policy with two lags of monetary policy rate, quarterly inflation, and unemployment

Heteroscedastic and autocorrelated (AR-1) robust standard errors in parenthesis

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source Muñoz and Schmidt-Hebbel (2013) their reaction to inflation forecasts is weaker (with smaller and less significant coefficients) than that exhibited by ITers.

We conclude that IT central bank exhibit larger aversion to inflation volatility than NITers and react more aggressively to shocks of inflation and inflation forecasts than NIT central bank.

3.4 Inflation Levels, Inflation Volatility, and Growth

Does adoption of IT reduce average long-term inflation rates? Committing to an explicit inflation target could signal central bank' stronger preference for lower inflation, compared to central bank that adopt alternative monetary regimes. What does the evidence show? The answer depends critically on the selection of the empirical model used to address this issue and the country composition of treatment and control groups.

We review results from 9 studies that estimate inflation differences between IT and NIT countries (Table 5).[6] Eight are based on inflation regressions that test for IT regime dummies using OLS cross-section, propensity matching score methods or panel IV methods, using very different control and treatment groups. Ball and Sheridan find no significant inflation differences in a small cross-section sample comprised only by AEs. Many other studies find that IT has reduced long-term inflation rates.

The point that the results depend critically on the choice of estimation method and composition of treatment and control groups is forcefully made by Mishkin and Schmidt-Hebbel (2007). To start, using a cross-section sample of AEs that is larger than Ball and Sheridan's, Mishkin and Schmidt-Hebbel find that long-term inflation is 1.2 % higher in IT than in NIT countries. However, when the time dimension is considered in the previous sample, by applying a panel IV model, these authors report that the inflation difference between IT and NIT countries is not different from zero. Quite a different result is obtained when comparing pre-IT and post-IT inflation rates of 21 ITers: their average reduction in long-term inflation is 5.0 %.

One study uses a structural dynamic model for inflation to identify the significance of an IT regime dummy, after controlling for 14 other inflation determinants, in a large panel sample (Calderón and Schmidt-Hebbel 2010). Results from several estimation methods show that long-term inflation rates are from 3 % to 6 % lower in 24 IT countries compared to a group of 73 NIT countries.

We conclude that there is systematic evidence that among EMDEs long-term inflation is lower in IT than in NIT countries. However, there is no conclusive

[6]Further studies include Wu (2004), who finds that IT significantly reduces inflation in a cross-section of 22 AEs. However, Willard (2006), using the same dataset as Wu, but different methods, finds only small and non-significant effects for AEs. Other studies, focusing only on EMDEs, find that the introduction of IT has reduced inflation rates, including Goncalves and Salles (2008), Biondi and Toneto (2008), Brito and Bystedt (2010), and Yamada (2013).

Table 5 Effects of inflation targeting on long-term inflation levels in different country groups, 9 studies

Authors	Sample: treatment group; control group	Estimation method	Difference in long-term inflation rate
Ball and Sheridan (2005)	AEs: 7 IT; 13 NIT	Cross-section OLS	Zero
Vega and Winkelried (2005)	World: 23 IT; 86 NIT	Propensity score matching	–2.6 to −4.8 %
IMF (2005)	EMDEs: 13 IT; 22 NIT	Cross-section OLS	−4.8 %
Mishkin and Schmidt-Hebbel (2007)	21 IT; 13 NIT AEs	Cross-section OLS	+1.20 %
	21 IT; 13 NIT AEs	IV Panel	Zero
	21 post-IT; 21 pre-IT	IV Panel	−5.0 %
	Stationary IT; 13 NIT AEs	IV Panel	Zero
Batini and Laxton (2007)	21 IT; 29 NIT	Cross-section OLS	−4.8 %
Lin and Ye (2007)	AEs: 7 IT	Propensity score matching	Zero
Gemayel et al. (2011)	EMDEs: 10 IT; 29 NIT	Cross-section OLS Various panels	−3 % −2 to −3 %
Calderón and Schmidt-Hebbel (2010)	World: 24 IT; 73 NIT	Multi-variate structural inflation model; Panel Models: Fixed Effects, Random Effects, and System GMM	−3 to −6 %
Samarina et al. (2014)	25 AEs and 59 EMDEs	Propensity score matching	Zero for AEs and negative for EMDEs

Notes The second column identifies the number of countries in the treatment group comprised by inflation targeting (IT) countries and in the control group comprised by either non-inflation targeting (NIT) or IT countries. The column also identifies the full or partial samples as corresponding to the world, advanced economies (AE) or emerging/developing economies (EMDE). The last column reports the long-term inflation rate differences are those of the treatment groups compared to the control groups; values are statistically different from zero, and zero means statistically not different from zero
Source Authors' calculations

evidence that long-term inflation levels are lower in IT countries compared to samples comprised by AEs that do not target inflation. This does not contradict the finding that compared to the pre-IT period, ITers attained lower inflation rates after adopting IT. However, similar stabilization progress was achieved by NIT AEs after 1990, during the Great Moderation period.

Empirical studies on the effects of IT on inflation volatility are less conclusive. For world samples, Vega and Winkelried (2005) report significant results. However, Lin and Ye (2007) and Mishkin and Schmidt-Hebbel (2007) do not find any significant effects of IT on inflation volatility. Regarding EMDEs alone, and as opposed to the findings on inflation levels, IT is found to have no robust effects on inflation volatility. Vega and Winkelried (2005), Batini and Laxton (2007), and Lin and Ye (2007) show that IT reduces inflation volatility in EMDEs, while Mishkin and Schmidt-Hebbel (2007), Goncalves and Salles (2008), and Brito and Bystedt (2010) report non-significant effects. The bottom line here is that IT does not affect inflation volatility robustly—neither in AEs nor in EMDEs.

The impact of IT on the real economy is even less conclusive, for AEs and EMDEs alike. Brito and Bystedt (2010) is the only study reporting a negative significant effect of IT on growth, which the authors attribute to their associated finding that IT has lowered inflation. In contrast to the former, Naqvi and Rizvo (2009) report non-significant effects of IT on growth. On output volatility, Goncalves and Salles (2008) report a negative effect of IT. However, Batini and Laxton (2007) and Mishkin and Schmidt-Hebbel (2007) report non-significant effects of IT on growth volatility.

Summing up, the world evidence suggests that the introduction of IT has not changed significantly macroeconomic performance in AEs, measured by first and second moments of inflation and output. However, IT has helped in reducing inflation significantly in EMDEs, both in comparison to their own pre-IT history and to NIT EMDEs. Yet there is no robust evidence that IT has contributed to lower inflation volatility or to changes in growth and output volatility in EMDEs.[7]

Hence the comparative advantage of IT is generally not reflected in improved first and second moments of inflation and output but in other dimensions of monetary policy and its efficiency, which are discussed below.

3.5 Anchoring Inflation Expectations

One of the main potential strengths of IT, relative to other monetary regimes, is that an explicit target for inflation could better anchor expectations and forecasts of future inflation. Expectations of future inflation at the monetary policy horizon—around 2 years—that are close to the inflation target and relatively insensitive to transitory shocks contribute to low and stable actual inflation. What does the evidence say about the stability of inflation expectations in IT countries, compared to non-IT countries?

Johnson (2002) reports that IT countries have lowered inflation expectations compared to their pre-IT periods. Castelnuovo et al. (2003) find that long-term inflation expectations are well-anchored in all AEs, ITers and NITers, except Japan. Both Levin et al. (2004) and Demertzis et al. (2009) find that IT has contributed significantly to anchor inflation expectations. Cecchetti and Hakkio (2010) report

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[7]This conclusion on the effect of IT on output volatility is in contrast to Svensson's (2010) earlier review of the literature, where he reports that IT has reduced output volatility in both AEs and EMDEs.

only small effects of IT on stabilizing inflation expectations. Gürkaynak et al. (2010) provide evidence that an explicit and credible inflation target helps to anchor the private sector's views regarding the distribution of long-run inflation outcomes.

How does IT affect inflation expectations in EMDEs? This question is particularly relevant for EMDEs that adopt IT as a stabilization tool, embarking on a path of declining inflation targets toward the medium term goal of attaining low and stationary target and inflation levels. Early evidence by Schmidt-Hebbel and Werner (2002) for Brazil, Chile, and Mexico on their initial IT years (mostly including IT transition periods with variable yearly targets) shows that IT adoption contributed significantly in stabilizing inflation expectations, both regarding expectation levels and structure. While the weight of past inflation in determining inflation expectations fell gradually during the first years of IT, the weight of target levels increased. More recently, Capistran and Ramos-Francia (2010) show that, controlling for other factors, the dispersion of inflation forecasts in EMDEs is lower in IT countries than in NITers.

A related, key question is how sensitive inflation expectations are to news or shocks. Gürkaynak et al. (2010) and Davis (2014) report that expectations in IT countries react significantly less to shocks than expectations in NIT countries.

In the current policy environment of several industrial countries, where inflation is very low, a relevant issue is about the behavior of expectations when targeting inflation from below. Ehrmann (2015) reports that under persistently low inflation, inflation expectations are not as well-anchored as when inflation is around target. Still, even under persistently low inflation, the author concludes that in the IT country group identified by him, expectations are generally better anchored than they were in Japan over its long period of low inflation.[8]

From this evidence we conclude that IT has generally contributed to a better anchoring of inflation expectations than other monetary regimes. This is true for all IT countries but is particularly strong for EMDE ITers.

3.6 Monetary Policy Effectiveness: Policy Efficiency Frontiers

Performance of monetary policy can be assessed using the inflation and output variability trade-off faced by the policymaker. This trade-off allows to construct an efficiency frontier, also known as the Taylor curve (Taylor 1979). The inflation-output variability frontier is understood by considering an economy that is hit by two types of disturbances: aggregate demand and aggregate supply shocks.

[8]Ehrmann's panel of 10 advanced countries/regions includes three important economies that are not conventionally classified as ITers (and therefore are also excluded from our set of 36 IT countries): the Euro Zone, Switzerland, and the U.S. It is likely that these three economies suffer more from persistently weak inflation than the other 7 IT countries. Therefore it is possible that the author's reported better anchoring of expectations in IT countries is under-estimated.

Aggregate supply shocks move output and inflation in opposite directions, forcing the monetary authority to face a trade-off between inflation and output variability. Cecchetti et al. (2006) develop a model to derive the monetary policy efficiency frontier and the distance from actual macroeconomic performance to the frontier, applied to 24 individual countries.

Mishkin and Schmidt-Hebbel (2007) apply the method of Cecchetti et al. (2006) to estimate monetary policy efficiency frontiers for different panels of countries: ITers before IT adoption, ITers after IT adoption, and a stringent control group of NITers comprised by 13 macroeconomic high-performing AEs (including the U.S., the Euro Zone, and Japan). Their results show that efficiency frontiers have significantly improved (i.e., shifted inwards) after IT adoption, both among all ITers and among stationary ITers—and gains are larger under stationary IT. In addition, actual macroeconomic performance has significantly improved after IT adoption and the distance between actual performance and the efficiency frontier has declined, reflecting gains in monetary policy efficiency. Again, these gains are larger when countries have attained stationary inflation and target levels. The relative gains are large among AEs (Fig. 13) and even larger among EMDEs (Fig. 14). Unsurprisingly, the efficiency frontier of AEs is positioned significantly

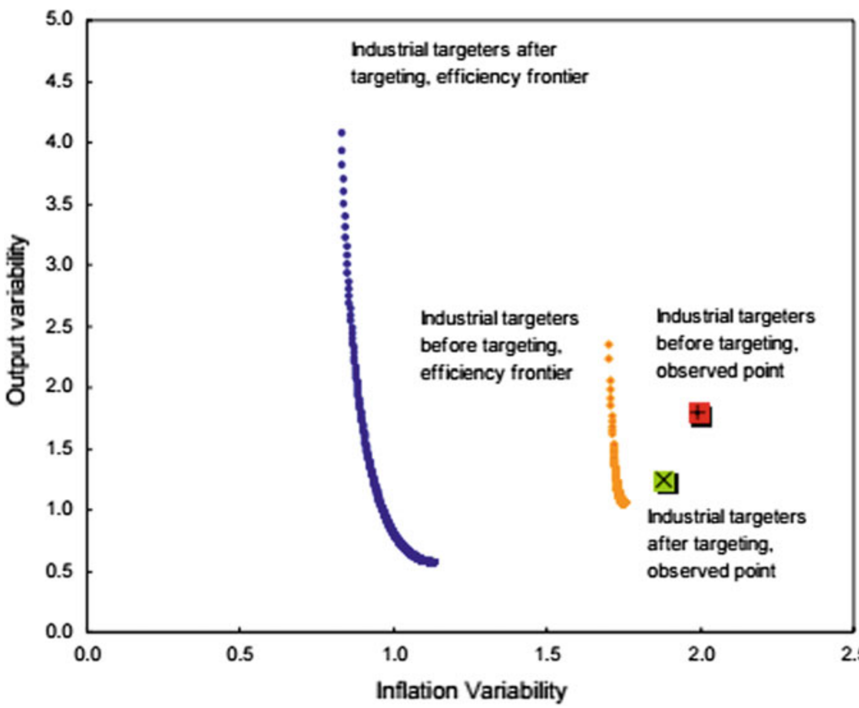

Fig. 13 Monetary policy efficiency frontiers and observed macroeconomic performance points in AE Targeters before IT and since starting IT until 2004. *Source* Mishkin and Schmidt-Hebbel (2007)

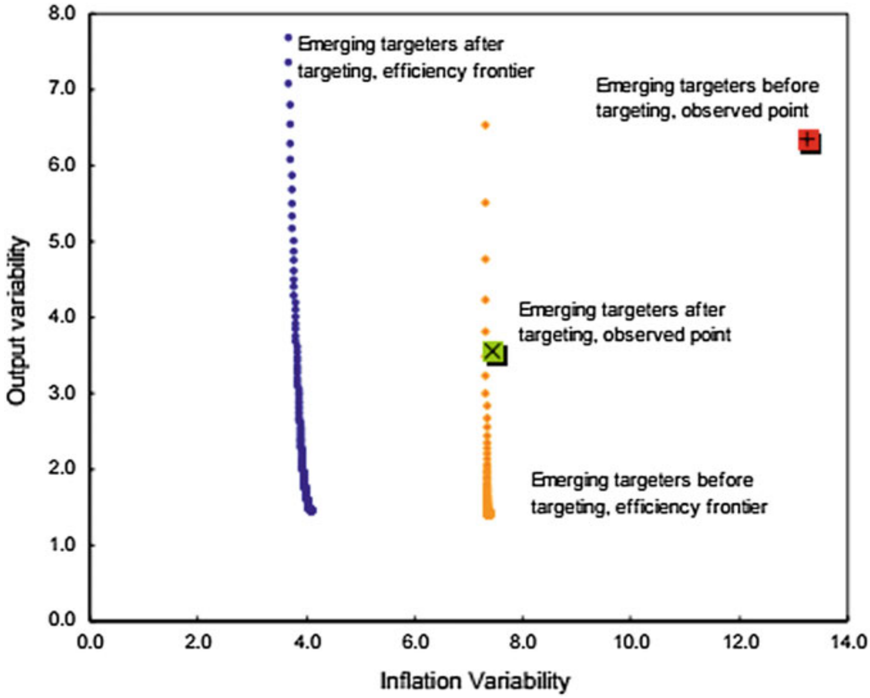

Fig. 14 Monetary policy efficiency Frontiers and observed macroeconomic performance points in EMDE targeters before IT and since starting IT until 2004. *Source* Mishkin and Schmidt-Hebbel (2007)

more inward, and their observed inflation and output variability is significantly less, than in EMDEs (comparing Figs. 13 and 14).

4 IT Under Stress: Before, During, and Since the Global Financial Crisis

Until the mid-2000s, it was argued that IT had not been tested yet and that it could fail in the face of a major inflation shock or a deep recession. In particular, IT was often seen as free-riding on the benefits of the two preceding decades labeled as the Great Moderation Era, during which most countries in the world—with or without IT—experienced large and sustained reductions in trend inflation and the volatility of both inflation and output.

Soon after, IT (as well as all other monetary regimes) was first tested by the huge oil and food price shock of 2007–2008. The second test was the Global Financial Crisis and Great Recession of 2008–2009. In the following I review how IT fared under both tests and review a related issue: if IT central bank exhibit financial stability concerns when setting policy rates.

4.1 The Oil and Food Price Shock of 2007–2008

The international commodity price boom was reflected in surging food and energy prices in 2007–2008, reverting briefly in 2008–2009. As a result, average headline inflation roughly doubled in the first half of 2008, to 4 % in AEs and 9 % in EMDEs. Although inflation targets were overshot in IT countries, headline inflation generally increased by less than in NIT countries (Habermeier et al. 2009). This result is attributed to more currency appreciation (under more flexible exchange-rate regimes in IT countries) and higher degrees of central bank transparency, leading to higher policy credibility and more stable inflation in IT countries.

4.2 The Global Financial Crisis

The second test to IT in the world was the GFC and subsequent Great Recession of 2008–2009. It first brought a temporary reversal of the 2007–2008 commodity price shock, compounded by the most serious financial crisis and deepest recession since the Great Depression. Monetary authorities in advanced countries and regions—particularly in those most affected by the GFC, including the US, UK, Euro Zone, and Japan—reacted quickly by reducing interest rates toward the zero lower bound and starting quantitative easing measures that expanded domestic liquidity and central bank balance sheets in unprecedented ways and amounts. Monetary policy measures where complemented by financial rescue programs targeted at all financial institutions after Lehman Brothers' failure and by expansionary fiscal policies. Financial-sector interventions and expansionary macroeconomic policies in crisis-hit AEs were conducted at a speed, intensity, and international synchronicity that is historically unprecedented. Monetary and fiscal policies Other AEs and EMDEs, not directly affected by financial crises, also adopted expansionary macroeconomic policies, in reaction to the meltdown in private aggregate demand and the deep recession in crisis-affected countries.

How did IT countries cope during the tail event that hit the world economy between August 2008 and 2009–2010, compared to NIT countries? ITers lowered policy rates by more and this translated into larger real interest rate differentials than in NITers (De Carvalho Filho 2010). This implied that ITers were less likely to face deflation scares, saw sharper real depreciations, and had lower unemployment rates than NITers. Among AEs, ITers exhibited relatively stronger growth performance than NITers. Roger (2009) also finds that macroeconomic forecasts were less affected by the financial crisis in ITers, compared to NITers.

In more recent work, Fry-McKibbin and Wang (2014) test the performance of ITers during the 2007–2012 downturn compared to NITers, and separately for AEs and EMDEs. Using propensity score methods, the authors show that IT has worked better for AEs: during this period, inflation and GDP growth were found to be higher and unemployment lower in the treatment group of 10 ITers in comparison to the control group of 21 NITers. However, for EMDEs (18 ITers, 42 NITers), and during this period, no significant differences were found regarding inflation and growth performance, while unemployment was (surprisingly) larger in IT countries.[9]

Therefore IT economies, and in particular AEs under IT, performed generally better in the crisis than economies under other monetary regimes. IT central bank adopted a more aggressive monetary response to the crisis, their economies had a better inflation and output performance, and they exhibited more stable macroeconomic forecasts during the crisis.

4.3 Inflation Targeting and Financial Stability

The GFC has implied a quantum shift in the conduct of monetary policy in both IT and NIT countries. The breakdown of financial markets and market liquidity, the deep ensuing recession, and the attainment of the zero lower bound in several AEs forced their central bank to develop and implement very quickly quite extraordinary measures of financial market support and monetization, based on quantitative easing and massive balance-sheet expansion. While much of the action has taken place in countries and regions that are not ITers (in particular, the U.S. and the euro zone) some IT countries have also implemented important non-orthodox policies of quantitative easing (including the U.K., Sweden, and Japan, an ITer since 2013). At the same time, a new macro-prudential framework is developing at the level of individual countries and multilaterally, under regulation agreed under the aegis of the BIS (Basle III).

Quantitative easing and macro-prudential regulation are toolkits that affect the conduct of both monetary policy and macro-prudential policies of central bank, relatively independently of their choice of monetary regime—IT or otherwise. However, a particular question on the relation between monetary policy and financial stability arises here. Do central bank react to financial variables, in addition to inflation and output variability? And do IT central bank react to financial variables too?

Muñoz and Schmidt-Hebbel (2012) address these questions by adding three financial variables to their generalized Taylor equation. These are exchange-rate devaluation (reflecting possible fear of floating and fear of pass-through), the

[9]The authors also report that fiscal outcomes (deficit and debt levels) were stronger for both AE and EMDE ITers, compared to NITers, during the 2007–2012 period.

change in stock market prices (signaling possible bubbles), and the growth in bank credit to the private sector (indicating possible overheating), to test for leaning-against-the-wind policy behavior that reflects concern for financial stability.

Using real-time data for a world panel of monthly data extending from 1994 to 2011 and comprising 28 AEs and EMDEs, a dynamic error-correction panel-data model is applied to the model. The authors report that central bank generally react to the exchange rate and to credit flows, in addition to inflation and output shocks—both in the full sample of 28 countries and in the sub-sample of IT countries. This confirms that IT central bankers do not behave differently from NIT central bank in their concern and reactions to financial stability objectives when setting policy rates.

5 Lessons for the Future of Inflation Targeting in EMDEs

What are the main lessons for IT in EMDEs? Considering the lessons, which are the main challenges for the future of IT in EMDEs and, in particular, in lower income countries?

5.1 Lessons from the World Experience of IT in EMDEs

EMDEs in general, and lower income countries in particular, exhibit lower levels of institutional development and macroeconomic stability than AEs. This weakens there capability of adopting IT. In fact, per capita income—as a proxy of the latter variables—has been found to be a significant determinant of the likelihood of having IT in place.

For many years it was thought that for IT to work successfully, stringent pre-conditions had to be satisfied. Batini and Laxton's (2007) results laid this belief to rest, by showing that pre-conditions are only satisfied in part (and, in many cases, to a poor degree) by all countries at the time they adopted IT. In fact, all IT countries continued strengthening gradually their institutional and macroeconomic conditions after adopting IT.

This is very good news for EMDEs and, in particular, for lower income countries, who may consider adopting IT before or while they are strengthening their central bank, the conduct of monetary policy, and their macroeconomic performance. In fact, since 2002 half of the new adopters of IT belong to the group of low and lower middle-income countries (according to the World Bank 2016 classification): Armenia, Georgia, Ghana, Guatemala, India, Indonesia, Moldova, Philippines, and Uganda.

Many EMDEs have adopted IT at moderate initial inflation rates that exceed 3 % (Fig. 5). They have used—or are using—the new monetary regime as an inflation stabilization tool that represents a commitment device for their central bank and a nominal anchor to influence inflation expectations. Often this implies setting annual or multi-annual targets on a declining schedule toward low and stationary target and inflation levels. Many central bank practice initially partial IT, which includes adopting an exchange-rate target in addition to the inflation target (e.g., Chile, Colombia, and Israel in the 1990s) or intervene heavily in foreign exchange markets to stabilize their currency even without committing to an explicit exchange-rate target (e.g., Colombia, Brazil, and Peru). However, transition periods under partial IT are risky. Therefore, several partial and converging EMDEs have graduated to full-fledged IT, adopting a free floating exchange rate and committing to a low and constant target level. Among EMDEs stationary targets are on average close to 3 %, slightly above the average stationary target of 2 % in AEs.

Using descriptive data, we found that the average absolute inflation deviation from target levels over the full IT period in 28 IT countries is 2.1 % in EMDEs, which is higher than the average 1.3 % observed in AEs. Considering that IT periods include transition periods of high and variable inflation target levels and inflation rates, the average inflation deviation in EMDEs is surprisingly low. This represents significant success of IT in EMDEs, contributing to its appeal to low and middle-income countries, which are often affected by large inflation shocks.

A large number of studies have documented the fact that IT has contributed to reduce significantly long-term inflation rates in EMDEs, both in comparison to their own pre-IT history and to NIT EMDEs. This means that IT has been a successful stabilization device for countries with higher inflation rates. Yet there is no robust evidence that IT has contributed to reduce inflation volatility or to change growth and output volatility in EMDEs.

There is also systematic evidence documenting hat IT has contributed to a better anchoring of inflation expectations in EMDEs than other monetary regimes. Compared to NITers, IT has been found that to reduce inflation expectations and change the structure of inflation expectations toward inflation target levels. Under IT the sensitivity of inflation expectations to shocks is significantly smaller than in NIT countries.

Evidence on monetary policy efficiency shows large gains for EMDEs under IT. After IT adoption, policy efficiency frontiers have shifted significantly toward lower combinations of inflation and output volatility, and the distance between actual performance and the efficiency frontier has declined, reflecting significant improvements in monetary policy efficiency.

5.2 Challenges for the Future of IT in EMDEs

All IT central bank face significant challenges that have to they should addressed if they aim at improving further their macroeconomic performance and monetary policy efficiency. However, IT is significantly more challenging for central bank in EMDEs—and particularly in lower income EMDEs—than in AEs, due to several reasons.

First, institutional conditions at central bank are weaker in countries with generally less developed institutions and at lower levels of development. This hampers the capacity of central bank to satisfy supporting conditions for successful IT, including lack of legal independence, weaker internal technical capabilities, and weaker domestic financial markets to conduct open-market operations. Second, domestic inflation responds more weakly to monetary policy actions due to less developed financial markets several structural features in EMDEs, particularly those at lower levels of income. Third, goods and labor markets often work less efficiently and flexibly, so that domestic inflation is less responsive to monetary policy actions. Fourth, commodity price shocks (in particular food price shocks) have a larger impact on inflation because the CPI weight of food is larger. Finally, exchange rate volatility is higher in EMDEs, and large exchange rate shocks are reflected in higher domestic inflation variability because devaluation to inflation pass-through coefficients are higher in EMDEs.

The first challenge is for EMDEs that are considering IT adoption. They have to evaluate if they satisfy minimum standards of conditions in each of four broad categories for successful IT (Batini and Laxton 2007): central bank institutional independence, central bank technical infrastructure, economic structure, and financial system development and health. Among the latter, important conditions that enhance the start of IT are: a reasonable degree of functioning monetary transmission, operational independence in the conduct of monetary policy, and absence of commitment to a particular level of the exchange rate (Gemayel et al. 2011). Even if conditions are rather poorly satisfied, IT could be started, as long as central bank commit to a feasible program to upgrade conditions over the medium term.

The second challenge of central bank that are prospective IT adopters or have started IT is to show and to prove a strong commitment to inflation as their dominant policy objective. An empirical result of IT—and possibly one of the key reasons for its success—is that IT central bank exhibit larger aversion to inflation volatility than NITers and react more aggressively to shocks of inflation and inflation forecasts than NIT central bank.

The third challenge is for those EMDEs that have adopted IT but are on a convergence path toward lower inflation and/or are partial ITers (for example, because they have an explicit or an implicit exchange rate target). As of 2015, half of the world's ITers—all of them EMDEs—have in place target level mid-points of 4 % or above (which are likely to be lowered toward lower stationary levels in the future) and many IT EMDEs intervene heavily in foreign exchange markets. Having in place two nominal anchors and variable annual inflation targets represents a straightjacket that often limits severely the conduct of monetary policy during the transition toward low stationary target and inflation levels. Therefore, transition periods toward full-fledged IT and stationary targets should be kept as short as possible.

A final challenge for ITers on a convergence path to low inflation is to avoid accommodation of positive inflation shocks by raising inflation target levels. Several EMDEs raised their target levels for a temporary period, most of them in response to the large commodity price shock of 2007–2008. Although the consequences of such actions have not been researched systematically, it seems that their costs (sacrifice of policy credibility and prolongation of adjustment period to low and stationary target levels) have exceeded their benefits (reduction of inflation deviations from targets).

Beyond these four challenges faced by IT EMDEs, we refer now to three final challenging issues faced by EMDEs and AEs alike.

Strengthening central bank independence, transparency, and accountability. Central bank laws are changed at very low frequency and therefore not many improvements in central bank independence should be expected in the following years. Yet central bank independence seems to be an important condition for the long-term success of monetary policy, in particular in EMDEs that have adopted IT. While generally IT central bank are at the forefront of transparency in the world community of central bank, most IT central bank face two key challenges to upgrade significantly their transparency: regular publication of their future policy rate forecasts and of key unobservable variables: potential GDP (and the output gap), the natural rate of unemployment, the neutral policy rate, and the equilibrium exchange rate.

Strengthening flexible IT. Compared to NIT central bank, the evidence shows that the weight on inflation is larger under IT. This result and the additional fact that the Phillips curve has flattened since the 1990s leads some observers to conclude that the inflation weight is sub-optimally high under IT, and therefore output should be weighted more heavily in the conduct or policy or that IT should be replaced by a dual mandate over inflation and unemployment like the one adopted by the US Federal Reserve. There are several ways to address this concern within the IT framework. The key one is flexible IT, as defined above, which distances itself strongly from rigid IT by acknowledging the weight attached to output volatility and the tolerance to temporary deviations from targets. Reinforcing this line of argument, it is sometimes argued that IT central bank should communicate more explicitly their concern for output stabilization (Woodford 2003; Svensson 2007), without stating unemployment target like the Federal Reserve does. Another way to reflect more concern for output variability is by lengthening the monetary policy horizon beyond the standard 2 years (Mishkin 2008; Gillitzer and Simon 2015). However, this option should be carefully evaluated against the potential cost of weakening policy credibility and un-anchoring inflation expectations when adopting a looser monetary policy stance consistent with a longer policy horizon.

Price-level targeting. There is some discussion on the optimality of targeting inflation compared to targeting the CPI price level. Svensson (1999) and Vestin (2006) were the first in evaluating the relative benefits of adopting price-level targeting (PLT). Its main advantage over IT is that inflation deviations from targets (from the targeted path of the price level) are not bygones, as they are under IT. In order to put the price level back on its target path, an inflation deviation has to be followed, through appropriate policy actions, by future inflation deviations of the opposite sign. This strength of PLT is particularly relevant under conditions of very low inflation or even deflation, such as those observed in several European countries since the Great Financial Crisis and in Japan since the early 1990s. As forward-looking agents anticipate monetary action that brings the price level back to its target path, and hence future inflation that compensates for current low inflation, the likelihood of deflation is lower under PLT than under IT and, when it occurs, the likelihood of getting sooner out of it is higher.[10] Therefore PLT could emerge as a variation of IT that could improve efficiency of the policy conduct and its macroeconomic outcome.

5.3 Inflation Targeting in Emerging-Market/Developing Economies

Against these odds, many central bank in EMDEs have successfully adopted IT since the 1990s. Although their policy transparency tends to be lower and their inflation deviations from targets are higher than in AEs (Figs. 10 and 9, respectively), they have been able to upgrade their policy framework and improved their inflation performance before and after adopting IT. It is encouraging that recent IT adopters include several low and middle-income EMDEs countries such as Albania (in 2009), Moldova (in 2010), Uganda (in 2012), Paraguay (in 2013), and India (in 2015).

6 Concluding Remarks

Inflation targeting (IT) was started by New Zealand in 1990 and has since spread to 35 other advanced and emerging/developing countries to date. Drawing from existing and new research, this paper has taken stock of IT's past performance, its current strengths and limitations, and its main challenges to remain the monetary regime of choice in the future.

Adopting and developing IT took many different forms but central bank gradually converged to a common policy framework after adopting IT. This framework itself continues evolving over time. Theoretical pre-conditions for IT were not in place when most central bank adopted IT but they have proven to be de facto post-conditions required for strengthening the IT framework over time. Empirical evidence points toward institutional and macroeconomic variables that raise the likelihood for countries to adopt IT and maintain this regime over time. Several EMDE ITers started with partial IT and at higher target and inflation levels, to converge only gradually to stationary target fully fledged IT. The IT framework

[10]Walsh (2009) reports counter-factual simulation results for the stabilizing effects of PLT on U.S. inflation expectations, if the Federal Reserve had implemented a PLT regime since the start of the Great Financial Crisis.

itself has evolved since its inception 25 years ago: today its transparency is much more developed, internal technical capacity at central bank has been developed, and strict IT has given way to flexible inflation targeting.

A selective review of the large evidence of macroeconomic and policy performance reveals key findings about the world's IT experience. Many of these findings apply more forcefully to EMDEs, which are 25 of the world's current 36 IT countries. IT central bank do not differ on average from NITers regarding overall independence—but they are world record holders regarding central bank transparency and accountability. Inflation target levels vary across ITers but, in the medium term, when stationary target levels are attained, the range of target levels is very narrow. Average inflation deviations from targets also vary across ITers and tend to be higher in EMDEs. IT central bank tend to be more hawkish: their policy actions reveal larger weights on inflation variability than those of NIT central bank. However, their commitment to flexible IT is reflected in tolerance bands around inflation target mid-points and to policy horizons that average 2 years into the future. Long-term inflation is not generally lower in IT countries, and similar results apply to other macroeconomic outcomes, including inflation volatility, output growth, and output volatility. Most evidence on inflation expectations points toward a better anchoring of expectations under IT than under other monetary arrangements. Monetary policy efficiency has improved under IT but the best-performing IT central bank do not dominate the best-performing NIT central bank.

The last decade presented the greatest challenges to IT: the commodity price shock of 2007–2008 and the Global Financial Crisis and its aftermath. Evidence shows that policy and macroeconomic performance has been better under IT. Other evidence also suggests that IT central bank react not only to inflation and output but also to financial variables—and to a similar degree as NIT central bank do—and this has been observed both before and after the Global Financial Crisis.

IT is significantly more challenging for central bank in EMDEs—and particularly in lower income EMDEs—than in AEs. However, against the odds, since 2002 half of the new adopters of IT belong to the group of low and lower middle-income countries, including India, the world's most recent IT adopter.

EMDEs, and lower income countries in particular, face several challenges when adopting IT. EMDEs that are considering IT adoption have to evaluate if they satisfy minimum standards of conditions in four broad categories for successful IT: central bank institutional independence, central bank technical infrastructure, economic structure, and financial development and health. If conditions are rather poorly satisfied at the start of IT, central bank should commit to a feasible program of upgrading conditions over the medium term. Prospective IT adopters or countries that started IT recently have to show a strong commitment to inflation as their dominant policy objective. Countries that are on a convergence path toward lower inflation and/or are partial ITers should keep their transition periods toward full-fledged IT and stationary targets as possible. During their transition period they should avoid accommodation of positive inflation shocks by raising inflation target levels.

Beyond these challenges faced by IT EMDEs, all IT countries—both EMDEs and AEs—face three additional challenges to strengthen their IT framework in the future: improving central bank independence, transparency, and accountability; strengthening flexible IT without giving up low inflation as the key policy mandate; and evaluating seriously adoption of price-level targeting.

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International Policy Coordination and Emerging-Market Economies

Barry Eichengreen

1 Introduction

Volatility causes strains, and the volatility associated with the global financial crisis was no exception. The crisis strained relations among monetary policymakers in advanced countries and emerging markets alike.

At first those relations developed harmoniously, as central banks and governments, all but irrespective of country, responded to the global crisis by cutting interest rates, injecting liquidity into financial markets, implementing unconventional monetary measures, and expanding fiscal policy. In addition, in 2008 the U.S. Federal Reserve extended currency swap lines to advanced-country central banks in need of dollar liquidity (the Bank of Canada, the Bank of Japan, the Bank of England, the Swiss National Bank, and the European Central Bank, among others) and in addition to the central banks of a quartet of emerging markets (Mexico, Brazil, Singapore, and South Korea). All this was viewed as a textbook example of successful international cooperation.

Starting in 2010, events then took a more fractious turn. A corollary of the aggressive balance sheet expansion by the Federal Reserve undertaken in response to a deep recession was sharp depreciation of the U.S. dollar against the currencies of emerging markets. The subsequent period saw a "tsunami" of capital flows from the U.S., where interest rates were low, to still-strongly-growing emerging markets, where they were high. A wide variety of economies, but most notably the BRICS countries—Brazil, Russia, India, China, and South Africa—were visibly affected.

For policymakers, the effects were not welcome. In September 2010, Brazilian finance minister Guido Mantega complained that America was engaged in a currency war. He suggested that the U.S. was attempting to push down the dollar in

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0_19

order to boost exports as a way of countering deficient domestic demand and complained that this beggar-thy-neighbor response worked to the detriment of America's trading partners. Brazilian president Dilma Rouseff echoed his complaint in the spring of 2012 and again on a visit to the White House later that year. The common implication was that the Fed was failing to take adequate account of the impact of its policies overseas and specifically on emerging-market economies. In so doing it was leaving global welfare gains on the table. It followed that policy would have been better had it been more systematically coordinated between the advanced countries, most notably the United States, on the one hand and emerging and developing countries on the other.

A second round of criticism then followed in the summer of 2013 after U.S. Federal Reserve chair Ben Bernanke unexpectedly suggested that the U.S. might soon begin "tapering" its purchases of government and mortgage-backed securities. Given the prospect of an increase in U.S. interest rates sooner than expected previously, capital flows reversed direction. Exchange rates and equity prices fell in emerging markets, and bond spreads jumped. These events forced hard adjustments on emerging-market central banks, which were forced to hike interest rates and expend a portion of their hard-earned foreign-currency reserves, and on emerging-market corporations which had borrowed extensively offshore, taking advantage of low U.S. interest rates, and incurred a heavy burden of dollar-denominated debts.

Emerging markets then suffered a further blow when the Fed actually began tapering in December 2013. Another round of criticism of U.S. policy action predictably followed. Brazil's Mantega criticized the Federal Reserve's communications strategy as inadequate and its message as "confused." Senior Turkish and Russian officials weighted in with further criticisms of U.S. policy. Ksenia Yudaeva, number two at Russia's central bank, suggested that certain central banks needed to "think more globally."[1] Although she did not mention the Federal Reserve by name, it was clear who she had in mind. The IMF called on the United States to bear in mind the impact on other countries of its policy adjustments. India's central bank governor, Raghuram Rajan, criticized U.S. policies of quantitative easing as excessive and complained that their reversal was creating financial risks for other countries, including his own. As Rajan put it, "the Fed should worry [more] about the effect of its policies on the rest of the world." "International monetary co-operation," he concluded, "has broken down."[2]

These complaints received a not-very-sympathetic hearing from U.S. policymakers. The particulars of the U.S. response, like the particulars of the preceding criticism, were easy to anticipate for aficionados of the earlier literature, dating from the 1980s, on international policy coordination.[3] Although the conflict over the cross-border repercussions of national policies in the 1980s had essentially been

[1]Cited in Smyth (2014).

[2]Quoted in Elliott (2014).

[3]See Buiter and Marston (1985) for a well-known compendium of this earlier research. More references to this earlier generation of work are provided below.

limited to the advanced countries, whereas they now extended to emerging markets, the underlying issues were the same.[4] Failure to internalize the cross-border externalities associated with national policy was leading to an inefficient global outcome. Officials in different countries needed to negotiate mutually beneficial adjustments in national policies that took these international spillovers into account.

But internalizing the effects was not easy. Policymakers were legitimately preoccupied by domestic objectives. Central banks like the Fed had mandates that did not acknowledge the legitimacy of foreign welfare. Fiscal policy was made by divided governments subject to checks and balances and characterized by fractious coalitions, limiting the ability of treasury and finance ministers to make binding commitments to their foreign counterparts and hindering efforts to coordinate monetary and fiscal policies. Nor was it clear what of value other countries could offer the United States in return for policy adjustments. Uncertainty about the structure of the economy (in academic parlance "uncertainty about the model") complicated internationally coordinated policy adjustments. Given the wrong model (or, under certain conditions, even the right model), policy coordination might be counterproductive. Undue attention to the external effects of national policies might cause officials to "take their eye off the ball" and fail to prioritize stable prices and domestic growth; it might result in a neglect of policy essentials. At the end of the day it was not clear that countries would be better off with internationally coordinated policies as opposed to each following an "own house in order" rule.

Such concerns, to reiterate, were familiar from the earlier literature. What was different now was the additional dimension, namely the emerging-market context.

2 Macroeconomic Policy Coordination in Theory and Practice

For many years, discussions of international policy coordination in academic and practical policymaking circles bore the imprint of the seminal contributions of Cooper (1968) and Hamada (1976). Cooper highlighted the case for coordinating monetary, fiscal and exchange rate policies in the Atlantic Community (his term)—that is, among the advanced countries on the two sides of the North Atlantic. Hamada (Cooper's student in part) formalized these ideas by specifying and analyzing a simple two-country model in which aggregate-demand-management policies affected both the home and foreign economies. Hamada demonstrated the suboptimal nature of the Nash equilibrium in which policy was formulated without

[4]In addition to the conflicts among advanced countries described in the remainder of this paragraph, there were also complaints from developing countries that the sharp increase in interest rates engineered by the Fed as part of the Volcker disinflation had capriciously disrupted capital flows to emerging markets and precipitated the developing-country debt crisis (see Whitehead 1986).

regard to its impact on the foreign country, but in which domestic officials responded to the impact on their country of policy changes abroad.

Development of this apparatus focused attention on the advanced countries and on their monetary and fiscal policies, these being the initial motivations for and applications of the model. Emerging markets, it could be argued, were just a sideshow from the standpoint of global macroeconomic conditions, given their still limited weight in the world economy.[5] Financial markets remaining tightly regulated, trade rather than financial flows (and the current rather than the capital account of the balance of payments) were the main channels of cross-border spillovers. The first of these presumptions changed with the Latin American debt crisis, the Asian miracle, and the emergence of emerging markets, first and foremost China. The second then changed with the growth of international capital flows and financial exposures, a fact signaled by the Herstatt crisis in 1974, in which the insolvency of a mid-size German bank disrupted international payments, threating U.S. financial institutions and prompting the creation of the Basel Committee on Banking Supervision as a mechanism for coordinating financial policies.

Awareness that emerging markets were also integral to this equation was slow in coming. There was some recognition that the Latin American debt crisis that erupted in 1982 had been preceded and in a sense was precipitated by the sharp increase in U.S. interest rates adopted by the Federal Reserve, under Paul Volcker, with the goal of bringing down U.S. inflation. The Tequila Crisis of 1994–1995 was preceded by another sharp run-up in U.S. interest rates, which played a key role in the difficulties experienced in Mexico, Argentina, and other Latin American countries. An emergency dollar swap facility extended through the Exchange Stabilization Fund, anticipating steps taken in 2008–2009, was arranged in response. In the case of 1997–1998 and Asia, the crisis was blamed (in part) on the low level of interest rates in the U.S. (and Japan) in the preceding period, which caused Asia to be flooded with cheap foreign-currency-denominated liquidity.[6] The crisis, when it then hit, created problems for the money-center banks on the lending side of the equation, leading to emergency assistance for the stricken countries from the IMF (and in some cases the United States).

By this point, the policy linkages and spillovers between advanced countries and emerging markets were too prominent to ignore. But, as is not infrequently the case, it took time for the academic literature to catch up.[7] In the meanwhile, analysis focused on the conditions under which Hamada-like results obtained, on the magnitude of the effects, and on counterexamples. The literature enjoyed a second

[5]Or at least the kind of symmetric two-country model developed by Hamada was not easily adapted to a world of highly asymmetric advanced and developing countries.

[6]The exchange rate pegs operated by many Asian countries also played a role in amplifying this linkage (Eichengreen 1999).

[7]Cooper (1993) was an early effort to apply the insights of the policy coordination literature to spillovers between advanced and emerging markets.

wind in the 1980s, when (as already noted) the Volcker disinflation and Reagan tax cuts led to a sharp rise in the dollar, with reverberations in other countries. Critics observed that Hamada's result—and the argument that U.S. policy was having negative effects on other economies—depended on the assumption of instrument scarcity—that national policymakers possessing, say, two objectives but only one policy instrument could not fully offset the impact on their domestic objectives of policy initiatives abroad. Buiter and Kletzer (1990) emphasized the distinction between pecuniary and nonpecuniary externalities. Where the spillover effects of domestic policy are purely pecuniary (that is, all they do is change prices), nothing in principle prevents foreign policymakers with a sufficient number of instruments from just changing them back. If, however, the externalities are such that the change in policy abroad has additional (nonpecuniary) effects that are not so easily reversed, then the case for cooperation is strengthened.

This perspective makes it easier to understand emerging-market complaints about Federal Reserve policy starting in 2010. The weak dollar, which had as its mirror image strong emerging-market currencies, was not easily offset, and it hampered the development of manufacturing where learning effects and other growth-positive externalities were localized. The tsunami of capital flowing into emerging markets created financial stability risks that were not easily contained by unproven macroprudential policies. The limited effectiveness of capital controls and flexible exchange rates in providing insulation meant that policymakers in emerging markets were in effect operating in an environment of instrument scarcity.[8]

At the same time, efforts to operationalize the Hamada framework, starting with Oudiz and Sachs (1984), reached the uncomfortable conclusion that the gains from coordination were small, at most a few percentage points of GDP. Their result was uncomfortable for academics, who find it easier to publish findings of large effects than small ones, and for officials heavily invested in policy coordination efforts. It followed from the small magnitude of the benefits that the most important thing policymakers could do to maximize welfare, in terms of macroeconomic policies, was to put their own house in order.

Subsequent studies tweaked the models to see whether different assumptions about structure and parameters yielded significantly different results.[9] My reading of this literature is that it provided strong evidence that the gains from policy

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[8]To quote Rajan (2014), "Exchange rate flexibility in recipient countries in these circumstances sometimes exacerbates booms rather than equilibrates. Indeed, in the recent episode of emerging market volatility after the Fed started discussing taper in May 2013, countries that allowed the real exchange rate to appreciate the most during the prior period of quantitative easing suffered the greatest adverse impact to financial conditions. Countries that undertake textbook policies of financial sector liberalization are not immune to the inflows—indeed, their deeper markets may draw more flows in, and these liquid markets may be where selling takes place when conditions in advanced economies turn. Moreover, macroprudential measures have little traction against the deluge of inflows—Spain had a housing boom despite its countercyclical provisioning. Recipient countries should adjust, of course, but credit and flows mask the magnitude and timing of needed adjustment.".

[9]The most comprhensive study along these lines is Bryant et al. (1989).

coordination were small under normal conditions but that they could be large, exceptionally, in unusual circumstances when marginal changes in domestic policies do not have the usual, predictable marginal impact on domestic markets (when nonpecuniary externalities are significant and pervasive).

This reading is consistent with international experience following the global financial crisis, as shown by, among others, Haberis and Lipinksa (2014). These authors analyzed a two-country model where one country is at the zero lower bound, in the manner of the U.S. after 2008. They showed that more stimulative policy in that country worsens the other country's trade-off between stabilizing inflation and the output gap when home and foreign goods are close substitutes, as is typically the case (and where the existence of a trade-off follows from the assumption of instrument scarcity). Looser foreign policy leads to a relatively more appreciated home real exchange rate, which induces large amounts of expenditure switching away from home goods when goods are highly substitutable at a time (that is, at the zero lower bound) when home policy is trying to boost demand for home goods.[10]

Empirically, Fratzscher et al. (2012) estimated the cross-border spillovers of quantitative easing by the United States, finding that the effects were not overwhelming. Looking at emerging markets, they found a significant impact of QE on sovereign spreads and equity prices (negative and positive, respectively) and little effective insulation from capital controls and exchange rate adjustments by countries on the receiving end of U.S. capital flows. But the effects were not obviously large enough to create serious discomfort for emerging markets. A number of other studies focusing on the financial crisis itself suggest, at the same time, that cooperative policy adjustments, especially in 2009, were critical for averting a global financial meltdown. They had very large macroeconomic and welfare benefits, in other words.[11]

The literature then elaborated reasons why policy coordination might be welfare reducing rather than enhancing. Rogoff (1985), in an influential early study, showed that efforts to coordinate internationally might interfere with a commitment to follow time-consistent policies. A variety of other counterexamples built on the theory of the second best, formalizing the idea that otherwise first-best moves in the direction of international cooperation might be welfare reducing in the presence of other distortions. Too much attention to the interaction of domestic and foreign economic policies, Feldstein (1988) suggested, might distract officials both at home and abroad from following sound and stable policies.

These reservations and objections found echoes in discussions of national policies in the global financial crisis. Efforts to coordinate expansionary initiatives in 2009 were counterproductive insofar as they were indiscriminate; they led to larger budget deficits and heavier debts not only for countries that could afford them

[10]When domestic and foreign goods are not such close substitutes, however, the effect becomes relatively small.

[11]See for example Bayoumi and Pickford (2014).

but also for countries that could not, like Greece (Eichengreen 2015). China's decision to undertake a massive fiscal stimulus and open the liquidity tap caused a credit boom that fueled a dangerous rise in property prices and slowed the rebalancing of its economy (Williams 2013). Rather than putting their own houses in order, emerging markets, hoping for accommodation from the Federal Reserve, failed to pursue the hard policy reforms needed to sustain growth and ensure stability in a normal interest-rate environment. Foreign criticism of the Fed's tapering talk threatened to tempt the U.S. central bank into neglecting its central mandate of price stability and sustainable high employment (Dudley 2014). Influential voices inside and outside the Federal Reserve warned that if the U.S. central bank bowed to the criticism and therefore hesitated to wind down its securities purchases while delaying the normalization of interest rates, the results would be counterproductive (Taylor 2013; Bullard 2014).

Taylor and Bullard went on to argue that because the gains from policy coordination are small, the decentralized equilibrium in which each central bank follows an appropriate domestically oriented monetary policy rule closely approximates the first-best equilibrium while avoiding the incentive problems and counterproductive side effects of international coordination. Central banks possess no scarcity of instruments, in this view, since they have, or should have, only one objective, namely low and stable inflation, or in some formulations of the Taylor Rule a weighted average of deviations from the inflation target and the output gap. There are no significant nonpecuniary externalities to complicate the central bank's pursuit of that policy target, by assumption. Each national central bank following an appropriate Taylor Rule and disregarding misguided calls to adjust policy with foreign conditions in mind leads to an equilibrium that approximates the best of all possible worlds.[12]

This view suggests that officials in emerging markets like India, rather than complaining about Federal Reserve policy, should concentrate on deploying their own instruments appropriately, adjusting their monetary and fiscal policies so as to maintain low inflation and create an environment conducive to growth, and using macro- and micro-prudential supervision to address risks to financial stability. When they instead urged the Fed to limit its securities purchases in 2012 and then to slow the rate at which it tapered them in 2013–2014, they should have considered the counterfactual: how less expansionary Federal Reserve policy in 2012 would have slowed U.S. and global growth, making it more difficult for policymakers in emerging markets to achieve their objectives, and how a slower pace of tapering in 2013–2014 might have created inflation and financial stability risks for the United States and, in turn, the global economy.

The counterargument, advanced by Governor Rajan and others, was that emerging markets like India lacked a full complement of policy instruments with which to respond to the cross-border repercussions of Federal Reserve policy. Allowing the rupee to rise sharply when the Fed was engaged in quantitative easing

[12]In contrast to Taylor, Bullard (2014) also presents an "alternative view" in which distortions are present and the gains from policy coordination can be significant.

and capital was flowing toward India would have had negative implications for the development of manufacturing owing to the existence of learning effects (an example of a Buiter–Kletzer nonpecuniary externality).[13] Cutting interest rates on the other hand would have exacerbated the inflation problem. Better from India's point of view would have been for the Fed to loosen less.

Similarly, when the Fed began tapering, causing capital flows to reverse direction, the rupee exchange rate fell sharply. Given the magnitude and speed of the fall, not responding would have exacerbated confidence problems. The Reserve Bank of India was therefore forced to raise interest rates despite the fact that the growth outlook was deteriorating. Better from India's point of view would have been for the Fed to move more slowly and tighten less. Once again this would have obviated the need for uncomfortable interest rate adjustments in India and other emerging markets in its position.

3 Information Sharing as International Cooperation

International macroeconomic policy coordination refers to the reciprocal adjustment of monetary and fiscal policies so as to take their cross-border repercussions and likely foreign response into account. International economic cooperation, on the other hand, encompasses not just efforts to coordinate monetary and fiscal policies but also other forms of international collaboration, such as information sharing, regulatory harmonization and the extension of liquidity swap lines and credits.

Information about the future helps officials to plan. It follows that information sharing is useful for helping policymakers to anticipate and interpret policy changes abroad and adjust smoothly to their implementation. A shared assessment is also needed in order for officials in different countries to work together and agree on coordinated adjustments in policies.[14] Thus, much of the criticism of Bernanke's invocation of the possibility of tapering in the summer of 2013 was on the grounds that the Fed had done little to pave the way for the remark. Bernanke's comments came as a surprise to financial markets and to policymakers in other countries.

The latter were caught unawares in the sense that they had not formulated strategies for dealing with Fed tightening and were uncertain of how to respond. For example, the Reserve Bank of India under its then governor, Duvvuri Subbarao, responded to the fall in asset prices and to softening growth prospects by cutting interest rates, but when markets reacted negatively the Reserve Bank then felt compelled to reverse course and hike rates.[15] The requisite policy adjustments were sharp, since policy had not begun to move in advance of the unanticipated Fed

[13]See the discussion of Buiter and Kletzer (1990) above.

[14]For examples see Frankel and Rockett (1988).

[15]When the actual taper commenced in December 2013 India responded more coherently, in part because Fed tightening was no longer a surprise (see Basu et al. 2014).

statement. This made the disruptive impact on markets and growth all the greater. Consequently, much emerging-market criticism of the Fed revolved around the inadequacy of its communication policy and its failure to more effectively share information about its intentions.

It is not as if mechanisms for facilitating information sharing were lacking. Central bankers meet monthly at the Bank for International Settlements, and important emerging markets now participate in these discussions at Basel. Finance ministers and central bankers meet biannually as members of the Group of Twenty (G20), and their deputies meet to share information and analysis all but continuously; a majority of the Group's 20 members represent emerging markets of one sort or another.[16]

The IMF through its surveillances, spillover reports, and executive board assessments provides another channel for sharing information on national policies and their repercussions and for working toward a consensus on how members should respond. The IMF weighed in on the international repercussions of tapering in 2014, as noted above. The question about IMF analysis, as always, is whether Fund members, especially large members that do not borrow from the institution, will take its recommendations seriously and adjust policy accordingly. It is whether emerging markets, which remain underrepresented in terms of executive board seats and quotas, will regard the Fund's analysis and advice as legitimate or whether they will dismiss the information it purports to convey as disproportionately shaped by the institution's advanced-country members.

There is also the worry that, with a membership approaching 200 in number, the IMF is too large and unwieldy to constitute a convenient vehicle for central bank cooperation. Some observers (including the present author, in Eichengreen et al. 2011) have suggested creating a dedicated body, an "International Monetary Policy Committee" of central bankers, perhaps constituted along the lines of the G20, to meet separately and reach a consensus that could then be reported to leaders and to IMF membership as a whole. Others (Caruana 2012; Mohan and Kapur 2014) have expressed doubts about whether such a consensus would be forthcoming and whether it would lead to cooperative adjustments in policies.

4 From Monetary to Financial Cooperation

As noted, the Herstatt crisis in 1974 brought to the fore the importance of foreign-exchange exposures and the fickleness of foreign-exchange market liquidity, directing the attention of central bankers and regulators to the importance of adequate capital for internationally active banks. This led to the Basel Concordat of

[16]In addition, representatives of a number of international organizations (the IMF, World Bank, OECD) participate in G20 meetings. I return below to the role of these institutionalized venues for information sharing.

1975 and then the Basel Capital Accord, negotiated by the G10-based Basel Committee on Banking Supervision.[17] The Basel Capital Accord focusing on capital adequacy for internationally active banks was adopted in 1988 by a group of central banks and other national supervisors—advanced countries all—working through the Basel Committee on Banking Supervision.[18]

Cooperation arranged through these entities prevented a destabilizing race to the bottom by national supervisors seeking to maintain or enhance the international competitive position of their banks. But while the Basel Accord provided a capital buffer sufficient to prevent major advanced-country banks from failing due to the Tequila, Asian, and Russia-LTCM crises, it did not prevent major bank failures in emerging markets, in Asia during the 1997–1998 crisis for example (Leuven and Valencia 2008). This prompted complaints that the Basel process failed to address the needs of emerging markets, although those doing the complaining did not always specify those needs or explain how they could be better met. Be this as it may, the result was enlargement of the Bank for International Settlements and Basel Committee to incorporate emerging markets. The response extended also to the creation in 1999 of the Financial Stability Forum (now the Financial Stability Board), with more extensive emerging-market representation, to coordinate at the international level the work of national financial authorities, to enhance the effectiveness of regulatory, supervisory and other financial sector policies, and to serve as financial-reform-and-regulation secretariat for the G20.

Finally this experience led to efforts to revise the Basel Accord. Again this process focused on capital requirements, and again negotiations were dominated by the advanced countries. The revised standard, Basel II, allowed large banks with internal models for use in risk management, typically based in advanced countries, to utilize them also to calculate risk exposures and capital requirements. But Basel II exempted lines of credit extended for less than one year from capital requirements. It permitted banks to further reduce their required capital by shifting assets off-balance sheet to special purpose vehicles. It allowed banks to use credit ratings and current market valuations to price risk, amplifying procyclicality. These flaws all became apparent in the global financial crisis.[19] Some might say that outcomes would have been better had regulators been forced to focus on the capital and regulatory needs of domestic banks rather than blindly and overconfidently signing onto the Basel standard and process.[20]

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[17] The Basel Accord is interpreted as a prime instance where institutionalized interaction led to the development of an intellectual consensus among key decision makers on how precisely policies should be coordinated (Kapstein 1989).

[18] Members included Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[19] Having been adopted more than 3 years earlier, in 2004, in Europe then in the United States, Basel II arguably did more to aggravate the banking crisis in Europe than the United States.

[20] Basel II of course allowed regulators to impose requirements at the national level even more demanding than those specified by the accord, but there was a natural tendency to converge to the Basel standard.

The response to the crisis, Basel III, was negotiated in 2010–2011 and implemented in 2013–2015 (with provision for its implementation over longer periods in some emerging markets, through 2019 in India, for example—Gokarn 2014 provides details). Basel III included not just capital but also liquidity requirements, as well as a leverage ratio to limit the ability of banks to game the system. It tightened requirements for off-balance sheet items and vehicles. It introduced a countercyclical buffer encouraging regulators to require additional bank capital during periods of high credit growth.

While emerging markets were more intimately involved in this third round of financial cooperation, there were still criticisms that they were poorly served by the result. Banks and regulators in developing countries had not succumbed to the worst excesses of the credit boom; it was not clear why they too should be held to higher standards. By requiring additional capital to be held against short-term loans, Basel III raised the cost of trade finance on which developing countries disproportionately depend. By building on U.S. and European accounting standards, Basel III left little room for addressing the special financial circumstances of emerging markets. By requiring banks to meet stringent liquidity requirements, it discriminated against developing countries in which liquid corporate and government bonds are in short supply. By retaining the internal rating-based method of calculating capital requirements, Basel III gave a leg up to large banks in advanced countries that had invested most heavily in such methods. By raising capital charges on derivative instruments traded over the counter, the new system favored advanced markets where central counterparty clearinghouses are more easily established.

Closely related to these initiatives are macroprudential policies that countries, including developing countries, have put in place since the crisis to deal with risks to financial stability. These include conventional measures like capital controls, but tweaked to rise and fall during credit booms and busts, together with capital surcharges for systemically significant financial institutions to address the problem of too big to fail and too big to save. They include innovative measures like variable caps on permissible loan-to-value ratios to address excesses in housing markets, like those adopted by New Zealand. They include controversial measures to limit destabilizing capital flows by taxing or controlling them at the border, as countries like Brazil and India have done. All these measures, but most visibly capital controls, give rise to the possibility of capital-flow diversion and, thus, of policy spillovers to other countries, creating a prima facie case for coordination.

The IMF responded to this last observation by suggesting a code of conduct for capital-control-like measures. Ultimately, it stepped back from proposing a formal code, bowing to opposition from emerging markets like India and Brazil which feared that the code would do less to ensure coordination than to limit recourse to the instrument. In any case, there are grounds for questioning whether a code specifying conditions under which the imposition of controls is appropriate will be enough to address the spillover problem. The answer hinges in part on the magnitude of the spillovers. Forbes et al. (2012) suggest that spillovers can be substantial. Garcia (2014), in a case study of the impact on Chile of recent Brazilian controls, concludes to the contrary that they are minor. This would seem like an important dispute to resolve.

Cooperation on regulatory and macroprudential policies is important, and progress on regulatory and macroprudential cooperation is being made. But cooperation in this area is far from perfect, and emerging markets remain underserved, in part because they have failed to do more to offer alternatives to the proposals advanced by the high-income countries and to form a united front.

5 Cooperation on Swap Lines and Credits

A final form of cooperation that was prominent in the global crisis, as already noted, were currency swaps as a form of emergency liquidity assistance. In practice, "currency swaps" is code for "dollar swaps" by the Federal Reserve, since the global banking system runs on dollar liquidity (Shin 2011), although other central banks also extended more limited swap lines during the crisis: the ECB negotiated swap agreements with the central banks of Switzerland, Hungary, Denmark, Latvia, Poland, and the UK, for example, while the Bank of Japan negotiated a swap arrangement with South Korea and subsequently with India.[21]

The Fed's dollar swaps in particular are widely viewed as ensuring the liquidity of global financial markets at a critical time, as buttressing confidence, and as enhancing the effectiveness of monetary policy. They are thus seen as a shining example of central bank cooperation.

But they are also controversial and, as a crisis containment tool, potentially problematic. Foreign financial conditions are not part of the Fed's mandate. Federal Reserve policymakers are uncomfortable about extending them, since they wish to limit their institution's financial and political exposure. The transcripts of the Federal Open Market Committee from the autumn of 2008 document members' reservations.[22] An implication of those reservations is that when Federal Reserve dollar swaps are extended, they are extended only to a limited range of countries, presumably including those whose liabilities are especially important for the stability of the U.S. banking system.[23] India is said to have been among the countries whose requests were rebuffed (while other countries said to have approached the Fed but which were denied include Chile, Peru, Indonesia, and Iceland).[24] It is not clear whether future Federal Reserve officials will be even this accommodating or,

[21]The BOJ-RBI swap agreement was initially negotiated in 2012, to be effective for 3 years; its size was then increased from $15 billion to $50 billion in early 2014 (Bank of Japan 2014).

[22]See Federal Reserve Board (2014).

[23]This is argued by Morelli et al. (2015).

[24]On this see Prasad (2014), pp. 202–211.

if they are, whether Congress will allow them to proceed.[25] In 2013 six key-currency central banks (those of the U.S., Canada, England, Japan, Switzerland, and the Eurozone) agreed to convert the swap arrangements they negotiated during the global crisis into permanent standing facilities. But they did not extend those permanent facilities to Mexico, Brazil, Singapore, South Korea or other emerging markets.

An alternative for emerging-market central banks is to self-insure. Accumulating large dollar reserves can be costly, however (Rodrik 2006). Moreover, emerging markets are reluctant to use their reserves, insofar as doing so is seen as sending a negative signal, damage from which is outweighed only by the negative signal sent by a collapsing exchange rate. The Bank of Korea accumulated more than $240 billion of foreign reserves, fully 20 % of GDP, prior to the global financial crisis (Aizenman 2009; Allen and Hong 2011), but saw itself as able to use only a small portion, the markets suggesting that $200 billion was a red line that should not be crossed. Given the central bank's reluctance to intervene further, pressure on the won abated only when the country received its $40 billion dollar swap facility with the Federal Reserve.

Yet another option is for dollar-rich emerging markets to negotiate swap arrangements among themselves. In the wake of the Asian crisis, the members of the Association of Southeast Asian Nations (ASEAN) together with China, Japan, and South Korea (known collectively as ASEAN+3), launched the Chiang Mai Initiative (now Chiang Mai Initiative Multilateralization, or CMIM), a network of bilateral (and now multilateral) swap lines with one another. National reserves committed to this arrangement amount to $240 billion at the time of writing. The CMIM nominally offers its members two facilities: a precautionary line that qualifies members for 6-month financing ex ante for up to two years, and a stability facility providing finance for up to three years to countries with more serious needs and problems. More recently, the BRICS countries announced the creation of a Contingent Reserve Arrangement (CRA) to which they were prepared to commit $100 billion of reserves.

In principle, these are ways for central banks and governments in emerging markets to step in where the Federal Reserve fears to tread. Assuming that economic and financial shocks affect the members at different times and with differing degrees of severity, they are a mechanism for monetary co-insurance.

The unanswered question is whether these arrangements are just paper tigers. The CMIM in its 15 years of existence has never been used, not even during the global financial crisis. The CRA is still too new to have been activated; in any case it is too small to make much of a difference in a global crisis. Borrowing is governed by quotas. India can thus borrow up to a maximum of $18 billion from its CRA partners. Recall that the Fed provided $40 billion to Brazil, Mexico, Singapore, and South Korea—each—in 2008. In 2002 the IMF provided a $30 billion

[25]Recall how the Congress tightened restrictions on use of the Exchange Stabilization Fund (strictly speaking, by the Treasury and not the Fed) in response to its repeated use in earlier crises.

standby credit to Brazil, and global capital flows and financial markets have continued to expand since then. Perhaps the CRA, like the CMIM, should be seen as a work in progress. Presumably its capitalization and the drawing rights of members will continue to grow. Time will tell.

One explanation for failure to activate these arrangements is counterparty risk. Lenders worry about being paid back promptly and in full, not without reason since they are lending into a crisis. This is of course why all loans of nonnegligible size come with conditions attached. But central banks and governments seeking to develop regional reserve pools lack the reliable monitoring technology, adequately insulated from politics, required to provide firm surveillance of borrowers and to monitor their progress. They lack a political process capable of setting loan conditions. The ASEAN+3 countries have established an ASEAN+3 Macroeconomic Research Office as an independent regional surveillance unit to monitor regional economies and support the CMIM. But whether the unit will acquire the independence needed to issue blunt assessments remains to be seen.

The difficulty the BRICS will face in establishing anything analogous, given their diversity and lack of traditional political ties, should not be understated. This is reason to question whether their proto-reserve pool will become operational. The BRICS Treaty (2014) indicates that members in order to draw must be in compliance with their surveillance and disclosure obligations to the IMF under Articles IV and VIII of the Fund's Articles of Agreement, suggesting that the BRICS countries still feel compelled assign this delicate task to the IMF.

A still more difficult nut to crack is the negotiation of conditionality, given Asian countries' tradition of noninterference in the affairs of their neighbors and the reluctance of emerging markets, given histories of colonial and economic dependence, to countenance outside interference. The members of CMIM and CRA have attempted to finesse this issue by requiring countries to first negotiate a standby arrangement with the IMF, which has experience in negotiating such conditionality, when they seek to draw more than 30 % of their CMIM and CRA quotas. Similar conventions govern bilateral swap arrangements. Thus, the Bank of Japan has made negotiation of an IMF program (actual or imminent) a precondition for drawing more than 20 % of its recently negotiated swap line with India.

The problem here is IMF stigma: governments of emerging markets are reluctant to enter into IMF programs for fear of adverse economic and political consequences. The IMF has sought to ameliorate this by creating lightly conditioned precautionary lending facilities, notably a Flexible Credit Line (FCL) for countries with strong policies, along with a Precautionary and Liquidity Line (PLL) for countries whose policies are not quite strong enough for a FCL. Ex post conditionality is limited (requirements are "focused," in IMF-speak). Because qualifying countries are presumed to have strong policies, because they prequalify for access when times are good, and because conditionality is noninvasive, there should be no stigma. Thus, Henning (2014) suggests linking access to CMIM and CRA quotas above 30 % not to regular standby arrangements but to these facilities.

In practice, despite the lightening of conditionality and other inducements (favorable interest rates, higher-than-traditional access limits), emerging markets still fear sending a negative signal. To date, only five have applied for such lines, and none have drawn them. It may be that the IMF's emerging-market members face a collective action problem. Collectively they would be better off if all countries with strong policies sought prequalification, but if only a handful seek to do so, investors will infer that their policies are not in fact as strong as those of countries that keep their distance. To address this dilemma, Truman (2010) suggests "comprehensive prequalification," in which the IMF unilaterally prequalifies members. This proposal has not met with much support from governments themselves, however.

Another explanation for the reluctance of countries to access these facilities is failure to reform IMF governance so as to enhance voice and representation of emerging markets—a failure that damages the perceived legitimacy of the institution. The perception that the IMF remains a creature of the advanced countries means that emerging markets applying to these facilities will still be seen (or see themselves) as supplicants crawling to their richer brethren for help.

Henning suggests further that qualification of a member for a Flexible Credit Line (and, by implication, a PLL) should "create a presumption" that the country would then be extended a swap arrangement by "a key-currency central bank."[26] The question is how strong a presumption. Would the Fed be willing to delegate the decision of whether to extend a swap arrangement to a multilateral body like the Fund? The argument that it would rests on the idea that a Flexible Credit Line will be extended only to countries with strong policies, minimizing risk to the Fed's balance sheet. Moreover, consequential decisions within the Fund are made by consensus, and the U.S. as the largest single shareholder has effective veto power. U.S. officials would be further reassured by the fact that the recipient would be able to draw on its Flexible Credit Line to redeem its swap operations if necessary.

The argument that the Fed will reluctant to delegate such power is that the Treasury and not the central bank occupies the U.S. seat on the IMF Executive Board and that, regardless of the identity of the occupant, Congress would not look favorably on such delegation. Legally, only the Treasury can transfer resources to the IMF. For the Fed to do so would surely be regarded in the U.S. political circles as inconsistent with its mandate.

6 What Emerging Markets Should Expect and What They Can Do

How much international cooperation around monetary and related policies can emerging-market economies reasonably expect?

[26]This follows up on an earlier suggestion by the government of South Korea, when it chaired the G20 in 2010, and by Rajan (2014) that bilateral swaps by the Fed and other key central banks be somehow multilateralized through the IMF.

In Eichengreen (2014) I argue that international cooperation is most likely in four circumstances. First, cooperation is most likely when it centers on technical issues like prudential supervision and regulation, as opposed to more high-profile and politicized monetary and fiscal policies. Discussions of technical issues tend to be undertaken by specialists who, possessing shared training and background, are predisposed to reach common understandings and achieve an intellectual consensus on what needs to be done. Delegation to specialists can also help to insulate policy coordination from politics, although when technical issues are important to special interests even those discussions can be politicized.

Second, cooperation is most likely when it is institutionalized, so that procedures and precedents create presumptions about the appropriate conduct of policy and reduce the costs of reaching an agreement. One definition of an institution is a set of durable rules and understandings that shape expectations, interests and behaviors—rules and understandings that can range from informal norms to formal obligations for what constitutes acceptable behavior and that are sometimes embodied in an organization, sometimes not. History suggests that international policy coordination is more likely when it is institutionalized in this sense.

Third, cooperation is most likely when it is concerned with preserving an existing set of policies and behaviors (when it is concerned with preserving a "policy regime") rather than directed at altering policies. Having sunk the costs of establishing a regime, policymakers will have an incentive to cooperate in its preservation. Much successful international cooperation is therefore of the regime-preserving type. In contrast, cooperation not directed at preserving an existing regime will be more difficult to arrange.

Fourth, monetary, macroeconomic, and financial cooperation is most likely in the context of broad comity among nations. Conflict over other issues, whether economic or noneconomic, complicates efforts to reach agreement on even technical economic and financial policies. It does not provide a favorable backdrop for policy coordination.

Others have suggested still other facilitating conditions. Kindleberger (1973) points to the presence of a dominant country able and willing to act so as to help stabilize the system; Keohane (1984) points to the importance of a "hegemonic" country, if not in acting unilaterally, then in organizing a coalition of the willing. Manhart et al. (2008), in extending the framework to emerging markets, refer to the concept of "anchor countries," that is, of countries like the BRICS whose economic weight, regional influence, and ability to shape international politics are crucially important for achieving shared international goals. Eichengreen and Uzan (1993) emphasize the importance of policymakers in different countries subscribing to common or at least compatible economic models. Frankel (1988) points to uncertainty as limiting the scope for successful policy coordination, where he distinguishes uncertainty about the initial position of the economy, about the appropriate objective of policy, and about the model linking policy action to their effects.

These perspectives suggest that emerging markets should not expect too much of international coordination of monetary policies. The United States is no longer as dominant economically and politically as after World War II, and no other country is in a position to assume its hegemonic role. The U.S. is no longer able to act unilaterally as it did with, say, the Marshall Plan. In a world with more systemically significant countries with diverse economic histories and structures, it can no longer as easily organize a coalition of governments and central banks as in the era of Cooper's Atlantic Community. Central bankers in different countries evidently subscribe to different models; U.S. officials believe that the domestic benefits of an activist monetary policy far outweigh any negative spillovers to the rest of the world, whereas officials in emerging markets conclude otherwise. There is uncertainty on both sides of this divide about the appropriate targets of policy, the correct model linking policy to the economy, and the initial position at any point in time. This is a clear implication of disagreements across the advanced-country-emerging-market divide during the Fed's three rounds of quantitative easing and then its "taper."

The one exception to this generation was at the height of the global financial crisis in late 2008 and early 2009. There was then high anxiety about the survival of the prevailing regime of open trade and global financial markets. Seeing the international system (the "policy regime") hanging in the balance, countries, organized through the G20 and otherwise, were able to take concerted action to simultaneously expand supplies of money and credit, boost public spending, and shun beggar-thy-neighbor trade policies. But this same perspective suggests that circumstances where it is "merely" the fate of a particular country or group of countries that is at stake may be less conducive to such extensive international coordination. Gokarn (2014) similarly warns against the possibility that the G20 may only be effective as a "wartime" grouping.

This reference to the G20 points to the positive role of standing institutions for monetary policy coordination. But the Basel Committee and FSB focus on supervision and regulation of the banking and financial systems, respectively, rather than on monetary policy per se. Notwithstanding its enlargement to include emerging market members and its support for cooperation on regulation, the BIS has no particular comparative advantage in assuming a monetary-policy-coordination role. Swap arrangements between advanced countries and emerging markets remain ad hoc rather than permanent. This leaves the G20 and the IMF, where the G20 process and membership are ad hoc, whereas the IMF lacks legitimacy in the eyes of emerging markets. The resulting picture is at best mixed.

The idea that international cooperation is easier when it centers on technical issues that can be delegated to specialists suggests that emerging markets should be able to make more headway in discussions of regulatory issues, whether in the Basel Committee, the FSB or the IMF. By implication, cooperation may be more productive when it focuses on crisis prevention, to be achieved through stronger financial supervision and regulation, than when it seeks to extract concessions from foreign central banks on the stance of monetary policy.

Otherwise, the only feasible strategy for emerging markets is to work to better insulate themselves and insure against shocks from the advanced economies, since they are unlikely to get advanced-country central banks to alter their policies with the impact on foreign countries in mind. Hanging together is better than hanging separately. Common standards and practices for the use of capital controls will avoid shifting vulnerabilities from one country to another. Reserve pooling, where the pool is actually used, will limit the need for costly reserve accumulation.

Above all, sound and stable policies will limit vulnerabilities and render the vicissitudes of policy in the advanced countries less of a concern. In other words, policy coordination begins at home.

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C. Ghate and K.M. Kletzer (eds.), *Monetary Policy in India*,
DOI 10.1007/978-81-322-2840-0

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