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Abstract

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Keywords: monetary policy, Reserve Bank of India, event study, monetary transmission, structural VAR, external instruments

JEL Code: E44, E52, E58, G10

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1 Introduction

Accurately assessing the impact of monetary policy on the economy is essential for policymakers, market participants and academics alike. However, using changes in central bank policy tools to measure monetary policy is complicated by the fact that these tools are typically changed endogenously in response to evolving macroeconomic conditions. To get around this problem, economists have relied on isolating exogenous or unexpected variation in central bank policy actions. In the advanced economies, there is a large literature that uses high frequency financial market data around monetary policy announcements for this purpose (see Altavilla et al. (2019) and Swanson (2021) for prominent recent examples). However, we know little about whether this framework is appropriate for emerging countries.

In this paper we use the Indian context to provide a road map for how to gauge monetary shocks in an emerging country setting. Specifically, we buttress high-frequency financial market data with a narrative analysis of official central bank statements and corresponding media discussion. This narrative analysis is especially useful when financial market depth is a concern and helps identify time periods when the high-frequency data is unreliable. In the process we create a publicly available time-series database of policy dates and shocks based on announcements by the Reserve Bank of India (RBI).

For the first part of our approach, we use data on Overnight Index Swap (OIS) rates[1] to overcome three limitations of the existing literature on monetary transmission in emerging countries, especially in India.[2] First, emerging country central banks often use multiple tools to conduct monetary policy (the RBI has used repo rate, reverse repo rate, bank rate and cash reserve ratio among others) and researchers end up choosing one of these rates as the main policy tool or combine them in some ad-hoc manner. Tracking OIS rates allows us to capture changes in short-term funding conditions regardless of the central bank tool(s). Second,

[1]While the bulk of the analysis in this paper uses OIS rates, we also show that using government T-bill rates gives broadly similar results.

[2]For examples of work on Indian monetary transmission see Sahoo and Bhattacharyya (2012), Das (2015), Sensarma and Bhattacharyya (2016), Montiel et al. (2016), Ghosh et al. (2021) among others.

researchers have typically focused only on changes in the policy tool(s) in studying monetary transmission without isolating the unexpected component. By focusing on the change in OIS rates in a narrow window around RBI monetary policy announcements we are able to capture the unexpected (or surprise) component of RBI decisions. And by decomposing the RBI's actions into anticipated and surprise components, we show that financial markets only respond to the surprise component. Third, researchers have mostly relied on the contemporaneous policy rate as the sole policy tool without considering the effects of central bank communication about future rates. By using OIS rates of various maturities (from 1 month up to 1 year), we are able to capture any potential information gleaned by the market about the future path of the policy rate from RBI communication.

We find that OIS rates move markedly more on RBI announcement days and that there are two distinct dimensions of information revealed on these days. The 1 month OIS rate responds substantially when the RBI makes surprise changes (or non-changes) to the contemporaneous short-term policy interest rates. Over and above that there is also movement in medium maturity OIS rates (3 months to 1 year). In other words, markets do indeed revise their expectations about future policy rates in response to RBI communication independent of the RBI decision to set the short-term policy rate. To capture these two separate effects we construct "target factor" and "path factor" shocks following the work of Gürkaynak et al. (2005).

The second part of our approach involves a narrative analysis where we attempt to answer the following question: How reliable are OIS rates (and thus our two factors) at capturing revisions of market expectations in response to RBI decisions? To better understand this we examine official monetary policy statements of the RBI. We combine this with an analysis of the reaction of the Indian financial media to the announcements. Focusing on dates associated with prominent changes in our factors, we find that, overall, our factors capture surprises that are consistent with our reading of the RBI decisions, the language used in the statements and the corresponding media discussion.

There is one clear exception to this. Around the period of the Global Financial Crisis in 2007-09, the target factor shocks (driven by the 1 month OIS rates) exhibit large movements on RBI announcement days that are difficult to square with the corresponding RBI statements or media reaction. We think one possibility that might explain this could be the presence of heightened liquidity premia in the OIS markets during the Global Financial Crisis. We make sure to check that our results on monetary transmission are not driven by this period.

Outside of this period, there are clear instances where surprise (non) changes of the RBI's policy rate are captured by corresponding target factor shocks. For example, in the immediate aftermath of the Demonetization announcement of 8 November, 2016, the media narrative showed that markets were quite sure that at the 7 December, 2016 meeting, the monetary policy committee (MPC) was going to cut the policy repo rate. However, the MPC decided not to change the repo rate, resulting in a contractionary monetary policy shock, which gets captured by one of the larger positive realizations of our target factor measure.

For the path factor, there are a handful of instances when the RBI statement gave explicit guidance about the future stance of monetary policy. For instance, on 25 October, 2011 Governor Subbarao's use of the phrase *".. further hikes may not be warranted"* was a clear signal to the markets of a dovish outlook on rates. This expansionary shock results in a large negative realization of the path factor.

However, most of the other monetary policy statements are not so direct about the future policy stance. The statements are also verbose–especially those in our early sample (2003-2013)–and involve detailed discussions of the economic outlook. In our reading we typically found phrases that could signal either a hawkish or a dovish stance. Nevertheless, we see substantial movement in the path factor throughout our sample, suggesting that markets knew which particular component of the statement was more informative. Overall, our results suggest that "forward guidance" from the RBI is not typically explicit about the future path of the policy rate as is often the case for the Federal Reserve or the ECB. Instead, Indian financial markets extract information from somewhat opaque RBI communication that talks

about future rates through the lens of evolving macroeconomic and financial conditions.

We then use the monetary shocks to study the transmission of RBI actions to the financial markets and the real economy. We start with an event study response of key financial variables on RBI announcement days. We find that there is a systematic relationship of government bond yields and stock prices (but not the exchange rate) with surprise news about the policy rate. Positive (contractionary) realizations of both target and path factor shocks raise government bond yields and lower stock prices but have no discernible impact on the exchange rate.

10 year government bond yield responds substantially more to information revealed in RBI statements about the future path of monetary policy rather than to surprise changes in the short-term policy rates. The stock market (Nifty 50 index) on the other hand responds more to the target factor. These results are consistent with the conventional findings in the literature on advanced countries in bond (Kuttner (2001)) and stock (Bernanke and Kuttner (2005)) markets. In the Indian context, there does not exist a substantial body of high frequency work on bond market response, and the evidence on the stock market response is inconclusive so far.[3] This highlights the importance of our approach of using OIS rates.

In February 2016 India officially adopted inflation targeting (IT) as the monetary policy framework. This led to the formation and operationalisation of the Monetary Policy Committee (MPC) from October 2016 onwards and coincided with the switch from the tenure of Governor Rajan to Governor Patel in September 2016. It is natural to ask if this regime switch led to changes in the dynamics of monetary shocks or their transmission?[4] We find that the size of the OIS rate changes on RBI announcement days are roughly similar if we split our sample in two by separating into a pre- and post- IT/MPC era. In other words, there is no evidence that markets were more (or less) surprised by RBI decisions in the post-IT/MPC regime.

[3]See for example Prabu et al. (2016), Agrawal (2007), Sasidharan (2009) and Khuntia and Hiremath (2019) for stock market response.

[4]See Eichengreen et al. (2020) for a broader evaluation of the inflation targeting regime.

However, there is substantial variation in the financial market response if we look across RBI governor regimes. Our sample period (2003-2020) overlaps with the tenures of three governors before the establishment of the MPC and two governors in the MPC regime. Most notably, we find that both bond yields and stock prices react only to path factor shocks under the tenure of Governor Raghuram Rajan, suggesting that markets were only paying attention to RBI statements and communication and were not reacting to repo rate surprises. Under the subsequent MPC regime, bond market response is entirely reversed and bond market only responds to target factor shocks while the stock market does not respond to either shock. We posit that the stock market response under the MPC regime could be a sign of central bank "information effects" becoming more important, see for example Campbell et al. (2012). Overall, the event-study results suggest that stock and bond markets pay careful attention to the actions and communication of the RBI. Moreover, the market's assessment of which particular tool (actions or words) is more effective changes from governor to governor.

Our event study results also help shed light on two recent high frequency studies exploring the impact of the move to the IT regime. Das et al. (2020) study the information transmission from RBI to financial markets by focusing on volatility and trading volume in financial markets. They find that the move to the IT regime does not change information transmission. Mathur and Sengupta (2019) conduct a text-mining analysis of the RBI's monetary policy statements and find that adoption of IT led to shorter and more readable RBI statements but not any direct evidence that this led to substantial changes in transmission of RBI actions.

These two papers use OIS rates to proxy for the monetary policy surprise, but they both only use the 1 month OIS rate. Our results on the other hand highlight the key role of the path factor, which is especially important because the pre-IT period under Governor Rajan was one where markets paid the most attention to RBI statements. In other words, trying to draw conclusions about the impact of IT on information transmission is potentially incomplete without considering the forward guidance aspect of monetary policy. Overall, our analysis suggests that instead of a pre-IT versus post-IT view of the RBI, it is perhaps more helpful

to think about regime shifts in RBI policymaking in terms of changes in the governorship.[5]

Finally, we study the transmission of the monetary policy shocks to macroeconomic variables using a structural vector autoregression (SVAR) model, similar to the recent work of Kamber and Mohanty (2018) for China. The factors constructed from OIS rates for the RBI announcement dates are natural candidates for use as external instruments in identifying the dynamic causal impact of monetary policy. We follow the approach of Gertler and Karadi (2015) and consider a VAR where the policy tool of the RBI is modeled with the 1 year interest rate. We consider a range of variables to use as instruments (target and path factors, individual OIS rates and first principal component). Based on a weak instrument analysis, among all these variables only the path factor is appropriate to use for identification in an SVAR setting.

Using the path factor as an instrument we estimate the impulse respones of output and inflation to a monetary policy shock. After a contractionary shock, prices (measured with the CPI index) fall on impact and the effect lasts for 6 months. This is in contrast to applying the commonly used Cholesky or recursive identification strategy which leads to the so-called "price puzzle" i.e. prices rise in response to a contractionary monetary policy shock. Measuring output with the index of industrial production we find that a contractionary shock actually raises output and it stays high for over a year. While this is at odds with conventional theory, it is similar to results found in the existing literature on Indian monetary policy transmission, see for example Mishra et al. (2016). One important factor that might hamper the effectiveness of monetary transmission in India is fiscal dominance of monetary policy, as documented for example by Gupta and Sengupta (2016) and Acharya (2020). In general, results on the transmission from the policy rates to output and inflation are largely ambiguous in the studies that have estimated the VAR model in the Indian context.[6]

While monetary policy shocks and the corresponding announcement dates are readily avail-

[5]This line of thinking is also consistent with related work of Mustafi and Sengupta (2020).

[6]See for example, Aleem (2010), Mohanty (2012), Khundrakpam and Jain (2012), Paramanik and Kamaiah (2014) among others.

able for developed countries, this is not the case for the RBI for our full sample. Since the MPC regime in 2016, RBI meeting dates and accompanying statements have been released to the public on regularly scheduled dates and are available on the RBI's website. Before this, however, RBI's announcements were relatively irregular and not always announced in advance. We hope that making our list of dates together with our measures of monetary policy shocks available publicly will aid future research on Indian monetary policy.[7]

The rest of the paper is organised as follows. In Section 2 we provide a brief description of the monetary policy framework in India. In Section 3 we construct the monetary policy shocks from OIS rates and present the narrative analysis in Section 4. In Section 5 we present a detailed analysis of the transmission of the shocks to financial markets and the real economy and, finally in Section 6 we summarize our main findings and outline avenues of future research.

2 Monetary policy framework in India

The monetary policy framework in India has evolved substantially over the last couple of decades. From the early 2000s till 2015, the RBI's monetary policy decisions were governed by a 'multiple indicator approach' (MIA) (Dua, 2020). The goals of monetary policy were defined in terms of price stability and output growth but without any specific quantitative targets and the RBI would take into consideration a host of macroeconomic factors. Until the early 2000s, the cash reserve ratio (CRR) was actively used to manage liquidity in the system.[8] From 2000 onwards, there was a shift towards using the repo rate and the reverse repo rate as the main monetary policy instruments.[9] However, until about 2012, the CRR would be adjusted from time to time to manage liquidity.

[7]These can be accessed from authors' website at https://aeimit.weebly.com/data.html or https://sites.google.com/view/rasesite/public-goods/data-on-monetary-policy-shocks-in-india?authuser=0.

[8]CRR is the minimum cash balance that a scheduled commercial bank is required to maintain with the RBI as a certain percentage of its net demand and time liabilities (NDTL).

[9]The repo rate is the rate at which the RBI provides overnight liquidity to the banks against the collateral of government securities, whereas the reverse repo rate is the interest rate at which the RBI absorbs liquidity, on an overnight basis, from banks against the collateral of eligible government securities.

In 2016 India officially adopted inflation targeting (IT) as the monetary policy framework by amending the Reserve Bank of India Act, 1934. Price stability is the main objective of India's monetary policy under this new regime, with an eye on output growth. The gradual move towards IT began the previous year when Governor Rajan signed the Monetary Policy Framework Agreement with the Ministry of Finance, formally specifying that India would adopt IT as its monetary policy framework. Under IT, RBI has to achieve a medium-term CPI (consumer price index) inflation of 4 percent with a symmetric 2 percent band around that. The primary policy instrument is now the repo rate.

This heralded a major shift from an adhoc, discretionary, multiple-indicators based monetary policy framework to a more target-driven framework. The operating procedure of monetary policy also became more streamlined as several provisions of transparency and accountability were introduced to bolster the credibility of the IT framework. For example if inflation remains above 6% or below 2% for three consecutive quarters then the RBI is required to provide the reasons for the failure, and propose remedial measures and the expected time to return inflation to the target. A six-member monetary policy committee (MPC) was set up chaired, by the RBI Governor, in order to take monetary policy decisions under this new regime.[10] The RBI is required by law to publish the resolution adopted by the Committee at the conclusion of every MPC meeting, which is scheduled for six times a year.

Our sample period running from September 2003 to December 2020 covers the tenures of five RBI Governors, namely, Y.V.Reddy, D.Subbarao, Raghuram Rajan, Urjit Patel and Shaktikanta Das. The last two regimes coincide with the period of MPC and IT whereas the MIA period overlaps with the tenures of Governors Reddy and Subbarao. The tenure of Governor Rajan can be thought of as a transition phase.

During the MIA period, the RBI publicly communicated its decisions partly through official statements published on the RBI's website on the dates of monetary policy announcements,

[10]The MPC consisting of three external members and three members from the RBI, including the Governor, held its first meeting in October, 2016.

and partly through unscheduled circulars. While the statements contained detailed descriptions of the RBI's assessment of current domestic and global economic situations as well as its future economic outlook and rationale explaining the monetary policy decision, circulars merely announced the decision without any accompanying explanation. While circulars were entirely unexpected, the release of statements was relatively more predictable and by and large followed specific periodic intervals for a Governor regime, though sometimes the intervals changed within the same regime. During the tenures of Governor Reddy and Subbarao, more than 30% of the monetary policy related communication was via circulars whereas with the MPC, this has almost gone down to zero. In the five year period from 2016 to 2020, only one circular was used to announce monetary policy, during the peak of the Covid-19 pandemic in April 2020. Table 1 provides a Governor-wise summary of the monetary policy statements and circulars during our sample period.

The monetary policy statements were usually longer and more verbose during the MIA period, compared to the IT regime. As described in (Mathur and Sengupta, 2019), statements during Governor Reddy's time were the lengthiest and those of the MPC have been the least verbose. With the advent of IT, monetary policy statements have not only become shorter, they are also more readable and more focused on the issues of price stability and growth. They are still quite long, when compared to the advanced economy central banks. The annual calendar of monetary policy meetings get published on the RBI website at the start of the year.

Under the MIA regime, the RBI Governor in office would usually call a press conference on the day of the monetary policy announcement and during or after the press conference the monetary policy statement would be published on the RBI's website. During the IT regime, the MPC meets for 3 days, and on the third day at the end of the meeting, the RBI Governor conducts a press conference where he announces the decision of the MPC and the resolution statement is uploaded on the RBI's website.

3 Constructing monetary policy shocks

To identify the effect of monetary policy, one cannot directly use changes in the monetary policy instrument (for example the short-term interest rate). The endogenous reaction of the central bank's policy instrument to economic conditions leads to the classic simultaneous equation bias. This problem can be overcome by isolating exogenous variation in the policy instrument. There is a large literature that uses high-frequency changes in derivatives (most commonly interest rate futures) to measure monetary policy shocks; see Kuttner (2001) for an early example. However, interest rate futures are not actively traded in the Indian financial markets. In this section we provide details on how rates on overnight indexed swaps (OIS) can be used to capture monetary policy surprises and document their transmission in Section 5. In Section 5 we also show that monetary transmission is broadly similar if we instead use T-bill rates (3 month and 1 year) to construct monetary shocks.

OIS contracts are derivatives in which parties exchange fixed and floating interest rate payments. The floating rate payments are typically tied to the overnight interbank rate which is a good proxy for the central bank's monetary policy instrument. For India, the Mumbai Interbank Offer Rate (MIBOR) is the relevant floating rate for the OIS rates that we study. See Rituraj and Kumar (2021) for further details on the OIS market in India.

Lloyd (2018) shows that OIS rates accurately measure interest rate expectations for various countries. Moreover, he argues that OIS rates are likely to have relatively low counterparty risk and liquidity premia. In recent work OIS rates have been used to study monetary shocks of the ECB (Altavilla et al. (2019)) and China (Kamber and Mohanty (2018)). In the Indian context, a recent report by the RBI (Rituraj and Kumar (2021)) shows that OIS rates are indeed a reliable way to measure the market's expectation about the future path of the repo rate.

While the repo rate is now the primary policy tool, the RBI has relied on a combination of a few different policy tools in the past, as explained in Section 2. During our sample from

2003 to 2020, the prominent other ones are the cash reserve ratio, the reverse repo rate, and the bank rate.[11] In Figure 1, the top panel plots the four monetary policy tools. The repo and reverse repo rate were changed by the RBI throughout the sample, but this is not true of the other two rates. The bank rate is kept fixed at 6% from the beginning of our sample in 2003 to 2012, while the CRR is kept fixed at 4% from early 2013 up until the start of the pandemic in 2020. Overall, when multiple policy tools are changed at the same time, they are typically done in the same direction.

The bottom panel of Figure 1 plots the repo rate together with the 1 month and 1 year OIS rates. We omit the other OIS rates here to make the graph readable. This figure shows that OIS rates are a reasonable proxy for capturing the general trend in movement of the policy interest rates in India. In this paper we are interested in estimating the causal impact of RBI's monetary policy actions and thus we focus our analysis on RBI announcement days. The RBI announcement dates in our sample correspond to dates when information was revealed about changes (or non-changes) in the repo rate, the reverse repo rate, the bank rate and the cash reserve ratio. These announcements were made using either statements or circulars or press releases.

We analyse a total of 115 RBI announcement dates, excluding a total of five RBI announcements. We drop four circulars in October 2008 which were right after the bankruptcy of Lehman Brothers and related financial turmoil (Oct-6, Oct-10, Oct-15 and Oct-20). We also drop the May-18, 2004 meeting that is right after the announcement of the Union government election results. These announcement dates do not include dates when the RBI released information about its open market operations (OMO). The purpose of these purchase or sale operations is primarily to stabilize the liquidity in the market and hence, these announcements are unrelated to information about the future path of the policy rate. We leave the analysis

[11] The bank rate is the interest rate at which the RBI provides long-term loans to commercial banks without any collateral. In 2011 RBI instituted the marginal standing facility (MSF). The MSF rate, which has so far been changed only on a handful of occasions is the interest rate at which the RBI provides money to those commercial banks who are facing acute shortage of liquidity.

of these OMO dates for future research.

We use the daily change in OIS rates on these RBI announcement days to construct our measure of monetary policy shocks. One approach to characterize monetary policy shocks is to use the change in the shortest maturity rates to capture unexpected changes (or non-changes) to the policy rate target. For example, Bernanke and Kuttner (2005) do this for US data using the current month's fed funds futures rate. Das et al. (2020) and Mathur and Sengupta (2019) use the 1 month OIS rate to calculate monetary surprises for India. However, this approach ignores any information revealed by the central bank about the future path of the policy rate. Based on this idea, there is a large body of literature that uses longer maturity futures and OIS rates to capture forward guidance, see Gürkaynak et al. (2005) for an early influential paper.

Do higher maturity interest rates respond to information in RBI announcements over and above surprise changes in the policy rate target? We show in the next subsection that the answer is an emphatic yes. Before proceeding to this we would like to emphasize the importance of using OIS rates to isolate the unexpected component of policy rate changes. For the handful of studies that use high-frequency data to estimate monetary policy transmission in India, the focus has typically been on analysing responses to changes in the policy repo rate, without effectively accounting for the monetary policy surprises.

In our analysis, we find that financial markets in India do not react to repo rate changes (or non-changes) if these were expected. Instead markets react only to the surprise component. We break down the change in the repo rate as the sum of the expected component and unexpected component, $\Delta i = \Delta i^e + \Delta i^u$. Then using the change in the 1 month OIS rate as a proxy for the unexpected component of the change in the repo rate we back out the expected change, $\Delta i^e = \Delta i - \Delta i^u$. In Appendix Table A.4 we analyze the response of asset prices to both the expected and unexpected components of RBI's rate decisions and show that it is the unexpected component that has a systematic effect but not the expected component. This highlights the importance of isolating the unexpected component of repo rate changes.

Next we show that it is also important to look at the effect of RBI announcements on longer maturity OIS rates to fully characterize monetary policy shocks.

3.1 OIS rate changes on RBI announcement days

To capture surprises to the policy rate target and any surprises to the expected path of the policy rate, we analyze change in OIS rates of various maturities on RBI announcement days. We focus on five OIS rates of maturities 1,3,6,9-month and 1-year. We start by plotting the change in each of the five OIS rates on RBI announcement days in Figure 2. The grey shaded region shows the period from January 2007 to December 2009 reflecting the Global Financial Crisis and the figure shows that OIS rate changes are clearly more volatile in this period, especially for shorter maturities. In Sections 4 and 5 we discuss this period in more detail and show that our main results are robust to excluding these dates, but for now they are included in our sample.

The top panel of Table 2 shows summary statistics of daily change in OIS rates for RBI announcement days and all other days. OIS rates of all maturities move substantially more (roughly twice as much) on RBI announcement days, as can be seen from the standard-deviations. This is reassuring and is a first indication that OIS markets are indeed reacting to the information revealed by the RBI. In Appendix Table A.1 we show summary statistics for OIS rate changes broken down by individual governor regimes. The table confirms that the pattern of OIS rates moving more on RBI announcement days is pervasive and occurs for all governors in our sample.

Appendix Table A.1 also helps understand if there have been changes in the size of the shocks over time, perhaps due to greater transparency or change in the monetary policy operating regime with the shift to MPC and IT. The top panel of the table shows the change in the 1 month and 1 year OIS rates by governor regimes. The standard deviation decreases with each successive governor regime from Reddy to MPC, suggesting that the size of surprises

has gone down over time. However, there are two issues that complicate this interpretation.

First, the level of the interest rate has changed substantially over the sample period and has been on a downward path since 2012. Higher level of the interest rate will mechanically lead to larger surprises in the OIS rates. To account for this we calculate the percent change in daily OIS rates rather than just the change.

Second, as we discuss in Section 4 the Global Financial Crisis was a period with large shocks to the OIS rates. To account for this we drop the period from January 2007 to December 2009. These results presented in the bottom panel of Appendix Table A.1 show that there is no longer any evidence of decline in size of shocks over time. The standard deviation is lowest under Governor Rajan but not substantially lower. Interestingly, since the official implementation of IT lines up with the start of the MPC regime, the table also shows that there is no evidence of IT changing the size of monetary surprises. This is true even if we start the IT regime in early 2015 under Governor Rajan when it was first announced.

Based on these results, we think it is more helpful to think about regime shifts of RBI policy in terms of changes in governor regimes rather than pre-IT vs. post-IT regimes.

3.2 Factor analysis of OIS rate changes

Surprise news about the repo rate (and the other short-term rate policy instrument used by the RBI) is directly reflected in higher volatility of the short end of the OIS rate curve on RBI announcement days. These surprises should also result in higher volatility in medium term OIS rates, based on the term structure relationship. This can be seen from the substantial amount of correlation across the maturities in the changes in OIS rates on RBI announcement days. For example, the correlation of the change in the 1 month OIS with the change in 3 month OIS is 0.85 and with the change in 1 year OIS rate is 0.61.

A natural question is how much independent variation is there in medium term OIS rates relative to shorter ones. In other words, is there some form of "forward guidance" or "news" revealed by the RBI about future policy rates that moves medium term rates independently

of short end rates? To tackle this question we conduct a factor analysis.

Let X denote a T x r matrix of the daily change in the OIS rates on RBI days, where T is the number of time periods and r represents the number of OIS rate changes used. We focus on 115 RBI announcements as explained in detailed above in Section 3.1. We use 5 OIS rates: 1,3,6,9-month and 1-year and perform a principal components analysis of these OIS rate changes, $X = F\Lambda + \widetilde{\eta}$ where F is a T x k matrix of principal components, Λ is a k x 1 vector of factor loadings and $\widetilde{\eta}$ is an error term.

Table 3 shows that the first principal component explains 85% and the second one explains 12% more of the variation in the five OIS rate changes. Together the first two principal components explain almost 97% of the variation and suggest that there are two "dimensions" of variation in the OIS rate changes on RBI announcement days. In other words, the first two principal components capture most of the information being revealed by the RBI on announcement days. But these principal components are both correlated with short and long end of the OIS rate curve and thus prevent us from attaching any economic meaning. To provide a structural interpretation, we follow the approach of Gürkaynak et al. (2005) and transform these two principal components into the so-called "target" and "path" factors.

The target factor is intended to capture surprise changes to the central bank's short-term policy rate target. The path factor is intended to capture surprise changes to forward guidance, or any surprise news that makes markets change their expected path for future policy rates. These two factors are constructed to be orthogonal to one another, just like the principal components. This means that the path factor captures news about future rates that is uncorrelated to surprise changes to the contemporaneous policy target rate. This is performed using a factor rotating methodology and in Appendix Section A we provide details on how these are computed.

Table 4 shows the share of the variance of each individual OIS rate change that is explained by the target and path factors. The target factor explains 98% of variance in the 1 month OIS rate while the path factor explains 0% (by construction). As the maturity increases notice

that the target factor explains less and the path factor explains more of the variation. For the 1 year OIS rate, the path factor explains about two-thirds while the target only explains a third. The important implication is that RBI announcements are moving medium term rates independent of their effect on short rates.

To provide even more intuition about the target and path factors, in Appendix Figure A.1 we show scatter plots that makes the following relationship clear: the target factor is highly correlated (0.98) with the changes in the 1 month OIS rate. The path factor is highly correlated (0.97) with the residual from regressing the 1 year OIS rate on the 1 month OIS rate.

In Figure 3 we plot the target and path factors, with shadings to demarcate the governor regimes. We normalize the factors in the following way. The target factor is scaled to have a unit effect on the 1 month OIS rate. The path factor is scaled to have the same effect that the target factor does on the 1 year OIS rate. The target factor has large positive and negative realizations during the regimes of Governors Reddy and Subbarao coinciding with the Global Financial Crisis, followed by much smaller realizations for the rest of the sample. The path factor on the other hand shows uniformity in the size of the realizations across most of the sample with just slightly elevated values around the Global Financial Crisis. In the next subsection we provide an attempt at interpreting the big realizations of the two shocks by conducting a narrative analysis where we bring in evidence from RBI statements and the related media discussion.

An alternative to the two-factor approach taken here is to use just the first principal component, as done recently in Nakamura and Steinsson (2018). The correlation between the first principal component and the target factor is greater than 0.9, while correlation with the path factor is only around 0.3. Thus, in terms of the Indian financial market response, the first principal component approach would be more akin to just using the target factor. Relatedly, in Section 5 we discuss that there are two main issues why our two factor approach is preferable. First, using only one factor means losing out on substantial explanatory power

in the high frequency response of asset prices, especially bond yields. Second it leads to a weak instrument problem in a proxy structural vector autoregression framework and makes the one factor approach unsuitable for studying the impact on macroeconomic variables as well. In the event that some researchers want to use a single variable to capture monetary shocks for India, we have made this series of the first principal component publicly available.[12]

Is there any evidence of asymmetry in the measure of monetary shocks? The principal component analysis that we perform normalizes the two shocks to have mean zero and thus makes it difficult to answer that question. But we can look at the raw OIS rate changes to get an idea. Table A.2 shows the number of "expansionary" and number of "contractionary" RBI announcements based on whether the sign of the change is negative or positive. Focusing on the 1 year OIS rate, the table shows that there is not much evidence of asymmetry with only slightly more contractionary surprises (59) compared to expansionary surprises (50).

However, there seems to be more asymmetry when we look within governor regimes. For Governors Reddy and Subbarao there are notably more contractionary surprises (relative to expansionary) but under the MPC, there are more expansionary surprises. In Section 5 we explore if the transmission to financial markets depends on whether there is an expansionary or contractionary surprise.

In the next section we conduct a narrative analysis where we examine the RBI meeting dates with the biggest changes in the target and path factors and try to relate the language in the statement released by the RBI and related media discussion to the estimated target and path factors.

4 Narrative Analysis

Our approach in this paper relies on using OIS rates to capture how the markets interpret the RBI's decisions about the policy rate target and any signals about the path of the future

[12]See link: https://aeimit.weebly.com/data.html.

policy rate. A narrative analysis serves as an external validation exercise for our approach and also helps shed light on the nature of the communication used by the RBI. Specifically, we read through the official RBI statements and the corresponding discussion of the RBI announcement in The Economic Times newspaper, a leading English financial daily considered to be a trusted source for economic and financial news in India. Our analysis reveals that typically there is a clear and intuitive link between the target/path factor shocks and RBI decisions, communication and related media coverage.

However, there is one stark exception to this rule. Target factor shocks around the Global Financial Crisis imply market surprises that are too large to be reconciled with RBI actions or description of market's reaction in the media. Thus for our main narrative analysis in this section we will drop the period from January 2007 to December 2009, providing a discussion of the target factor shocks in Global Financial Crisis towards the end of this section. We focus on the top two realizations of the target and path factor for each governor regime. These dates are listed in Table 5 and Table 6 together with a description of the key takeaway for that date from our analysis.

For the discussion of the top target factor dates (shown in Table 5), we rely more on media commentary to interpret the shocks associated with the policy rate changes because what matters here is what the RBI *did* instead of what the RBI *said*. Other than the period noted above, we find that when the newspaper articles highlight a surprise change (or non-change) by the RBI, it aligns well with the direction and size of the surprise as measured by the target factor shock.

A noteworthy date is 7 December, 2016, the largest target factor of the IT regime. This meeting came right after the Demonetization announcement of November 8, 2016 when more than 85% of currency was withdrawn from circulation by the Indian government. The markets were almost certain that the RBI would cut rates but the MPC kept rates unchanged citing inflationary pressures. This took the markets by surprise and is reflected in a contractionary monetary policy shock with a large positive realization of the target factor. The table also

shows other examples of the market surprise being accurately captured by the target factor, for instance the higher than expected rate cut under Governor Rajan in September 2015 and the no change under Governor Subbarao in July 2012 when the market expected a rate cut.

But the target factor also captures meetings where the repo rate decision was not the main action that the markets were anticipating (and later reacting to). For example, in Governor Rajan's first RBI announcement on September 21, 2013, he increased the repo rate but simultaneously lowered the marginal standing facility rate (MSF). The media narrative was more focused on the MSF rate before the announcement and the negative realization of the target factor on this date is consistent with this narrative. Similarly, on December 11, 2006, Governor Reddy announced through an unscheduled circular an increase in the CRR by 50 basis points, but did not change the repo rate. The media discussion focused on unexpected increase in the CRR and a positive realization of the target factor is consistent with this narrative.

Next, to help us understand how the market reacts to the communication from the RBI, we look at the notable path factor dates. For our sample period, the RBI officially described its stance on forward guidance in a document titled "Communication policy of RBI" as follows:[13]

> *The RBI's approach to communicating the policy stance is to explain the stance with rationale, information and analysis but to refrain from explicit forward guidance with a preference for market participants and analysts to draw their own inferences.*

Our analysis confirms that the RBI does not give explicit guidance about the future path of the policy rates. Instead we find that market infers hints about the future direction of the policy rate from RBI discussion about the macroeconomic outlook. From our reading of the RBI statements we find that these are quite verbose and often have conflicting messages about

[13]This archived document can be accessed at https://web.archive.org/web/20181029064140/https://rbi.org.in/Scripts/CommunicationPolicy.aspx In July 2021, the RBI updated their communication policy (calling it "Version 2.0") where they removed the line about "refrain from explicit forward guidance" and replaced it with *"The Reserve Bank explains the monetary policy measures and stance with the rationale, information and analysis to enable market participants and other stakeholders to provide clarity about its assessment of the evolving situation."* This new policy can be found at https://bit.ly/2V6sCIm

the economic outlook. Nevertheless, the media discussion tends to focus on a dominant theme from the statements and we find that the path factor estimate is generally consistent with this dominant theme.

In some instances, the media reaction is clearly focused on a particular phrase in the RBI statement to gauge the future direction of monetary policy. As shown in Table 6, a notable instance is the 25 October, 2011 statement under Governor Subbarao's tenure. The repo rate was raised by 25 basis points but–consistent with the media discussion– this move was entirely expected and we get a target factor of essentially zero. However, the statement discussed a downward revision of future inflation and had the sentence "*... if the inflation trajectory conforms to projections, further rate hikes may not be warranted*". The media articles all prominently mention this particular phrase when reporting the dovish stance of the RBI. The substantially negative path factor captures this expansionary shock, and indeed it is the largest in magnitude in our entire sample.

Another example of the market reacting to what the RBI said in its statement is 3 June, 2014, the second highest path factor realisation during Governor Rajan's tenure. RBI left the repo rate unchanged at 8% and the monetary policy statement mentioned: "*If the economy stays on this course, further policy tightening will not be warranted. On the other hand, if disinflation, adjusting for base effects, is faster than currently anticipated, it will provide headroom for an easing of the policy stance*". The large negative realization of the path factor implies that the markets expected that because the policy rate had been left unchanged in this meeting, the RBI would lower the repo rate by even more in the next year compared to what the markets had anticipated prior to the meeting. Indeed, the RBI brought the repo rate down from 8% to 7.75% at its 15 January 2015 meeting.

Finally, an example of how the market deciphered clues about policy actions from a mixed message from the RBI statement is the 5 December, 2019 statement under Governor Das during the IT regime. After lowering the repo rate in 5 consecutive meetings from 6.25% to 5.15% between February 2019 and October 2019, the RBI decided to keep the rate unchanged

but the MPC's statement highlighted risks to both growth and inflation going forward. To quote from the statement: " *In the judgement of the MPC, inflation is rising in the near-term, but it is likely to moderate below target by Q2:2020-21. It is, therefore, prudent to carefully monitor incoming data to gain clarity on the inflation outlook.*" and "*The MPC recognises that there is monetary policy space for future action. However, given the evolving growth-inflation dynamics, the MPC felt it appropriate to take a pause at this juncture.*". The media reaction focused on the MPC's communication about upside risks to inflation and implied that the RBI will not cut rates as much in the future (relative to previous expectations). Our estimate of a large and positive path factor is again consistent with this media narrative.

In Appendix Table A.5 we list some of the dates from the Global Financial Crisis period when the target factor realisations were excessively high, reflecting the high volatility in the underlying OIS rates during this period. For example, on 30 March, 2007, RBI raised the repo rate by 25 basis points whereas the target factor is valued -1.586, suggesting that markets expected the RBI to raise the policy rate by almost 2%. Expectations for such a massive increase in policy rates would have surely been discussed in the financial media, but we find no such mention.

Our narrative analysis shows that once we exclude this volatile crisis period, there are clear instances where surprise movements in the policy rate got captured by our estimated target factors. For the path factor while there are a few instances when the RBI's monetary policy statements contained explicit forward guidance about the future path of interest rates, by and large the markets deciphered information from the RBI's communication about future policy stance and macroeconomic conditions.

5 Transmission of monetary shocks

In this section we explore the transmission of the two kinds of monetary policy shocks to the economy. First, in Section 5.1 we document the high frequency response of financial market

prices to the two monetary shocks as captured by the target and path factors. Next, in Section 5.2 we study the response of output and inflation with a monthly structural vector autoregression using the monetary shocks as instruments for identification.

5.1 High frequency transmission to financial markets

We study the response of government bond yields, stock returns and currency returns to the target and path factors using an event study approach. We focus on a daily window around each RBI announcement. The regression takes the following form.

$$\Delta s_t = \alpha + \beta_1 target_t + \beta_2 path_t + \varepsilon_t \tag{1}$$

Δs_t is the change/return in the asset price measured based on closing price on day of RBI announcement relative to the previous trading day's closing price. We use data on the 5 year and 10 year government bond yields, the returns on the benchmark Nifty 50 index listed on the National Stock Exchange (NSE) and the returns on the INR\USD exchange rate. The bond yield, the stock market, and exchange rate data are from Reuters Datastream and the OIS data is from Blooomberg.

The sample has 115 observations from September 2003 to December 2020.[14] For each asset price we report two columns. In the first column we run the regression excluding the path factor (i.e. setting β_2 to zero). In the second column we add the path factor to the regression. This exercise will allow us to easily see the contribution of each type of monetary shock in explaining the variation in the asset price change. Note that since the two factors are orthogonal by construction, coefficients from including both factors in the regression will be exactly the same as putting one factor individually in the regression.[15] This can be seen by noticing that the coefficient on the target factor does not change across the two columns.

[14]The exchange rate regression has only 111 observations.

[15]Thus we do not present results for regressions with only the path factor for space considerations.

Moreover, while the contribution of target factor to the R^2 is apparent in the first column, the contribution of the path factor to the R^2 is the difference between the R^2 of the two columns.

Recall that the target factor is scaled to have a unit effect on the 1 month OIS rate and the path factor is scaled to have the same effect that the target factor has on the 1 year OIS rate. For ease of interpretation in Appendix Table A.3 we regress the five OIS rates on the target and path factors and show that the coefficient of both the target factor and path factor in the 1 year OIS rate regression is 0.26. In other words a 100 basis point increase in the target and path factors corresponds to a 26 basis point increase in the 1 year OIS rate. Table 7 reports the results from estimation of Equation 1 with t-statistics in parentheses that are calculated using White heteroskedasticity-robust standard errors.

The target and path factors both have a statistically significant and positive effect on 5 and 10 year government bond yields. The path factor has a bigger effect on the 10 year yield relative to the target factor: the coefficient is more than twice as large. A path factor shock that increases the 1 year OIS by 26 basis points leads to a 19 basis point increase in the 10 year government bond yield, but there is only a 7 basis point increase in response to a target factor shock. Thus long term bond yields respond substantially more to information revealed in RBI statements about the future path of monetary policy rather than to surprise changes in the short-term policy rates. The R^2 from the two columns corroborates that the path factor contributes substantially more in explaining movements in the bond yields. Adding the path factor increases the R^2 from 0.03 to 0.49 for the 10 year yield.

As an alternative to using OIS rates, we also construct monetary shocks using data on Indian government T-bills. Due to the limited data availability of Indian government T-bills we measure the alternate target factor as the change in the 3 month T-bill rate and the path factor as the residual from regressing the 1 year T-bill rate on the 3 month T-bill rate. Table A.6 shows the transmission to stock, bond and foreign exchange markets using these alternative measures. It is apparent that the results are very similar to our baseline results in Table 7.

There is significant heterogeneity in the bond market response across governor regimes. In Appendix Table A.7 we show the bond market response separately by governor regimes, grouping Urjit Patel and Shaktikanta Das into the "MPC" regime.[16] Under Governors Reddy and Subbarao, the bond yield response to both target and path factors is similar to the full sample response reported in Table 7. However, under Governor Rajan and the MPC, the responses are drastically different from the full sample and from each other. Under Governor Rajan, the target factor has no effect (i.e. small and statistically insignificant effect) and explains essentially 0% of the variation in the 10 year yield. But the 10 year yield response to the path factor is substantially larger (five times as much relative to the overall sample effect) and explains all of the 0.62 R^2.

Notably, this pattern completely reverses under the MPC regime. The 10 year yield response to the target factor is ten times larger than the overall sample effect and the path factor becomes insignificant. These results suggest that bond markets were only paying attention to RBI statements and communication under the Rajan regime, and were not reacting to surprise changes in the repo rate. However, under the MPC the bond market stopped responding completely to information revealed in the statement, instead responding to only surprise changes (and non-changes) in the repo rate.

Both target and path factors also cause a statistically significant impact on the stock market in the full sample. Unlike the bond market, the stock market responds more to the target factor than to the path factor in the overall sample. Stock prices fall by 3.3% in response to a target factor shock but only by 1.5% in response to a path factor shock.[17] The bulk of the explanatory power is attributed to target factor (0.13 from target factor and only 0.04 from path factor).

[16]We club together the last two governors into an MPC regime due to the relatively fewer observations available in each governor's regime. There are potentially important differences in implementation of monetary policy across the two regimes, for example the narrowing of the corridor between the repo and reverse repo rate under Urijit Patel and the growing use of the reverse repo rate as the effective reference rate in the Shaktikanta Das regime.

[17]The size of the effect is roughly similar to the response of Indian stock prices to US monetary policy shocks, see for example Lakdawala (2021).

One reason for the lower responsiveness of stock prices to the path factor could be related to the so-called "information effect". The idea is that monetary announcements convey information about the current and future stance of monetary policy but also about the central bank's internal macroeconomic forecasts. This revelation of information about macro fundamentals comes from specific language used in the statement and thus is more likely to be captured by the path factor and not the target factor.[18] For stock prices, the information effect works in the opposite direction of a conventional monetary shock. For example, if the RBI signals that they are going to raise rates because the economy is growing faster than the markets had been expecting, then the news of higher rates would lower stock prices through higher discount rates. But the news about higher growth would raise stock prices due to higher expected cash flow. Note that the information effect works in the same direction as the conventional monetary shock effect for bond yields.

There is again substantial variation in stock response across governors regimes with shifting importance of target and path factors, there results are presented in Appendix Table A.8. Under Governors Reddy and Rajan the stock market responds primarily to the path factor but under Subbarao the target factor is the bigger driving force. Under MPC the stock market does not respond significantly to either target or path factor and the R^2 from the regression is essentially zero. The information effect is a potential candidate for explaining the heterogenous response across governors. In this paper we do not directly investigate the role of the information effect in driving the financial market's response to RBI announcements but it appears to be a promising area for future research.

The foreign exchange market does not react systematically to either target or path factor in the overall sample. The exchange rate is defined as Indian rupees per US dollar, so an increase represents a depreciation of the Indian rupee. The coefficients imply a depreciation in response to the target factor but an appreciation in response to the path factor, but neither

[18]For a detailed discussion of how forward guidance by the central bank can have information effects, see Campbell et al. (2012). For an example of recent work on the relationship between stock prices and central bank information effects see Lakdawala and Schaffer (2019).

effect is statistically significant. One potential reason for this might be that the RBI actively intervenes in the foreign exchange market on a regular basis to stabilise the exchange rate, as documented in Patnaik and Sengupta (2022). As a result, it may be difficult to capture the response of the exchange rate to monetary policy announcements.

As discussed in Section 3, the changes in OIS rates around the Global Financial Crisis of 2007-09 appear to be less reliable than the rest of the sample. Hence we check to see if the baseline results presented in Table 7 are sensitive to excluding the period corresponding to the global financial crisis. In Appendix Table A.10 we estimate Equation 1 dropping all RBI dates from January 2007 to December 2009. The results are quite similar to the baseline case. This is reassuring and suggests that transmission of monetary shocks to financial markets is not driven by the turbulent period around the Global Financial Crisis.

For our baseline regressions, asset price responses are measured with a daily window around RBI announcements. One concern with this approach is that the financial markets may not be getting enough time to digest all the information revealed in the RBI announcement, especially the ones that come later in the day. As a robustness check in Appendix Table A.11 we regress the 2 day change/return in the 5 and 10 year bond yields, the Nifty and the exchange rate on the target and path factors and show that the results are very similar.

An alternative to the two factor approach taken in this paper to construct monetary policy shocks is to just use the first principal component. The idea is that it is a more parsimonious way to capture monetary policy shocks in a single measure. To compare this with our approach, in Appendix Table A.12 we regress the asset price changes/returns on the first principal component of OIS rate changes. The qualitative pattern of the effect on asset prices is similar to that we documented in Table 7, viz. bond yields rise, stock prices fall and exchange rate does not respond much to a monetary tightening. However, quantitatively there are important differences, especially for bond yields where the R^2 from the regression is substantially lower with the first principal component approach, for example the 10 year yield regression R^2 is 0.49 with two factors but only 0.14 with one. Thus we think it is important

to use two factors to better characterize the full effect of RBI actions and communication on financial markets.

Finally, we explore any potential asymmetric effects of the monetary policy shocks. We categorize RBI announcement dates as "expansionary" or "contractionary" based on the sign of the change in the 1 year OIS rate. We separately run the event study regression of Equation 1 for these two sets of dates. We exclude the dates that resulted in no change in the 1 year OIS rate. Appendix Table A.13 reports the regression results. For bond yields, there is no evidence of asymmetric effects. The path factor-which is the major driver of bond yields-shows identical effects across expansionary and contractionary dates. However, for the stock market there appears to be some evidence of an asymmetric effect. On expansionary days the stock market does not respond significantly to either the target or path factor. But on contractionary days, the stock market responds strongly. The target factor coefficient on contractionary days is similar in size to the overall coefficient reported in Table 7. The path factor coefficient is twice as large as that in Table 7. The exchange rate response is insignificant on both expansionary and contractionary days.

Overall, we find strong high frequency evidence that the financial markets are responding systematically to the information revealed by the RBI on announcement days as captured through our monetary shocks. In the next section we explore the lower frequency response of macro variables to the monetary shocks.

5.2 Transmission to real economy

We use a structural vector autoregression to estimate the dynamic impact of monetary policy on output and inflation. The monetary shocks are used as external instruments (or proxies) to identify the causal effect of RBI's actions.

Consider the structural VAR where y_t is an n x 1 vector of macroeconomic variables and

α_i are n x n parameter matrices

$$Ay_t = \alpha_1 y_{t-1} + \ldots + \alpha_p y_{t-p} + \varepsilon_t \tag{2}$$

The components of the error terms ε_t are assumed to be uncorrelated with each other and interpreted as structural shocks. We pre-multiply by A^{-1} to get the reduced form VAR

$$y_t = \delta_1 y_{t-1} + \ldots + \delta_p y_{t-p} + u_t \tag{3}$$

where $u_t = B\varepsilon_t$ and $A^{-1} = B$ Also note that $E[u_t u_t'] = E[BB'] = \Sigma$. This reduced form VAR can be estimated in a straightforward manner. However identification of the impulse responses to the structural shocks requires an estimate of the matrix $B = A^{-1}$, which requires further restrictions. In this paper we will follow the external instruments procedure outlined and developed by Stock and Watson (2002) and Mertens and Ravn (2013) and used recently in an Indian context by Lakdawala and Singh (2019)

The key requirement is to find an instrument that is correlated with the monetary policy shock but uncorrelated with the other structural shocks. Denote the policy shock as ε_t^p and the non-policy shocks as ε_t^q. For a given instrument Z_t, these two conditions are written as

$$E[Z_t \varepsilon_t^{p'}] = \phi \tag{4}$$

$$E[Z_t \varepsilon_t^{q'}] = 0 \tag{5}$$

The baseline VAR is a simple 4 variable monthly VAR with a measure of output, prices, exchange rate and an indicator that captures the stance of monetary policy. We use the monthly average of the 1 year OIS rate for this purpose, following the work of Gertler and Karadi (2015). The idea is to have this variable capture shocks to both changes in the target policy rate and any "forward guidance". Economic activity is measured using the index of industrial production and inflation is measured using the Consumer Price Index. The exchange

rate is the monthly average of the INR \USD exchange rate. We use 12 lags in the estimation. To use our target and path factors or OIS rate changes in general–which have been constructed on RBI meeting days–they need to be converted to a monthly frequency. We follow the simple procedure of summing any shocks that happen within the month. We have also tried an alternative methodology that adjusts for the fact that RBI meetings fall on different days in the month, with similar results.

One issue with using the external instruments identification strategy is the weak instruments problem. To explore the strength of the factors as instruments we present the results from the first stage regressions in Appendix Table A.14. The table shows the regression of the reduced-from residual from the OIS 1 year rate equation of the four variable VAR on the target and path factors, the first principal component of the five OIS rates and the individual OIS rates as well. The estimates show that none of the individual OIS rate changes nor the first principal component would serve as effective instruments in the VAR, as they are all insignificantly related to the residual. Some of them even have the wrong sign, changes in the 1 month and 3 month OIS rate and first principal component are negatively associated to the 1 year residual. The second row shows that the target factor also is negatively related to the residual and its effect is insignificant.

Only the path factor is significantly related to the 1 year residual. The F-statistic is around 7, which is close the recommendation of 10 that is usually used in the applied literature. Moreover, the R^2 for the path factor is also substantially higher than all the other cases. Thus in our estimation we use the path factor as the instrument to identify the structural impulse responses in the VAR.

Figure 4 plots the impulse response to a one unit contractionary shock to the 1 year OIS rate. After rising on impact, the 1 year rate falls back towards zero after about a year. CPI falls on impact. The effect is marginally significant and reverts back to zero after a few months. The Indian rupee appreciates on impact and effect last for about a year. Contrary to the expected effects of a contractionary monetary policy shock, output rises on impact.

While the estimated impulse response of output is not significant on impact, it is significant around the 6 month mark. While this result is surprising from the perspective of conventional macroeconomic theory, it is consistent with prior evidence on Indian monetary transmission using VAR models (Mishra et al. (2016)).

We compare our identification approach to the commonly used Cholesky (or recursive) identification scheme. In Appendix Figure A.2 we show the impulse responses for the baseline VAR identified using the Cholesky identification. The ordering of the variables is i)IIP, ii)CPI, iii)1y OIS and iv) INR\USD. Industrial production and CPI are thus not allowed to react contemporaneously to the monetary policy shock, as is common in this literature. But our external instrument identification shows that output goes up while CPI falls on impact. Moreover, while the Cholesky identification allows for the exchange rate to respond contemporaneously, the estimated impact is close to zero, compared to the appreciation in the external instruments framework. Overall, using the Cholesky identification would appear to mis-characterize the response of the economy to a monetary policy shock.

We also explore the effect of monetary policy shocks on bond and equity markets using the VAR. To do so, we add them to the baseline VAR and plot the impulse responses in Appendix Figure A.3. On impact the 10 year yield rises around 70 basis points and the response stays statistically significant for about a year. Stock prices fall on impact but steadily rise over the next months.

Overall, we see that while the monetary shock has the expected impact on financial market variables and even inflation, the effect on output is at odds with standard macroeconomic theory. What could be driving this result? As has been documented in the literature, the monetary transmission mechanism is weak in India and results from the literature are often inconclusive (for example, Aleem (2010), Mohanty (2012), and Mishra et al. (2016)). One intriguing explanation for the positive response of output to a contractionary monetary shock could be related to the information effect discussed above, whereby a contractionary shock

is related to good news about the economy.[19] Thus if agents revise their expectations and decisions in response to the good news then that could contribute to higher economic activity.

Alternatively, it could be the more prosaic issue that the index of industrial production is not accurately capturing economic activity in India. We use this index as it is the only readily available indicator of economic activity at a monthly frequency. Investigating the appropriateness of using index of industrial production as an accurate proxy for broader economic activity in detail remains an important but open question. Another potentially important factor that might help explain the lack of an effective monetary transmission is fiscal dominance of monetary policy, as documented by Gupta and Sengupta (2016) and described at length in Acharya (2020).

6 Conclusion

We have constructed a new measure of monetary policy shocks for India using data on OIS rates. We complement this with a narrative analysis to highlight when these shocks are reliable at capturing the surprise component of RBI's decisions. The surprise component involves both unexpected (non) changes to the policy rate and guidance–typically not explicit– about the future direction of the policy rate. These shocks can be readily used to investigate the monetary transmission mechanism in India. We use these shocks in a high frequency event study framework to identify the response of financial markets and find that stock and bond markets respond substantially. We also use the shocks as external instruments in a monthly SVAR and find that while prices fall in response to a contractionary shock output actually rises.

We think that our strategy of combining high-frequency financial market data together with a careful reading of the policy statements and media discussion provides a template for investigating the monetary transmission mechanism more broadly in emerging countries. We

[19]For evidence of central bank information effects in a structural VAR setting, see Lakdawala (2019) and Jarociński and Karadi (2020).

have also made the Indian monetary shocks data publicly available to researchers with the hope that our work in this paper dovetails into a more widespread effort in understanding the monetary transmission mechanism in India. For example, a more detailed investigation of the effect of monetary shocks on broader interest rates in the economy, including rates in interbank markets and longer term interest rates directly affecting firms and households is an important area for future research.

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Figure 1: Policy tools of the RBI and OIS rates

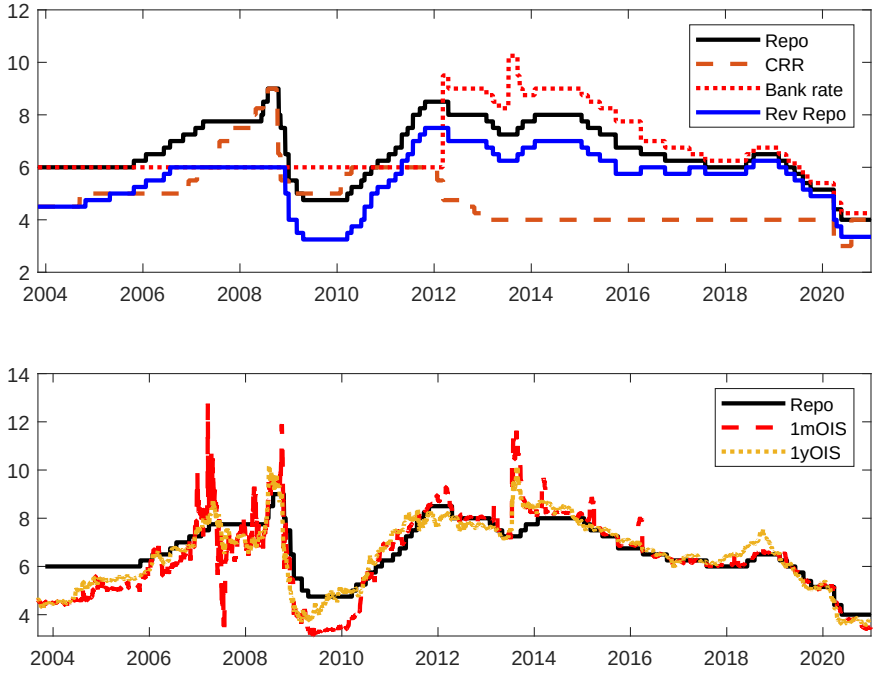


Figure 2: Change in OIS rates on RBI announcement days

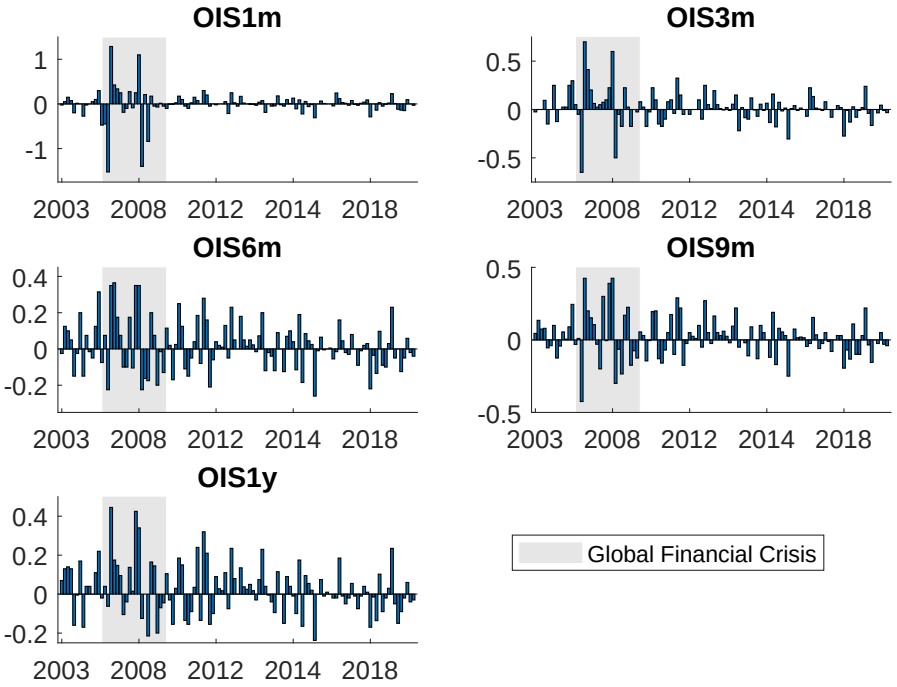


Figure 3: Target and Path Factors

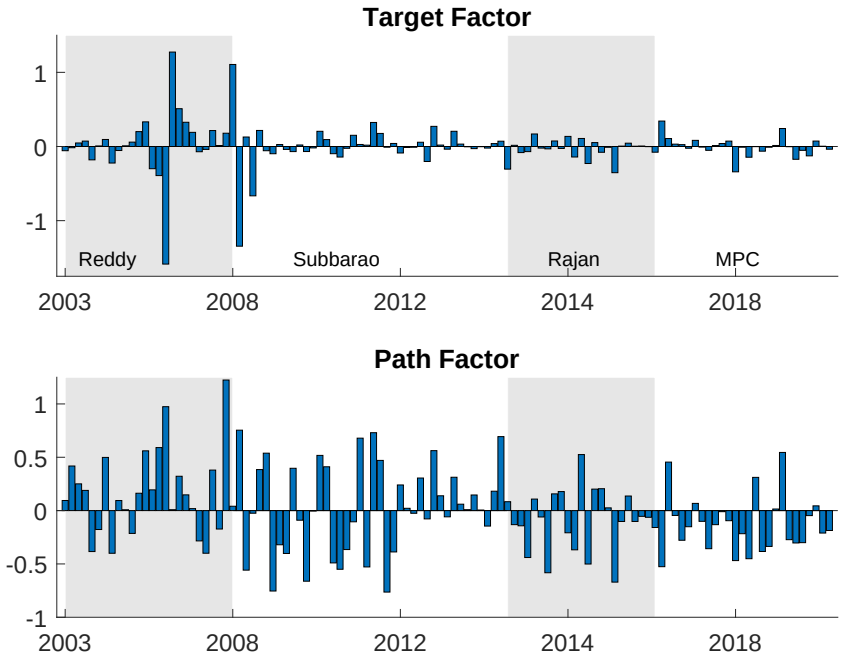
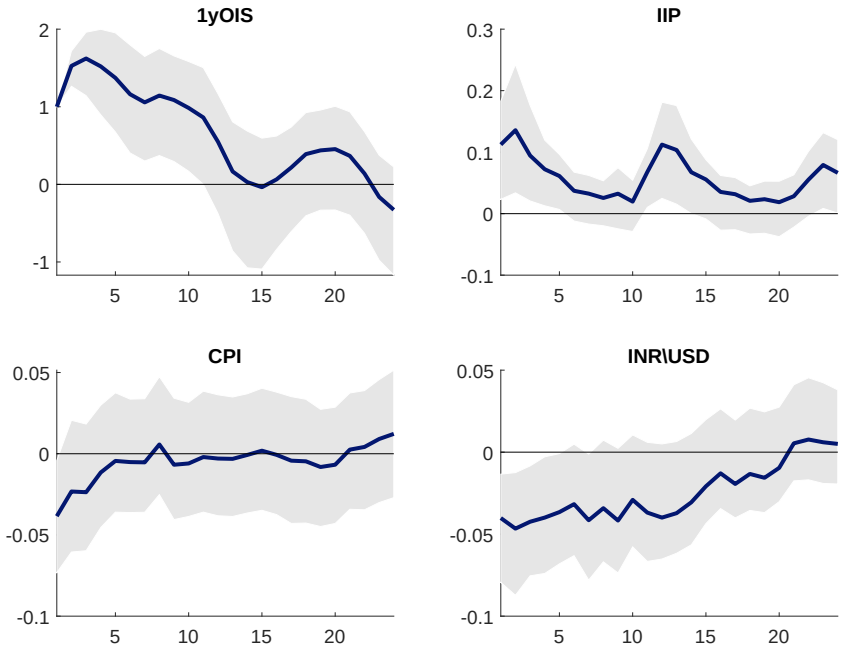


Figure 4: Impulse response to a monetary policy shock



Impulse responses to a 100 basis point shock to the 1 year OIS rate identified using the external instruments/ proxyVAR methodology, with the path factor used as the instrument. The sample runs from September 2003 to December 2020. The shaded grey areas represent bootstraped 90% confidence intervals.

Table 1: Monetary Policy communication instruments of the RBI, 2003–present

Governor	**Term**	**Instruments of communication**	**Statement intervals**
Dr. Y.V. Reddy	2003-09-06 to 2008-09-05	Statements (17); Circulars (8); Press releases (2)	3, 4, 6 months
Dr. D. Subbarao	2008-09-05 to 2011-09-04 2010-09-16 to 2013-06-17	Statements (20); Circulars (13) Mid-quarter reviews/Press releases (12)	3 months
Dr. Raghuram Rajan	2013-09-04 to 2016-09-04	Statements (19); Circulars (1) Mid-quarter reviews/Press releases (2)	2, 3 months
Dr. Urjit Patel (MPC)	2016-09-04 to 2018-12-05	Statements (14)	2 months
Shaktikanta Das (MPC)	2019-02-07 to Present	Statements (15); Circulars (1)	2 months

The tenures of Governors Urjit Patel and Shaktikanta Das overlap with the period of formal inflation targeting. The current Governor Shaktikanta Das has till date (till June 2021) presided over 15 monetary policy statements of the monetary policy committee (MPC).

Table 2: Summary statistics of OIS rate changes

	RBI Statement days			All other days		
	Mean	Std-dev	Obs	Mean	Std-dev	Obs
OIS 1m	-0.001	0.298	115	0.000	0.163	4399
OIS 3m	0.019	0.167	115	0.000	0.095	4399
OIS 6m	0.017	0.134	115	0.000	0.075	4399
OIS 9m	0.019	0.140	115	0.000	0.073	4399
OIS 1y	0.025	0.128	115	-0.001	0.056	4399

Summary statistics for daily change in OIS rates on RBI announcement days and all other days. The sample runs from September 2003 to December 2020.

Table 3: Share of variance of OIS rate changes explained by principal components

1st PC	85.1
2nd PC	11.7
3rd PC	1.9
4th PC	0.7
5th PC	0.6

The table shows the share of variance explained of changes in the five OIS rates (1,3,6,9-month and 1-year) on RBI announcement days by the principal components. The sample has 107 observations from September 2003 to December 2020.

Table 4: Share of variance of individual OIS rate changes explained by target and path factor

OIS rates	Target factor	Path factor	Unexplained
1 month	0.976	0.000	0.024
3 month	0.817	0.112	0.071
6 month	0.456	0.499	0.045
9 month	0.573	0.378	0.049
1 year	0.366	0.594	0.040

The table shows the share of variance explained of changes in individual OIS rates on RBI announcement days by the target and path factor. The sample has 107 observations from September 2003 to December 2020.

Table 5: Top Target Factors: A Narrative Analysis

Date	Regime	Target Factor	Path Factor	Description
11 Dec. 2006	Reddy	0.33	0.56	Repo rate unchanged at 7.25%, CRR increased from 5% to 5.5% with an unscheduled circular. Market was not expecting CRR change: "In a surprise move, RBI announced a hike in the Cash Reserve Ratio" (ET, *Call rates likely to hold firm, 11 Dec, 2006*).
18 Apr. 2006	Reddy	-0.22	-0.40	Repo rate unchanged at 6.5%. Market was expecting RBI to raise rates: "And a large section of the market thinks that given a choice, he will go ahead with rate hikes." (ET, *Reddy unlikely to go soft on interest rates, 17 Apr, 2006*).
26 Jul. 2011	Subbarao	0.32	0.73	Repo rate increased from 7.5% to 8%, more than market expectation: "All 15 market participants polled by ET over the weekend were unanimous the central bank would raise repo rate by 25 basis points" (ET, *RBI set to raise key rates by 25 basis points today, 26 Jul, 2011*).
18 Jun. 2012	Subbarao	0.27	0.56	Repo rate unchanged at 8%, market expected a decrease: "Markets expected the RBI to cut rates to boost growth ..." (ET, *Banks to underperform markets in short term on RBI move, 19 Jun, 2012*).
29 Sept. 2015	Rajan	-0.35	-0.67	Repo rate lowered from 7.25% to 6.75%. Media report: "The 50 basis point cut in the repo rate was higher than the market expectation of 25 basis points ..." (ET, *Analysts, economists react with surprise, elation, 30 Sep, 2015*).
20 Sept. 2013	Rajan	-0.31	0.08	Repo rate raised from 7.25% to 7.5% but marginal standing facility (MSF) rate lowered to 9.5% from 10.25%. Market were conflicted, with some expecting lower MSF but no change in repo. (ET, *RBI governor Raghuram Rajan may keep interest rates intact, 20 Sep, 2013*).
7 Dec. 2016	MPC	0.34	-0.53	Repo rate unchanged at 6.25%, surprising markets: "The RBI decision shocked the market as everybody thought a 25 basis point rate cut was a certainty" (ET, *RBI keeps rates unchanged, projects momentum loss for economy, 8 Dec, 2016*).
5 Oct. 2018	MPC	-0.34	-0.47	Repo rate unchanged at 6.5%. Media report: "Last week, an ET survey conducted among 25 participants predicted a quarter percentage points rate increase ..." (ET, *Bond market cheers RBI decision, rupee slides, 6 Oct, 2018*).

The table shows the top two target factors from each of the three RBI Governor regimes during the MIA phase, and also from the Inflation Targeting regime during which monetary policy decisions are taken by a six-member MPC.

Table 6: Top Path Factors: A Narrative Analysis

Date	Regime	Target Factor	Path Factor	Description
11 Dec. 2006	Reddy	0.33	0.56	Repo rate unchanged at 7.25%, CRR increased from 5% to 5.5% with an unscheduled circular. The RBI had tightened monetary policy in the previous two announcements. With RBI holding the repo rate constant in this particular circular, markets responded to announcement by expecteding a rate hike soon. Indeed, on 31 January, 2007 RBI raised the repo rate from 7.25% to 7.5%.
24 Jan. 2006	Reddy	0.09	0.50	Repo rate increased from 6.25% to 6.5%. RBI statement : "Indications of pick up in aggregate demand are getting stronger...It is important to respond in a timely and even pre-emptive manner to these developments to ensure that generalised inflation spirals do not develop..." Market reaction focused on stronger economy (ET, *Reddy gets bullish, revises GDP to 7.5-8% Jan 25, 2006*)
25 Oct. 2011	Subbarao	-0.01	-0.76	Repo rate raised from 8.25% to 8.5% but the RBI said in its statement:"..inflation rate will decline significantly in December and continue on that trajectory ..." and "... if the inflation trajectory conforms to projections, further rate hikes may not be warranted." Media focused on revised inflation outlook and especially the phrase "further rate hikes may not be warranted" (ET, *RBI hikes rates again, may take a break now, 26 Oct, 2011*).
26 Jul. 2011	Subbarao	0.32	0.73	Repo rate increased from 7.5% to 8%. RBI said in its statement: "Considering the overall growth and inflation scenario, there is a need to persevere with the anti-inflationary stance". Media reaction focused on hawkish tone. (ET *RBI raises key policy rates by 50 bps; loans to get costlier, 27 July,2011*)
29 Sept. 2015	Rajan	-0.35	-0.67	Repo rate lowered from 7.25% to 6.75%. With inflation in check, media discussion focused on concerns about lower growth: "RBI sees underlying growth trends as subdued enough to require more aggressive stimulus" (ET, *Analysts, economists react with surprise, elation, 30 Sep, 2015*).
3 Jun. 2014	Rajan	-0.03	-0.58	Repo rate unchanged at 8%. RBI statement gave dovish outlook: "If the economy stays on this course, further policy tightening will not be warranted. On the other hand, if disinflation, adjusting for base effects, is faster than currently anticipated, it will provide headroom for an easing of the policy stance".
5 Dec. 2019	MPC	0.24	0.55	Repo rate unchanged at 5.15%. Media latched onto inflation focus of RBI "... inflation control is the prime objective of money policy." (ET, *Shocking' pause? No, RBI is just awaiting signals from FM's Budget, 6 Dec, 2019*)
7 Dec. 2016	MPC	0.34	-0.53	Repo rate unchanged at 6.25%. Markets were surprised by no change but media discussion also focused on downward revision of growth forecasts. From RBI statement: "The outlook for GVA growth for 2016-17 has turned uncertain after the unexpected loss of momentum by 50 basis points in Q2." (ET, *RBI keeps rates unchanged, projects momentum loss for economy, 8 Dec, 2016*)

The table shows the top two path factors from each of the three RBI Governor regimes during the MIA phase, and also from the Inflation Targeting regime during which monetary policy decisions are taken by a six-member MPC.

Table 7: Response of asset prices to monetary shocks

	5y yield		10y yield		Nifty		INR/USD	
Target Factor	0.15	0.15	0.07	0.07	-3.28	-3.28	0.24	0.24
	[2.98]	[5.60]	[1.70]	[3.13]	[-2.05]	[-2.11]	[1.03]	[1.04]
Path Factor		0.19		0.19		-1.53		-0.02
		[10.63]		[11.12]		[-2.14]		[-0.11]
Constant	0.00	0.00	0.01	0.01	-0.29	-0.29	-0.04	-0.04
	[0.08]	[0.10]	[1.16]	[1.60]	[-1.23]	[-1.27]	[-0.85]	[-0.85]
Obs.	115	115	115	115	115	115	111	111
R^2	0.15	0.53	0.03	0.49	0.13	0.17	0.02	0.02

The table shows RBI announcement day regressions of bond yields (5 year and 10 year), Nifty 50 return and INR\USD exchange rate on target and path factors. For each asset price the first column shows a regression with just a constant and the target factor. The second column adds the path factor. The sample has 115 observations (111 for the exchange rate) from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Appendices

A Details on constructing Target and Path Factors

The idea in Gürkaynak et al. (2005) is to transform these two factors such that they have a meaningful economic interpretation. The first one is intended to reflect surprise changes in the short rate (1m OIS in our case) called the target factor. The second one and other as changes in medium to longer-term rates that are orthogonal to changes in the The goal is to construct two new factors Z_1 and Z_2 from the first two principal components F_1 and F_2 by finding an orthogonal matrix U

$$[Z_1 \ Z_2] = [F_1 \ F_2]U \tag{6}$$

U matrix has 4 unique elements and requires 4 restrictions for identification

$$U = \begin{pmatrix} \alpha_1 & \beta_1 \\ \alpha_2 & \beta_2 \end{pmatrix}$$

The first two come from a simple normalization that imposes the columns of U to have unit length, i.e. $\alpha_1^2 + \alpha_2^2 = 1$ and $\beta_1^2 + \beta_2^2 = 1$. Next, we maintain the orthogonality of the two factors $E(Z_1 Z_2) = 0$, which gives $\alpha_1\beta_1 + \alpha_2\beta_2 = 0$. Finally we impose the condition required for identification of the path factor, i.e. that the second factor Z_2 is not related to the 1 month OIS rate change. This condition is given by $\gamma_2\alpha_1 - \gamma_1\alpha_2 = 0$. To see this last condition, let γ_1 and γ_2 be the factor loadings on F_1 and F_2 for change in current month's futures contract (given by X(1))

$$X(1) = \gamma_1 F_1 + \gamma_2 F_2 \tag{7}$$

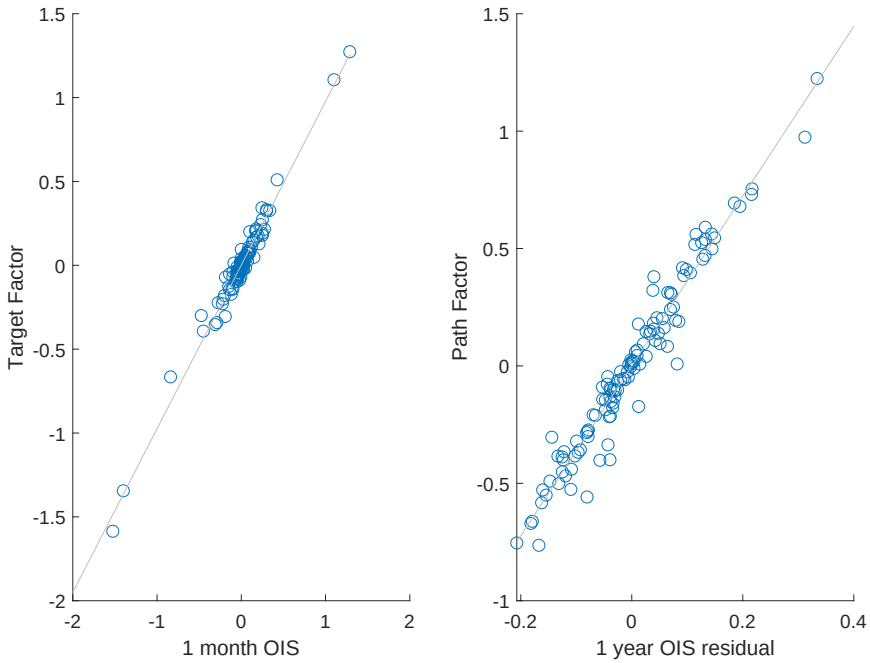
From equation 6 we can write

$$\begin{aligned} F_1 &= \frac{1}{\alpha_1\beta_2 - \alpha_2\beta_1}\left[\beta_2 Z_1 - \alpha_2 Z_2\right] \\ F_2 &= \frac{1}{\alpha_1\beta_2 - \alpha_2\beta_1}\left[-\beta_1 Z_1 + \alpha_1 Z_2\right] \end{aligned}$$

Now plug these into equation 7 and impose the condition that the loading of Z_2 on $X(1)$ is zero to get the restriction $\gamma_2\alpha_1 - \gamma_1\alpha_2 = 0$.

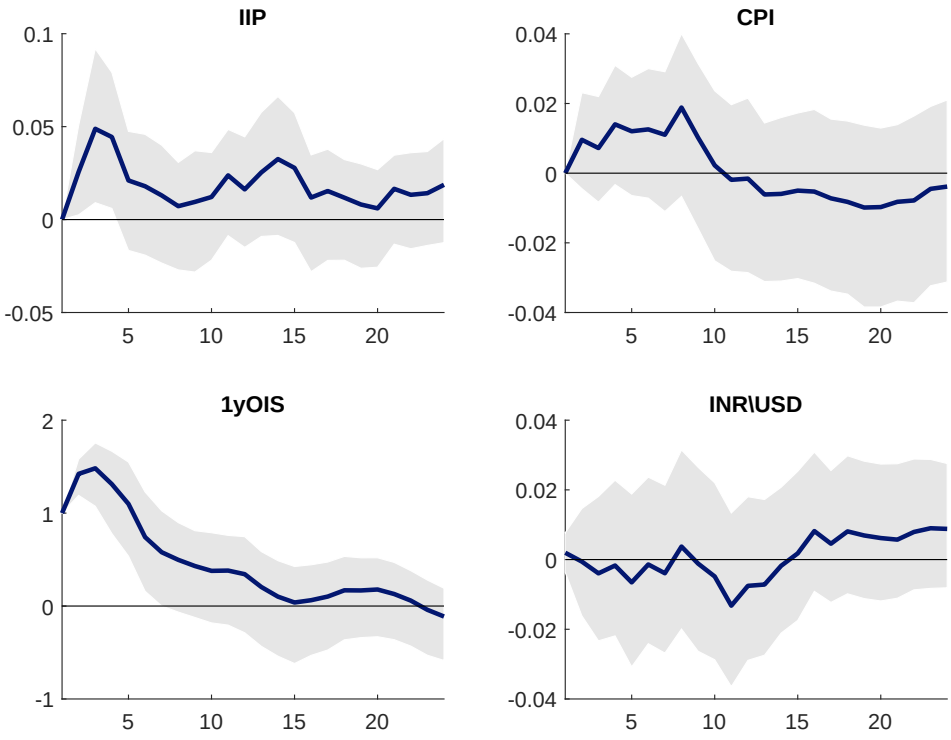
B Figures

Figure A.1: Scatter plot of target and path factors with OIS rates



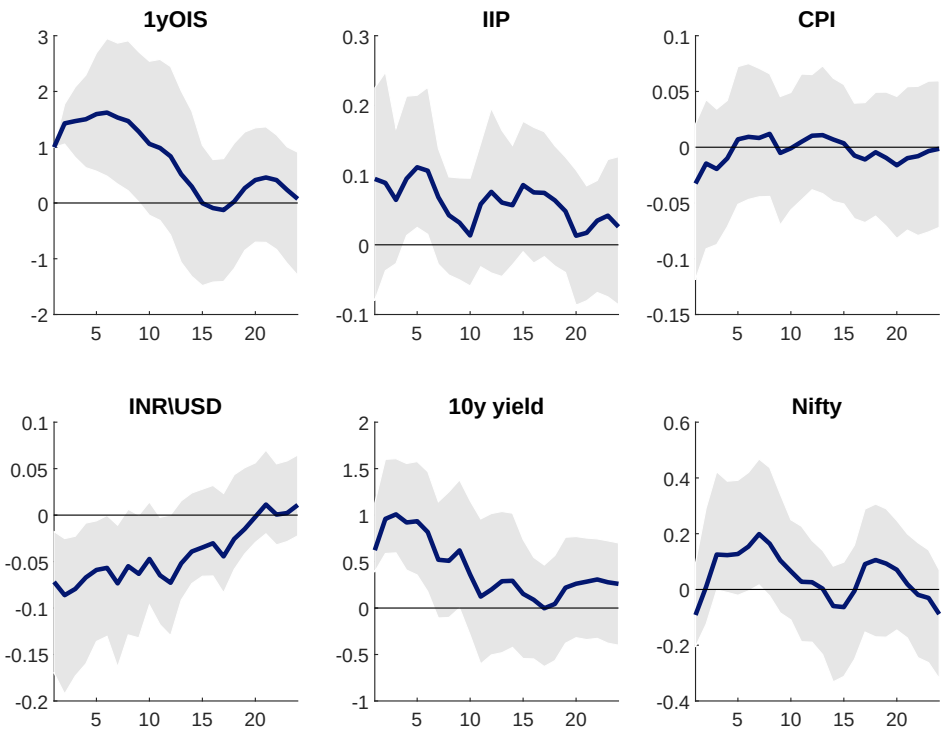
The left panel shows the scatter plot of target factor vs. 1 month OIS rate changes on RBI announcement days. The right panel shows the scatter of path factor vs. residual from regressing 1 year OIS rate on 1 month OIS rate on RBI announcement days. The sample is September 2003 to December 2020.

Figure A.2: Impulse response to a monetary policy shock: Cholesky identification



Impulse responses to a 100 basis point shock to the 1 year OIS rate identified using Choleksy (recursive) ordering. The sample runs from September 2003 to December 2020. The shaded grey areas represent bootstrapped 90% confidence intervals.

Figure A.3: Impulse response to a monetary policy shock



Impulse responses to a 100 basis point shock to the 1 year OIS rate identified using the external instruments/ proxyVAR methodology, with the path factor used as the instrument. The sample runs from September 2003 to December 2020. The shaded grey areas represent bootstrapped 90% confidence intervals.

C Tables

Table A.1: OIS rate summary statistics by governor regime

Panel A:	RBI statement days			All other days		
	OIS 1m	OIS 1y		OIS 1m	OIS 1y	
	Std-dev		Obs	Std-dev		Obs
Reddy	0.466	0.148	25	0.247	0.061	1279
Subbarao	0.329	0.142	41	0.152	0.077	1259
Rajan	0.114	0.098	22	0.101	0.034	761
MPC	0.111	0.089	27	0.037	0.029	1102

Panel B:	RBI statement days			All other days		
	OIS 1m	OIS 1y		OIS 1m	OIS 1y	
	Std-dev		Obs	Std-dev		Obs
Reddy	0.066	0.021	25	0.034	0.008	1279
Subbarao	0.053	0.023	41	0.021	0.012	1259
Rajan	0.014	0.013	22	0.012	0.004	761
MPC	0.020	0.016	27	0.007	0.005	1102

Panel C:	RBI statement days			All other days		
	OIS 1m	OIS 1y		OIS 1m	OIS 1y	
	Std-dev		Obs	Std-dev		Obs
Reddy	0.023	0.019	14	0.018	0.006	851
Subbarao	0.015	0.018	32	0.016	0.009	927
Rajan	0.014	0.013	22	0.012	0.004	761
MPC	0.020	0.016	27	0.007	0.005	1102

The table shows summary statistics for daily movements in OIS rates on RBI statement days and all other days. Panel A shows the daily change and Panel B show the daily percentage change from Sep-2003 to Dec-2020. Panel C shows daily percentage change for the same sample but dropping the statements in the Global Financial Crisis from Jan-2007 to Dec-2009.

Table A.2: Number of expansionary and contractionary changes in OIS rates and factors

	OIS 1m		OIS 1y		Target Factor		Path Factor	
	# Exp	# Contr	# Exp	# Contr	# Exp	# Contr	# Exp	# Contr
Reddy	10	13	7	17	15	10	13	12
Subbarao	17	19	15	24	20	21	22	19
Rajan	10	8	9	10	8	14	12	10
MPC	12	13	19	8	14	13	14	13
Total	49	53	50	59	57	58	61	54

The table shows the number of RBI announcements that were expansionary (#Exp) or contractionary (#Contr) based on sign of the corresponding rate change being negative or positive. Dates when the rate change is zero are excluded from the table. The sample runs from September 2003 to December 2020.

Table A.3: Regression of OIS rates on target and path factors

	1m		3m		6m		9m		1y	
Target Factor	1.00	1.00	0.51	0.51	0.31	0.31	0.36	0.36	0.26	0.26
	[50.33]	[50.33]	[13.67]	[31.21]	[6.07]	[27.45]	[10.26]	[19.94]	[4.16]	[15.22]
Path Factor		0.00		0.15		0.25		0.23		0.26
		[0.00]		[12.65]		[35.97]		[23.68]		[34.54]
Constant	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
	[-0.27]	[-0.27]	[2.91]	[4.66]	[1.90]	[6.61]	[2.26]	[6.70]	[2.67]	[10.64]
Obs.	115	115	115	115	115	115	115	115	115	115
R^2	0.98	0.98	0.82	0.93	0.46	0.95	0.57	0.95	0.37	0.96

The table shows the regression of OIS rates of various maturities on target and path factors. For each asset price the first column shows a regression with just a constant and the target factor. The second column adds the path factor. The sample has 107 observations from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.4: Response of asset prices to repo rate changes

	10y yield		Nifty		INR	
Total repo rate change	0.04		0.25		-0.12	
	[0.99]		[0.14]		[-0.64]	
Expected change		0.03		0.65		-0.13
		[0.79]		[0.44]		[-0.75]
Unexpected change		0.10		-2.77		0.16
		[1.73]		[-1.99]		[0.42]
Constant	0.01	0.01	-0.29	-0.28	-0.04	-0.04
	[1.20]	[1.22]	[-1.18]	[-1.22]	[-0.85]	[-0.90]
Obs.	115	115	115	115	111	111
R^2	0.01	0.05	0.00	0.14	0.00	0.03

The table shows RBI announcement day regressions of 10 year bond yield, Nifty 50 return and INR\USD exchange rate to total repo rate change, expected rate change and unexpected rate change measured using 1 month OIS rate. For each asset price the first column shows a regression with just a constant and the total repo rate change. The second column has a constant and decomposition of total repo rate change into expected and unexpected component. The sample has 107 observations (103 for the exchange rate) from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.5: Top target factors during Global Financial Crisis period (2007-2009)

Date	Regime	Target factor	Path factor	Discussion
30 Mar. 2007	Reddy	-1.586	0.974	Repo rate was increased
3 Nov. 2008	Subbarao	-1.344	0.754	Repo rate was lowered.
31 Jul. 2007	Reddy	1.274	0.008	Repo rate was left unchanged.
24 Oct. 2008	Subbarao	1.106	0.041	Repo rate was left unchanged.

Table A.6: Response of asset prices to alternate monetary shocks

	5y yield		10y yield		Nifty		INR/USD	
Tbill Target Factor	0.22	0.22	0.14	0.14	-1.07	-1.07	-0.25	-0.25
	[2.14]	[4.21]	[2.01]	[4.01]	[-0.77]	[-1.15]	[-2.03]	[-1.66]
Tbill Path Factor		0.17		0.15		-2.02		0.13
		[6.78]		[6.28]		[-2.76]		[1.17]
Constant	0.00	0.00	0.01	0.01	-0.29	-0.29	-0.04	-0.04
	[0.27]	[0.34]	[1.35]	[1.65]	[-1.15]	[-1.20]	[-0.90]	[-0.91]
Obs.	114	114	114	114	114	114	110	110
R^2	0.19	0.49	0.09	0.38	0.01	0.09	0.01	0.02

The table shows RBI announcement day regressions of bond yields (5 year and 10 year), Nifty 50 return and INR\USD exchange rate on target and path factors constructed from 3 month and 1 year T-bill rates. For each asset price the first column shows a regression with just a constant and the target factor. The second column adds the path factor. The sample has 114 observations (110 for the exchange rate) from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.7: Response of 10 year government bond yield to monetary shocks

	Reddy		Subbarao		Rajan		MPC	
Target Factor	0.06	0.06	0.04	0.04	-0.01	-0.01	0.72	0.72
	[1.37]	[2.67]	[0.71]	[1.48]	[-0.02]	[-0.04]	[5.67]	[4.72]
Path Factor		0.19		0.17		0.92		0.32
		[9.20]		[9.74]		[3.88]		[1.35]
Constant	0.03	0.03	0.01	0.01	0.01	0.01	0.00	0.00
	[1.59]	[2.67]	[0.63]	[1.09]	[0.36]	[0.58]	[-0.29]	[-0.30]
Obs.	25	25	41	41	22	22	27	27
R^2	0.05	0.67	0.02	0.67	0.00	0.62	0.50	0.55

The table shows RBI announcement day regressions of 10 year government bond yield on target and path factors, broken down by RBI governor regimes. The first column shows a regression with just a constant and the target factor. The second column adds the path factor. "MPC" represents the period from September 2016 to December 2020 covering the governorships of Urjit Patel and Shaktikanta Das. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.8: Response of Nifty stock index to monetary shocks

	Reddy		Subbarao		Rajan		MPC	
Target Factor	-1.20	-1.20	-6.82	-6.82	-0.84	-0.84	-1.46	-1.46
	[-1.10]	[-0.91]	[-4.20]	[-4.10]	[-0.21]	[-0.33]	[-0.51]	[-0.50]
Path Factor		-4.70		0.42		-10.75		-1.12
		[-5.06]		[0.57]		[-3.30]		[-0.46]
Constant	-0.42	-0.42	-0.42	-0.42	-0.39	-0.39	0.09	0.09
	[-0.64]	[-0.84]	[-1.22]	[-1.23]	[-0.92]	[-1.07]	[0.25]	[0.25]
Obs.	25	25	41	41	22	22	27	27
R^2	0.03	0.43	0.51	0.51	0.00	0.26	0.01	0.01

The table shows RBI announcement day regressions of Nifty stock returns on target and path factors, broken down by RBI governor regimes. The first column shows a regression with just a constant and the target factor. The second column adds the path factor. "MPC" represents the period from September 2016 to December 2020 covering the governorships of Urjit Patel and Shaktikanta Das. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.9: Response of INR\USD exchange rate to monetary shocks

	Reddy		Subbarao		Rajan		MPC	
Target Factor	0.07	0.08	0.81	0.81	-1.36	-1.36	-1.26	-1.26
	[0.49]	[0.49]	[2.63]	[2.64]	[-1.50]	[-1.55]	[-3.30]	[-2.62]
Path Factor		0.03		-0.01		0.40		0.68
		[0.22]		[-0.03]		[0.58]		[0.58]
Constant	-0.03	-0.03	-0.04	-0.04	0.02	0.02	-0.10	-0.10
	[-0.60]	[-0.61]	[-0.45]	[-0.45]	[0.21]	[0.22]	[-1.54]	[-1.56]
Obs.	23	23	40	40	21	21	27	27
R^2	0.02	0.02	0.14	0.14	0.13	0.14	0.13	0.15

The table shows the regression of INR\USD exchange rate on target and path factors, broken down by RBI governor regimes. The first column shows a regression with just a constant and the target factor. The second column adds the path factor. "MPC" represents the period from September 2016 to December 2020 covering the governorships of Urjit Patel and Shaktikanta Das. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.10: Response of asset prices to monetary shocks: Excluding global financial crisis

	5y yield		10y yield		Nifty		INR/USD	
Target Factor	0.53	0.53	0.41	0.41	-5.12	-5.12	-0.50	-0.49
	[4.46]	[4.43]	[3.77]	[3.79]	[-2.24]	[-2.31]	[-1.13]	[-1.12]
Path Factor		0.49		0.49		-3.43		1.29
		[3.20]		[3.43]		[-1.66]		[2.00]
Constant	0.00	0.00	0.01	0.01	-0.19	-0.19	-0.04	-0.03
	[-0.21]	[-0.24]	[1.01]	[1.18]	[-0.89]	[-0.90]	[-0.76]	[-0.71]
Obs.	94	94	94	94	94	94	91	91
R^2	0.29	0.46	0.21	0.43	0.07	0.09	0.01	0.08

The table shows RBI announcement day regressions of bond yields (5 year and 10 year), Nifty 50 return and INR\USD exchange rate on target and path factors. For each asset price the first column shows a regression with just a constant and the target factor. The second column adds the path factor. The sample runs from September 2003 to December 2020 but excludes the global financial crisis from January 2007 to December 2009 and has 94 observations (91 for exchange rate). t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.11: Response of asset prices to monetary shocks: 2 day changes

	5y yield		10y yield		Nifty		INR/USD	
Target Factor	0.15	0.15	0.07	0.07	-4.26	-4.26	0.54	0.54
	[2.98]	[5.54]	[1.45]	[2.27]	[-1.49]	[-1.54]	[1.30]	[1.37]
Path Factor		0.24		0.23		-1.80		-0.24
		[8.92]		[9.46]		[-1.71]		[-1.19]
Constant	0.02	0.02	0.02	0.02	-0.70	-0.70	-0.04	-0.04
	[1.17]	[1.47]	[1.74]	[2.19]	[-2.15]	[-2.19]	[-0.68]	[-0.68]
Obs.	115	115	115	115	115	115	115	115
R^2	0.08	0.41	0.02	0.38	0.11	0.15	0.06	0.07

The table shows RBI announcement day regressions of bond yields (5 year and 10 year), Nifty 50 return and INR\USD exchange rate, measured using two day changes, on target and path factors. For each asset price the first column shows a regression with just a constant and the target factor. The second column adds the path factor. The sample has 115 observations from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.12: Response of asset prices to monetary shock (1st principal component)

	5y yield	10y yield	Nifty	INR/USD
1st PC	0.15	0.10	-2.70	0.18
	[4.24]	[2.82]	[-2.47]	[1.06]
Constant	0.00	0.01	-0.29	-0.04
	[0.08]	[1.23]	[-1.26]	[-0.85]
Obs.	115	115	115	111
R^2	0.30	0.14	0.16	0.02

The table shows RBI announcement day regressions of bond yields (5 year and 10 year), Nifty 50 return and INR\USD exchange rates on the first principal component of OIS rate changes. The sample has 115 observations (111 for the exchange rate) from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.13: Response of asset prices to monetary shocks: Asymmetric effects

	5y yield		10y yield		Nifty		INR/USD	
	Exp	Contr	Exp	Contr	Exp	Contr	Exp	Contr
Target Factor	0.15	0.06	0.05	0.00	-1.76	-3.32	0.40	-0.17
	[2.64]	[1.09]	[0.98]	[-0.09]	[-1.20]	[-0.98]	[1.13]	[-0.81]
Path Factor	0.15	0.14	0.14	0.16	1.02	-3.35	-0.22	0.27
	[3.93]	[4.95]	[2.91]	[4.88]	[0.86]	[-2.26]	[-0.77]	[0.97]
Constant	-0.02	0.03	-0.02	0.04	0.43	0.16	-0.08	-0.05
	[-1.11]	[2.19]	[-0.68]	[2.35]	[0.84]	[0.34]	[-0.73]	[-0.67]
Obs.	50	59	50	59	50	59	48	57
R^2	0.17	0.24	0.16	0.24	0.12	0.17	0.12	0.03

The table shows RBI announcement day regressions of bond yields (5 year and 10 year), Nifty 50 return and INR\USD exchange rate, on target and path factors. For each asset price the first column shows a regression just for expansionary dates and the second column just for contractionary dates. The sample runs from September 2003 to December 2020. t-statistics based on White heteroskedasticity-robust standard errors are reported in parentheses.

Table A.14: First stage effects of high-frequency shocks on VAR residuals

1st PC	-0.06							
	[-0.50]							
Target Factor		-0.14						
		[-0.91]						
Path Factor			0.17					
			[2.62]					
OIS1m				-0.15				
				[-1.03]				
OIS3m					-0.05			
					[-0.16]			
OIS6m						0.13		
						[0.40]		
OIS9m							0.10	
							[0.30]	
OIS1y								0.18
								[0.52]
Observations	195	195	195	195	195	195	195	195
R^2	0.01	0.02	0.04	0.02	0.00	0.00	0.00	0.01
F-statistic	0.25	0.83	6.87	1.06	0.03	0.16	0.09	0.28

The table shows the results from a first stage regression of the residual of the 1 year OIS rate on OIS rate changes and factors constructed from OIS rate changes The VAR has the following four variables: log(industrial production), log(cpi), log(INR\USD) and 1 year OIS rate. The sample runs from September 2003 to December 2020.