The Growing Impact of US Monetary Policy on Emerging Financial Markets: Evidence from India*

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Abstract

Much research has been devoted to studying the international spillover effects of US monetary policy. However, a lot of the focus has been on the recent unconventional monetary policies undertaken by the Federal Reserve. Combining high frequency financial market data with a time-varying parameter approach we show that US monetary policy decisions have had significant effects on the Indian stock markets well before the use of unconventional policy tools and that these effects have gotten stronger over time. In addition to the conventional channel of surprise changes in the policy rate, we find that US monetary shocks are also transmitted through an uncertainty channel, which is especially important for announcements about large scale asset purchases (quantitative easing). Using firm level stock prices, we also show that the higher sensitivity of the aggregate response is uniform across the stock market and is not driven by the increased exposure of any specific industry to US monetary policy. Instead, our results suggest that it is driven by the portfolio decisions of foreign institutional investors, the exchange rate becoming more sensitive to US monetary policy and the global financial cycle working through volatility and risk aversion.

Keywords: International Transmission of U.S. Monetary Policy, Emerging Stock Markets, Foreign Institutional Investors, Quantitative Easing, Monetary Policy Uncertainty

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1 Introduction

The past few decades have seen increasing financial integration of emerging market countries into the global economy. One of the concerns raised by this phenomenon is the potential vulnerability of financial markets in emerging economies to monetary policies of advanced countries. Given the importance of financial markets for the overall economy, policymakers in emerging economies are paying close attention to monetary policy decisions in advanced economies (Rajan (2015)). This is especially true of US monetary policy, which is a major driver of the global financial cycle (Rey (2015)).

While there is a large literature that explores the effects of US monetary policy on emerging economies, we expand on this literature along three main dimensions. First, we use a novel measure of policy rate uncertainty to study the transmission of monetary policy uncertainty shocks. These uncertainty shocks together with the more commonly used interest rate shocks help us capture two distinct dimensions of monetary policy spillover. Second, we combine firm-level data with high-frequency financial market indicators to shed light on the transmission mechanism of monetary spillover to Indian financial markets. We believe that these results are particularly interesting because India is considered to be one of the most vulnerable to US monetary policy.[1] Finally, the literature has tended to focus more on the recent unconventional episode of US monetary policy beginning with the financial crisis. We combine a time-varying parameter approach with data spanning three decades and document how there have been gradual but significant changes in the spillover effects of US monetary policy over time.

The analysis is carried out using a high-frequency identification approach that isolates changes in the prices of derivative contracts in a narrow window around the Federal Open Market Committee's (FOMC) monetary policy announcements. The first shock (labeled MP surprise) uses futures contracts to capture surprise changes to the target federal funds rate as well as forward

[1]India has been included in the so-called "fragile five" countries (others are South Africa, Turkey, Indonesia and Brazil) whose economic performance is especially sensitive to global financial conditions and the role of US acting as the hegemon.

guidance.[2] The second shock we use is novel in this literature and captures uncertainty about monetary policy decisions. Following the approach of Bauer, Lakdawala, and Mueller (2019), we use options data to construct the MP uncertainty measure as the change in the standard deviation of the distribution of expected interest rate outcomes.[3] Recent work has highlighted the importance of uncertainty and risk aversion for international asset prices, see for example the work of Rey (2015) and Bruno and Shin (2015). There is also evidence for the substantial effects of US uncertainty on emerging economies, see Bhattarai, Chatterjee, and Park (2019).[4] Our MP uncertainty variable is a high-frequency measure that allows for the identification of the effects of US monetary policy specific uncertainty on the Indian financial markets.

We find time variation in the response of Indian stock prices to US monetary policy shocks with an increase in the intensity of the effect over time. The aggregate Indian stock market was essentially non-responsive to US monetary policy shocks in the early 1990s. Since then there has been a gradual increase in the responsiveness to both MP surprise and MP uncertainty shocks starting from the late 1990s to early 2000s. The effect of the MP surprise turns statistically significant in the early 2000s with a peak effect reached towards the end of the sample that indicates almost a 3% fall in stock prices in response to a 25 basis point shock.[5] The effect of the MP uncertainty shock starts increasing a few years later, turning statistically significant around 2007-2008 with a peak effect that is roughly half the size of the MP surprise effect.

Using a sample of 21 emerging countries to study the effects of both conventional and unconventional US monetary policy actions, Chen, Griffoli, and Sahay (2014) find that financial markets have been more responsive to unconventional actions. Our paper adds to this result by documenting that the spillovers have gradually increased over time–starting before the start of unconventional policy actions–and highlighting that there have been two separate dimensions of

[2]We use Eurodollar futures contracts expiring up to 8 quarters ahead.

[3]Our baseline results use option prices to construct a fixed-horizon measure capturing uncertainty about the four-quarter ahead interest rate.

[4]For recent work exploring the impact of US uncertainty on the Indian economy see Ghosh, Sahu, and Chattopadhyay (2017).

[5]Interestingly, this effect is even larger than the effect of US monetary actions on the US stock market, see for example the recent work of Lakdawala and Schaffer (2019).

the spillover effect. Moreover, our use of firm-level data enables the study of the disaggregated transmission mechanism as we discuss below. Our results provide an additional insight in interpreting the literature's findings on the spillover effects of US monetary policy. In addition to Chen, Griffoli, and Sahay (2014), Fratzscher, Lo Duca, and Straub (2017), Chari, Stedman, and Lundblad (2018), Tillmann (2016) and Bhattarai, Chatterjee, and Park (2015) among others, have found big effects of US quantitative easing on emerging market countries. We find evidence that US unconventional policy has worked primarily through the uncertainty channel. Specifically, the Federal Reserve's announcements about quantitative easing had big effects on emerging financial markets mostly because these announcements lowered uncertainty about future monetary policy decisions. Bauer and Neely (2014) and the related literature has shown that QE announcements moved international asset prices by affecting the expected path of the policy rate (i.e. a first-moment signalling channel). Our results suggest that international transmission also occurs through a second-moment signalling channel.

There is evidence that certain industries in developing countries are more exposed to US monetary policy, see for example Lin and Ye (2018). Using firm-level stock price data we find that both the monetary policy shock measures have essentially uniform effects across the different industries in the Indian stock market for the full sample period. In other words, the increased responsiveness in the post-crisis sample does not appear to be driven by certain sectors becoming more responsive to US monetary policy shocks. Instead, we provide evidence that US MP surprise mainly transmits through the movement in the exchange rate and related financial flows (i.e. the equity flows attributed to (FII) foreign institutional investors).[6] However, US MP uncertainty shocks transmit to stock prices through their effect on volatility–we measure this using the implied volatility on the Nifty 50 index. This is consistent with the the work of Miranda-Agrippino and Rey (2020) that finds that US monetary policy has substantial effects on global volatility and risk aversion. Overall, our Indian stock results suggest that in addition to the traditional Mundell-

[6]There is work that emphasizes the importance of foreign institutional investors for the Indian stock market, see for example Garg and Dua (2014). Our results highlight the response to US monetary surprise shocks as a specific dimension along which the role of foreign institutional investors and the exchange rate market is especially important.

Fleming type transmission of US MP surprises through the exchange rate, there is an additional global financial cycle transmission through changes in uncertainty that has grown in prominence since the financial crisis of 2007-09.

Our work is related to the large literature on the spillover effects of US monetary policy. Within this literature, there is a set of relevant papers that study the effects of US monetary policy on emerging market economies including India, see Eichengreen and Gupta (2015), Aizenman, Binici, and Hutchison (2016), Dedola, Rivolta, and Stracca (2017), Bhattarai, Chatterjee, and Park (2015), Moore, Nam, Suh, and Tepper (2013), Tillmann (2016), Georgiadis (2016) and Bowman, Londono, and Sapriza (2015) among others. These papers have mostly focused on the recent unconventional monetary policies conducted by the Federal Reserve, with special attention paid to the tapering of the balance sheet. In contrast, in this paper we are interested in characterizing the response of the stock market over a longer horizon to both monetary policy surprise and uncertainty shocks, in addition to exploring the firm level responses of stock prices. There has also been some work that focuses specifically on the response of Indian financial markets to US monetary policy shocks. The results from this literature are mixed.[7] The advantages of our approach compared to these studies are the ability to control for expectations effects using the futures market data, the longer sample period and the additional use of the monetary policy uncertainty measure.

The rest of the paper is organized as follows. In the next section we layout the details of the data including the high frequency derivatives contracts used to construct our preferred measure of the US monetary policy shocks. This is followed by section 3 where we present the results using aggregate stock market data. In this section we also focus on the transmission channel of US quantitative easing actions and conduct a time-varying parameter estimation of the aggregate effects. In section 4 we consider potential explanations for the increased aggregate sensitivity to US monetary policy shocks. Next, in section 5 we report the panel regression results from using individual stock price data. Section 6 concludes by offering some closing remarks.

[7] Prabu, Bhattacharyya, and Ray (2016) find no significant effect while Patra, Khundrakpam, Gangadaran, Kavediya, and Anthony (2016) find some effect in initial quantitative episodes of 2008-2009.

2 Data

2.1 Constructing U.S. Monetary Policy Shocks from Financial Markets Data

To identify the effect of monetary policy on stock prices, one cannot directly regress stock prices on the monetary policy instrument (for example the short-term interest rate). The endogenous reaction of both stock prices and the central bank's policy instrument to common economic conditions leads to the classic simultaneous equation bias. Thus the literature has tried to isolate exogenous variation in the policy instrument to overcome this problem. In this paper we follow the work of Gürkaynak, Sack, and Swanson (2005) and Bernanke and Kuttner (2005), which isolates monetary shocks using high-frequency identification and financial market data. In this section we explain the construction of our two preferred measure of monetary shocks. First, we construct a popular measure of monetary policy shock using the change in the level of futures rates based on the work of Kuttner (2001) among others. This shock is labeled MP Surprise and captures a first moment shock to the expected future path of the FOMC's policy rate. We complement this shock by constructing a second measure that reflects a second moment shock to the expected future path of the FOMC's policy rate. This shock labeled MP Uncertainty is constructed from options on Eurodollar futures contracts following the work of Bauer, Lakdawala, and Mueller (2019).

2.1.1 MP Surprise

Let $p_t^{(h)}$ be the price of a futures contract at time t that matures in $t+h$, where the underlying asset is the short rate. Assuming no arbitrage, this futures contract should capture the market's expectation of the federal funds rate expected in the future. Specifically we can write

$$p_t^{(h)} = E_t i_{t+h} \tag{2.1}$$

where $E_t i_{t+h}$ is the expected rate at $t+h$ conditional on information available at time t.[8] The monetary shock is then calculated as the change in the futures price in a window around the FOMC meeting. Let e_t represent the monetary shock and ε represent the length of the window, then

$$e_t^{(h)} = p_t^{(h)} - p_{t-\varepsilon}^{(h)} \tag{2.2}$$

The original work by Kuttner (2001) used the current month's futures contract ($h = 0$) to calculate the monetary shock. This measure captured surprise changes in the federal funds rate target. But these monetary shock measures can be constructed for different values of h, i.e. using contracts that expire in different months. The idea behind using these contracts is to capture FOMC announcements about future policy changes, including forward guidance about the future path of the federal funds rate and any announcements about large scale asset purchases that moves market interest rates.

In this paper we use futures contracts expiring up to 2 years ahead. This is based on the arguments of Swanson and Williams (2014) and Hanson and Stein (2015) that the Fed's forward guidance operates at roughly a 1 to 2 year horizon. Specifically, we use the eight Eurodollar futures contracts, expiring one quarter ahead (ED1) to 8 quarters ahead (ED8). Eurodollar futures are contracts with payoffs tied to the three-month LIBOR rate which is highly correlated with the federal funds rate.[9] For the baseline results, the surprise in each contract is measured as the change in the futures rate in a daily window around FOMC policy decisions. Taken together, the eight contracts contain rich information about the short and medium term path of expected interest rates.

To summarize this information in a parsimonious way we perform a principal component

[8]There may also be a risk-premium term but this is not crucial to our analysis and moreover Piazzesi and Swanson (2008) find that fed funds futures risk-premia are slow-moving and do not change much around FOMC announcements.

[9]Futures markets also exist for contracts with the federal funds rate as the underlying instrument. However, using fed funds futures is impractical for our purpose because their market is much less liquid and the data availability more limited in terms of length of horizons of the derivative contracts.

analysis. Let X denote a T x 8 matrix of the change in the price of the 5 futures contracts, where T is the number of FOMC meetings. We can then perform a principal components analysis of the futures price changes

$$X = F\Lambda + \widetilde{\eta}$$

where F are factors, Λ are factor loadings, and $\widetilde{\eta}$ is an error term. The first principal component of F explains more than 85% of the total variation across all the contracts. We therefore use this first principal component as one of our measures of monetary policy shocks and label it MP surprise.[10]

The top panel of Figure 1 plots the MP surprise measure. Our sample runs from January 1991 to June 2018. There are 243 total FOMC policy decisions over this time frame. This includes both scheduled and unscheduled FOMC meetings. In the appendix Table A.1, we show that the main results are similar if we remove the unscheduled meetings from our sample.

2.1.2 MP Uncertainty

We follow Bauer, Lakdawala, and Mueller (2019) in constructing the uncertainty measure from prices of Eurodollar futures and options. The futures prices are from Bloomberg and the option prices are directly from the Chicago Mercantile Exchange. The approach uses the model-free estimate of implied volatility proposed by Jiang and Tian (2005). They show that the integrated return variance between t (when the derivatives prices are measured) and $t + \tau$ (when the contract matures) is given by

$$IRV_{t,\tau} = E\left[\int_t^{t+\tau} \left(\frac{dF_j}{F_j}\right)^2\right],$$

where F_t is the futures price at time t. This return variance can be estimated in a straightforward fashion using observable option prices. The estimation approach does not require any parametric assumptions, and is valid for general jump-diffusion processes. We use the formula given in equation (6) of Jiang and Tian (2005) and a smooth call-price function fitted to the options

[10] This is similar to the measure used in Nakamura and Steinsson (2018) except they use futures contracts expiring up to one year ahead. In the appendix Table A.1 we show that our results are robust to using futures contracts expiring up to just 1 year ahead.

data. The measure of uncertainty equals $F_t\sqrt{IRV_{t,\tau}}$, which captures the risk-neutral standard deviation of the short-term interest rate at $t+\tau$ conditional on prices at t. We calculate this measure for a 1 year horizon based on the longest availability of options data. To obtain data for a fixed horizon from the available option and futures prices, which have expirations at fixed dates and therefore varying horizons, we follow Wright (2017) and linearly interpolate prices to fixed horizons based on available expirations. We use the movement in this standard-deviation around FOMC meetings as our measure of the change in uncertainty resulting from US monetary policy actions.

This measure captures changes in the market's perceived uncertainty as driven by FOMC announcements. The big changes in the measure tend to correspond to specific changes in the forward guidance language used by the FOMC. For example, two of the biggest falls happen in December 2008 and August 2011 when the terms *"... for some time"* and "... at lest until mid-2013" were introduced by the FOMC to explicitly signal lower rates for a longer period than the market had previously expected. Thus the measure captures any change in uncertainty about the timing of future decisions. But the measure also captures uncertainty about the magnitude of future decisions. For example, the biggest increase in uncertainty happens in October 2008, when the FOMC in coordination with other central banks cut interest rates, but their statement left it unclear what particular action was likely at the next meeting.

This measure is plotted in the bottom panel of Figure 1 and labelled "Raw MP uncertainty". As the above equations make clear, the Raw MP uncertainty measure has a level effect, i.e. it depends on the level of the futures rate. Thus in our empirical results we will first purge this level effect from our measure. Specifically, we first regress the raw MP uncertainty measure on the MP surprise measure detailed above. Then we use the residual as our preferred measure of monetary policy uncertainty (labeled MP uncertainty) for regression analysis. This measure is similar to the Raw MP uncertainty measure with a correlation of 0.89, and is plotted together with the raw measure in the appendix Figure A.3. For all the regression analysis in the paper we use the orthogonalized measure and refer to it simply as MP uncertainty.

A variety of alternative approaches to measure monetary policy uncertainty have been proposed in the literature that can be viewed as being complementary to ours. One approach uses the textual analysis of newspaper articles to construct a measure of monetary policy uncertainty (Baker, Bloom, and Davis (2016) and Husted, Rogers, and Sun (2019)). This framework captures monetary policy uncertainty from a potentially broader perspective but leaves some question about which specific policy tool the uncertainty applies to. Whereas our measure captures uncertainty specific to the policy rate. Moreover, news-based measures reflect the sentiment of journalists as opposed to our measure which relies on market participants. But since the news approach relies on counting specific words in newspaper articles, calculating daily changes is inherently noisy and thus it is less useful in high-frequency studies. Other measures rely on model based stochastic volatility (Creal and Wu (2017)) or dispersion among forecasters (Istrefi and Mouabbi (2017)). Both these approaches are typically only available at monthly or even lower frequencies. There are also approaches taken in the literature to construct uncertainty using the implied volatility approach which is similar to ours. Examples include Neely (2005), Swanson (2006), Emmons, Lakdawala, and Neely (2006), Bauer et al. (2012), Chang and Feunou (2014), Bundick, Herriford, and Smith (2017) and De Pooter, Favara, Modugno, and Wu (2018). A key difference is that all these papers make distributional assumptions while calculating the implied volatility but our measure relies on the more general model-free approach of Jiang and Tian (2005).

2.1.3 Scaling of the Monetary Shocks The MP surprise measure is a composite measure based on various futures contracts, constructed from the principal component analysis as outlined in section 2.1.1. Thus its scale is arbitrary. Following the literature, we scale the MP surprise such that the regression coefficient can be interpreted as the percent change in the stock market indices in response to an unexpected 25 basis point increase in the 1 year ahead federal funds rate. The MP uncertainty measure is the change in the standard deviation obtained from options prices as explained above in section 2.1.2. Since this measure is new, there is no guidance available in the literature in terms of its scaling. We choose to normalize the MP uncertainty measure to have unit standard deviation, i.e. its coefficient can be interpreted as the percent change in the stock market indices in response to a one standard deviation uncertainty shock. However, it is not straightforward to compare the size of the effects of the two monetary policy shocks from the coefficients of the baseline regression, shown below in equation 3.1. As a guide, we note that the standard deviation of the changes in the 1 year Treasury yield on FOMC days in our sample is a little under 7 basis points. Thus a 25 basis point MP surprise shock reflects roughly a 4 standard deviation effect. Thus one simple rule of thumb to gauge the effect of a standard deviation monetary policy shock from the regression results is to divide the MP surprise coefficient by 4 before comparing to the MP uncertainty coefficient.

2.2 Indian Stock and Financial Market Data

To measure the response of the Indian stock market we use the percentage change in the Nifty 50 and NSE 500 aggregate indices, as well as that of individual stocks that are included in the NSE 500. The data are obtained from Bloomberg. The FOMC monetary policy decision is typically announced around 2pm EST on a Wednesday. Since the Indian stock markets are closed at this time, we use closing stock prices on the next business day to measure the reaction of the stock market. The stock return is then calculated comparing this price to the closing price on the calendar day of the FOMC meeting. For example, for the FOMC meeting that occurred on June 13th 2018, we construct the return of Indian equities by comparing the closing price on June 14th with the closing price on June 13th. For the Nifty 50 index we have data starting in January 1991, while the NSE 500 data is only available from February 1995 onwards. In addition to the stock market data, we use daily data on the Indian Rupee - US Dollar exchange rate that is measured at the close of the trading day in India, the 10 year government bond rate and net investment of foreign institutional investors into Indian equity markets. The source for these three variables is also Bloomberg.

Table 1 reports the summary statistics for the return on the stock indices and the U.S. monetary shocks separately for days corresponding to FOMC meetings and non-FOMC meeting days. The summary statistics are presented for four samples in addition to the full sample. We see a few interesting patterns. In the overall sample the standard deviation of stock returns on

FOMC days is roughly similar to the standard deviation on non-FOMC days. But this belies important differences in the subsamples. In the 1990s, the standard deviation of stock returns on non-FOMC days is actually higher relative to FOMC days, implying that FOMC days are not major news events for the stock market. This pattern reverses sometime in the early 2000s, after which the standard deviation on FOMC days is higher. This suggests that Indian stock markets have been reacting more to FOMC meetings starting around the turn of the century. We also notice that the standard deviation of the Nifty 50 and NSE 500 stock indices has fallen since the 2008 crisis relative to the pre-crisis period for both FOMC and non-FOMC days.

3 Aggregate Stock Index Results

The regression analysis is carried out using an event study approach following Bernanke and Kuttner (2005). The goal is to use derivative contracts to control for market expectations and isolate the unexpected component of monetary policy decisions. The identification strategy relies on measuring the stock returns and monetary shocks in a narrow window around FOMC meetings. The assumption is that no other major news event is systematically driving financial prices in this window. As discussed above, we use a daily window for the results in this paper. The baseline results are then just an ordinary least squares regression of the Indian stock market index return on the U.S. monetary policy shocks. Let ΔS_t denote the return on the stock index,[11] the MP surprise is denoted by mps_t and MP uncertainty by mpu_t.[12]

$$\Delta S_t \quad = \quad \alpha + \beta mps_t + \gamma mpu_t + \varepsilon_t \tag{3.1}$$

The baseline estimates from this regression are presented in Table 2 for the 2 stock market

[11]The stock return corresponding to a FOMC meeting on day t is calculated as the change from closing price on day $t+1$ relative to closing price on day t as explained in detail in Section 2.2

[12]Recall that we use the orthogonalized *mpu* measure for all regressions. For γ, it does not matter whether we orthogonalize *mpu* (w.r.t. *mps*) or not. Since γ is the marginal effect of *mpu* holding *mps* constant, it does not matter whether "we remove the effect" of *mps* from *mpu* or not. However, our decision to orthogonalize will matter for β. We choose to orthogonalize because of the effect of the level of interest rates on its uncertainty that we mentioned above.

indices. Our sample runs from 1991 to 2018 but we exclude the FOMC meetings in the peak of the financial crisis from July 2008 through June 2009. This approach is common in the literature (see for example Nakamura and Steinsson (2018)), but our results are very similar if we include these dates, as discussed at the end of this subsection. The first column shows the results using the full available sample. These results suggest roughly a 0.9% fall in the Nifty 50 in response to a 25 basis point MP surprise tightening. While the size of the response is non-negligible, the effect is not statistically significant. However, there are interesting differences when we focus on specific subsamples. For the first nine years of the sample from January 1991 to January 2000 (results shown in column 2) the response of stock prices to MP surprise is small and insignificant. suggesting essentially no role for US monetary policy in determining Indian stock prices in this sample. However, for the 2000-2018 sample (shown in column 3) stock prices have responded more strongly to MP surprise, with a 2.2% fall that is statistically significant (p-value less than 0.01). Columns 4 and 5 split the post-2000 sample into a pre-crisis and a post-crisis sample. These results show that stock prices have been responding even more strongly (2.9% fall) since the crisis relative to before the crisis (2% fall). The reaction of the NSE 500 is broadly similar to the Nifty 50 with small differences in the early sample as the NSE 500 data is only available starting in 1995.

Table 2 also shows the stock market response to MP uncertainty shocks. The first column which shows the full sample results implies that a one standard deviation increase in MP uncertainty increases stock prices by .015%, a negligible effect that is also statistically insignificant. Similar to the story with MP surprise, we see that in the early part of the sample, Indian stocks did not react much to MP uncertainty shocks. Even in the 2000 to 2008 sample (column 4) there is essentially a zero response of stocks to MP uncertainty. But in the post-crisis sample of 2009 to 2018, there is a 0.3% fall in stock prices in response to a one standard deviation increase in MP uncertainty, and which is statistically significant (p-value less than 0.01).[13] It is worth high-

[13]For comparing the size of this coefficient to the MP surprise one, in terms of standard deviation effects it amounts to almost half the size of the MP surprise effect. This can be seen by dividing the MP coefficient by 4 before comparing to the MP uncertainty coefficient as explained in Section 2.1.3 above.

lighting that Indian stocks are responding to news about the uncertainty of the future monetary policy decisions even when we control for unexpected changes to the level of the future path of interest rates (i.e. the MP surprise). Finally, looking at the fit of the regression, we see that the R^2 for the for the early part of the sample is low and around 0.02. But the R^2 for the post-2000 sample is substantially larger at around 0.15.

Our results provide two important insights in interpreting the literature's findings on the spillover effect of US monetary policy. First, while most of the literature has focused on the recent unconventional monetary policies carried out since the financial crisis, the results from Table 2 suggest that US monetary policy was having substantial spillover effects starting as early as 2000. In section 3.2 we investigate the timing of when US monetary policy started significantly affecting Indian financial markets using a time-varying parameter framework. Second, focusing on the large scale asset purchases (or quantitative easing), recent work (for example Tillmann (2016) and Bhattarai, Chatterjee, and Park (2015)) has found big effects on emerging market countries. In section 3.1 we shed light on how announcements about quantitative easing affected the Indian stock market through our two measures of monetary policy shocks.

We conclude this section by discussing some results that establish the robustness of the baseline results. First, in our baseline specification we excluded a handful of FOMC meetings around the financial crisis. Our results are essentially unchanged when we include these particular meetings in our sample. Second, we used an extended set of futures contracts, expiring up to 2 years ahead to construct our measure of MP surprise. We get very similar results when we use futures contracts that expire only up to 1 year ahead, as is common in the event study literature, see for example Nakamura and Steinsson (2018). Next, in our baseline sample we used both scheduled and unscheduled FOMC meetings. We find that the results when excluding the unscheduled FOMC meetings are also very similar to our baseline results. These robustness results are presented in Table A.1 in the appendix.

Finally, a common alternative to the approach used here is to proxy the US monetary policy shocks with the 10 year Treasury bond rate. This is especially the case when evaluating the effects of quantitative easing, for domestic effects see for example Greenlaw, Hamilton, Harris, and West (2018) and for international spillovers see Ahmed and Zlate (2014) and Bhattarai, Chatterjee, and Park (2015) among others. Table A.2 in the appendix shows the results from our baseline specification but using the 10 year Treasury bond rate as the proxy for the monetary policy shock. The results are shown for the pre-crisis and post-crisis samples. For both the Nifty 50 and the NSE 500 the effects of the 10 year yield are statistically insignificant and smaller in magnitude, especially so in the post-crisis sample. Additionally the R^2 of the regressions are also substantially lower at around 0.03 compared to around 0.15 for our baseline specification. Thus, there is a striking difference between using our preferred measure of monetary policy shocks compared to the 10 year Treasury bond rate, both in terms of the size of the effects and the statistical significance. We conclude that our measures provide capture crucial information about monetary policy changes that are lost when using the longer-term Treasury yields alone.

In summary, there is clear evidence for the growing importance in recent years of both level (or first moment) shocks and uncertainty (or second moment) shocks about the expected path of the Federal Reserve's policy rate for Indian stock prices.

3.1 Effects of Quantitative Easing

This section investigates the role of the unconventional monetary policy of large scale asset purchases or quantitative easing (QE) carried out by the Federal Reserve as a response to the financial crisis. As discussed above, there is a large literature that focuses on the spillover of QE to emerging markets. In Table 3 we list the important dates related to the three major bond buying programs (QE1, QE2 and Q3), in addition to the Maturity Extension Program (MEP) also known as "Operation Twist" and the announcement of the end of the QE program referred to as the "Taper". We use the dates from Fawley, Neely, et al. (2013) but restrict the sample to only FOMC meetings days.[14] This is done to stay consistent with the analysis of this paper of focusing on FOMC meeting days. Table 3 also lists the change in the Indian equity indexes and the two measures of monetary policy shocks.

[14] We add the June 19 FOMC meeting in 2013 to the Fawley, Neely, et al. (2013) dates which was used to announce the start of the bond tapering policy.

MP Surprise shocks are mostly negative, especially for QE1, reflecting a downward revision of expected future rates (first-moment signalling channel) as emphasized by Bauer and Rudebusch (2014). But for almost all of the QE announcements monetary policy uncertainty also falls.[15] While it is the case that FOMC meetings on average lower uncertainty, the meetings which accompanied information about QE have lowered uncertainty more.[16] This means that QE also has a substantial second-moment signalling channel.

Looking at the Indian equity indices, we notice large movements in prices on QE related FOMC dates, with numerous returns over 2% in absolute value. The standard deviation of the Nifty 50 index return on QE related FOMC days is 2.2, substantially higher than 1.5 on non QE related FOMC days. A two-sample F test of equality in variances can be rejected at the 5% level. For days with large equity returns, the sign of the return is the opposite that of the MP surprise and MP uncertainty, with one notable exception: December 16, 2008. On this day the FOMC decided to cut the federal funds rate from 100 basis points to establish a target range for the federal funds rate of zero to 25 basis points. Both our monetary policy shock measures show large negative values for this date. However, the Indian equity markets fell by almost 3%. This meeting is a prime candidate of the so-called "Fed Information Effect" where an expansionary monetary policy shock can have seemingly contractionary effects as the market interprets the policy action as providing a signal about deteriorating fundamentals.[17] Thus in our regression analysis below we will leave out this particular data point. In Appendix Table A.7 we show that information effects are not important for our results more generally for other meetings.

We rerun the baseline regression from Equation 3.1 but add a QE dummy which equals 1 for the dates shown in Table 3, along with interactions of this dummy with the MP shock measures.

[15] The MP uncertainty measure is shown here in its raw form. Recall that in the baseline results we first obtained the residuals from a projection of the raw uncertainty measure on the MP surprise measure. Then we standardized this residual (unit variance) to use in the stock return regressions. In Table 3 we instead list the uncertainty measure directly, i.e. without the orthogonalization and standardization (labeled "Raw MP Uncertainty").

[16] Specifically, focusing on the 2000 to 2018 sample, the mean of the Raw MP Uncertainty measure on QE related FOMC dates is $-.039$, which is more than double the value on non-QE related FOMC dates, where it is equal to $-.014$. A two sample t-test of equality in the means is rejected with a p-value less than .01.

[17] At this meeting, the FOMC also gave guidance in its statement that "..weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time."

The two key differences are that we now include the FOMC meetings days around the financial crisis but drop the December 16, 2008 meeting as mentioned above. These results are presented in Table 4 for the 2000 to 2018 sample. The coefficients on the interaction of QE dummy with both MP surprise and MP uncertainty are statistically significant. However, the coefficient on MP surprise is positive while that on MP uncertainty is negative. Both shocks have a negative effect on stock prices on non-QE days. This means that on QE days, the effect of MP surprise is weaker (net effect of 0.46 and not significant) and that of MP uncertainty is substantially stronger (-1.47 and significant). Specifically, the FOMC meetings that revealed information about QE purchases resulted in a fall in uncertainty about future policy decisions (i.e. the second-moment signalling channel) and had a significant positive effect on Indian financial markets.[18] As we will discuss below in Section 4, the transmission of US monetary policy uncertainty to Indian stock market works through its effect on volatility and risk aversion, consistent with the global financial cycle story of Miranda-Agrippino and Rey (2020).

3.2 Time Variation in Stock Market Response

In this section we explore the time variation in the stock response in more detail. Specifically, we are interested in investigating whether the stock market response exhibited sudden discrete changes or whether the response is better described by a gradually changing process.

To test for discrete jumps in the stock market response we use the structural break tests recommended by Bai and Perron (1998). We treat the break point(s) as unknown and use the modified Schwarz criterion and the sequential procedure outlined in Bai and Perron (2003) to find the break points and test for their significance. Both procedures fail to reject the null of no break.[19] But the regressions in table 2 do point towards instability in the response coefficient.

[18] Chen, Griffoli, and Sahay (2014) find that the spillover per unit of monetary policy surprise is larger from unconventional policy, which coincides with the post-crisis period. How does this relate to our finding of increased sensitivity to MP Uncertainty? It turns out that Chen, Griffoli, and Sahay (2014) use a slightly different way of constructing monetary policy shocks than is common in the literature, they use long term Treasury bond rates as well (up to 30 years). A story consistent with both this paper and that of Chen, Griffoli, and Sahay (2014) is that uncertainty is driving the larger responsiveness of international financial markets through its effects on long term US Treasury yields. Indeed, Bauer, Lakdawala, and Mueller (2019) show that uncertainty changes on FOMC days are important drivers of long term US Treasury yields.

[19] These results are excluded here for brevity.

Thus, next we explore whether there has been a gradual change in the stock market response. We do this by setting up a time-varying parameter framework. We posit a flexible random walk process for the evolution of the time varying response coefficients. Thus the model can now be written in state space form as follows

$$\Delta S_t = \alpha + \beta_t mps_t + \gamma_t mpu_t + u_t \quad (3.2)$$

$$\beta_t = \beta_{t-1} + \varepsilon_{\beta,t} \quad (3.3)$$

$$\gamma_t = \gamma_{t-1} + \varepsilon_{\gamma,t} \quad (3.4)$$

In this system we make the additional assumption that the error terms are normally distributed, $u_t \sim N(0,R)$, $\varepsilon_{\beta,t} \sim N(0,Q_\beta)$ and $\varepsilon_{\gamma,t} \sim N(0,Q_\gamma)$, and that they are mutually uncorrelated. With the normal errors and linear structure this model can be estimated using the Kalman Filter. Specifically, the likelihood function can be evaluated using the prediction error decomposition method. The parameters $\{\alpha, R, Q_\beta, Q_\gamma\}$ can then be estimated with maximum likelihood. Using the estimated parameters we can construct an estimate of the time-varying parameters β_t and γ_t. Specifically, we consider the so-called smoothed value given by $E[\beta_t|\Omega_T]$ and $E[\gamma_t|\Omega_T]$ where Ω_T is information available in the full sample, from $t = 1$ to $t = T$.

The smoothed response coefficients for the Nifty 50 index are reported in Figure 2 with the solid blue lines. The dashed blue lines depict the one standard deviation confidence intervals. The top panel of Figure 2 shows that there is a clear downward trend in the stock market response to US MP surprise shocks. In the early 1990s there is a small and insignificant effect on the stock market. From the late 1990s up unitl 2008, there is a slow and gradual increase in the size of the coefficient with a trough around -3%. Then the response stabilizes around this -3% mark. The response turns statistically significant around the early 2000s. The pattern is similar for the response to MP uncertainty shocks with two main differences. The trend downwards (i.e a more negative response) does not start until the early 2000s and becomes significant only in the post-financial crisis sample. The results for NSE 500 index are very similar and shown in Figure

A.1 in the appendix.

These results suggest that US monetary policy decisions started becoming more important for Indian financial markets starting in the early 2000s with the peak effect in the post-crisis sample. The gradual increase in the response rules out any sudden changes in institutional or economic factors as being the likely driving forces. We next explore potential explanations for this increased responsiveness.

4 Understanding the stock market response

The literature has discussed various channels through which US monetary policy can affect emerging markets. Consistent with a Mundell-Fleming framework, we show here that the transmission of conventional US MP surprise shocks works primarily through the exchange rate and the corresponding equity market flows of foreign investors. On the other hand, US monetary policy uncertainty shocks are driven by the risk channel related to the global financial cycle. Since the transmission of MP uncertainty is a novel result, we start by discussing the conceptual framework underlying the uncertainty transmission to better understand the empirical results.

The general framework for US monetary policy uncertainty transmission to US asset prices works through a risk-based channel. From a basic asset pricing setup the expected returns on a risky asset (R_{t+1}) relative to the risk free rate (R_t^f) depend on the covariance of returns with the stochastic discount factor (M_{t+1}). Writing the covariance in terms of standard deviation and correlation we get $E_t R_{t+1} - R_t^f = \frac{Corr_t(-M_{t+1}, R_{t+1})}{E_t M_{t+1}} \sigma_t(M_{t+1}) \sigma_t(R_{t+1})$. If a change in uncertainty about future short rates (MP uncertainty) is related to uncertainty about returns on the risky asset ($\sigma_t(R_{t+1})$), higher short-rate uncertainty raises expected excess returns and lowers the price of the risky asset. What explains the transmission of US monetary policy uncertainty to international asset prices? We find that it can be explained with the story of the global financial cycle and changes in aggregate risk aversion, as put forth by Miranda-Agrippino and Rey (2020) and Bruno and Shin (2015) among others. We also provide suggestive evidence to rule out flight to safety (Bhattarai, Chatterjee, and Park (2019)) and international portfolio balance (Alpanda and Kabaca (2019)) channels of uncertainty.

There are important changes happening to the Indian economy in the sample period considered here. There is a prominent upward trend over time in the amount of goods and services traded by India with advanced countries, especially with the United States. This increase in trade is a natural candidate for explaining the increased responsiveness we have found. In the next section, using firm level stock data we show some suggestive evidence that the trade story is unlikely to be main reason behind the increased responsiveness. At the same time there has been a substantial, albeit gradual, increase in the level of financial integration experienced by India as well.[20] We now turn to the evidence that points to the role of financial flows, related exchange rate movements and aggregate risk aversion as the likely source of the explanation.

In this paper, since we are using a high frequency event study approach, we focus on four important financial market variables that are available at this frequency and that can help us understand the transmission channels discussed above. They are the Indian Rupee to US Dollar exchange rate (INR/USD), the 10 year Indian government bond rate, the net flows into Indian equity markets from foreign institutional investors (FII flows)[21] and the implied volatility of the Nifty 50 index (Nifty VIX). The data for the FII flows and the 10 year bond rate are available from 1999 and the Nifty VIX is only available from 2008. The exchange rate is calculated as daily percent change, 10 year bond rates and Nifty VIX are calculated as daily changes and reported in percentage points, while the FII flows is the daily net flows reported as 100 millions of US dollars.

Table 5 shows the summary statistics and Table 6, presents the correlation of these variables with the Nifty 50. In the post-crisis sample, the standard deviation and correlation with stock prices on FOMC days is higher than i)that on non-FOMC days in the post-crisis sample and

[20]While de jure measures of capital account openness for India have not changed dramatically (see for example Chinn and Ito (2008)), there have potentially been large de facto changes (see for example Mishra, Montiel, and Sengupta (2016) and Hutchison, Sengupta, and Singh (2012)). There has also been recent work that has argued that liberalization of the capital account in India has happened at a gradual pace, see for example Sen Gupta and Sengupta (2014) and Hutchison, Pasricha, and Singh (2012).

[21]Overall, the general pattern of the cumulative FII flows mirrors the total gross capital flows into India. Thus we can treat the FII flows as a reasonable proxy for overall capital flows.

ii)that on FOMC days in the pre-crisis sample, hinting at the role of these variables in explaining the mechanisms.

We first investigate how the US monetary policy shocks affect these variables. Table 7 presents these regressions for the pre-crisis and post-crisis samples. The first two columns show the effects on the exchange rate, which is defined in terms of Indian Rupees per US Dollar so an increase in the exchange rate implies a depreciation of the Indian rupee. Neither US monetary shocks have a large or statistically significant effect on the exchange rate in the pre-crisis sample. In the post-crisis sample, a contractionary MP surprise leads to a significant depreciation in the Rupee. The 10 year government bond yield responds significantly to US MP surprises in both the samples, however the effect in the pre-crisis sample is roughly half that of the post-crisis sample. Net FII flows do not respond significantly to MP surprise shocks in the pre-crisis sample. However, there is a bigger and statistically significant fall in the post-crisis sample in response to a MP surprise tightening. The regressions for the three variables (available in pre-crisis sample) also show that the R^2 goes up considerably (more than doubling) for the post-crisis sample, consistent with the story that emerged from the stock market regressions that Indian financial variables are being more strongly affected by US MP surprises in the more recent years. On the other hand, the US MP uncertainty shock does not affect these three variables but has a statistically significant and positive impact on the Nifty VIX.[22] Next, we explore to what extent the effects of US monetary shocks are transmitted to the Indian stock markets through these variables.

We take the following approach to gauge the role of these financial variables in driving the responsiveness of Indian stock prices to US monetary policy shocks. In the baseline results presented in Table 2, we regressed the stock returns on the monetary policy shocks. Here we add the three financial variables as controls to the baseline regression. Then we compare the coefficients on the US monetary policy shocks from the baseline regressions to these extended regressions. If US monetary policy transmission is working entirely through the USD/INR exchange rate,

[22]Both shocks have a statistically significant and positive effect on the Nifty VIX, but MP uncertainty shocks account for the majority the variation in the Nifty VIX. Specifically, in unreported results we find that three-fourths of the R^2 is due to MP uncertainty.

the 10 year government bond rate, the net FII flows and Nifty VIX then we should expect the coefficient on the policy shocks in the extended regressions to go to zero. On the other hand, if US monetary policy does not work through these variables then the coefficient on the policy shocks should be similar to the baseline case.

Table 8 shows these regressions with the controls one at a time and simultaneously, together with the baseline specification for the pre-crisis (top panel) and post-crisis (bottom panel) sample. For the pre-crisis sample, the coefficient on MP surprise (-1.9 without these controls) does not fall much for any of the specifications and continues to remain statistically significant. Only the 10 year bond rate has a statistically significant effect on stock prices in the pre-crisis sample. In the post-crisis sample, the results change dramatically. The coefficient on MP surprise (-2.9 without the controls) falls substantially (essentially to zero with all controls together) and even becomes statistically insignificant. The biggest effects are through the exchange rate, Nifty VIX and Net FII flows and the coefficients on these three coefficients are strongly significant.[23] This suggests that US MP surprise shock are primarily transmitted to the Indian stock markets through the nexus between the exchange rate and net FII flows[24] and partly through the Nifty VIX. On the other hand, the transmission of MP Uncertainty shocks transmits entirely through the Nifty VIX (going from -0.265 to essentially zero) and remaining unchanged for the other cases.

For the first-moment shocks, the role of the exchange rate and foreign portfolio flows is apparent in driving stock prices. But the role of volatility in the stock market driving the transmission may not be as obvious. First, as documented in Bauer, Lakdawala, and Mueller (2019), US monetary policy uncertainty has large effects of various measures of risk in US financial markets (including the S&P 500 VIX). The response of Indian stock prices through risk is consistent with the empirical results of Miranda-Agrippino and Rey (2020) who find measures of global risk aversion responding strongly to US monetary shocks. They outline a framework with global

[23] However the coefficient on the 10 year bond is not significant in the post-crisis sample.

[24] This is related to the work of Patnaik, Shah, and Singh (2013), who find that foreign investors play an important role in the Indian equity markets on days with big increases in the US stock market.

banks and asset managers with heterogenous risk preferences that can rationalize the result. This builds on models that use leverage of international banks (Bruno and Shin (2015)), or financial intermediaries more generally (Coimbra and Rey (2017)) to explain the spillover.

We also explore the importance of two alternative channels of uncertainty transmission highlighted in the recent literature. Bhattarai, Chatterjee, and Park (2019) study the international spillover of overall US uncertainty and find a "flight to safety" channel which is crucially dependent on the response of the country's monetary authority to US shocks. In Appendix Table A.5 we show that when we measure the RBI's response with short-term interest rates and foreign exchange reserves, we do not find any role for this channel in the transmission of the US monetary policy uncertainty shocks. We also investigate the role of the international portfolio balance channel, see for example the recent work of Alpanda and Kabaca (2019). We use the term premium estimates on the 10 year Indian government bond as a mechanism through which this channel might work. Appendix Table A.6 shows that we do not find any role for this channel either.

Finally, we investigate the role of a variety of Indian macro variables like current account, stock market liquidity, the level of inflation (and a dummy for the inflation targeting regime). These results are presented in Appendix tables A.3 and A.4 and show that these variables also do not play a role in the transmission of US monetary shocks.

5 Firm Level Stock Results

To complement the aggregate stock market index results from sections 3 and 4 we also explore the response of individual stock prices to U.S. monetary shocks. We use data on the firms that make up the NSE 500 index as of August 2018. The combined market capitalization of these 500 companies accounts for more than 90% of the total stock market capitalization on the National Stock Exchange. Our data is limited in two noteworthy dimensions. First, from 1995 onwards various firms were removed from the NSE 500 index. We do not have data on the stock price for these firms. Second, various new firms have been added in the recent years to the sample and thus for some firms we have relatively fewer observations.

Columns 1 and 3 of Table 9 present a pooled panel regression of the individual stock returns in the NSE 500 on the U.S. monetary policy shocks for a pre-crisis and post-crisis sample respectively. Since the monetary shock measures does not vary across individual stocks in a given time period, the standard errors are clustered along the time dimension. T-statistics based on these clustered standard errors are reported in the parentheses. We have also run these panel regressions with a firm fixed effect and the estimated coefficients were very similar to the OLS coefficients reported here. The response coefficients in both samples are broadly consistent with to the overall NSE 500 index results from Table 2. There is a larger negative response of stock prices to both U.S. MP surprise and US MP Uncertainty shocks in the post-crisis sample. Moreover, when we control for the exchange rate, 10 year government bond rate, net FII flows and Nifty VIX, the pattern that emerges is consistent with the aggregate results from Table 8.

There are two reasons we might have expected the coefficients to be somewhat different compared to the NSE 500 index results. First, the NSE 500 index is a weighted index, while the panel regression here effectively weights the individual stocks equally. Second, we do not have data for firms that were dropped from the NSE 500 index. Thus differences resulting from this issue should be more pronounced in the earlier sample period, which is exactly what Table 9 shows. Overall, the results from the firm level and NSE 500 index regressions are similar enough that we can conclude that the panel data is reasonably representative of the NSE 500 index. We next explore whether there is any heterogeneity in the response of individual stock returns and importantly if changes in this heterogeneity can explain the growing importance of the stock response to US monetary policy shocks.

We start by exploring whether there are any notable differences in the stock response by industry. Table 10 shows the summary statistics when we group the firms by sectors according to the Global Industry Classification Standard (GICS). This table also lists the number of firms in each sector, average market capitalization (in billions of US$) over the full sample (1999 to

2018) and mean return and standard deviation for a pre-crisis and post-crisis sample.[25] There is an interesting difference in the pre-crisis and post-crisis samples. The mean and standard deviations are substantially higher on FOMC days in the pre-crisis sample relative to the post-crisis sample. The standard deviations across industries are fairly uniform with the “Real Estate” sector being the most volatile while the “Health Care” sector is the least volatile. The “Consumer Discretionary” and “Financials” sectors have the most firms but the average market capitalization is higher for the “Energy” and "Telecommunication Services" sector. However there have been changes in the relative share of market capitalizations across industries over time. In the online appendix Table A.2, we show these trends over time. The “Financials” sector contributed to 7% of the total market capitalization in 1999 but almost 25% by 2018. To a lesser extent the share of the “Consumer Discretionary” sector has gone up as well, while the “Consumer Staples” and “Energy” sectors have experienced the biggest falls. Finally, the “Information Technology” sector’s share has also gone up relative to its level in 1999, but only by around 2%.

This pattern of changing importance of sectors offers a potential candidate for the increased responsiveness of the aggregate index return to US monetary shocks. For this story to make sense, we would expect to see that the sectors that have gained a larger share of the total market capitalization are also the ones that are more sensitive to US monetary policy shocks. We test this hypothesis by running regressions of firm level stock returns on U.S. monetary shock separately for each sector, for a pre-crisis and post-crisis sample. The results are presented in Figure 3 with 90% confidence intervals represented with the vertical lines. Again, the standard errors are clustered along the time dimension. In the pre-crisis sample, the MP surprise responses across industries are all remarkably close to the pooled estimate from Table 9 of -1.75. The response of the Real Estate and Utilities sectors is slightly more negative at around -4 but with larger confidence intervals. In the post-crisis sample the response coefficients are again quite similar across industries, close to the more negative aggregate coefficient of -2.3. Thus there appears to be an increased responsiveness to MP surprise shocks uniformly across all industries going

[25]The mean and standard deviations are calculated by averaging first over time and then across firms.

from the pre-crisis to the post-crisis sample.[26] This is the case for the MP uncertainty variable as well. In the pre-crisis sample, the response of all the sectors is clustered around .3, this is slightly larger than the baseline pooled coefficient from Table 9, most likely due to the effective firms changing in our sample as discussed above. In the post crisis-sample, when the sample issue should be a less of concern, we see the industry responses are bunched around $-.3$, which is close to the pooled baseline coefficient. Overall, for both shocks the responsiveness is remarkably similar across sectors in both the pre and post-crisis samples.

Thus, an important point emerges from this industry level analysis. The increased responsiveness in the post-crisis sample does not appear to be driven by certain sectors becoming more responsive to US monetary policy shocks. Rather, the increased responsiveness is a phenomenon that affects all industries in the Indian economy. The regression analysis from Section 4 argues that this aggregate factor works through the nexus of the exchange rate market, portfolio decisions of foreign institutional investors and the global financial cycle.

6 Conclusion

In this paper we document the growing impact of US monetary policy on the Indian stock market. Using high frequency derivatives data, we construct two measures of US monetary shocks: a shock that captures surprise changes in the future path of the Federal Reserve's policy tool and a shock that captures uncertainty about future policy decisions. While the aggregate Indian stock market was unresponsive to U.S. monetary shocks in the early 1990s, there has been a gradual increase in the responsiveness over the past two decades, with the peak effect felt after the financial crisis. Monetary shocks captured by surprise changes to the policy rate started having significant effects on Indian financial markets in the early 2000s. On the other hand, monetary policy uncertainty shocks have become more important since the financial crisis, playing a crucial role in the transmission of the announcements of large scale asset purchases

[26] We have also tried running a regression with dummies for each sector interacted with the monetary policy shock and we found that most of the interaction coefficients are insignificant, regardless of which sector we choose as the baseline sector.

(quantitative easing).

We also investigate the mechanism driving the increase in the sensitivity of the Indian financial market response over time. Firm level stock return data show that the reaction to US monetary policy was similar across sectors in both pre and post-crisis samples, pointing to the role of aggregate factors in driving the results. Using daily financial flows data we show that MP surprise transmission is driven primarily by the role of foreign institutional investors and the exchange rate movements, while MP uncertainty transmission works through the global financial cycle and its effects on volatility and risk-aversion.

The framework used here can be extended to study the effects on other emerging economies in a straightforward manner. While this paper has focused on the financial market response, a natural extension is to study the effects of the two US monetary shocks on macroeconomic variables in emerging economies.[27] Another promising approach involves merging detailed firm level balance sheet data with the high frequency financial market data used here to explore if certain characteristics make firms more or less susceptible to US monetary policy shocks.

[27]See Lakdawala and Singh (2019) for recent work on this topic.

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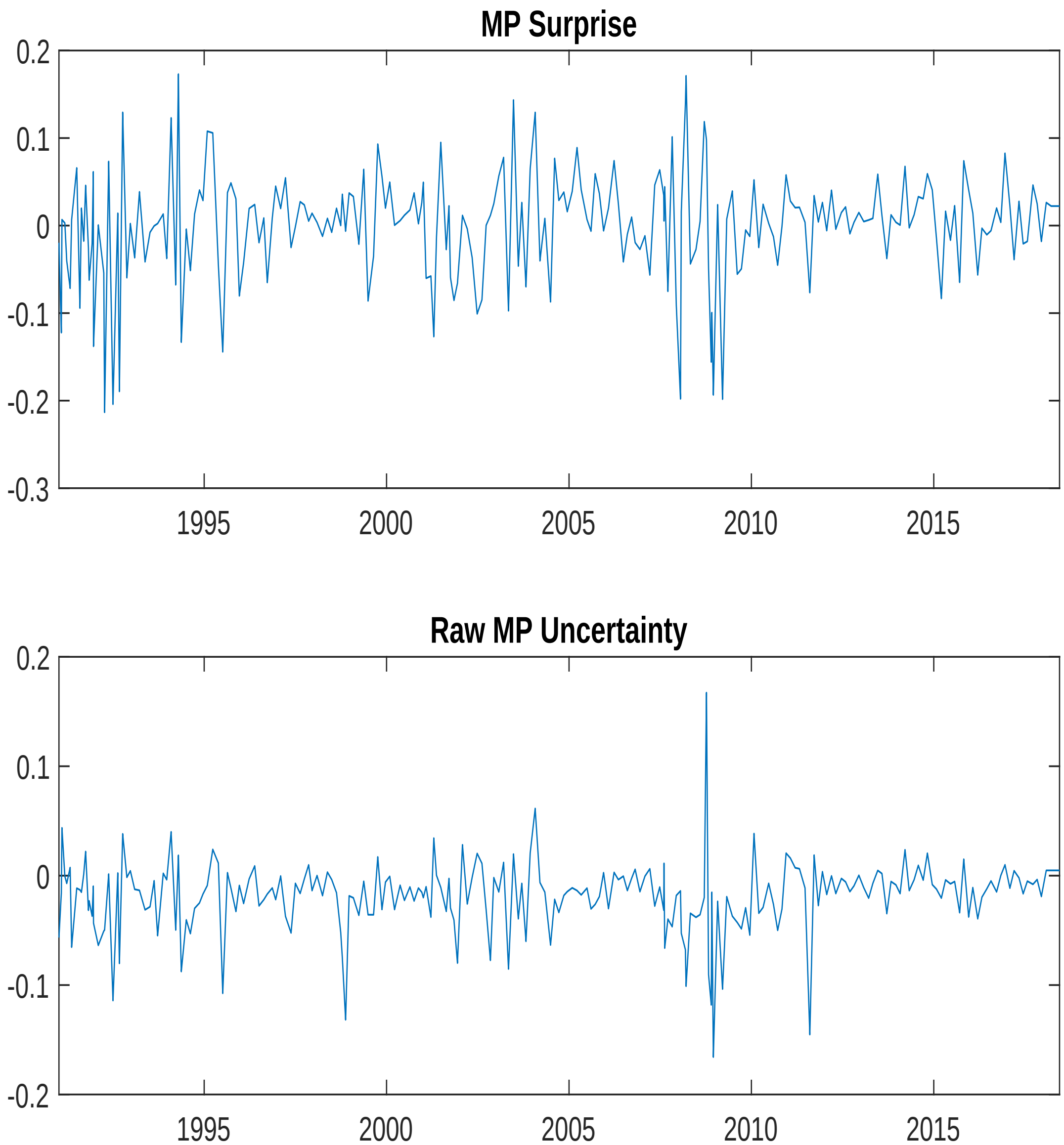
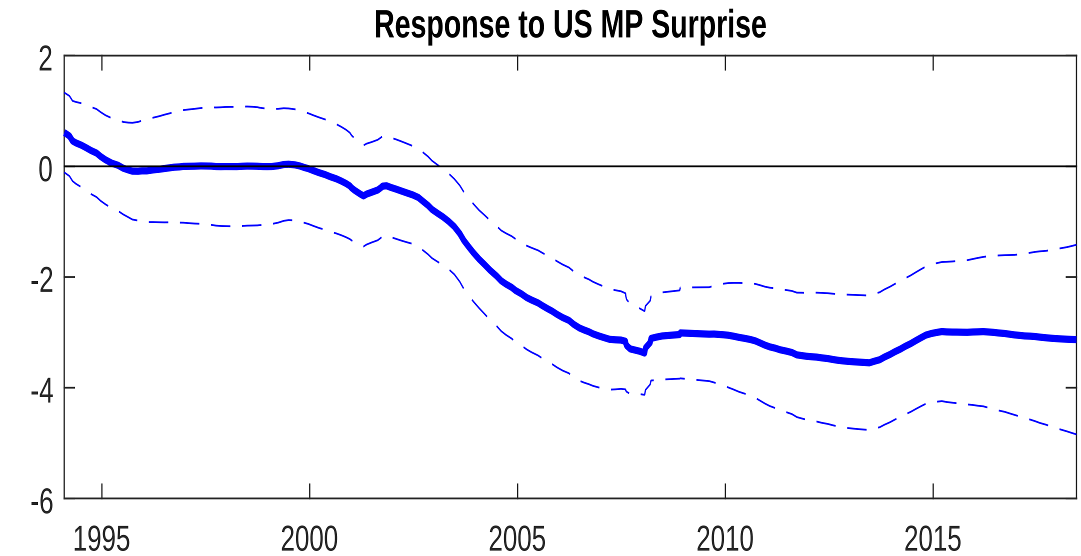
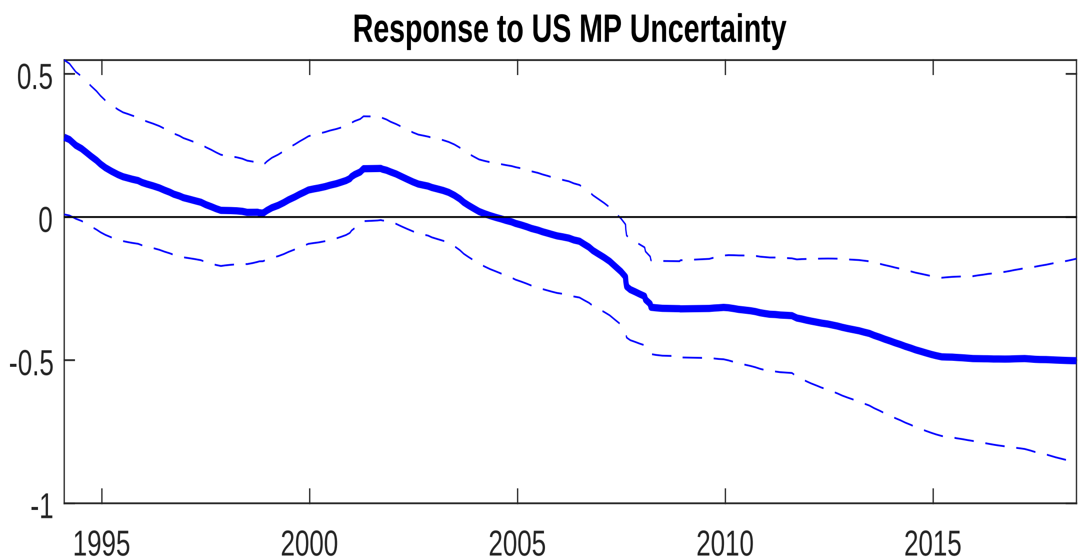
Figure 1: U.S. Monetary Policy Shocks



This figure plots the monetary shocks constructed from Eurodollar futures and options data around FOMC announcements from 1991 to 2018. The top panel shows the MP surprise and the bottom panel shows the Raw MP uncertainty measure, see sections 2.1.1 and 2.1.2 for details.

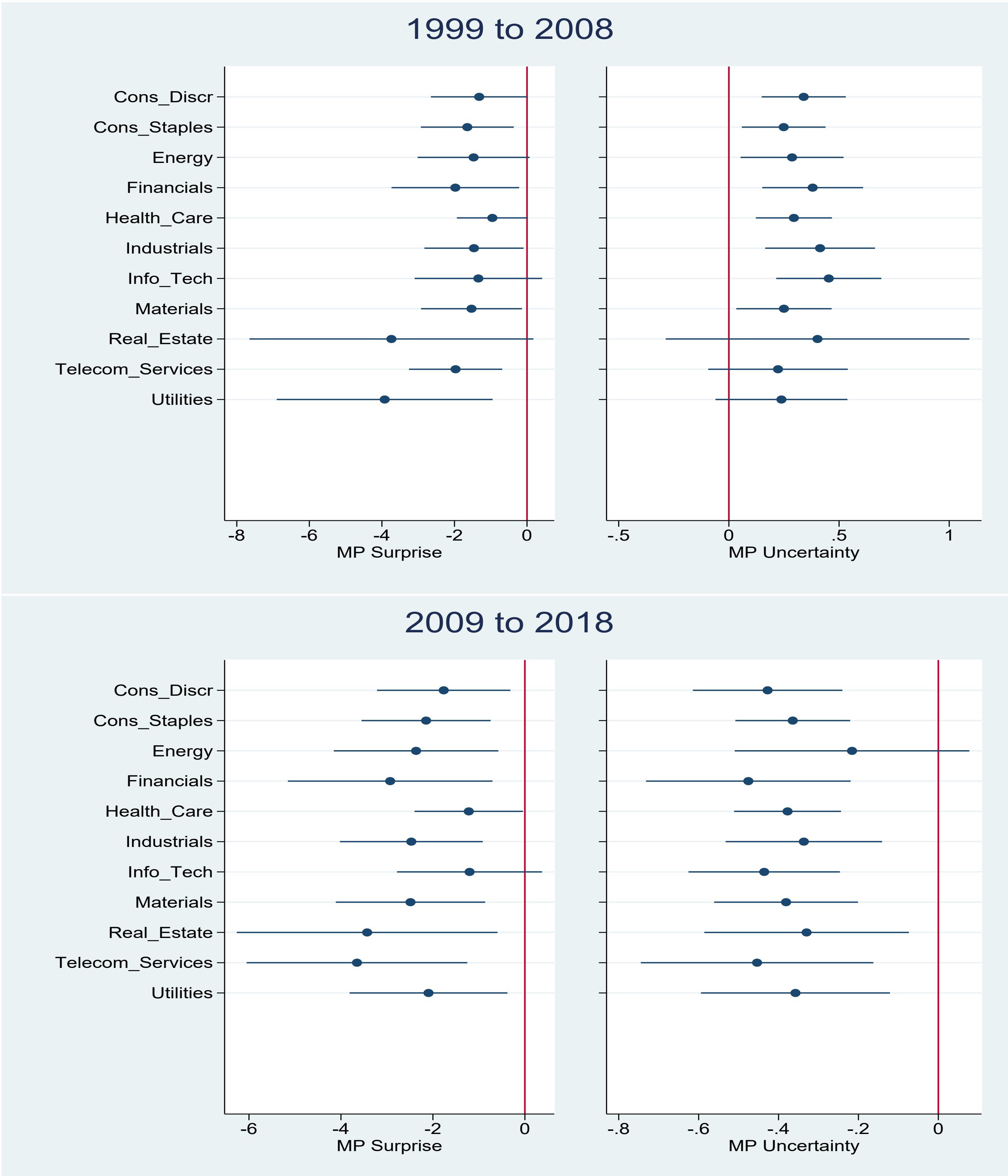
Figure 2: Time-varying response of Indian stock returns to US monetary shocks





Smoothed estimates of the response of the Nifty 50 index to US MP surprise and US MP uncertainty shocks from the time-varying parameter estimation, detailed in section 3.2. The dashed blue lines show the one standard deviation confidence bands.

Figure 3: Response of Indian stock returns to US monetary shocks by industry



Regression coefficients of individual Indian stock returns grouped by sectors according to the Global Industry Classification Standard (GICS) on U.S. monetary policy shocks for the two samples 1999 to 2008 (top panel) and 2009-2018 (bottom panel). 90% confidence intervals calculated using robust standard errors clustered along the time dimension are represented with the horizontal bars.

Table 1: Summary statistics for Indian stock returns and U.S. monetary policy shocks

Sample: Jan 1991 to Jun 2018 (Feb 1995 to Jun 2018 for NSE 500)

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nifty 50	0.33	1.69	-7.13	6.53	0.03	1.69	-13.94	15.07
NSE 500	0.36	1.50	-7.43	6.40	0.03	1.52	-13.75	13.96
U.S. MP Surprise	0.00	0.25	-0.85	0.69	N/A			
U.S. MP Uncertainty	0.00	1.00	-4.27	5.49	N/A			

Sample: Jan 1991 to Jan 2000 (Feb 1995 to Jan 2000 for NSE 500)

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nifty 50	0.20	1.83	-5.22	5.34	0.03	2.04	-13.34	11.38
NSE 500	0.41	1.27	-2.29	3.93	0.04	1.60	-7.63	7.06
U.S. MP Surprise	-0.02	0.27	-0.85	0.69	N/A			
U.S. MP Uncertainty	0.00	1.00	-4.19	2.33	N/A			

Sample: Feb 2000 to Jun 2018

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nifty 50	0.39	1.61	-7.13	6.53	0.03	1.48	-13.94	15.07
NSE 500	0.35	1.55	-7.43	6.40	0.02	1.50	-13.75	13.96
U.S. MP Surprise	0.01	0.23	-0.79	0.68	N/A			
U.S. MP Uncertainty	0.00	1.00	-4.04	5.22	N/A			

Sample: Feb 2000 to Jun 2008

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nifty 50	0.61	1.84	-7.13	6.53	-0.01	1.75	-13.94	7.66
NSE 500	0.51	1.80	-7.43	6.40	-0.02	1.80	-13.75	7.41
U.S. MP Surprise	0.00	0.29	-0.79	0.68	N/A			
U.S. MP Uncertainty	0.00	1.00	-2.96	4.52	N/A			

Sample: Jul 2009 to Jun 2018

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nifty 50	0.13	1.17	-4.26	3.53	0.04	1.03	-6.29	3.67
NSE 500	0.14	1.13	-3.92	3.23	0.04	1.00	-7.19	3.57
U.S. MP Surprise	0.03	0.13	-0.33	0.33	N/A			
U.S. MP Uncertainty	0.00	1.00	-5.36	2.27	N/A			

Indian stock returns are reported as percent changes in the index. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table 2: Regressions of Indian stock returns on US monetary policy shocks

	Nifty 50				
	1/91 - 6/18	1/91 - 1/00	2/00 - 6/18	2/00 to 6/08	7/09 - 6/18
U.S. MP Surprise	-0.870	0.525	-2.239	-2.010	-2.899
	[-1.39]	[0.60]	[-3.28]	[-2.61]	[-2.75]
U.S. MP Uncertainty	0.015	0.183	-0.159	-0.015	-0.265
	[0.12]	[0.80]	[-1.49]	[-0.10]	[-2.35]
Constant	0.347	0.208	0.468	0.721	0.215
	[3.47]	[1.07]	[4.40]	[4.65]	[1.66]
Observations	234	85	149	77	72
R-squared	0.02	0.02	0.14	0.14	0.16

	NSE 500				
	2/95 - 6/18	2/95 - 1/00	2/00 - 6/18	2/00 to 6/08	7/09 - 6/18
U.S. MP Surprise	-1.793	-0.026	-2.203	-2.014	-2.742
	[-3.02]	[-0.04]	[-3.27]	[-2.63]	[-2.71]
U.S. MP Uncertainty	-0.106	-0.140	-0.114	0.058	-0.292
	[-1.34]	[-0.96]	[-1.30]	[0.49]	[-2.61]
Constant	0.434	0.410	0.430	0.642	0.218
	[4.64]	[2.11]	[4.18]	[4.27]	[1.77]
Observations	190	41	149	77	72
R-squared	0.09	0.01	0.14	0.15	0.17

Regressions of Indian stock returns on US MP surprise and US MP uncertainty measures for different samples. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses. FOMC meetings in the financial crisis from July 2008 through June 2009 are excluded.

Table 3: US QE Announcements on FOMC meeting days with US MP shocks and Indian equity returns

FOMC Meeting	Program	Nifty 50	NSE 500	MP Surprise	Raw MP Uncertainty
11/25/2008	QE1	3.57	2.41	-0.16	-0.12
12/1/2008	QE1	-0.94	-0.94	-0.10	-0.02
12/16/2008	QE1	-2.96	-3.02	-0.19	-0.17
1/28/2009	QE1	-0.90	-0.76	0.02	-0.02
3/18/2009	QE1	0.44	0.48	-0.20	-0.10
8/12/2009	QE1	3.20	3.12	-0.06	-0.04
9/23/2009	QE1	0.33	0.31	-0.05	-0.05
11/4/2009	QE1	1.15	1.63	-0.01	-0.03
8/10/2010	QE1	-0.74	-0.49	-0.01	-0.03
9/21/2010	QE2	-0.30	-0.34	-0.05	-0.05
11/3/2010	QE2	1.93	1.54	0.00	-0.03
6/22/2011	QE2	0.78	0.53	0.00	-0.01
9/21/2011	MEP	-4.26	-3.92	0.03	0.02
6/20/2012	MEP	0.86	0.89	0.01	0.00
9/13/2012	QE3	2.55	2.04	-0.01	-0.01
12/12/2012	QE3	-0.62	-0.77	0.01	0.00
6/19/2013	Taper	-2.94	-2.78	0.06	0.00

Indian stock returns and US MP surprise and US MP uncertainty measures on FOMC announcement days that contained information about QE. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is presented in raw format, see Section 3.1 for details.

Table 4: Regressions of Indian stock returns on US monetary policy shocks with QE interactions

	2/2000 - 6/2018	
	Nifty 50	NSE 500
US MP Surprise	-2.97	-3.03
	[-3.75]	[-3.82]
US MP Uncertainty	-0.42	-0.40
	[-2.02]	[-1.90]
QE Dummy	-0.59	-0.55
	[-1.19]	[-1.19]
US MP Surprise x QE Dummy	3.43	3.61
	[2.05]	[2.56]
US MP Uncertainty x QE Dummy	-1.05	-0.86
	[-2.03]	[-1.81]
Constant	0.54	0.50
	[4.41]	[4.25]
Observations	157	157
R-squared	0.24	0.24

Regressions of Indian stock returns on US MP surprise and US MP uncertainty measures. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. The QE dummy is set to 1 for dates listed in table 3. t-statistics based on robust standard errors are reported in parentheses.

Table 5: Summary statistics for exchange rate, 10 year bond, FII flows and Nifty VIX

Sample: Aug 1999 to Jun 2018

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
INR/USD	-0.01	0.29	-1.61	1.24	0.00	0.21	-2.21	2.62
10 yr bond	-0.01	0.07	-0.48	0.21	0.00	0.06	-0.77	0.80
Net FII	0.55	2.44	-8.62	15.58	0.38	1.63	-8.53	26.00

Sample: Aug 1999 to Jun 2008

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
INR/USD	-0.02	0.12	-0.55	0.34	0.00	0.13	-1.02	1.17
10 yr bond	-0.01	0.08	-0.48	0.21	0.00	0.06	-0.43	0.35
Net FII	0.21	2.19	-8.62	14.32	0.19	1.17	-8.08	9.82

Sample: Jul 2009 to Jun 2018

	FOMC Days				Non-FOMC Days			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
INR/USD	-0.01	0.40	-1.61	1.24	0.00	0.27	-2.21	2.62
10 yr bond	0.00	0.05	-0.18	0.18	0.00	0.05	-0.51	0.54
Net FII	0.94	2.66	-4.75	15.58	0.58	1.99	-8.53	26.00
Nifty VIX	-0.44	1.43	-5.93	6.21	-0.09	1.07	-12.47	6.10

The INR/USD exchange rate and 10 year bond rates are calculated as daily changes and reported in percent changes and percentage points respetively, while the FII flows is the daily net flows reported as 100 millions of US dollars and Nifty VIX is in percentage points.

Table 6: Correlation Coefficients

	1/99 to 6/08			
	FOMC Days		Non-FOMC Days	
	Coef	p-value	Coef	p-value
Corr(USD/INR, Nifty 50)	-0.182	0.10	-0.292	0.00
Corr(10yr, Nifty 50)	-0.289	0.01	-0.077	0.00
Corr(FII, Nifty 50)	0.022	0.84	0.282	0.00

	7/09 to 6/18			
	FOMC Days		Non-FOMC Days	
	Coef	p-value	Coef	p-value
Corr(USD/INR, Nifty 50)	-0.709	0.00	-0.450	0.00
Corr(10yr, Nifty 50)	-0.329	0.00	-0.077	0.00
Corr(FII, Nifty 50)	0.486	0.00	0.246	0.00
Corr(Nifty VIX, Nifty 50)	-0.628	0.00	-0.394	0.00

Correlation coefficients of the Nifty stock return, USD/INR exchange rate, 10 year government bond rate, net FII flows and Nifty VIX together with the corresponding p-values.

Table 7: Regressions of exchange rate, 10 year bond, FII flows and Nifty VIX on US monetary shocks

	INR/USD		10 year bond		Net FII		Nifty VIX
	1/99-6/08	7/09-6/18	1/99-6/08	09-6/18	1/99-6/08	09-18	7/09-6/18
U.S. MP Surprise	0.059	1.356	0.083	0.145	1.468	-6.362	2.829
	[0.96]	[4.03]	[3.49]	[3.49]	[1.41]	[-3.49]	[2.20]
U.S. MP Uncertainty	0.026	-0.011	0.009	-0.001	0.069	-0.249	0.618
	[1.35]	[-0.25]	[1.30]	[-0.33]	[0.43]	[-0.67]	[3.72]
Constant	-0.019	-0.044	-0.015	-0.008	0.188	1.122	-0.516
	[-1.52]	[-0.99]	[-1.69]	[-1.59]	[0.79]	[3.72]	[-3.43]
Observations	81	72	81	72	81	72	72
R-squared	0.07	0.21	0.08	0.16	0.03	0.11	0.26

Regressions of the INR/USD exchange rate, 10 year government bond and net FII flows on US MP surprise and US MP uncertainty measures for different samples. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses. FOMC meetings in the financial crisis from July 2008 through June 2009 are excluded.

Table 8: Regressions of Indian stock returns (Nifty 50) on US monetary policy shocks, controlling for financial variables

	1/1999 - 6/2008				
U.S. MP Surprise	-1.880	-1.767	-1.562	-1.894	-1.416
	[-2.47]	[-2.23]	[-2.21]	[-2.52]	[-1.97]
U.S. MP Uncertainty	0.034	0.083	0.066	0.031	0.124
	[0.22]	[0.57]	[0.42]	[0.20]	[0.81]
INR/USD Exchange Rate		-1.911			-2.258
		[-1.16]			[-1.48]
10 year bond			-3.828		-4.279
			[-2.59]		[-2.77]
Net FII flows				0.011	0.019
				[0.15]	[0.27]
Constant	0.745	0.708	0.687	0.744	0.635
	[4.72]	[4.35]	[4.43]	[4.67]	[3.99]
Observations	81	81	81	81	81
R-squared	0.12	0.14	0.16	0.12	0.19

	7/2009 - 6/2018					
U.S. Monetary Shock	-2.899	-0.061	-2.067	-1.772	-1.520	0.542
	[-2.75]	[-0.08]	[-1.89]	[-1.99]	[-1.45]	[0.59]
U.S. MP Uncertainty	-0.265	-0.289	-0.274	-0.221	0.036	-0.092
	[-2.35]	[-5.01]	[-2.52]	[-2.47]	[0.28]	[-1.18]
INR/USD Exchange Rate		-2.093				-1.396
		[-7.78]				[-4.90]
10 year bond			-5.723			-0.859
			[-1.72]			[-0.42]
Net FII flows				0.177		0.106
				[3.30]		[4.02]
Nifty VIX					-0.487	-0.265
					[-4.99]	[-2.94]
Constant	0.215	0.122	0.167	0.016	-0.037	-0.110
	[1.66]	[1.22]	[1.34]	[0.12]	[-0.28]	[-0.87]
Observations	72	72	72	72	72	72
R-squared	0.16	0.56	0.21	0.31	0.42	0.67

Regressions of Nifty stock returns on US MP surprise and US MP uncertainty measures controlling for INR/USD exchange rate, 10 year government bond, net FII flows and NIfty VIX individually and simultaneously in the last column. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table 9: Pooled regressions of individual Indian stock returns on US monetary policy shocks

	Individual NSE 500 Stock Returns			
	1/1999 to 6/2008		7/2009 to 6/2018	
U.S. MP Surprise	-2.2937	-2.0210	-2.2545	0.2371
	[-2.551]	[-2.665]	[-2.423]	[0.236]
U.S. MP Uncertainty	0.2560	0.2881	-0.3913	-0.1830
	[2.235]	[2.531]	[-3.526]	[-1.797]
USD/INR Exchange Rate		-0.3563		-0.6976
		[-0.280]		[-2.411]
10 year bond		-3.5166		-2.5842
		[-2.047]		[-1.124]
Net FII flows		0.0202		0.0263
		[0.281]		[0.917]
Nifty VIX				-0.3387
				[-3.878]
Constant	0.6009	0.5347	0.1815	-0.0801
	[3.963]	[3.449]	[1.533]	[-0.598]
Observations	22,163	22,163	31,475	31,475
R-squared	0.045	0.052	0.039	0.102

Pooled regressions of individual stock returns in the NSE 500 on US MP surprise and US MP uncertainty measures for different samples, controlling for INR/USD exchange rate, 10 year government bond and net FII flows. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on standard errors clustered along the time dimension are reported in parentheses.

Table 10: Summary statistics for firm level stock returns

Sector	No. of firms	Avg. Mkt. Cap	1999 to 2008		2009 to 2018	
			Mean	Std. Dev	Mean	Std. Dev
Consumer Discretionary	86	13.4	0.35	3.42	0.12	2.32
Consumer Staples	38	21.4	0.25	3.07	0.05	2.14
Energy	14	99.5	0.46	3.12	0.04	2.32
Financials	86	25.8	0.74	3.56	0.18	2.39
Health Care	41	13.8	0.41	2.59	0.13	2.02
Industrials	83	12.6	0.35	3.17	0.09	2.40
Information Technology	30	36.6	0.57	3.30	0.16	2.44
Materials	81	13.4	0.49	3.29	0.03	2.32
Real Estate	15	13.8	0.93	5.01	0.08	2.63
Telecommunication Services	6	76.6	0.93	3.26	-0.09	2.51
Utilities	21	37.0	0.73	3.37	0.03	2.11

Note: The table shows the summary statistics for individual stock returns grouped by sectors according to the Global Industry Classification Standard (GICS). The market cap is measured in billions of US$. The mean and standard deviations are calculated by first averaging over time and then averaging across firms within a sector on FOMC days.

Appendix A

Table A.1: Robustness of Baseline Results

Nifty 50

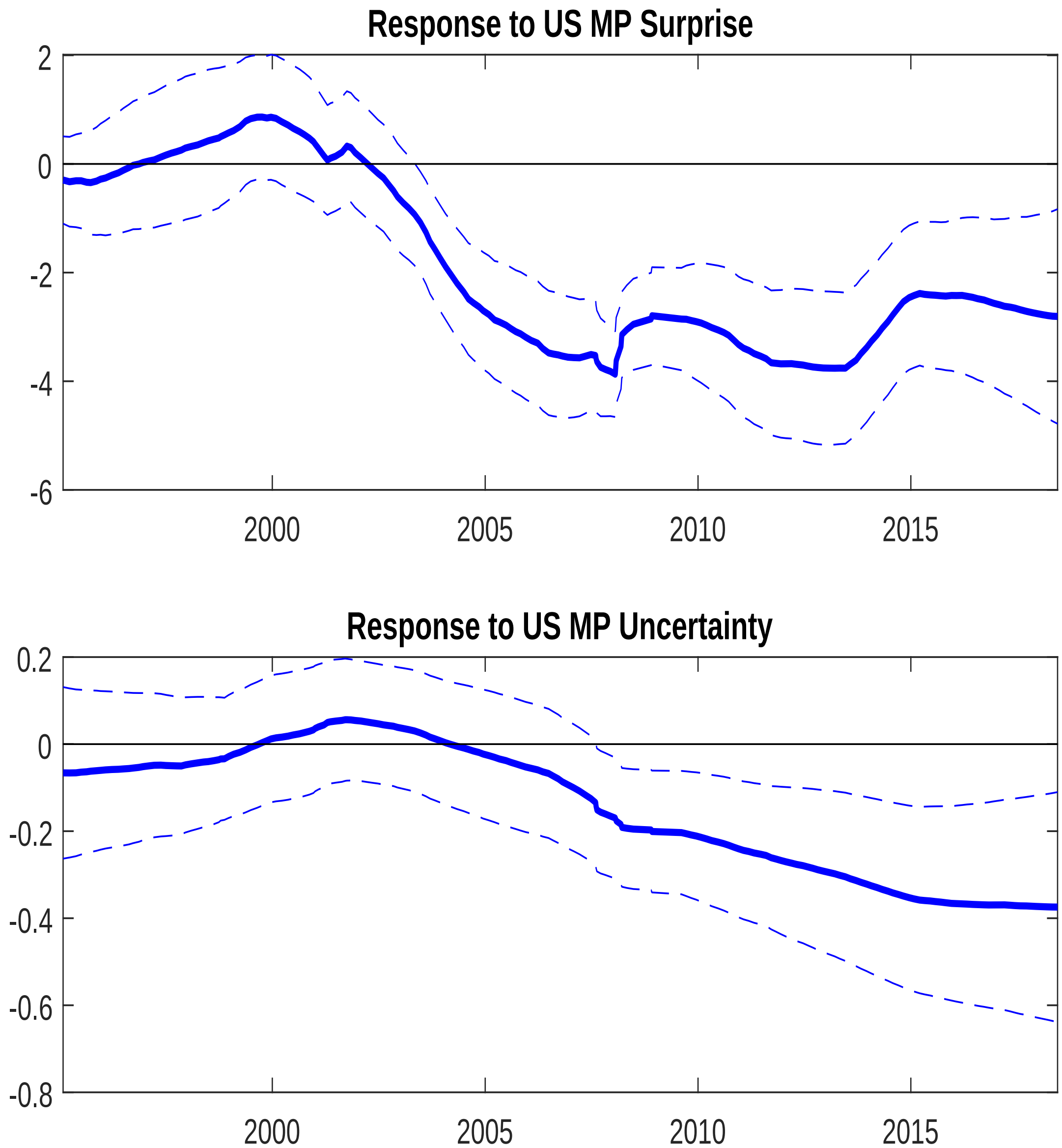
	Incl. Financial Crisis		Excl. Unscheduled Meetings		Alt. Futures Data (1 year)	
	2/00 - 6/08	7/09 - 6/18	2/00 - 6/08	7/09 - 6/18	2/00 - 6/08	7/09 - 6/18
U.S. MP Surprise	-2.075	-2.119	-1.314	-3.185	-2.353	-3.969
	[-1.97]	[-2.37]	[-1.74]	[-2.76]	[-3.13]	[-2.71]
U.S. MP Uncertainty	-0.311	-0.239	0.013	-0.265	-0.042	-0.287
	[-0.75]	[-2.18]	[0.10]	[-2.37]	[-0.27]	[-2.84]
Constant	0.616	0.211	0.521	0.167	0.714	0.287
	[3.23]	[1.51]	[3.53]	[1.33]	[4.80]	[2.14]
Observations	82	76	68	72	77	72
R-squared	0.13	0.11	0.05	0.16	0.19	0.17

NSE 500

	Incl. Financial Crisis		Excl. Unscheduled Meetings		Alt. Futures Data (1 year)	
	2/00 - 6/08	7/09 - 6/18	2/00 - 6/08	7/09 - 6/18	2/00 - 6/08	7/09 - 6/18
U.S. MP Surprise	-2.083	-2.013	-1.515	-3.016	-2.372	-3.846
	[-1.99]	[-2.40]	[-2.19]	[-2.72]	[-3.06]	[-2.76]
U.S. MP Uncertainty	-0.254	-0.268	0.071	-0.292	0.031	-0.302
	[-0.61]	[-2.51]	[0.60]	[-2.62]	[0.26]	[-3.02]
Constant	0.521	0.215	0.465	0.173	0.635	0.290
	[2.79]	[1.64]	[3.28]	[1.44]	[4.41]	[2.27]
Observations	82	76	68	72	77	72
R-squared	0.13	0.12	0.08	0.17	0.21	0.18

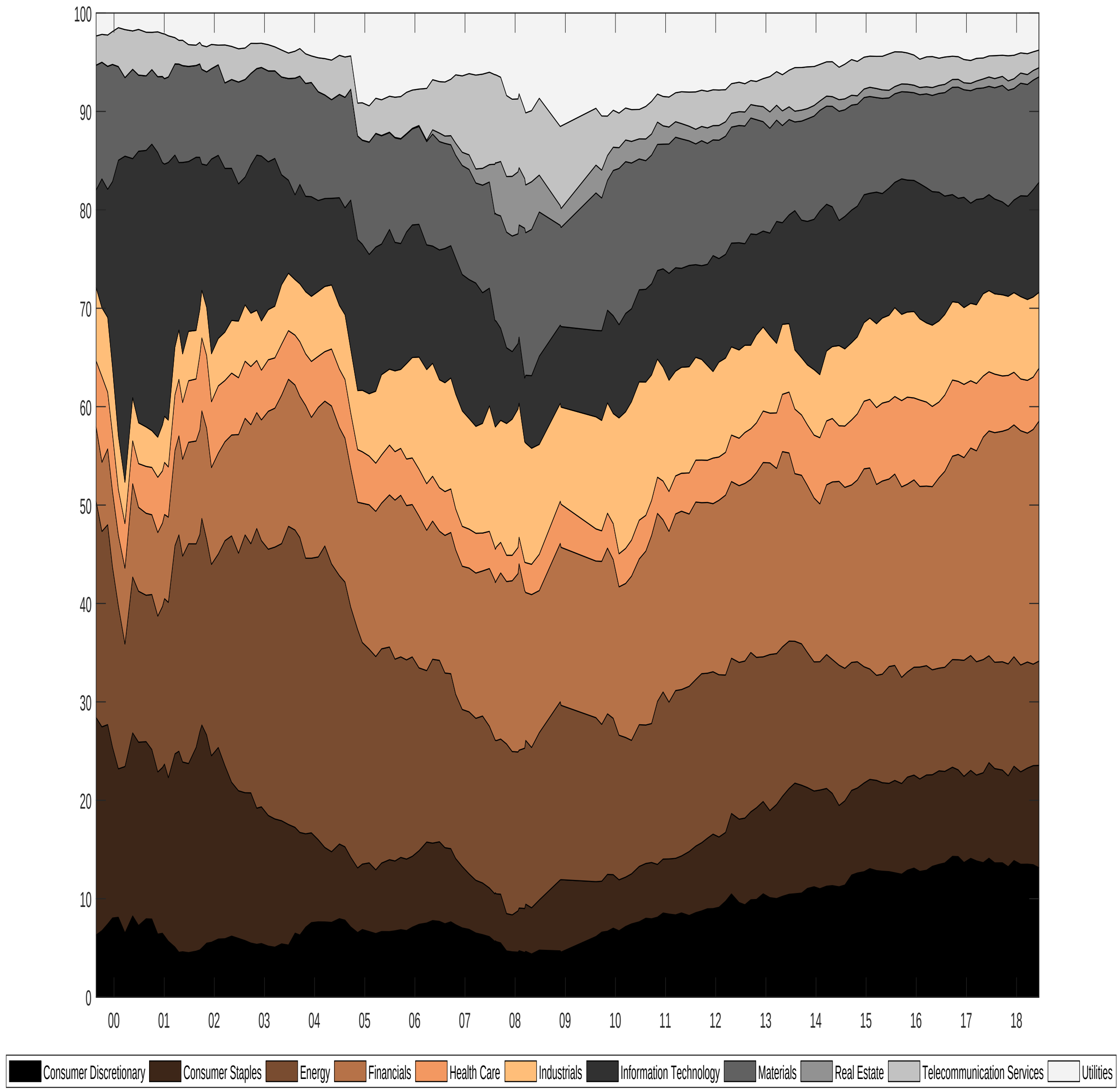
Regressions of Indian stock returns on US MP surprise and US MP uncertainty measures for different samples. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Figure A.1: Time-varying response of Indian stock returns to US monetary shocks



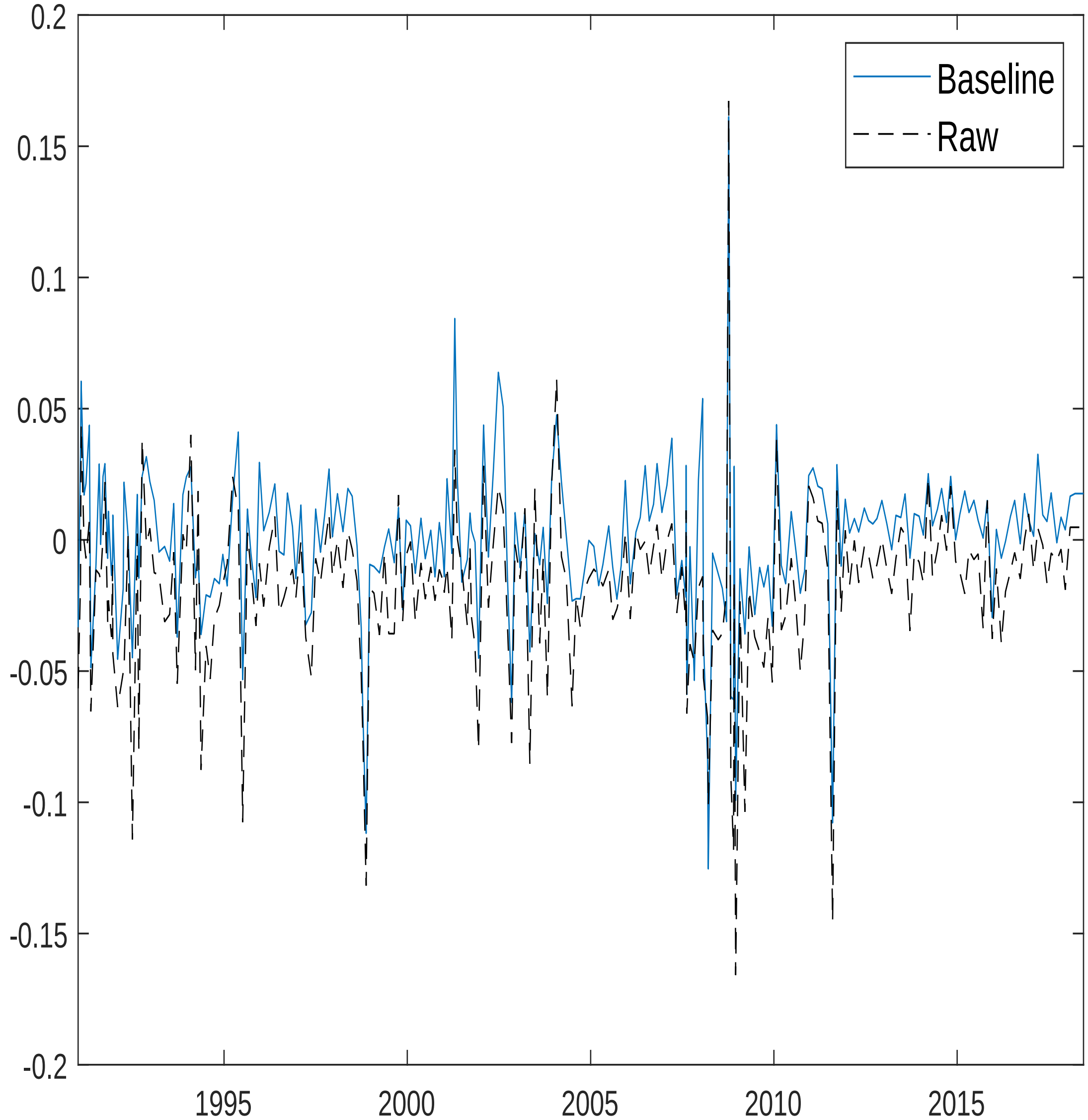
Smoothed estimates of the response of the NSE 500 index to US MP surprise and US MP uncertainty shocks from the time-varying parameter estimation, detailed in section 3.2. The dashed blue lines show the one standard deviation confidence bands.

Figure A.2: Share of Market capitalization by sector over time



This figure shows the time trend in the share of market capitalization of firms in the NSE 500 grouped by sectors according to the Global Industry Classification Standard (GICS).

Figure A.3: U.S. MP Uncertainty



This figure plots the two MP uncertainty measure constructed from Eurodollar futures and options data around FOMC announcements from 1991 to 2018. The solid line shows the baseline measure used in the regression analysis and the dashed line shows the raw measure. See sections 2.1.1 and 2.1.2 for details.

Table A.2: Regressions of Indian stock returns on US 10 year Treasury yield

	Nifty 50		NSE 500	
	2/00 to 6/08	7/09 - 6/18	2/00 to 6/08	7/09 - 6/18
US 10 year yield	-0.834	-0.772	-0.991	-0.694
	[-1.13]	[-1.23]	[-1.37]	[-1.14]
Constant	0.691	0.128	0.609	0.136
	[4.35]	[0.96]	[3.92]	[1.05]
Observations	77	72	77	72
R-squared	0.02	0.03	0.04	0.03

Regressions of Indian stock returns on US MP surprise and US MP uncertainty measures for different samples. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table A.3: Regressions of Indian stock returns on US monetary policy shocks, controlling for various variables

	Nifty 50						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
U.S. MP Surprise	-2.899	-3.118	-2.845	-2.895	-2.864	-2.864	-2.911
	[-2.75]	[-2.87]	[-2.82]	[-2.73]	[-2.69]	[-2.69]	[-2.87]
U.S. MP Uncertainty	-0.265	-0.291	-0.258	-0.264	-0.261	-0.261	-0.308
	[-2.35]	[-2.39]	[-2.19]	[-2.28]	[-2.26]	[-2.26]	[-2.40]
VIX		-0.102					-0.137
		[-0.85]					[-0.96]
Inflation			-0.002				0.003
			[-0.02]				[0.01]
Inf Target Dummy				-0.032			-0.090
				[-0.14]			[-0.55]
Current Account					0.013		-0.269
					[0.10]		[-0.62]
Turnover						0.097	0.269
						[0.70]	[1.30]
Constant	0.215	0.219	0.215	0.226	0.224	0.214	0.339
	[1.66]	[1.71]	[1.67]	[1.24]	[1.67]	[1.66]	[1.58]
R-squared	0.16	0.17	0.16	0.16	0.16	0.17	0.19

Regressions of Indian stock returns on US MP surprise and US MP uncertainty measures for different samples, controlling for level of VIX, CPI inflation, a dummy for inflation targeting period starting form May 2015, ratio of current account to GDP and turnover of Nifty 50. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table A.4: Regressions of Indian stock returns on US monetary policy shocks, interacting with various variables

	Nifty 50					
	(1)	(2)	(3)	(4)	(5)	(6)
U.S. MP Surprise	-2.899	-3.142	-3.576	-3.252	-4.302	-4.975
	[-2.75]	[-2.68]	[-2.86]	[-1.79]	[-2.51]	[-3.24]
U.S. MP Uncertainty	-0.265	-0.298	-0.191	-0.236	-0.118	-0.159
	[-2.35]	[-2.14]	[-1.42]	[-1.37]	[-0.86]	[-0.96]
VIX x MP Surprise		0.194				
		[0.12]				
VIX x MP Uncertainty		0.037				
		[0.23]				
Inf x MP Surprise			-1.517			
			[-1.23]			
Inf x MP Uncertainty			0.132			
			[0.90]			
IT x MP Surprise				0.922		
				[0.44]		
IT x MP Uncertainty				-0.009		
				[-0.03]		
CA x MP Surprise					2.674	
					[1.57]	
CA x MP Uncertainty					-0.143	
					[-0.81]	
Turnover x MP Surprise						0.313
						[0.18]
Turnover x MP Uncertainty						-0.068
						[-0.48]
Constant	0.215	0.164	0.235	0.237	0.278	0.232
	[1.66]	[1.08]	[1.77]	[1.24]	[1.95]	[1.64]
R-squared	0.16	0.23	0.20	0.16	0.20	0.17

Regressions of Indian stock returns on US MP surprise and US MP uncertainty measures for different samples, controlling for level and interaction of VIX, CPI inflation, a dummy for inflation targeting period starting form May 2015, ratio of current account to GDP and turnover of Nifty 50. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table A.5: Regressions of Indian stock returns on US monetary policy shocks, controlling for 3 month OIS and foreign exchange reserves

	2/2000 - 6/2008		7/2009 - 6/2018	
U.S. MP Surprise	-2.010	-1.938	-2.899	-2.064
	[-2.61]	[-2.72]	[-2.75]	[-2.24]
U.S. MP Uncertainty	-0.015	0.019	-0.265	-0.330
	[-0.10]	[0.12]	[-2.35]	[-2.95]
OIS 3 month		-0.153		-3.063
		[-0.14]		[-0.69]
FX Reserves		0.000		0.000
		[1.02]		[1.56]
Constant	0.721	0.617	0.215	0.100
	[4.65]	[3.69]	[1.66]	[0.76]
Observations	77	75	72	71
R-squared	0.14	0.16	0.16	0.20

Regressions of Nifty 50 stock returns on US MP surprise and US MP uncertainty measures for different samples, controlling for the change in the 3 month OIS rate and the change in the weekly foreign exchange reserves. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table A.6: Regressions of Indian stock returns on US monetary policy shocks, controlling for term premium of 10 year Indian government bond

	2/2000 to 6/2008		7/2009 to 6/2018	
U.S. MP Surprise	-2.010	-2.015	-2.899	-2.932
	[-2.61]	[-2.60]	[-2.75]	[-2.78]
U.S. MP Uncertainty	-0.015	-0.046	-0.265	-0.261
	[-0.10]	[-0.29]	[-2.35]	[-2.27]
10y Term Premium (India)		-1.789		-1.735
		[-2.29]		[-0.51]
Constant	0.721	0.688	0.215	0.217
	[4.65]	[4.45]	[1.66]	[1.70]
Observations	77	77	72	72
R-squared	0.14	0.17	0.16	0.17

Regressions of Nifty 50 stock returns on US MP surprise and US MP uncertainty measures for different samples, controlling for the term premium on the 10 year Indian government bond, estimated using the methodology of Joslin, Singleton, and Zhu (2011). The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. t-statistics based on robust standard errors are reported in parentheses.

Table A.7: Regressions of Indian stock returns on US monetary policy shocks, accounting for information effects

2/2000 to 12/2011

Baseline specification		Controlling for information effects	
U.S. MP Surprise	-2.408	U.S. MP Surprise	-2.665
	[-2.94]		[-3.24]
U.S. MP Uncertainty	-0.020	U.S. MP Uncertainty	-0.012
	[-0.14]		[-0.08]
Constant	0.558	Constant	0.543
	[3.96]		[3.94]
Observations	90	Observations	90
R-squared	0.16	R-squared	0.18

Regressions of Nifty 50 return on US MP surprise and US MP uncertainty measures. The MP surprise is normalized to reflect a 25 basis point increase in the expected 1 year ahead federal funds rate, while the MP uncertainty measure is normalized to have unit standard deviation. The second column cleans out information effects following the procedure in Lakdawala and Schaffer (2019). t-statistics based on robust standard errors are reported in parentheses. FOMC meetings in the financial crisis from July 2008 through June 2009 are excluded.