Hitotsubashi Journal of Economics 63 (2022), pp.104-125. © Hitotsubashi University
https://doi.org/10.15057/hje.2022006

FINANCIAL CRISIS AND THE GLOBAL TRANSMISSION OF U.S. MONETARY POLICY SURPRISES

KYOUNG-GON KIM*

Center for Defense Resource Management,
Korea Institute for Defense Analyses,
37 Hoegi-ro, Seoul 02445, South Korea.
Kyounggon.Kim@colorado.edu

Received March 2022; Accepted September 2022

Abstract

I identify how the Fed's dependence on unconventional monetary policy after the 2007-2008 financial crisis and its return to conventional policy in 2015 have affected the global influence of U.S. monetary policy. I divide the sample into three phases according to the Fed's monetary policy regimes: pre-crisis (Aug 2001-Nov 2008), crisis (Nov 2008-Dec 2015), and post-crisis (Dec 2015-Sep 2017). Daily variations in government bond yields and foreign exchange spot rates for 46 countries on FOMC meeting days show that the influence of U.S. monetary policy surprises intensified after the financial crisis. Responses are stronger in a group of emerging markets than in developed economies. I also find that more flexible exchange rate regimes lead to larger magnitudes of responses to U.S. monetary policy surprises. My results show that the decoupling of interest rates between the U.S. and other countries forced foreign financial markets to respond sensitively to U.S. monetary policy surprises after the financial crisis.

Keywords: financial crisis, monetary policy, interest rates, exchange rate
JEL Classification Codes: E43, E52, F31

I. *Introduction*

The COVID-19 pandemic forced the Federal Reserve (Fed) to cut the Fed Funds rate to zero and launch a new round of quantitative easing (QE). The Fed announced that it would keep its benchmark rate near zero through 2022 to help the economy recover from COVID-19 on June 10, 2020. The zero lower bound (ZLB) and QE remind us of the 2007-2008 financial

* This paper is a revised version of a part of my University of Colorado Ph.D. dissertation. I thank Martin Boileau, Miles Kimball, Alessandro Peri, Katie Moon, the Co-Editor of the journal, an anonymous referee, and seminar participants at California State University Los Angeles, University of Manitoba, and St. Lawrence University for the comments and useful discussions. Funding for this project was provided by the McGuire Center for International Studies.

crisis. Facing the second round of ZLB and QE, global financial markets have paid attention to the progress of the Fed's unconventional monetary policy whenever the Federal Open Market Committee (FOMC) meets. And the Fed finally raised the Fed Funds rate by 0.25 percent point on March 16, 2022 and signaled rate rises coming at each of the remaining six meetings in 2022. Regarding the resumption of the monetary tightening in post-COVID era, what lessons can we learn from the last crisis?

In this paper, I investigate whether the 2007-2008 U.S. financial crisis changed the influence of the Fed's surprising decisions on foreign financial markets. Specifically, I focus on how the Fed's dependence on unconventional monetary policy after the financial crisis and its return to conventional policy in 2015 affected the global influence of U.S. monetary policy surprises. Using daily variations in government bond yields and foreign exchange spot rates for 46 sample countries on FOMC meeting days, I find that the global influence of U.S. monetary policy surprises intensified after the financial crisis: The widening gap in interest rates between the U.S. and the rest of the world rendered foreign financial markets more sensitive to Fed decisions after the crisis.

The 2007-2008 financial crisis led to a global economic downturn and a European debt crisis. The Fed responded aggressively to the crisis by lowering the Fed Funds rate to a range between 0 and 0.25 percent, the lowest in its history. Also, the Fed adopted unconventional policies: forward guidance on future interest rates and QE with large-scale asset purchases (LSAP). The Fed eventually escaped the ZLB in December 2015 by raising the Fed Funds rate for the first time since 2006. As of November 2017, the Fed has raised the target range for the Fed Funds rate to between 1.00 and 1.25 percent. I design an empirical model that employs data covering all FOMC meetings from August 2001 to September 2017. I divide this sample into three phases according to Fed monetary policy regimes: pre-crisis, crisis, and post-crisis. I assume that unconventional monetary policies due to the financial crisis began when the Fed's plan for LSAP was announced (November 25, 2008) and ended when the Fed raised the Fed Funds rate again (December 16, 2015).[1]

I calculate U.S. monetary policy surprises by changes in the response of U.S. financial markets to the Fed's decision. To do so, I use high-frequency tick data for two types of futures, Fed Funds futures and 10-year Treasury futures, around the announcement of the Fed's decision (2: 15 pm ET). Fed Funds futures are financial contracts that reflect market views on the likelihood of Fed policy changes. These contracts have a payout based on the average effective Fed Funds rate that prevails over the calendar month specified in the contract. I define a *Fed Funds futures surprise* by the changes in the Fed Funds futures rate between 10 minutes before and 20 minutes after an FOMC announcement. Within this 30-minute window, the Fed Funds futures surprise measures the unanticipated component of the Fed's decision on the Fed Funds rate target (Kuttner(2001)). Ten-year Treasury futures are derivatives whose prices are closely tied to the prices of U.S. Ten-year government bonds and their yields. Ten-year Treasury bonds carry almost zero risk to the principal, and are thus considered to be an important measuring stick for market confidence about the future. I calculate a *Treasury futures surprise* by changes in the 10-year Treasury futures price within a 30-minute window around a FOMC

[1] Gilchrist et al. (2015) regard November 25, 2008, as the key date on which the Fed announced its plan for buying the debt obligations of government-sponsored enterprises (GSEs) and mortgage-backed securities (MBS) for the first time. In this study I follow their assumption that the unconventional monetary policy began on November 25, 2008.

announcement. The Treasury futures surprise captures the future path of expected interest rates contained in the Fed's announcement.

I measure the responses of foreign financial markets to U.S. monetary policy surprises by daily variations in government bond yields and foreign exchange spot rates in 46 countries on FOMC days. I examine how short-term (2-year), midterm (5-year), and long-term (10-year) sovereign bond yields respond to U.S. monetary shocks in pre-crisis, crisis, and post-crisis periods. My estimates indicate that the response of sovereign bond yields to U.S. monetary policy surprises differs not only across maturities, but also across periods. For an unanticipated increase in Fed Funds futures by 100 basis points, the yields on long-term sovereign bonds in the post-crisis period rise by an additional 168 basis points, relative to bond yields in the pre-crisis period. Likewise, an unexpected decrease in Fed Funds futures by 100 basis points leads to a decline in the yield on short-term sovereign bonds by 85 additional basis points in the crisis period compared to the pre-crisis period. Next, I investigate the relationship between foreign exchange spot rates and U.S. monetary policy surprises. My estimates show that a decline in the Fed Funds futures surprise of 100 basis points is associated with an appreciation in the local currencies of an additional 9 percent in the crisis period and an extra 25 percent in the post-crisis period compared to the pre-crisis period. I attribute this to the decoupling of interest rates between the U.S. and other countries. In the face of the financial crisis, the Fed cooperated with other central banks to prevent a deepening of the global credit crisis. However, when the Fed raised the Fed Funds rate in 2015, the policy coordination cracked; Europe and Japan kept their rates near zero. Central banks in emerging markets also didn't pursue premature monetary tightening. The widening interest rate gap between the U.S. and the rest of the world forced foreign financial markets to respond sensitively to the Fed's decision.

In an effort to identify whether emerging markets are more vulnerable to U.S. monetary policy shocks, I divide the sample of countries into two groups: developed economies and emerging markets. Overall estimates indicate that responses to U.S. monetary policy surprises are stronger in emerging markets than in developed economies. This finding is consistent with those reported by Chen et al. (2016). When taking into account exchange rate regimes (hard pegs, soft pegs, managed float, and free float), I find that free-floating arrangements lead to the larger responses to U.S. monetary policy surprises.

My findings are robust to an additional test. I isolate the component of changes in the 10-year Treasury futures price that is not related to the Fed Funds futures surprise. I define the *Residual surprise* as the error term from the regression of Treasury futures surprise on the Fed Funds futures surprise. The Residual surprise reflects the expected future path of interest contained in the FOMC announcement that is orthogonal to the movement in Fed Funds futures (Gürkaynak et al. (2005b); Wongswan (2009)). A bootstrapped two-step estimation method suggests that the responses of government bond yields and exchange rates to Fed Funds futures and Residual surprises become stronger after the financial crisis.

This paper contributes to the empirical literature that explores the global spillovers of U.S. monetary policy. The first contribution is showing that the unconventional monetary policy affected the influence of U.S. monetary policy surprises. The Fed's dependence on QE in the financial crisis led to a voluminous literature on how unconventional U.S. monetary policy affects global economies (Hartley and Rebucci (2020); Inoue and Rossi (2019); Claus et al. (2018); Gagnon et al. (2017); Banerjee et al. (2016); Chen et al. (2016); Lim and Mohapatra (2016); Meinusch and Tillmann (2016); Gilchrist et al. (2015); Bowman et al. (2015); Neely

(2015); Bauer and Neely (2014); Swanson and Williams (2014); Krippner (2013)). Hartley and Rebucci (2020) analyze how COVID-19 QE announcement affects sovereign bond rates. They find that the responses of 10-year government bond yields in emerging markets to the COVID-19 QE announcement are bigger than those in developed economies, which goes well with the results in my paper. Banerjee et al. (2016) show that unexpected U.S. monetary policy tightening leads to a fall in GDP, rise in interest rates, and depreciation in exchange rates in emerging market economies. Meinusch and Tillmann (2016) empirically find that QE is associated with higher output and inflation and lower nominal interest rates in U.S. However, Gagnon et al. (2017) find that U.S. unconventional monetary policy weakens the connection between U.S. bond yields and foreign currencies. To my knowledge, my paper is the first to identify different responses to U.S. monetary policy surprises, not only during the crisis but also in the post-crisis period, using high-frequency data.

The second contribution is showing that the magnitude of spillovers is different for developed economies and emerging markets. Gilchrist et al. (2016) find that U.S. monetary policy has a bigger effect on short- and long-term interest rates for developed economies relative to emerging markets. However, Chen et al. (2016) show that emerging markets are more likely to respond to QE when using monthly data between 2007 and 2013. I add empirical evidence that the responses of emerging markets to a U.S. monetary policy surprise became stronger than those of developed economies after the financial crisis. This implies that emerging markets would be more vulnerable than developed economies to a rise in the Fed Funds rate in the post-COVID era.

The remainder of the paper is organized as follows. Section 2 discusses the background of the study. Section 3 describes the data and methodology. Section 4 presents the results for spillover estimates of U.S. monetary policy surprises. Section 5 tests the robustness of the results, and Section 6 concludes.

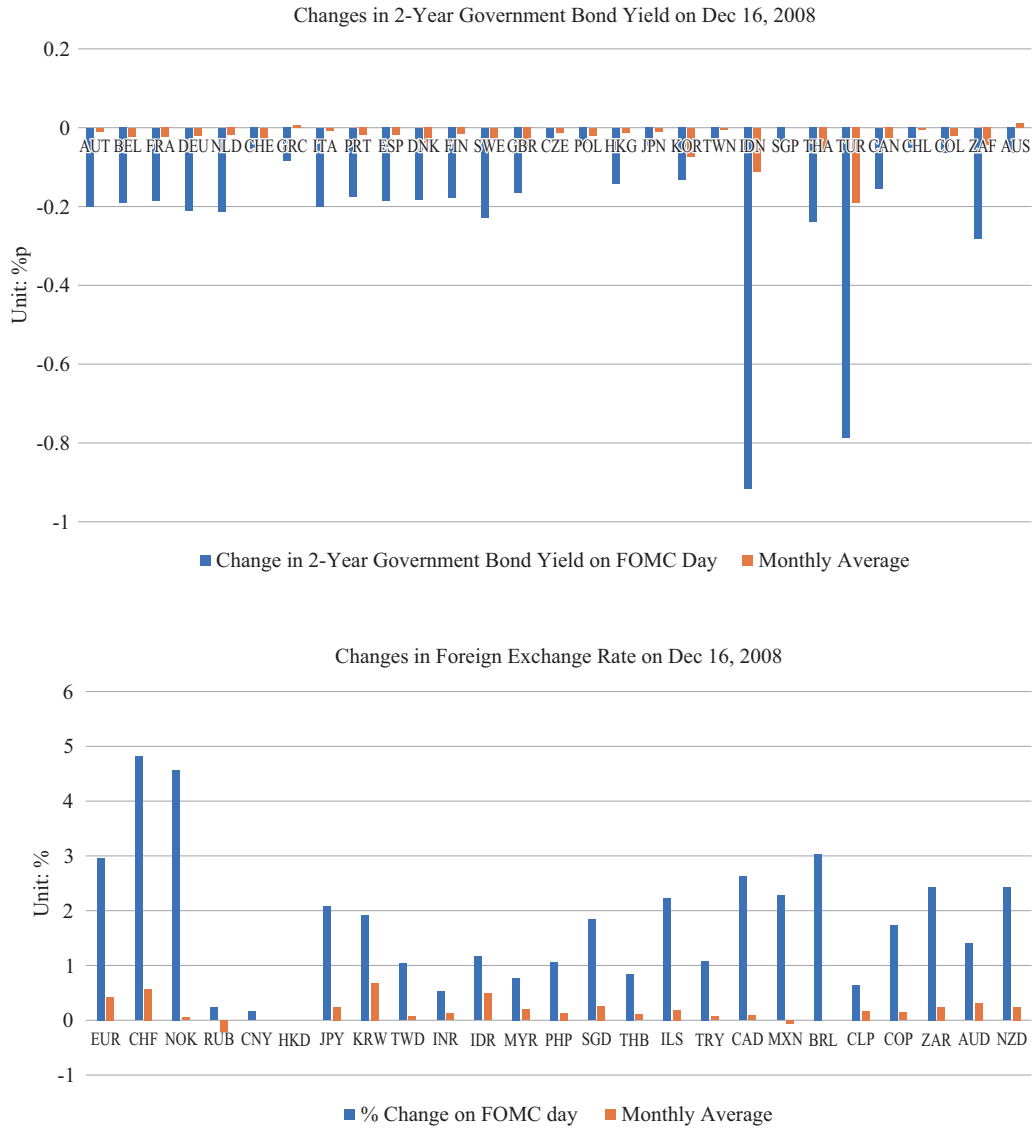
II. *Background*

1. Global Transmission Channels of U.S. Monetary Policy

When the Fed tightens its monetary policy, nominal interest rates in U.S. rise in the short run. According to carry trade activity, carry traders want to buy more U.S. bonds because U.S. bonds pay a higher interest rate than before (Anzuini and Fornari (2012)). As the demand for dollars to buy U.S. bonds increases, the dollar appreciates in the short run.[2] Figures 1 and 2 indicate that foreign government bond yields and exchange rates respond to the Fed's announcement in the direction forecast by carry trade activity. On December 16, 2008, the Fed decided to lower the Fed Funds rate to the range between zero and 0.25 percent. The decrease in the Fed Funds rate instantly led to a decrease in 2-year government bond yields and appreciation of local currencies in more than 30 countries for one day, as shown in Figure 1. After 4.5 years, on June 19, 2013, the Fed announced a *tapering* of QE policies by scaling back its bond purchases. On this day, the global financial market interpreted the announcement as a

[2] Two main conditions for carry trade are low exchange rate volatility and high interest rate differentials across countries.

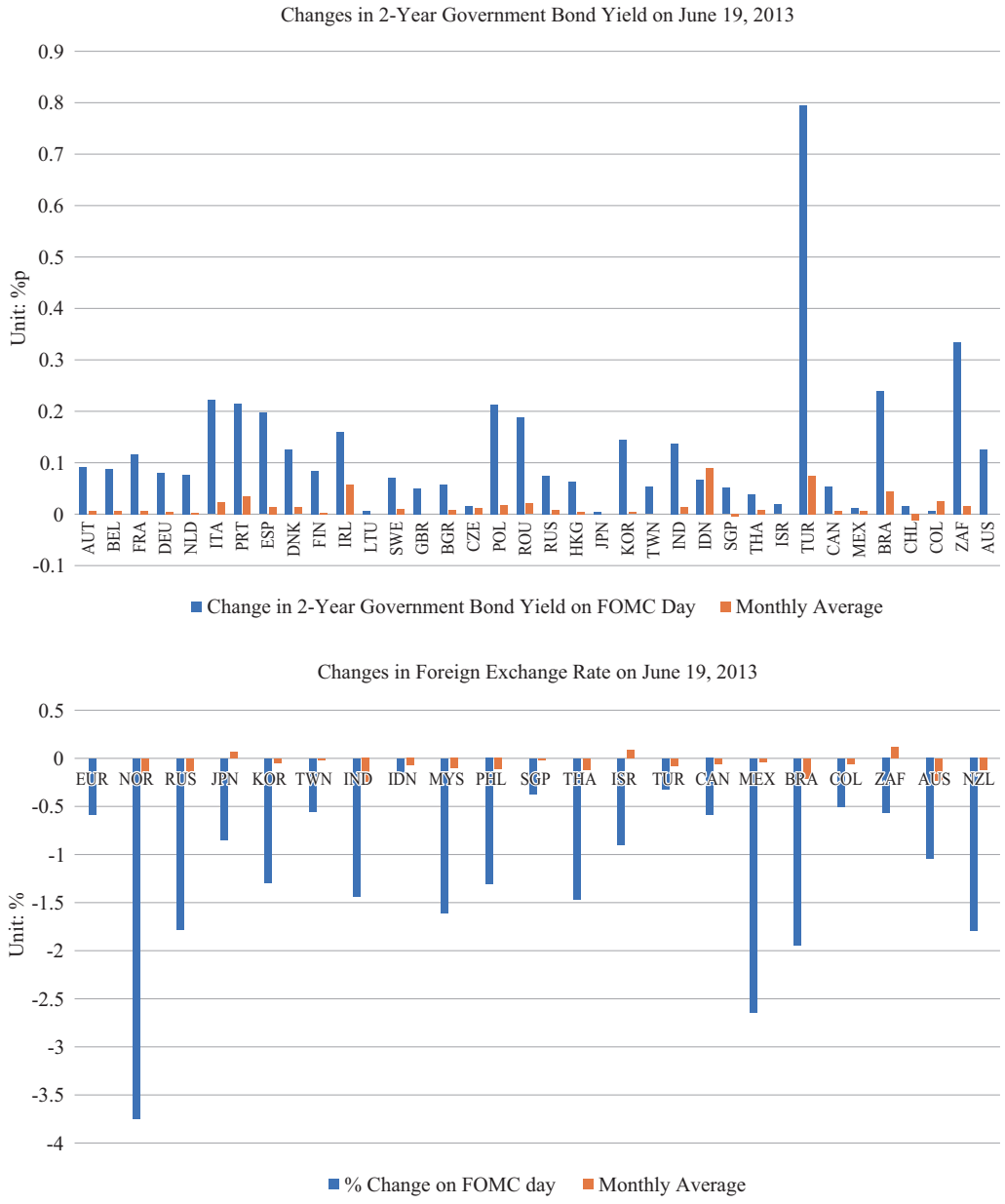
FIGURE 1. CHANGES IN FOREIGN GOVERNMENT BOND YIELDS AND EXCHANGE RATES ON DEC 16, 2008



signal that the Fed would raise the Fed Funds rate in the future. As a result, government bond yields increased and local currencies depreciated in 34 countries for one day, as shown in Figure 2.

Several other channels may also affect spillover of U.S. monetary policy (Rey (2016); Borio and Zhu (2012)). For example, according to the credit channel, when the Fed relaxes its monetary policy, nominal interest rates drop, and this leads to an increase in the equity price.

FIGURE 2. CHANGES IN FOREIGN GOVERNMENT BOND YIELDS AND EXCHANGE RATES ON June 19, 2013



As a result, the net worth of borrowers rises and global banks' lending increases. This could explain the positive correlation between short-term rates in foreign countries and the Fed Funds rate. The risk-taking channel has a similar mechanism. Relaxation of U.S. monetary policy

leads to drops in nominal interest rates. As the returns from safe assets decrease, banks apply relatively low credit standards. Accordingly, the global credit supply goes up and short-term rates in foreign countries move downward. Lastly, the balance sheet channel shows that even advanced economies cannot be free from the influence of U.S. monetary policy. When the Fed tightens its monetary policy, a foreign country's domestic currency depreciates. This helps increase the foreign country's exports. However, as banks become more cautious of the rising (dollar-denominated) value of foreign debt, interest rates rise and bank loans may decrease.

The empirical question is whether we can extend the response of foreign government bond yields and exchange rates to the Fed's decision to all FOMC meetings. If so, how much does U.S. monetary policy influence the movement in foreign government bond yields and exchange rates?

2. The Financial Crisis and Monetary Policy Regime

The 2007-2008 financial crisis was a huge turning point in the Fed's history. Before the crisis, the Fed managed the Fed Funds rate as a key instrument for its monetary policy. For example, on June 25, 2003, the Fed cut the Fed Funds rate by a 0.25 percentage point to 1 percent, the lowest level in 45 years, to overcome the 2001 recession. The very low interest rates led to a housing boom, solid pace of economic expansion, and improved labor market conditions. As a result, the Fed raised the Fed Funds rate to 1.25 percent on June 30, 2004, which was the first increase since 2000.

However, the 2007-2008 financial crisis, triggered by the bursting of the subprime mortgage bubble and the collapse of Lehman Brothers, dramatically changed the Fed's policy regime. On December 16, 2008, the Fed responded aggressively to the crisis by dramatically lowering the Fed funds rate to between zero and 0.25 percent, the lowest rate in its history. Facing the ZLB, the Fed had no room for additional moves in the Fed Funds rate if the economy did not improve soon. As a result, instead of adjusting the Fed Funds rate, the Fed adopted unconventional policies, such as forward guidance on future interest rates and QE with LSAP to stimulate the economy and keep market rates low. It tried to influence expectations for the future path of Federal Funds rates through the FOMC statement, a press release, and the chairperson's public speech. The Fed also cooperated with other central banks to prevent further deepening of the global credit crisis. For example, on October 8, 2008, the Federal Reserve and the central banks of the E.U., U.K., Canada, Sweden, and Switzerland cut their rates by one-half point. One week later, the U.S., E.U., and Japan also adopted a coordinated policy to prevent banks from failing. The unconventional monetary policy regime ended in December 2015, when the Fed raised the Fed Funds rate for the first time since 2006. This action officially marks "the end of an extraordinary seven-year period during which the Federal Funds rate was held near zero to support the recovery of the economy from the worst financial crisis and recession since the Great Depression." [3] Since then, as of November 2017, the Fed has raised the Fed Funds rate three times to the range of 1.00 to 1.25.

The question is how has the Fed's dependence on unconventional monetary policy after the financial crisis, and its return to conventional policy in 2015, affected the global influence of U.S. monetary policy? To address this question, I divide the sample into three phases: pre-

[3] Transcript of Fed Chair Janet Yellen's press conference, December 16, 2015.

crisis, crisis, and post-crisis. I assume that the financial crisis period began when the Fed's LSAP-I plan was announced (November 25, 2008) and ended when the Fed raised the Fed Funds rate again (December 16, 2015).

III. *Empirical Analysis*

1. Monetary Policy Surprises

I measure U.S. monetary policy surprises by changes in the response of U.S. financial markets to the Fed's decision. For this, I collect high-frequency tick data for two types of futures: Fed Funds futures and 10-year Treasury futures.

Fed Funds futures are financial contracts that reflect market views of the likelihood of Fed policy changes. The contracts have a payout based on the average effective Fed Funds rate that prevails over the calendar month specified in the contract. The Fed Funds futures rate 10 minutes before ($f_{t,-10}$) the FOMC announcement (2:15 pm, ET) on day d of a month with D days is calculated by the *average* of the effective overnight Fed Funds rate as follows:

$$f_{t,-10}=\frac{d(Realized)+(D-d)(Expected_{t,-10})}{D}, \tag{1}$$

where *Realized* is the effective Fed Funds rates during the past d days of the relevant month and $Expected_{t,-10}$ is the expectation of the Fed Funds rate for upcoming $D-d$ days of the month 10 minutes before the FOMC announcement. In equation (1), I solve for $Expected_{t,-10}$ to factor out the market's expectation for the Fed's decision before the announcement:

$$Expected_{t,-10}=\frac{D}{D-d}(f_{t,-10})-\frac{d}{D-d}(Realized). \tag{2}$$

Similarly, I calculate the expected value $Expected_{t,+20}$ for the Fed Funds rate for forthcoming *D-d* days of the month 20 minutes after the FOMC announcement:

$$Expected_{t,+20}=\frac{D}{D-d}(f_{t,+20})-\frac{d}{D-d}(Realized), \tag{3}$$

where $f_{t,+20}$ (the Fed Funds future rate 20 minutes after the FOMC announcement) reflects how the financial markets interpreted the Fed's decision ex post.

I define a Fed Funds futures surprise, FF_t, by changes in the expectation for the Fed Funds rate between 10 minutes before ($Expected_{t,-10}$) and 20 minutes after ($Expected_{t,+20}$) the FOMC announcement from equations (2) and (3):

$$FF_t=\frac{D}{D-d}(f_{t,+20}-f_{t,-10}). \tag{4}$$

Within a 30-minute window, the Fed Funds futures surprise (FF_t) measures the unanticipated component of the Fed's decision on the current Fed Funds rate target (Kuttner (2001); Gertler and Karadi (2015)). If there is no surprise in the Fed's decision, FF_t is zero, because $f_{t,-10}$ and $f_{t,+20}$ have the same value.

However, when the Fed Funds rate dropped to its ZLB in the financial crisis period, changes in the current Fed Funds future rate might be restricted. To address this problem, I employ 10-year Treasury futures that reflect a future path for monetary policy contained in the FOMC statement. Ten-year Treasury futures are derivatives whose prices are closely tied to the prices of U.S. 10-year government bonds and their yields. Ten-year Treasury bonds carry almost zero risk to principal, and thus, are considered to be an important measuring stick for market confidence about the future. For example, when confidence is high, the 10-year Treasury bond's price drops and yields go higher. I calculate a Treasury futures surprise, TYF_t, by changes in the 10-year Treasury futures price between 10 minutes before ($tyf_{t,-10}$) and 20 minutes after ($tyf_{t,+20}$) the FOMC announcement, as follows:

$$TYF_t = tyf_{t,+20} - tyf_{t,-10}. \tag{5}$$

Gürkaynak et al. (2005a) find that 75 to 90 percent of variations in 10-year Treasury yields respond to forward guidance in FOMC statements rather than the current Fed Funds rate target. Therefore, changes in the 10-year Treasury futures price within a 30-minute window around an FOMC announcement (TYF_t) capture the future path of expected interest rates contained in FOMC statements.

The sample period in my dataset includes all FOMC meetings from August 2001 to September 2017. The FOMC holds eight regularly scheduled meetings each year. In addition, the FOMC holds irregular intermeetings as needed. In meetings, the FOMC makes decisions on a target level for the Federal Funds rate and growth of the U.S. money supply. Each decision includes the future direction of U.S. monetary policy. This study covers all FOMC announcements from 130 scheduled meeting decisions.

For the financial crisis period (November 25, 2008-December 15, 2015), I also include important irregular events related to forward guidance, such as the announcement of LSAP, the chairperson's speech in Jackson Hole and conferences in the dataset.[4]

For each FOMC announcement, I calculate the Fed Funds futures surprise and Treasury futures surprise. Figures 3 and 4 display the sequence of each surprise. The large fluctuations in the Fed Funds futures surprise in the early 2000s are associated with the Fed's cutting the Fed Funds rate to fight off a recession, terrorist attacks, and the Iraq war. For example, on November 6, 2002, the market expected a 25 basis points cut before the FOMC announcement. However, the Fed decided to lower its Fed Funds rate target by 50 basis points to 1.25 percent. The larger than expected cut led to a big drop in the Fed Funds futures surprise. The next big ups and downs, in 2007 and 2008, correspond to the financial crisis. The sudden drop in Treasury futures on March 18, 2009, implies why I should consider the Treasury futures surprise along with the Fed Funds futures surprise. On this day, there was no change in the Fed Funds rate target. Instead, the Fed announced that it would purchase long-term Treasuries over the next 6 months and increase the size of purchases of agency debt and mortgage-backed securities. The negative value of the Treasury futures surprise reflects the market's response to the Fed's downward pressure on interest rates and forward guidance for the future path of its monetary policy.

[4] I calculate monetary policy surprises for irregular events by using the times for unconventional monetary policy actions provided by Gilchrist et al. (2015).

FIGURE 3. FED FUNDS FUTURE SURPRISE (August 2001 - September 2017)

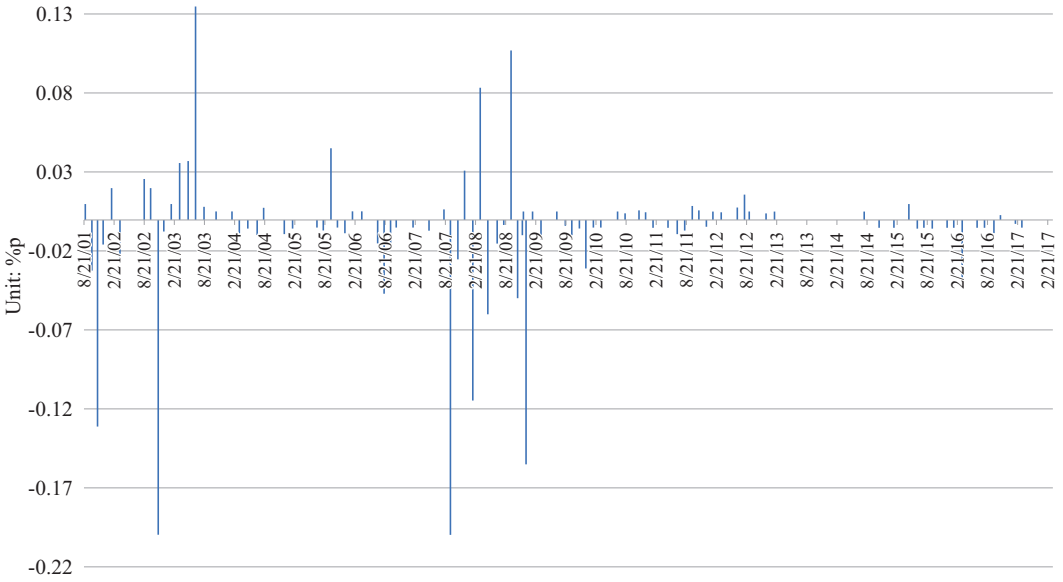


FIGURE 4. TREASURY FUTURE SURPRISE (August 2001 - September 2017)

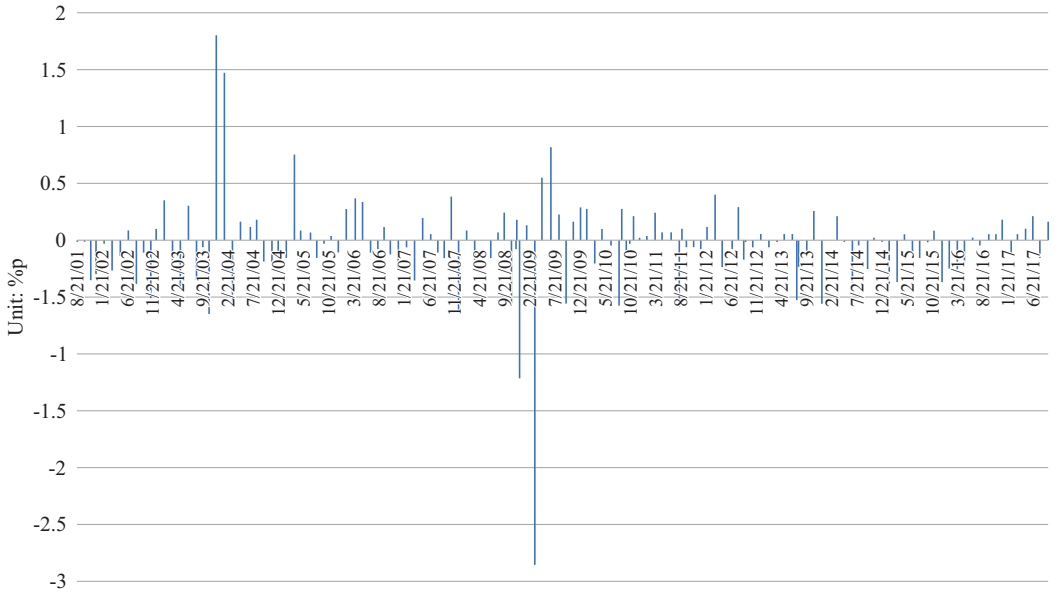


TABLE 1. THE SAMPLE COUNTRIES

	Division	Country
Europe (23)	Eastern Europe (6)	Bulgaria, Czech Republic, Hungary, Poland, Romania, Russia
	Northern Europe (7)	Denmark, Finland, Ireland, Lithuania, Norway, Sweden, U.K.
	Southern Europe (4)	Greece, Italy, Portugal, Spain
	Western Europe (6)	Austria, Belgium, France, Germany, Netherland, Switzerland
Asia (13)	East Asia (5)	China, Hong Kong, Japan, South Korea, Taiwan
	South and Southeast Asia (6)	India, Indonesia, Malaysia, Philippines, Singapore, Thailand
	Western Asia (2)	Israel, Turkey
America (7)	North America (2)	Canada, Mexico
	Central and South America (5)	Brazil, Chile, Colombia, Costa Rica, Venezuela
Africa (1)	Africa	South Africa
Oceania (2)	Oceania	Australia, New Zeland

2. Government Bond Yields and Foreign Exchange Rates

For each FOMC meeting and irregular event in the dataset, I collect daily variations in government bond yields and foreign exchange rates for 46 countries. As shown in Table 1, the sample countries in my dataset include both developed economies and emerging markets.

Changes in an n-year bond yield for country i on FOMC meeting day t within a 1-day period are calculated as

$$\Delta y_{i,t} = y_{i,t}(n) - y_{i,t-1}(n). \tag{6}$$

Figure 5 depicts the time zone of sample countries. Asian and European markets are closed at the time of the scheduled FOMC announcement. I use the 1-day window between t and $t+1$ for these markets to address a time lag.

The dataset on foreign government bond yield consists of 2-, 5-, and 10-year maturities. I investigate how short-term (2-year), midterm (5-year), and long-term (10-year) yields respond differently to U.S. monetary policy surprises. This allows me to compare the different movements at the short and long ends of the yield curve. To test whether the effects of U.S. monetary policy surprises are different across advanced and non-advanced economies, I divide the samples into two groups, developed economies and emerging markets, as shown in Table 2.

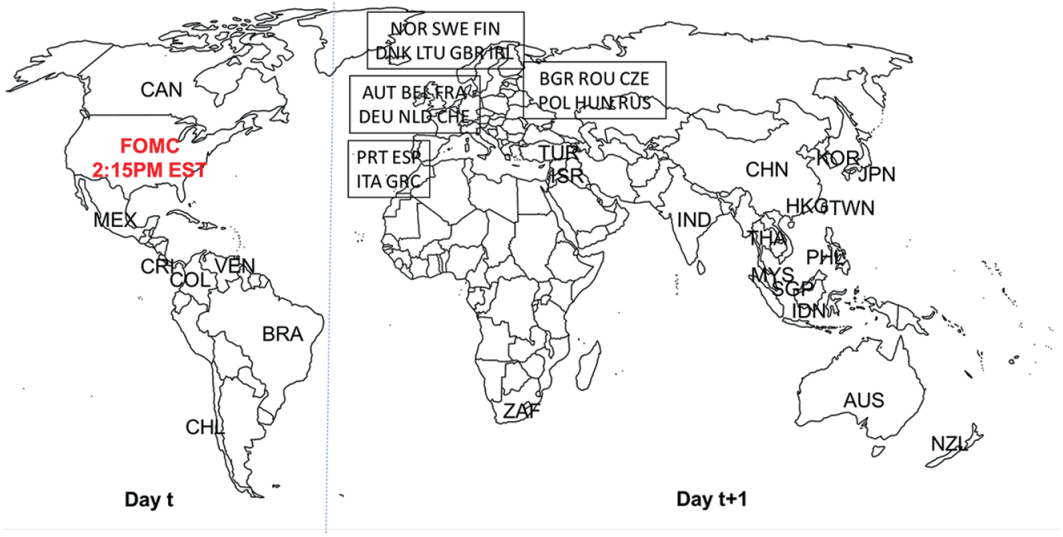
I calculate changes in the foreign exchange spot rate for country i on FOMC meeting day t as follows:

$$\Delta s_{i,t+1} = \frac{s_{i,t+1} - s_{i,t}}{s_{i,t}} \times 100, \tag{7}$$

TABLE 2. THE DIVISION OF GROUPS

	Country
Developed Economies	CAD, DEU, FRA, GBR, ITA, JPN, AUT, BEL, NLD, CHE, GRC, PRT, ESP, DNK, FIN, IRL, NOR, SWE, CZE, HUN, POL, KOR, ISR, TUR, MEX, CHL, AUS, NZL
Emerging Markets	LTU, BGN, ROU, RUS, CHN, HKG, TWN, IND, IDN, MYS, PHL, SGP, THA, BRA, COL, CRI, VEN, ZAF

FIGURE 5. TIME ZONE OF SAMPLE COUNTRIES



where $\Delta s_{i,t}$ is the percentage changes in the foreign exchange rate (in dollars per unit of non-U.S. currency) within a 1-day window.

The exchange arrangement in each country plays an important role in the responses of exchange rates to U.S. monetary shocks. For example, when a country opens its financial markets to foreign investors, it can experience sudden inflows and stops of foreign funds (Edwards (2007)). A country may fear a floating exchange regime that can magnify their vulnerability to the sudden outflow or inflow of foreign funds. This explains why some countries (mostly emerging markets) are inclined to peg their currency to the U.S. dollar, which may reduce the spillover of U.S. monetary policy surprises. In order to analyze how U.S. monetary policy surprises affect foreign exchange rates under different exchange rate regime, I categorize sample countries into four groups: hard pegs, soft pegs, managed floating, and free floating, as shown in Table 3. While most developed economies in my dataset adopt a fully floating exchange regime, many emerging market economies run managed float regimes or limited-flexibility regimes.[5]

TABLE 3. EXCHANGE RATES ARRANGEMENT

	Country
Hard Pegs	LTU, BGR, HKG
Soft Pegs	DNK, CZE, HUN, ROU, RUS, CHN, IND, IDN, MYS, SGP, THA, ISR, CRC, VEF
Managed Floating	CHF, KOR, PHL, TUR, BRA, COL, ZAF
Free Floating	EUR, IRL, NOR, SWE, GBR, POL, JPN, CAN, MEX, CHL, AUS, NZL

[5] The exchange rate regime is measured by IMF's *Annual Report on Exchange Arrangement and Exchange Restrictions*.

3. Empirical Methodology

U.S. monetary policy surprises on FOMC meeting days play a role as exogenous shocks to financial markets in foreign countries. I evaluate the global transmission of U.S. monetary policy surprises to foreign government bond yields and exchange rates using the following panel regression:

$$\Delta y_{i,t+1} = \alpha_0 + \beta_1 FF_t + \beta_2 TYF_t + \beta_3 CRISIS_t + \beta_4 POST_t + \beta_5 FF_t \cdot CRISIS_t + \beta_6 TYF_t \cdot CRISIS_t + \beta_7 FF_t \cdot POST_t + \beta_8 TYF_t \cdot POST_t + \mu_i + \varepsilon_{it}. \quad (8)$$

In equation (8), I regress the daily change in country i's financial variables ($\Delta y_{i,t+1}(n)$ for government bond yields and $\Delta s_{i,t+1}$ for exchange rates) around FOMC meeting day t on the Fed Funds futures surprise (FF_t) and Treasury futures surprise (TYF_t).[6] I include $CRISIS_t$ and $POST_t$ dummies to identify changes in the influence of U.S. monetary policy surprises after the U.S. financial crisis. $CRISIS_t$ is 0 in the pre-crisis period (before November 24, 2008) and 1 in the crisis period (i.e., between November 24, 2008, and December 15, 2015). Likewise, $POST_t$ has the value of 1 in the post-crisis period (after December 15, 2015). I add country fixed effects (μ_i) to capture country-specific time-invariant elements. ε_{it} captures all nonmonetary policy shocks that can affect movement in country i's government bond yields and exchange rates on the FOMC meeting day t.

β_1, β_2, β_3, and β_4 are commonly referred to as the direct effect of FF_t, TYF_t, $CRISIS_t$, and $POST_t$ on $\Delta y_{i,t+1}(n)$, respectively. The coefficients β_5, β_6, β_7, and β_8 for interaction terms between monetary policy surprises and dummies help estimate how the effects of monetary policy surprises differ by period.

For example, the net impact of FF_t on $\Delta y_{i,t+1}(n)$ is defined by

$$E[\Delta y_{i,t+1} \mid FF_t, CRISIS_t, POST_t] = \alpha_0 + \beta_3 CRISIS_t + \beta_4 POST_t + (\beta_1 + \beta_5 CRISIS_t + \beta_7 POST_t) FF_t. \quad (9)$$

The first derivative of equation (9) with respect to FF_t is

$$\frac{\partial E[\Delta y_{i,t+1} \mid FF_t, CRISIS_t, POST_t]}{\partial FF_t} = \beta_1 + \beta_5 CRISIS_t + \beta_7 POST_t. \quad (10)$$

In equation (10), β_1 represents the impact of FF_t on $\Delta y_{i,t+1}$ conditional on the value of $CRISIS_t$, and $POST_t$ being zero. β_5 indicates whether the effect of FF_t on $\Delta y_{i,t+1}$ is systematically different when $CRISIS_t$ has the value of 1. For example, a positive β_5 implies that the impact of the Fed Funds futures surprise on the daily change in sovereign bond yields grows more positive in the crisis period compared to the pre-crisis period. Likewise, β_7 allows me to compare differences in the effect of FF_t on $\Delta y_{i,t+1}$ between the pre-crisis and post-crisis period.

Along with the net effect in equation (9), the total effect of FF_t on $\Delta y_{i,t+1}$ in each period is calculated by

[6] Since FF_t, and TYF_t vary at the aggregate level, I may not assume independence of error terms across countries for each FOMC meeting. The nonindependence of error terms may underestimate standard errors (Moulton (1986)). I address the possible problem by clustering standard errors with ordering observations by group.

$$E[\Delta y_{i,t+1} \mid FF_t \neq 0, CRISIS_t = 1, POST_t = 0] = \alpha_0 + \beta_1 + \beta_3 + \beta_5, \quad (11)$$
$$E[\Delta y_{i,t+1} \mid FF_t \neq 0, CRISIS_t = 0, POST_t = 1] = \alpha_0 + \beta_1 + \beta_4 + \beta_7. \quad (12)$$

In equation (11), a positive value of $\alpha_0+\beta_1+\beta_3+\beta_5$ implies that a change in the Fed Funds futures surprise (FF_t) is positively associated with a daily change in foreign government bond yields ($\Delta y_{i,t+1}$) in the crisis period.

I use EME_i dummies to compare the responses to U.S. monetary policy surprises in a group of developed economies and emerging markets as follows:

$$\begin{aligned}\Delta y_{i,t+1} = {} & \alpha_0 + \beta_1 FF_t + \beta_2 TYF_t + \beta_3 CRISIS_t + \beta_4 POST_t + \beta_5 FF_t \cdot CRISIS_t + \\ & \beta_6 TYF_t \cdot CRISIS_t + \beta_7 FF_t \cdot POST_t + \beta_8 TYF_t \cdot POST_t + \beta_9 FF_t \cdot CRISIS_t \cdot EME_i + \\ & \beta_{10} TYF_t \cdot CRISIS_t \cdot EME_i + \beta_{11} FF_t \cdot POST_t \cdot EME_i + \beta_{12} TYF_t \cdot POST_t \cdot EME_i + \mu_i + \varepsilon_{it}. \end{aligned} \quad (13)$$

EME_i has the value of 1 in the group of emerging markets.

IV. *Results*

Table 4 shows that the response of sovereign bond yields to U.S. monetary policy surprises differs not only across maturities of bonds, but also across periods. For a decrease in the Fed Fund futures surprise of 100 basis points, yields on short-term sovereign bonds in the crisis period would be expected to decline by 85 basis points more than bond yields in the pre-crisis period. A surprise rise in the Fed Fund futures surprise has a stronger positive association with movement of midterm and long-term sovereign bond yields in the post-crisis period compared to the pre-crisis period. For example, a rise in the Fed Funds futures surprise of 100 basis points leads to an increase of 168 additional basis points in long-term foreign government bond yields in the post-crisis period relative to the pre-crisis period. This can be explained by the response of term premia to monetary policy uncertainty (Tillmann (2020); Shang (2022)). As uncertainty rises, the term premia tend to become smaller. The Fed's monetary tightening would have signaled to the market that U.S. economic growth is solid in the post-crisis period. As uncertainty decreased, the term premia would have increased. As a result, the responses of the midterm and long-term bond yields to the Fed Fund futures surprises would have been bigger. On the other hand, a short-term bond yield tends to be more directly affected by a benchmark interest rate than monetary policy uncertainties or future confidence. As the central banks in other countries except the U.S. were not yet ready for the policy tightening, the spillover of U.S. monetary policy on the short-term bond yield would have been limited in the post-crisis period.

Similarly, the midterm and long-term bond yields also have the stronger response to the Treasury futures surprise in the post-crisis period. For an unanticipated increase in Treasury futures by 100 basis points, 5-year and 10-year government bond yields increase by 4 to 7 additional basis points in the post-crisis period relative to the pre-crisis period. However, this result has no statistical significance.

Column (4) in Table 4 shows the relationship between foreign exchange spot rates and U.S. monetary policy surprises. My estimates indicate that a decline in the Fed Funds futures surprise of 100 basis points is associated with an appreciation in the local currencies of an additional 9 percent in the crisis period and an extra 25 percent in the post-crisis period,

TABLE 4. RESPONSE OF GOVERNMENT BOND YIELDS AND EXCHANGE RATES TO U.S. MONETARY POLICY SURPRISES

VARIABLES	(1) GOV2	(2) GOV5	(3) GOV10	(4) FX
FF	0.301***	0.307***	0.277**	-1.026**
	(0.104)	(0.112)	(0.112)	(0.491)
TYF	0.0418**	0.0431*	0.0307**	-0.273***
	(0.0196)	(0.0221)	(0.0154)	(0.0788)
FF × CRISIS	0.845***	0.296**	0.400***	-9.089***
	(0.262)	(0.136)	(0.134)	(2.370)
TYF × CRISIS	-0.0278	-0.00839	0.00669	0.174
	(0.0214)	(0.0231)	(0.0172)	(0.185)
FF × POST	0.647**	0.769***	1.681***	-25.46***
	(0.323)	(0.289)	(0.595)	(4.965)
TYF × POST	0.000768	0.0450	0.0723	0.0580
	(0.0504)	(0.0329)	(0.0468)	(0.701)
CRISIS	0.00199	0.000842	-0.0101	-0.170**
	(0.0119)	(0.00813)	(0.00693)	(0.0670)
POST	0.00459	0.00355	-0.00135	-0.104
	(0.0129)	(0.00687)	(0.00865)	(0.0919)
Constant	-0.00291	-0.00275	0.00215	0.0471
	(0.00578)	(0.00513)	(0.00407)	(0.0363)
Observations	4,479	4,436	4,627	4,885
R-squared	0.016	0.045	0.069	0.097
Adjusted R-squared	0.00412	0.0337	0.0587	0.0890

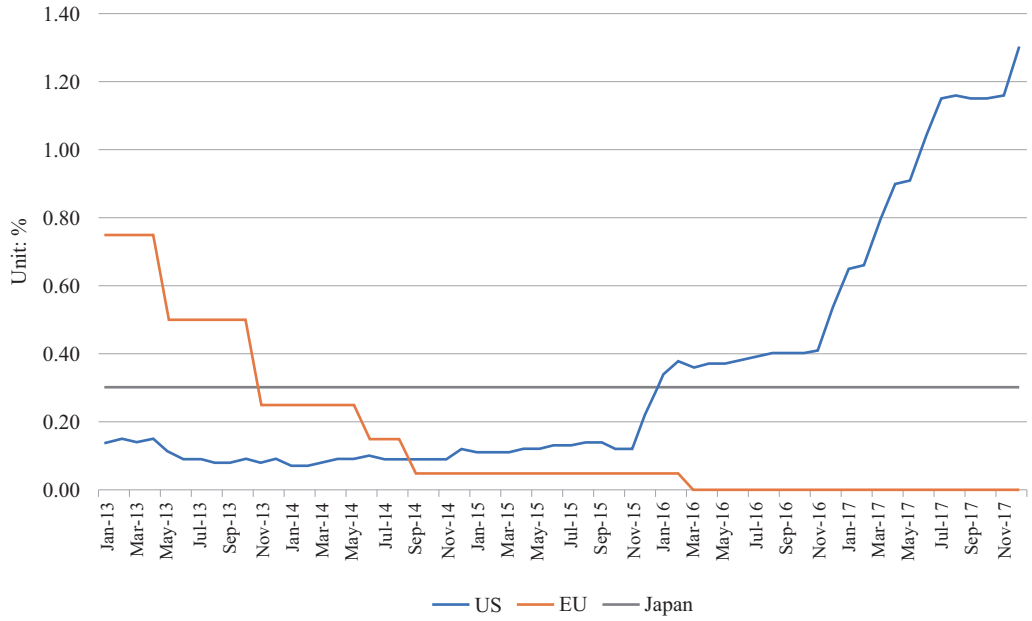
Note: The dependent variable is daily change in 2-year (GOV2), 5-year (GOV5), 10-year (GOV10) ahead government bond yield and daily percentage change in foreign exchange spot rate in dollars per unit of non US currency (FX) bracketing an FOMC announcement. The entries labeled "FF" denote a 30-minute window change in the Fed Fund Futures around an FOMC announment. The entries labeled "TYF" denote a 30-minute change in the 10-year Treasury Futures. "CRISIS" is 1 in the sample period between Nov 2008 and Dec 2015. "POST" is 1 in the sample period after Dec 2015. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

compared to the pre-crisis period.

I attribute the overall results to the decoupling of interest rates between the U.S. and other countries. In the face of the financial crisis, the Fed lowered the Fed Funds rate to the ZLB. It also cooperated with other central banks to prevent a deepening of the global credit crisis. Although the Fed has continued to raise interest rates since 2015, Europe and Japan have kept their rates near zero, as shown in Figure 6. Central banks in emerging markets also did not pursue premature tightening. As a result, the widening gap in interest rates between the U.S. and the rest of the world has caused foreign financial markets to respond sensitively to Fed decisions after the financial crisis.

Table 5 shows how sovereign bond yields in a group of developed economies and emerging markets react to U.S. monetary policy surprises. In the crisis period, 2-year and 5-year government bond yields in developed economies significantly respond to unexpected changes in Fed Fund futures. For example, the 100 basis points decrease in the Fed Fund futures leads to a drop in short-term and midterm government bond yields by 35 to 84 additional basis points in the crisis period, compared to the pre-crisis period. In the post-crisis period, the Treasury futures surprise affects the movement in 5-year and 10-year government

FIGURE 6. CENTRAL BANK RATES IN U.S., E.U., AND JAPAN



bond yields. An unexpected increase in Treasury futures by 100 basis points leads to marginal increases in foreign government bond yields by 6 to 8 basis points in the post-crisis period, relative to the pre-crisis period. For emerging market countries, an unanticipated decrease in the Fed Fund futures of 100 basis points is associated with an additional 43 basis points decrease in long-term bond yields in the crisis period, compared to the developed economies. In the post-crisis period, a rise in the Fed Fund futures surprise by 100 basis points is connected to additional increases in midterm and long-term foreign bond yields by 105 to 149 basis points, compared to the developed economies.

The results suggest that emerging markets' responses to U.S. monetary policy surprises became stronger than those of developed economies after the financial crisis. This finding is consistent with those reported by Chen et al. (2016). Central banks exert greater control over short-term bond yields by their own benchmark interest rates (Caceres et al. (2016)). Monetary policy coordinations on short-term interest rates among developed economies during the financial crisis may explain why the response of 2-year bond yields is greater than those of 5- and 10-year bond yields in the crisis period. On the other hand, long-term bond yields are relatively free to respond to external shocks. For example, the Fed managed to put downward pressure on interest rates under ZLB by purchasing long-term securities. In the post-crisis period, central banks in developed economies are reluctant to raise their short-term target interest rates. This may lead to a larger effect of U.S. monetary policy surprises on the long end of the yield curve rather than the short end. Meanwhile, interest rates around ZLB in developed economies led to cheap borrowing costs in emerging market economies. In the post-crisis period, however, the widening interest rate gap between the U.S. and the rest of the world forced emerging markets to respond sensitively to the tightening U.S. monetary policy.

TABLE 5. COMPARISON OF RESPONSES TO U.S. MONETARY POLICY SURPRISES

VARIABLES	(1) GOV2	(2) GOV5	(3) GOV10	(4) FX
FF	0.307**	0.319**	0.215	-1.265
	(0.119)	(0.125)	(0.149)	(0.835)
TYF	0.0328**	0.0373	0.0278	-0.319***
	(0.0163)	(0.0241)	(0.0175)	(0.0973)
FF × CRISIS	0.835**	0.347**	0.254	-9.633***
	(0.367)	(0.160)	(0.169)	(3.182)
TYF × CRISIS	-0.00801	-0.00556	0.0104	0.206
	(0.0209)	(0.0256)	(0.0193)	(0.253)
FF × POST	0.706	0.405	1.148**	-29.28***
	(0.504)	(0.329)	(0.558)	(5.671)
TYF × POST	0.0286	0.0662**	0.0845**	0.159
	(0.0277)	(0.0324)	(0.0373)	(0.843)
FF × EME	-0.0155	-0.0394	0.217	0.664
	(0.141)	(0.170)	(0.180)	(1.216)
TYF × EME	0.0329	0.0200	0.0109	0.129*
	(0.0345)	(0.0364)	(0.0130)	(0.0776)
FF × CRISIS × EME	0.0312	-0.189	0.438**	1.506
	(0.415)	(0.209)	(0.194)	(2.535)
FF × POST × EME	-0.164	1.052**	1.485**	10.56***
	(1.366)	(0.522)	(0.627)	(3.700)
TYF × CRISIS × EME	-0.0681*	-0.00938	-0.0136	-0.0886
	(0.0401)	(0.0380)	(0.0140)	(0.208)
TYF × POST × EME	-0.0867	-0.0623	-0.0367	-0.279
	(0.120)	(0.0539)	(0.0742)	(0.501)
CRISIS	0.00200	0.000806	-0.0103	-0.170**
	(0.0120)	(0.00816)	(0.00695)	(0.0670)
POST	0.00494	0.00347	-0.00161	-0.104
	(0.0128)	(0.00689)	(0.00868)	(0.0920)
Constant	-0.00300	-0.00271	0.00234	0.0470
	(0.00582)	(0.00516)	(0.00408)	(0.0363)
Observations	4,479	4,436	4,627	4,885
R-squared	0.016	0.046	0.073	0.099
Adjusted R-squared	0.00300	0.0329	0.0611	0.0897

Note: The dependent variable is daily change in 2-year (GOV2), 5-year (GOV5), 10-year (GOV10) ahead government bond yield and daily percentage change in foreign exchange spot rate in dollars per unit of non US currency (FX) bracketing an FOMC announcement. The entries labeled "FF" denote a 30-minute window change in the Fed Fund Futures around an FOMC announment. The entries labeled "TYF" denote a 30-minute change in the 10-year Treasury Futures. "CRISIS" is 1 in the sample period between Nov 2008 and Dec 2015. "POST" is 1 in the sample period after Dec 2015. "EME" is 1 when the sample country is in the group of emerging markets. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6 shows how the influence of U.S. monetary policy surprises on foreign exchange rates depends on exchange rate arrangements in specific countries. Hard-peg countries, such as Hong Kong, Bulgaria, and Lithuania, have fixed their exchange rates to minimize the vulnerability of their currency to exogenous shocks.[7] As a result, they show relatively small

[7] However, a hard-peg country must keep its monetary policy and interest rates in line with the other country. For

TABLE 6. RESPONSE OF FOREIGN EXCHANGE RATE TO U.S. MONETARY POLICY SURPRISES BY EXCHANGE RATE REGIME

Exchange Regime VARIABLES	Hard Peg FX	Soft Peg FX	Managed Float FX	Free Float FX
FF	-0.891	-1.266**	-1.205	-0.757
	(0.602)	(0.579)	(0.754)	(1.052)
TYF	-0.106*	-0.300***	-0.395***	-0.271***
	(0.0586)	(0.0953)	(0.121)	(0.0853)
FF × CRISIS	-5.991***	-7.643***	-13.97***	-9.553***
	(1.172)	(1.776)	(3.010)	(3.375)
TYF × CRISIS	0.0511	0.309**	0.235	0.115
	(0.111)	(0.150)	(0.243)	(0.248)
FF × POST	-12.10***	-22.61***	-25.46***	-29.59***
	(4.095)	(4.737)	(7.334)	(6.170)
TYF × POST	-0.612	0.000672	0.0547	0.279
	(0.594)	(0.614)	(0.877)	(0.857)
CRISIS	-0.0766	-0.129**	-0.194**	-0.224**
	(0.0473)	(0.0625)	(0.0773)	(0.0905)
POST	-0.0923	-0.1000	-0.212*	-0.0913
	(0.0805)	(0.0741)	(0.111)	(0.128)
Constant	0.0641**	0.0400	0.0573	0.0431
	(0.0265)	(0.0315)	(0.0445)	(0.0564)
Observations	404	1,627	544	2,174
R-squared	0.116	0.092	0.161	0.091
Adjusted R-squared	0.0933	0.0816	0.144	0.0817

Note: The dependent variable "FX" is daily percentage change in foreign exchange spot rate (in dollars per unit of non US currency) bracketing an FOMC announcement. The entries labeled "FF" denote a 30-minute window change in the Fed Fund Futures around an FOMC announment. The entries labeled "TYF" denote a 30-minute change in the 10-year Treasury Futures. "CRISIS" is 1 in the sample period between Nov 2008 and Dec 2015. "POST" is 1 in the sample period after Dec 2015. Clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

response of exchange rate to U.S. monetary policy surprises. In contrast, exchange rates in other regimes actively respond to unexpected changes in U.S. monetary policy. A surprise rise of 1 percent in Fed Fund futures is associated with a depreciation in local currencies by an additional 6 to 14 percent in the crisis period and an extra 12 to 30 percent in the post-crisis period, compared to the pre-crisis period. These results imply that the more flexible exchange arrangement leads to larger magnitudes of responses in foreign exchange rates to U.S. monetary policy surprises. In general, a floating exchange regime magnifies vulnerability to sudden outflows of foreign funds made by carry trade activity in the short run. However, when a country pegs its currency to another or intervenes in exchange markets to stabilize the value of its currency, it can reduce sensitivity to the volatility of capital flow. This explains why hard-pegged exchange regimes respond less to U.S. monetary policy surprises.

example, the Hong Kong dollar is pegged to USD, and Bulgaria and Lithuania pegged their currencies to EUR.

V. *Robustness*

In this study, I use two kinds of monetary policy surprises: the Fed Funds futures surprise and the Treasury futures surprise. However, these two surprises may contain overlapping information on the market's response to the Fed's decision, because they are measured within the same time window. I isolate the component of changes in the 10-year Treasury futures price that is not related to the Fed Funds futures surprise. The isolated component reflects the expected future path of interest rates contained in the FOMC announcement, which is orthogonal to the movement in Fed Funds futures (Gürkaynak et al. (2005b); Wongswan (2009)).[8] I define the isolated surprise component as the *Residual surprise* ($\widehat{Residual}_t$) by the error term from the regression of the Treasury futures surprise on the Fed Funds futures surprise:

$$TYF_t = \alpha_0 + \alpha_1 FF_t + Residual_t. \tag{14}$$

Then, I estimate the effects of FF_t and $\widehat{Residual}_t$ on changes in foreign government bond yields ($\Delta y_{i,t+1}$) and exchange rates ($\Delta s_{i,t+1}$), as follows:

$$\begin{aligned}\Delta y_{i,t+1} = {} & \alpha_0 + \beta_1 FF_t + \beta_2 \widehat{Residual}_t + \beta_3 CRISIS_t + \beta_4 POST_t + \beta_5 FF_t \cdot CRISIS_t \\ & + \beta_6 \widehat{Residual}_t \cdot CRISIS_t + \beta_7 FF_t \cdot POST_t + \beta_8 \widehat{Residual}_t \cdot POST_t + \mu_i + \varepsilon_{it}.\end{aligned} \tag{15}$$

This type of two-step OLS regression with a generated regressor ($\widehat{Residual}_t$) may cause inconsistent estimates of standard errors (Pagan (1984)). To address this problem, I employ a bootstrapping method. The bootstrapped standard errors are estimated on a random sample from the second stage with 200 repetitions. Table 7 suggests that the responses of government bond yields and exchange rates to Fed Funds futures and Residual surprises become stronger after the financial crisis. For example, an unanticipated decrease by 100 basis points in the Fed Funds futures rate causes foreign government bond yields to decline by 40 to 80 additional basis points in the crisis period, relative to the pre-crisis period. In particular, the Residual surprise plays a significant role in the movement in foreign government bond yields across all maturities in both the crisis and post-crisis period. A hypothetical 100 basis points cut in the Residual surprise leads to an extra 7 to 12 basis points decrease in government bond yields in the crisis period, compared to the pre-crisis period. In the post-crisis period, a rise in the Residual surprise by 100 basis points is associated with additional increase in foreign bond yields by 12 to 18 basis points, compared to the pre-crisis period. This suggests that the isolated component of the Treasury futures surprises is an effective way to capture the market's expectation on the future path of monetary policy. Nonetheless, this study has a potential limitation. It is shown that the long end of the yield curve is more affected by the Fed Funds future surprise than the Residual surprise, which is contrary to Gürkaynak et al. (2005b). Further research is needed to

[8] Gürkaynak et al. (2005b) and Wongswan (2009) calculated the isolated surprise component using 1-year eurodollar futures and named it as the "Path Surprise." I followed the same methodologies but used 10-year Treasury futures instead of eurodollar futures. To prevent confusion in the term, I labeled the isolated surprise component as the "Residual Surprise."

TABLE 7. RESIDUAL SURPRISE AND THE RESPONSES TO U.S. MONETARY POLICY SURPRISES

VARIABLES	(1) GOV2	(2) GOV5	(3) GOV10	(4) FX
FF	0.479***	0.498***	0.374***	-1.891***
	(0.105)	(0.107)	(0.0457)	(0.339)
Residual	-0.0828**	-0.0930**	-0.0408***	0.372***
	(0.0421)	(0.0455)	(0.0123)	(0.116)
FF × CRISIS	0.783***	0.395**	0.614**	-9.045***
	(0.269)	(0.154)	(0.267)	(1.431)
Residual × CRISIS	0.0967**	0.128***	0.0782***	-0.470***
	(0.0424)	(0.0467)	(0.0136)	(0.128)
FF × POST	0.823**	1.312***	2.441***	-26.38***
	(0.341)	(0.248)	(0.405)	(2.774)
Residual × POST	0.125**	0.181***	0.144***	-0.586***
	(0.0521)	(0.0496)	(0.0202)	(0.150)
CRISIS	0.00338	0.00101	-0.0108***	-0.171***
	(0.00937)	(0.00614)	(0.00360)	(0.0275)
POST	0.00458	0.00117	-0.00526*	-0.0987***
	(0.00979)	(0.00506)	(0.00319)	(0.0219)
Constant	-0.00487	-0.00451	0.00120	0.0522***
	(0.00547)	(0.00508)	(0.00230)	(0.0166)
Observations	4,479	4,436	4,627	4,885
R-squared	0.003	0.034	0.058	0.074
Number of Country	46	45	46	36
Adjusted R-squared	-0.00886	0.0222	0.0473	0.0655

Note: The dependent variable is daily change in 2-year (GOV2), 5-year (GOV5), 10-year (GOV10) ahead government bond yield and daily percentage change in foreign exchange spot rate in dollars per unit of non US currency (FX) bracketing an FOMC announcement. The entries labeled "FF" denote a 30-minute window change in the Fed Fund Futures around an FOMC announment. The entries labeled "Residual" denote a 30-minute change in the 10-year Treasury Futures that is orthogonal to "FF". "CRISIS" is 1 in the sample period between Nov 2008 and Dec 2015. "POST" is 1 in the sample period after Dec 2015. Standard errors in parentheses are estimated by a bootstrapping method with 200 repetitions. *** p<0.01, ** p<0.05, * p<0.1

unravel the puzzle in the correspondence between the yield curve and the components of the monetary policy decisions.

VI. *Conclusion*

The world after the pandemic may be different to the world that was. Yet as the Fed's resumption of tightening monetary policy shows, it has also become clear that much of what is happening is not new. In order to learn lessons from the past, I investigated how the Fed's dependence on unconventional monetary policy after the financial crisis and its return to conventional policy in 2015 have affected the global influence of U.S. monetary policy. To address this question, I divided sample periods into three phases according to the Fed's monetary policy regimes: pre-crisis, crisis, and post-crisis.

Overall, my results demonstrate the consequences of the chasm between U.S. monetary

policies and those of other countries. I showed that the global monetary policy divergence forced foreign financial markets to respond elastically to changes in the Fed Funds rate. The outbreak of COVID-19 led to the adoption of unconventional monetary policy in many central banks around the world again. As the Fed departs from the ZLB and QE by raising the Fed Funds rate in 2022, many countries would be exposed to the expanding gap of interest rates between U.S. and themselves. My findings can help foreign policymakers account for the strengthened influence of U.S. monetary policy shocks as they attempt to stabilize their economies in the post-COVID era.

References

Anzuini, A and F. Fornari (2012), "Macroeconomic determinants of carry trade activity," *Review of International Economics* 20 (3), pp.468-488.

Banerjee, R, M. Devereux, and G. Lombardo (2016), "Self-oriented monetary policy, global financial markets and excess volatility of international capital flows," *Journal of International Money and Finance* 68, pp.275-297.

Bauer, M and C. Neely (2014), "International channels of the Fed's unconventional monetary policy," *Journal of International Money and Finance* 44, pp.24-46.

Borio, C and H. Zhu (2012), "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?," *Journal of Financial Stability* 8 (4), pp.236-251.

Bowman, D, J. Londono, and H. Sapriza (2015), "US unconventional monetary policy and transmission to emerging market economies," *Journal of International Money and Finance* 55, pp.27-59.

Caceres, C, M. Carriere-Swallow, I. Demir, and B. Gruss (2016), *US monetary policy normalization and global interest rates*, International Monetary Fund.

Chen, Q, A. Filardo, D. He, and F. Zhu (2016), "Financial crisis, US unconventional monetary policy and international spillovers," *Journal of International Money and Finance* 67, pp.62-81.

Claus, E, I. Claus, and L. Krippner (2018), "Asset market responses to conventional and unconventional monetary policy shocks in the United States," *Journal of Banking & Finance* 97, pp.270-282.

Edwards, S (2007), "Capital controls, capital flow contractions, and macroeconomic vulnerability," *Journal of International Money and Finance* 26 (5), pp.814-840.

Gagnon, J, T. Bayoumi, J. Londono, C. Saborowski, and H. Sapriza (2017), "Unconventional monetary and exchange rate policies," *International Finance Discussion Paper*.

Gertler, M and P. Karadi (2015), "Monetary policy surprises, credit costs, and economic activity," *American Economic Journal: Macroeconomics* 7 (1), pp.44-76.

Gilchrist, S, D. López-Salido, and E. Zakrajšek (2015), "Monetary policy and real borrowing costs at the zero lower bound," *American Economic Journal: Macroeconomics* 7 (1), pp.77-109.

——, V. Yue, and E. Zakrajšek (2016), "The response of sovereign bonds yields to US monetary policy," *Series on Central Banking Analysis and Economic Policies* no. 24.

Gürkaynak, R, B. Sack, and E. Swanson (2005a), "The sensitivity of long-term interest rates to economic news: evidence and implications for macroeconomic models," *American*

Economic Review 95 (1), pp.425-436.

——, ——, and —— (2005b), "Do actions speak louder than words? The response of asset prices to monetary policy actions and statements," *International Journal of Central Banking* 1 (1), pp.55-93.

Hartley, J and A. Rebucci (2020), "An event study of COVID-19 central bank quantitative easing in advanced and emerging economies", Technical Report, National Bureau of Economic Research.

Inoue, A and B. Rossi (2019), "The effects of conventional and unconventional monetary policy on exchange rates," *Journal of International Economics* 118, pp.419-447.

Krippner, L (2013), "Measuring the stance of monetary policy in zero lower bound environments," *Economics Letters* 118 (1), pp.135-138.

Kuttner, K (2001), "Monetary policy surprises and interest rates: Evidence from the Fed funds futures market," *Journal of Monetary Economics* 47 (3), pp.523-544.

Lim, J and S. Mohapatra (2016), "Quantitative easing and the post-crisis surge in financial flows to developing countries," *Journal of International Money and Finance* 68, pp.331-357.

Meinusch, A and P. Tillmann (2016), "The macroeconomic impact of unconventional monetary policy shocks," *Journal of Macroeconomics* 47, pp.58-67.

Moulton, B (1986), "Random group effects and the precision of regression estimates," *Journal of Econometrics* 32 (3), pp.385-397.

Neely, C (2015), "Unconventional monetary policy had large international effects," *Journal of Banking & Finance* 52, pp.101-111.

Pagan, A (1984), "Econometric issues in the analysis of regressions with generated regressors," *International Economic Review*, pp.221-247.

Rey, H (2016), "International channels of transmission of monetary policy and the mundellian trilemma," *IMF Economic Review* 64 (1), pp.6-35.

Shang, F (2022), "The effect of uncertainty on the sensitivity of the yield curve to monetary policy surprises," *Journal of Economic Dynamics and Control* 137.

Swanson, E and J. Williams (2014), "Measuring the effect of the zero lower bound on medium and longer-term interest rates," *American Economic Review* 104 (10), pp.3154-85.

Tillmann, P (2020), "Monetary policy uncertainty and the response of the yield curve to policy shocks," *Journal of Money, Credit and Banking* 52 (4), pp.803-833.

Wongswan, J (2009), "The response of global equity indexes to US monetary policy announcements," *Journal of International Money and Finance* 28 (2), pp.344-365.