The growing impact of US monetary policy on emerging financial markets: Evidence from India

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Motivation: Spillover Effect of US Monetary Policy

Increasing financial integration of emerging market countries into the global economy.

India:

- Considered especially vulnerable to international financial flows ("fragile five")

United States:

- "Center" country of international monetary system
- Federal Reserve policy related to global financial cycle

Existing Work

Large literature on spillover effects of US monetary policy: Focus has mostly been on

- unconventional monetary policy since the crisis
- shocks to level of interest rate (first moment shocks)

Recent evidence on importance of second moment shocks

- Rey (2015)
- Bruno & Shin (2015)
- Bhattari, Chatterjee & Park (2018)

Contribution of This Paper

Estimate US monetary spillover effects on Indian equity markets

- Use an event-study approach with high-frequency data
- Use data going back to early 1990s combined with a time-varying parameter approach
- Study effect of both first moment (MP Surprise) and second moment (MP Uncertainty) shocks
- Shed light on transmission mechanism using other high-frequency financial variables and firm-level stock prices

Preview of the Results

Effect of US MP shocks increasing over time

- MP Surprise shocks significant since early 2000s
- MP Uncertainty shocks significant since financial crisis

Announcements about Large Scale Asset Purchases (QE)

- Work largely through MP Uncertainty shocks

Mechanism:

- No industry level variation in stock price response to US monetary shocks
- Exchange rate and portfolio decisions of FII have become more sensitive to MP Surprise shocks

Event-study Approach: FOMC Announcement Days

Measured in daily window around FOMC annoucement days

- ΔS_t: Nifty 50 stock return
- mps_t : US MP Surprise
- mpu_t: US MP Uncertainty

$$\Delta S_t = \alpha + \beta mps_t + \gamma mpu_t + \varepsilon_t$$

Identifying assumption:

- In the FOMC window, no systematic economic factors driving Indian financial markets (other than FOMC announcement)

US MP Surprise (first-moment shock)

Estimate surprise from changes in futures rates (Kuttner 2001)

- X_t: changes in futures rates around FOMC announcement (we use Eurodollar futures 1-8 quarters ahead)
- Like Nakamura and Steinsson (2018) we use the first principal component of X_t as MP Surprise
- First PC explains around 85% of total variation of X_t
- Scaled to have a 25 basis point increase in 1 year ahead rate

$\Rightarrow$ Captures changes in expected policy rate path

▸▸ Graph

US MP Uncertainty (second-moment shock)

Following the approach of Bauer, Lakdawala & Mueller (2018)

- Can use Eurodollar options to construct risk-neutral conditional distribution of the expected future short rate
- Construct change in the standard-deviation of this distribution around FOMC announcements (based on expected rates at 1 year horizon)
- Cleansed of "level effect", i.e. regress on MP Surprise and use residual as measure of MP Uncertainty ⏩ Level Effect
- Scaled to have unit standard deviation

$\Rightarrow$ Captures changes in uncertainty about expected policy rate path

⏩ MP Uncertainty Calculation Details ⏩ Graph

Indian Financial Market Data

Aggregate Stock Index: Nifty 50

- 1991 to 2018

Firm-level stock prices: 500 firms in NSE 500

- 1995 to 2018

Stock returns calculated as daily change on day after FOMC meeting relative to day of FOMC meeting

Other financial market data:

- USD/INR Exchange Rate (1991 to 2018)
- 10 year Government bond yield (1999 to 2018)
- Net equity inflows of Foreign Institutional Investors (FIIs) (1999 to 2018)

Summary Statistics

	Jan 1991 to Jun 2018			
	FOMC Days		Non-FOMC Days	
	Mean	Std Dev	Mean	Std Dev
Nifty 50	0.33	1.69	0.03	1.69

	Jan 1991 to Jan 2000			
	FOMC Days		Non-FOMC Days	
	Mean	Std Dev	Mean	Std Dev
Nifty 50	0.20	1.83	0.03	2.04

	Feb 2000 to Jun 2018			
	FOMC Days		Non-FOMC Days	
	Mean	Std Dev	Mean	Std Dev
Nifty 50	0.39	1.61	0.03	1.48

⏩ Detailed Summary Statistics

Baseline Results

	Nifty 50
	1991 - 2018
U.S. MP Surprise	-0.870
	[-1.39]
U.S. MP Uncertainty	0.015
	[0.12]
Constant	0.347
	[3.47]
Observations	234
R-squared	0.02

(t-statistics based on robust standard errors in parentheses)

Baseline Results

	Nifty 50	
	1991 - 2000	2000 - 2018
U.S. MP Surprise	0.525	-2.239
	[0.60]	[-3.28]
U.S. MP Uncertainty	0.183	-0.159
	[0.80]	[-1.49]
Constant	0.208	0.468
	[1.07]	[4.40]
Observations	85	149
R-squared	0.02	0.14

(t-statistics based on robust standard errors in parentheses)

Baseline Results

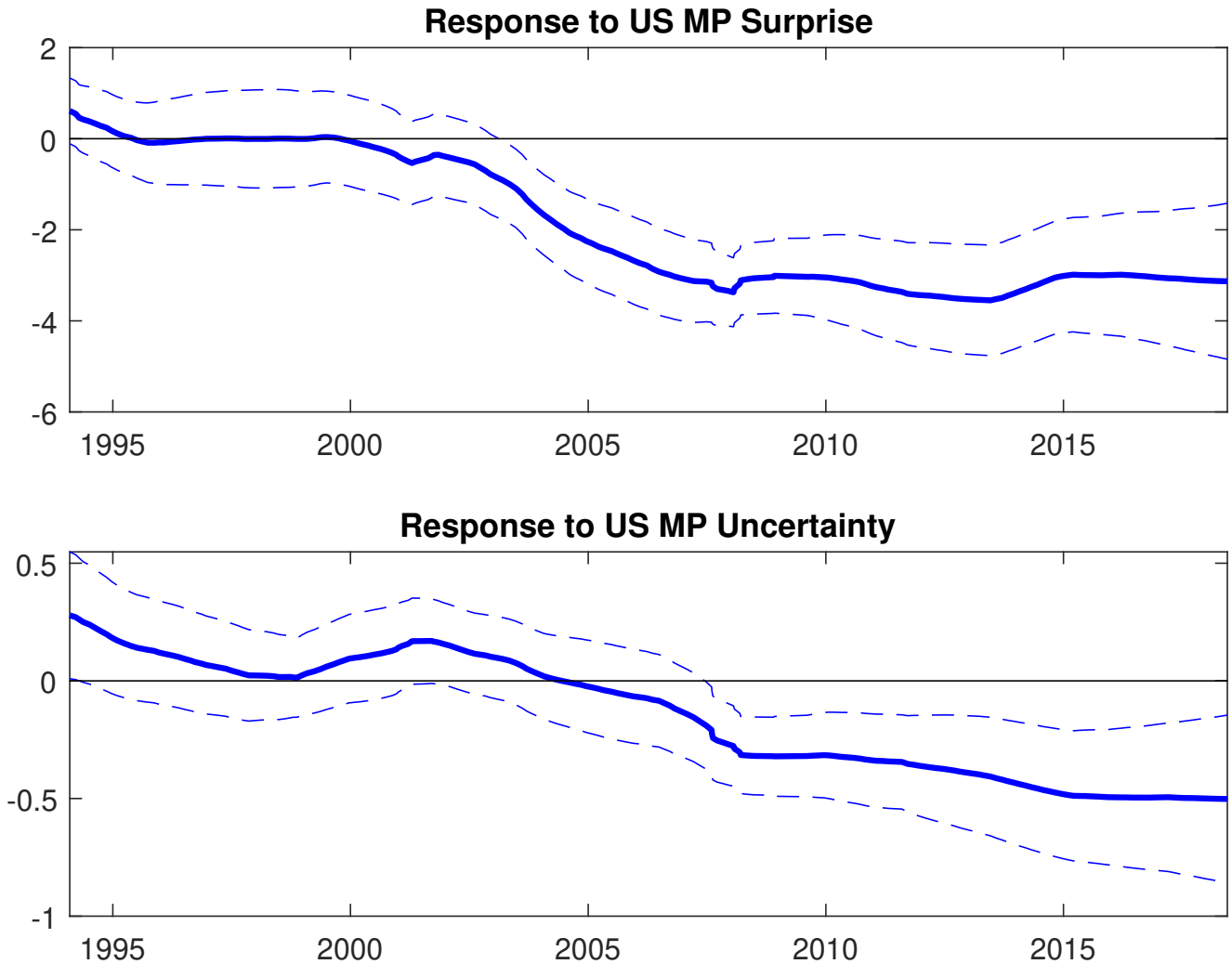
	Nifty 50	
	2000 to 2008	2009 - 2018
U.S. MP Surprise	-2.010	-2.899
	[-2.61]	[-2.75]
U.S. MP Uncertainty	-0.015	-0.265
	[-0.10]	[-2.35]
Constant	0.721	0.215
	[4.65]	[1.66]
Observations	77	72
R-squared	0.14	0.16

(t-statistics based on robust standard errors in parentheses)

⏩ Robustness Checks

Time-Varying Responses of Nifty 50

Kalman Filter Estimates



⏩ Details of Time-Varying Parameter Specification

QE Announcement Days

FOMC Meeting	Program	Nifty 50	MP Surprise	Raw MP Uncertainty
11/25/2008	QE1	3.57	-0.16	-0.12
12/1/2008	QE1	-0.94	-0.10	-0.02
12/16/2008	QE1	-2.96	-0.19	-0.17
1/28/2009	QE1	-0.90	0.02	-0.02
3/18/2009	QE1	0.44	-0.20	-0.10
8/12/2009	QE1	3.20	-0.06	-0.04
9/23/2009	QE1	0.33	-0.05	-0.05
11/4/2009	QE1	1.15	-0.01	-0.03
8/10/2010	QE1	-0.74	-0.01	-0.03
9/21/2010	QE2	-0.30	-0.05	-0.05
11/3/2010	QE2	1.93	0.00	-0.03
6/22/2011	QE2	0.78	0.00	-0.01
9/21/2011	MEP	-4.26	0.03	0.02
6/20/2012	MEP	0.86	0.01	0.00
9/13/2012	QE3	2.55	-0.01	-0.01
12/12/2012	QE3	-0.62	0.01	0.00
6/19/2013	Taper	-2.94	0.06	0.00

Transmission of QE Announcements

	2000 - 2018
	Nifty 50
US MP Surprise	-2.97
	[-3.75]
US MP Uncertainty	-0.42
	[-2.02]
QE Dummy	-0.59
	[-1.19]
MP Surprise x QE Dummy	3.43
	[2.05]
MP Uncertainty x QE Dummy	-1.05
	[-2.03]
Constant	0.54
	[4.41]
Observations	157
R-squared	0.24

(t-statistics based on robust standard errors in parentheses)

Understanding the Transmission Mechanism

Various channels of international monetary spillover

- Financial Flows, Trade, Exchange Rate
- Portfolio Balance, Information, Uncertainty

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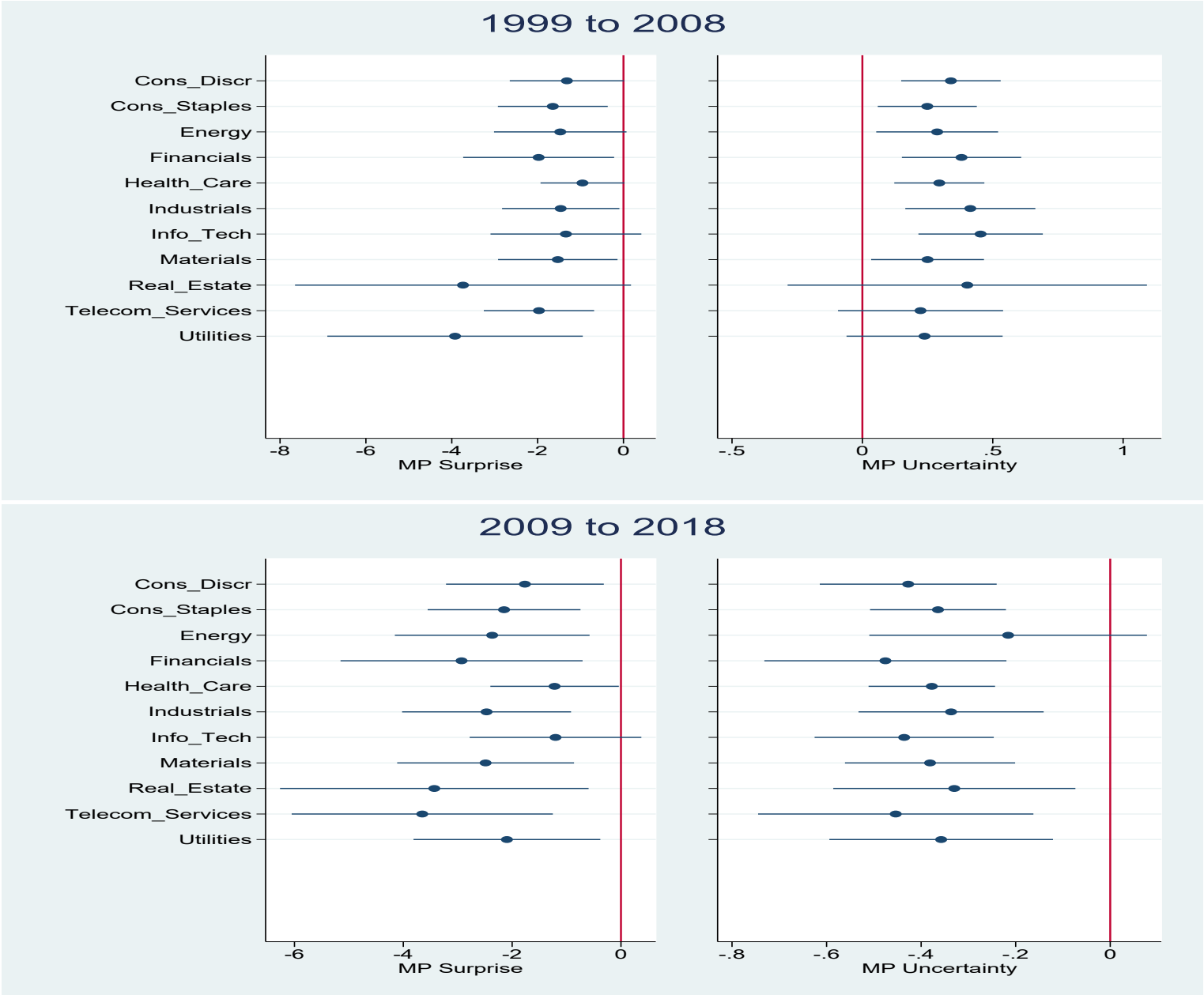
Approach with high-frequency data

1. Use industry-level stock prices
   - Investigate if certain sectors have become more/less responsive
2. Use other financial market data to understand transmission
   - USD/INR Exchange rate
   - Indian Government Bond Yields (10 year)
   - Net equity flows of Foreign Institutional Investors (FIIs)

Industry-Level Regressions



Role of Exchange Rate, FII flows and Bond yields

Baseline Result: US MP shocks $\Rightarrow$ Indian Stock prices

- Does this effect work through the financial variables?

Two part approach:

1. Establish that US MP shocks drive these financial variables
2. Extended regressions: Control for these financial variables in baseline specification

Compare coefficients from extended regressions to baseline

Role of Exchange Rate, FII flows and Bond yields

Correlation with Stock Market Return

	1999 to 2008			
	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

Role of Exchange Rate, FII flows and Bond yields

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	2009 to 2018			
	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

⏩ Detailed Correlation and Summary Statistics

US MP Surprise shocks drive Financial Variables

	INR/USD		10 year bond		Net FII	
	1999 - 2008	2009 - 2018	1999 - 2008	2009 - 2018	1999 - 2008	2009 - 2018
U.S. MP Surprise	0.059	1.356	0.083	0.145	1.468	-6.362
	[0.96]	[4.03]	[3.49]	[3.49]	[1.41]	[-3.49]
U.S. MP Uncertainty	0.026	-0.011	0.009	-0.001	0.069	-0.249
	[1.35]	[-0.25]	[1.30]	[-0.33]	[0.43]	[-0.67]
Constant	-0.019	-0.044	-0.015	-0.008	0.188	1.122
	[-1.52]	[-0.99]	[-1.69]	[-1.59]	[0.79]	[3.72]
Observations	81	72	81	72	81	72
R-squared	0.07	0.21	0.08	0.16	0.03	0.11

Role of Exchange Rate, FII flows and Bond yields

	Nifty 50			
	1999 - 2008		2009 - 2018	
U.S. MP Surprise	-1.880	-1.478	-2.899	0.238
	[-2.47]	[-2.07]	[-2.75]	[0.29]
U.S. MP Uncertainty	0.034	0.122	-0.265	-0.260
	[0.22]	[0.81]	[-2.35]	[-4.18]
INR/USD Exchange Rate		-2.102		-1.968
		[-1.41]		[-6.43]
10 year bond		-4.380		1.329
		[-2.91]		[0.65]
Net FII flows		0.059		0.104
		[0.79]		[3.81]
Constant	0.745	0.627	0.215	0.022
	[4.72]	[3.91]	[1.66]	[0.22]
Observations	81	81	72	72
R-squared	0.12	0.20	0.16	0.61

⏩ One at a time results

Conclusion

Effect of US MP shocks on Indian equity markets:

US MP Surprise Shocks:

- Important since early 2000s
- Increasing effects driven through exchange rate and FII portfolio flows

US MP Uncertainty Shocks:

- Important since the financial crisis
- Capture important component of QE transmission to Indian markets

Conclusion

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- Increasing effects driven through exchange rate and FII portfolio flows

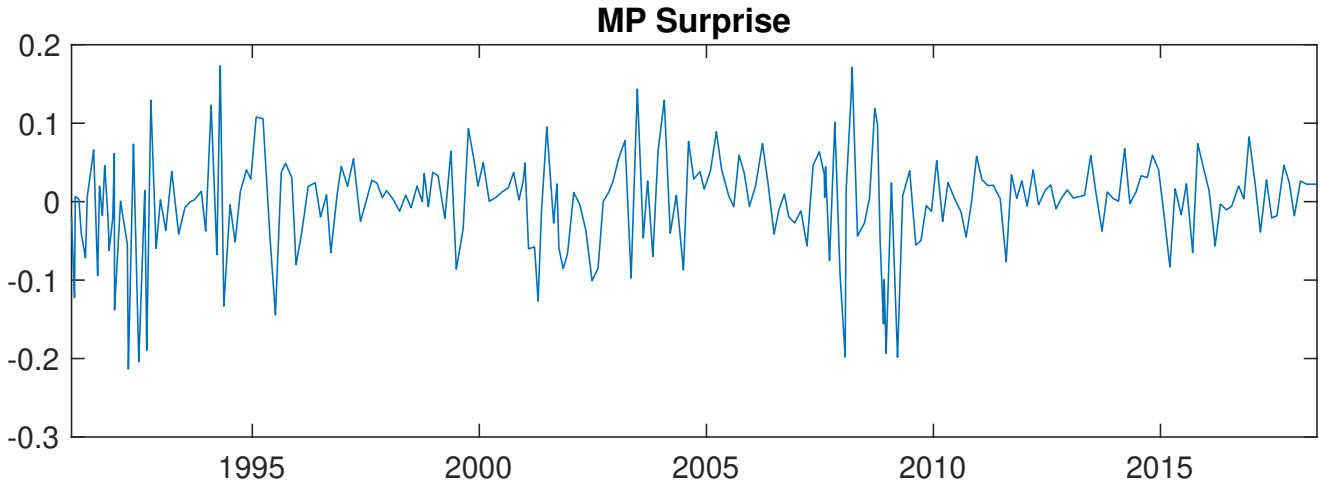
US MP Uncertainty Shocks:

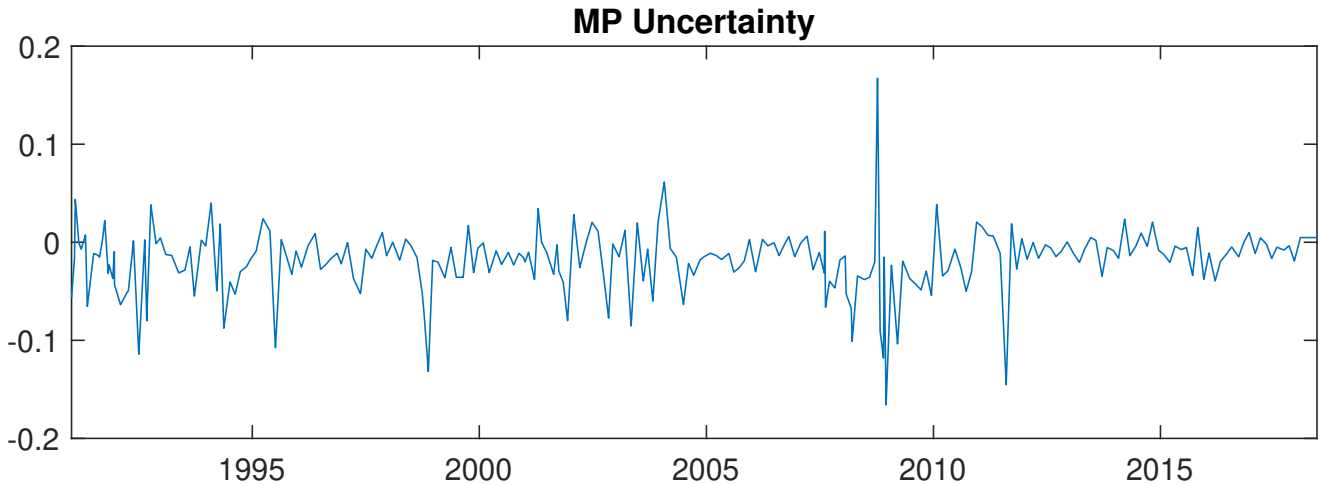
- Important since the financial crisis
- Capture important component of QE transmission to Indian markets

Future Work:

- Extend analysis to macroeconomic variables
- Use more detailed firm-level data to identify relevant characteristics

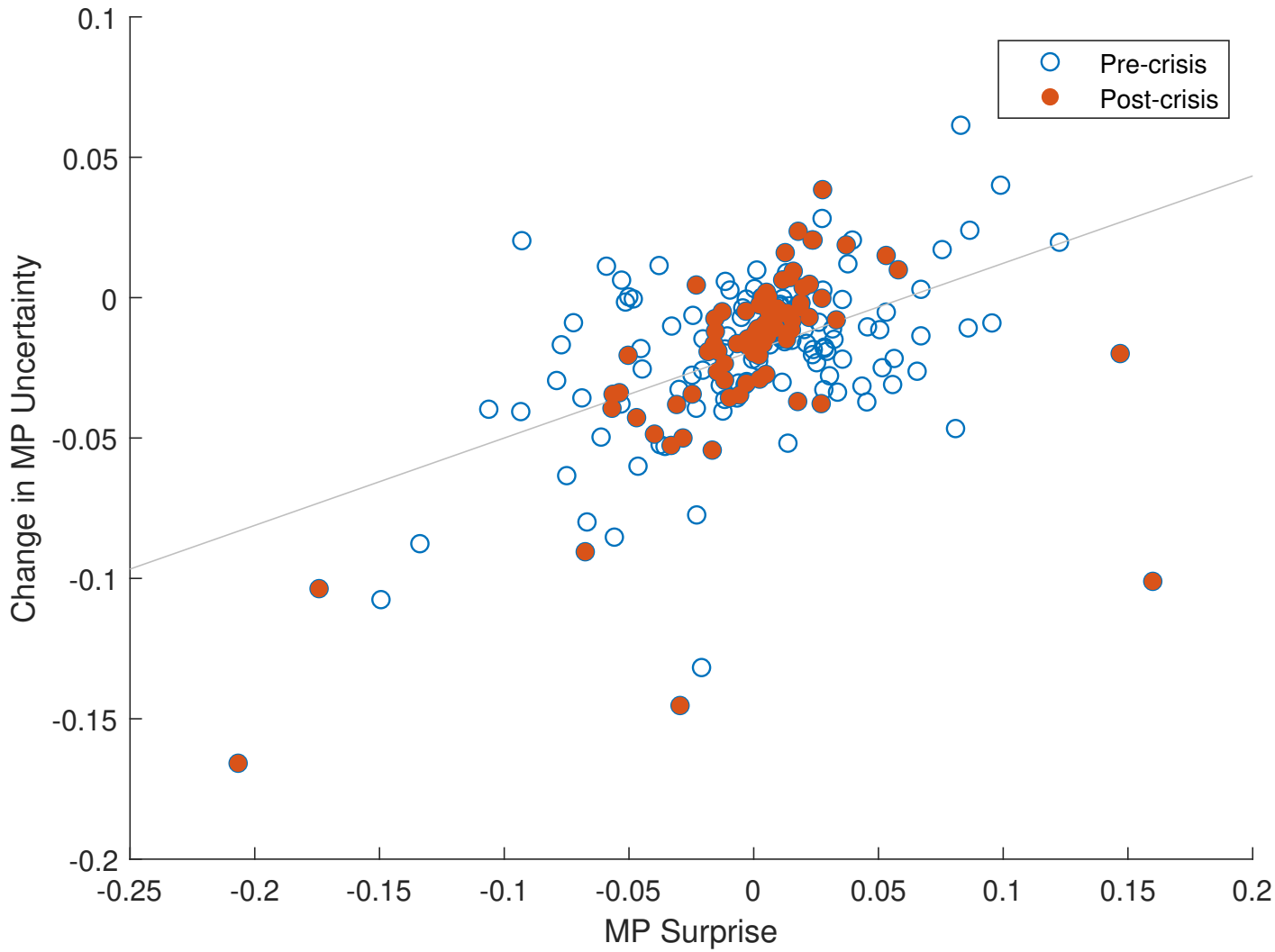
US MP Shocks





◂ MP Surprise ◂ MP Uncertainty

Correlation between MP Surprise and MP Uncertainty



How we estimate *MPU*

- Eurodollar futures
  - Most-traded interest rate derivative in the world
  - Underlying is three-month LIBOR, L_t
  - Quarterly expirations out to $>$ 4 years
- Options on Eurodollar futures
  - Essentially options on future LIBOR
  - Many puts and calls for each trading date and expiration
  - Sufficiently long history: our sample starts in 1994
- Calculate **risk-neutral conditional volatility** of future short rates based on Eurodollar option prices...

How we estimate *MPU*

Risk-neutral conditional volatility of future short rates:

1. Interpolate prices of options with **fixed horizon** τ, for example one year (like Wright, 2017)
2. Calculate **model-free implied volatility** σ_τ from the prices of puts and calls
   - No assumption of (log-)normality
   - Britten-Jones and Neuberger (2000), Jiang and Tian (2005)
   - Similar to VIX, but here underlying is interest rate
3. Conditional volatility of future short rate is

$$MPU_{t,\tau} = F_t \sigma_\tau \sqrt{\tau}$$

(because implied volatility is for annualized asset return)

Caveats

LIBOR $\neq$ federal funds rate

- LIBOR-OIS spread typically small and stable, so $Var_t(FFR_{t+\tau}) \approx Var_t(LIBOR_{t+\tau})$
- But spread shot up during the crisis, and somewhat elevated (though stable) more recently
- Solution: subsamples (and handwaving)

Risk-neutral $\neq$ real-world distribution

- Option-implied distributions contain risk adjustment
- We measure: amount of volatility $\times$ price of volatility
- Keep in mind when interpreting results

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		

	Nifty 50					
	Incl. Financial Crisis		Excl. Unscheduled Meetings		Alt. Futures Data (1 year)	
	2000 to 2008	2009 - 2018	2000 to 2008	2009 - 2018	2000 to 2008	2009 - 2018
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

Time-Varying Parameter Specification

$$
\begin{aligned}
\Delta S_t &= \alpha + \beta_t mps_t + \gamma_t mpu_t + u_t \\
\beta_t &= \beta_{t-1} + \varepsilon_{\beta,t} \\
\gamma_t &= \gamma_{t-1} + \varepsilon_{\gamma,t} \\
u_t &\sim N(0, R) \\
\varepsilon_{\beta,t} &\sim N(0, Q_\beta) \\
\varepsilon_{\gamma,t} &\sim N(0, Q_\gamma)
\end{aligned}
$$

- Use Kalman Filter to evaluate likelihood
- MLE estimation of parameters

Summary Statistics

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 Dec 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

Correlation with Stock Market Return

	1999 to 2008			
	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
Corr(USD/INR,10yr)	-0.057	0.61	0.029	0.17
Corr(USD/INR,FII)	-0.137	0.22	-0.230	0.00
Corr(10yr,FII)	0.167	0.14	0.042	0.05

	2009 to 2018			
	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(USD/INR,10yr)	0.533	0.00	0.104	0.00
Corr(USD/INR,FII)	-0.370	0.00	-0.195	0.00
Corr(10yr,FII)	-0.189	0.11	0.024	0.27

	Nifty 50			
	1999 - 2008			
U.S. Monetary Shock	-1.880	-1.767	-1.562	-1.965
	[-2.47]	[-2.23]	[-2.21]	[-2.61]
U.S. MP Uncertainty	0.034	0.083	0.066	0.030
	[0.22]	[0.57]	[0.42]	[0.19]
INR/USD Exchange Rate		-1.911		
		[-1.16]		
10 year bond			-3.828	
			[-2.59]	
Net FII flows				0.058
				[0.78]
Constant	0.745	0.708	0.687	0.734
	[4.72]	[4.35]	[4.43]	[4.56]
Observations	81	81	81	81
R-squared	0.12	0.14	0.16	0.12

	Nifty 50			
	2009 - 2018			
U.S. Monetary Shock	-2.899	-0.061	-2.067	-1.772
	[-2.75]	[-0.08]	[-1.89]	[-1.99]
U.S. MP Uncertainty	-0.265	-0.289	-0.274	-0.221
	[-2.35]	[-5.01]	[-2.52]	[-2.47]
INR/USD Exchange Rate		-2.093		
		[-7.78]		
10 year bond			-5.723	
			[-1.72]	
Net FII flows				0.177
				[3.30]
Constant	0.215	0.122	0.167	0.016
	[1.66]	[1.22]	[1.34]	[0.12]
Observations	72	72	72	72
R-squared	0.16	0.56	0.21	0.31