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US MONETARY POLICY AND INTERNATIONAL BOND MARKETS

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ABSTRACT

This paper uses high-frequency financial data to analyze the effects of US monetary policy—during the conventional and unconventional policy regimes—on international bonds markets. We focus on yields of dollar-denominated sovereign bonds issued by more than 90 countries since the early 1990s, which allows us to abstract from the policy-induced movements in exchange rates that otherwise confound the response of yields on foreign bonds denominated in local currencies. Our results show that yields on dollar-denominated sovereign debt are highly responsive to unanticipated changes in the stance of US monetary policy during both the conventional and unconventional policy regimes, and that the passthrough of unconventional policy actions to foreign bond yields is, on balance, comparable to that of conventional policy actions. In addition, a conventional US monetary easing leads to a significant narrowing of credit spreads on sovereign bonds issued by countries with a speculative-grade credit rating. During the unconventional policy regime, however, yields on speculative-grade sovereign debt move one-to-one with policy-induced fluctuations in yields on comparable US Treasuries. We also examine whether the response of sovereign credit spreads to US monetary policy differs between policy easings and policy tightenings and find no evidence of such asymmetry. This finding casts doubt on the notion that US monetary easings induce excessive risk-taking in international bond markets.

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1 Introduction

Among financially interconnected economies, unanticipated changes in the stance of monetary policy in one country can quickly "spill over" to other countries. While the debate surrounding monetary policy spillovers has a storied history in international economics (see Fleming, 1962; Mundell, 1963), the 2008–09 global financial crisis and its aftermath—a period during which the Federal Reserve and many other central banks implemented new and unconventional forms of monetary stimulus—has sparked intense interest in such international monetary policy spillovers, in both academic and policy circles (see Bernanke, 2018).

The canonical view of international monetary policy interactions, as exemplified by the Mundell-Fleming model, identifies the exchange rate channel as the primary mechanism through which domestic monetary policy actions affect macroeconomic conditions abroad.[1] At the same time, a monetary policy easing at home will lower domestic longer-term interest rates and raise prices of risky financial assets in the home country. With highly integrated global financial markets, investor portfolio rebalancing efforts will lead to capital flows to foreign countries, putting downward pressure on foreign longer-term yields and upward pressure on foreign asset prices, thereby easing financial conditions abroad.

In this paper, we contribute to the understanding of this so-called financial spillover channel. Specifically, using high-frequency price data on dollar-denominated sovereign bonds, we empirically quantify the transmission of US monetary policy shocks in international bond markets. By focusing on the dollar-denominated sovereign debt, we abstract from the policy-induced movements in exchange rates that can otherwise confound the response of yields on foreign bonds denominated in local currencies. Our results, therefore, quantify the extent of US monetary policy spillovers to foreign bond yields, which are entirely due to the financial channel as opposed to the exchange rate channel.[2] In addition, compared with most of the literature on monetary policy spillovers, we use a nearly ideal measure of unexpected changes in the stance of US monetary policy to identify policy shocks. Using these shocks, we analyze whether the strength and scope of the spillover effects differ between the conventional and unconventional US monetary policy regimes. Lastly, we examine how US monetary policy affects the credit spreads of dollar-denominated sovereign bonds.

[1] According to this view, a monetary easing at home lowers the domestic interest rate relative to foreign rates, inducing a depreciation of the domestic currency. One key implication of the Mundell-Fleming framework is that a central bank cannot freely adjust its policy rate to stabilize domestic output, while also maintaining a fixed exchange rate and an open capital account—a tradeoff frequently referred to as the "international policy trilemma" (see Obstfeld and Rogoff, 2002). Consistent with this prediction, Obstfeld et al. (2005), Goldberg (2013), Klein and Shambaugh (2015), and Obstfeld (2015), have shown that short-term interest rates of countries with flexible exchange rates have an appreciably lower correlation with the short-term rate of the "base" country, relative to countries with fixed exchange rates. Recently, however, Rey (2013, 2016) has argued that even floating exchange rates will not suffice to insulate domestic financial conditions from foreign monetary policy shocks—at least not without additional restrictions on capital mobility—thereby, reducing the "trilemma" to a "dilemma."

[2] In principle, one could convert local currency bonds into dollar-denominated bonds using FX swap agreements. However, as shown by Du et al. (2018), there is a significant time-varying gap between the FX-swap-implied dollar yield paid by foreign governments and the U.S. Treasury dollar yield. Using dollar-denominated sovereign bonds, therefore, provides a direct approach to study the financial spillover channel of US monetary policy to international bond markets.

To compare the transmission of conventional and unconventional policy measures to international bond markets, we follow Hanson and Stein (2015) and Gertler and Karadi (2015) and use changes in the 2-year nominal US Treasury yield on policy announcement days as a common instrument across the two policy regimes. In contrast to these two papers, we rely on the *intraday* changes in the 2-year US Treasury yield within a narrow window bracketing Federal Open Market Committee (FOMC) and other policy announcements to identify unanticipated US policy actions.[3] Implicit in this approach is a highly reasonable identifying assumption that any movement in the 2-year US Treasury yield in a narrow window bracketing policy announcements is due to the unanticipated changes in the stance of US monetary policy or the FOMC's communication regarding the path for policy going forward.

During the unconventional policy regime, the Federal Reserve implemented different forms of forward guidance regarding the future path of the federal funds rate. The FOMC also implemented a number of Large-Scale Asset Purchase programs (LSAPs), the primary goal of which was to influence longer-term yields on US Treasury and agency MBS securities through direct purchases of those assets. These policy actions were introduced to the public via announcements, either following the regularly-scheduled FOMC meetings or in special announcements that were held outside the regular FOMC schedule. As discussed more fully below, we analyze the extent and scope of US monetary policy spillovers to international bond markets during both the conventional and unconventional monetary policy regime.[4]

The paper contains two sets of related empirical exercises. In the first set, we analyze the response of yields on sovereign bonds denominated in US dollars to an unanticipated change in the stance of US monetary policy. Specifically, from the Thompson Reuters Datastream, we obtained daily secondary market prices of dollar-denominated sovereign bonds issued by more than 90 countries, both emerging market and advanced economies. We exploit the cross-sectional heterogeneity of our data by constructing sovereign bond portfolios. First, we construct bond portfolios based on duration. Second, the portfolios are conditional on whether a country falls into a speculative- or investment-grade portion of the credit quality spectrum. Consequently, we are able to quantify how the effects of US monetary policy on sovereign bond yields (and credit spreads) differs not only across the conventional and unconventional policy regimes but also across "high" and "low" risk countries.

The results from this exercise indicate that conventional US monetary policy is transmitted

[3] Hanson and Stein (2015) and Gertler and Karadi (2015) use *daily* changes in the 2-year US Treasury yield to identify monetary policy surprises. The use of intraday data allows us to rule out the potential reverse causality, a situation in which the daily change in the 2-year US Treasury yield, even on a policy announcement day, may not solely reflect changes in the stance of monetary policy but may also reflect the endogenous response of policy to changes in the economic outlook or other global macroeconomic or financial shocks.

[4] The start of the unconventional US policy regime can be dated to November 25, 8:15 a.m. Eastern Standard Time, when the FOMC announced—outside its regular meeting schedule—that it was going to initiate a program to purchase the direct obligations of, and mortgage-backed securities (MBS) issued by, the housing-related government-sponsored enterprises. A mere three weeks later, at the conclusion of its regular meeting on December 16, the FOMC announced that it was lowering the target federal funds rate to a range between 0 to 1/4 percent—its effective lower bound. Our definition of the conventional policy regime includes the "post-liftoff" period, that is, the period after December 16, 2015, when the FOMC raised the policy rate from its effective lower bound.

very effectively to both shorter- and longer-duration yields on dollar-denominated sovereign debt. The spillover effects of conventional US monetary policy across the portfolios of different durations are much more uniform compared with the unconventional policy regime. That said, the extent of spillovers from the US unconventional monetary policy actions to foreign bond yields is, on balance, similar to that estimated for the conventional policy regime. Our results also indicate that conventional US monetary policy has a differential effect on the yields of sovereign securities of different credit ratings, whereas the unconventional monetary policy actions had a similar effects on the investment- and speculative-grade sovereign bond yields.

Our second set of empirical exercises focuses on the sovereign bond credit spreads. An additional advantage of building bond portfolios from the "ground up" is that we can construct credit spreads that are not subject to the duration mismatch, which is a common problem plaguing standard sovereign credit spread indexes, such as the EMBI or EMBI+. The results from this set of exercises show that conventional US monetary policy actions have an economically large and statistically significant effect on credit spreads of dollar-denominated debt of countries with a speculative-grade credit rating. Specifically, credit spreads on risky sovereign debt are estimated to narrow (widen) significantly in response to an unanticipated US policy easing (tightening) during the conventional regime. Sovereign credit spreads for investment-grade countries, by contrast, do not respond to conventional US monetary policy; in other words, sovereign bond yields for low-risk countries are estimated to decline (increase) by about as much as the yields on comparable US Treasuries in response to a conventional US monetary policy easing (tightening).

The US monetary policy spillovers to international bond markets during the unconventional policy regime are somewhat more muted, according to our estimates. An unanticipated easing of US monetary policy during this period induces a decline in speculative-grade sovereign bond yields that is commensurate with that of yields on a portfolio of comparable US Treasuries. Interestingly, our results indicate that the passthrough of unconventional US monetary policy to sovereign bond yields for investment-grade countries is essentially one-to-one, that is, the same as during the conventional policy regime. Our analysis thus indicates that the unconventional policy actions undertaken by the FOMC over the past five years or so did not affect, on average, the level of sovereign credit spreads across the credit quality spectrum.

Lastly, we examine whether US monetary policy tightenings and easings have an asymmetric effect on international bond markets. To do so, we split our policy surprises based on their sign (i.e., positive vs. negative) and then estimate the response of sovereign bond credit spreads to those two shocks. We find no evidence of such asymmetry, a result that casts doubt on the notion that US monetary easings induce excessive risk-taking in international bond markets.

Our paper fits into a rapidly growing empirical literature aimed at quantifying the effects of unconventional policy measures on financial asset prices. Not too surprisingly, much of this research to date has analyzed whether purchases of large quantities of Treasuries, agency MBS, and agency debt by the Federal Reserve and various forms of forward guidance have lowered longer-term US benchmark yields and the associated private interest rates; see, for example, Gagnon et al.

(2011); Krishnamurthy and Vissing-Jorgensen (2011); Swanson (2011); Hamilton and Wu (2012); Justiniano et al. (2012); Wright (2012); D'Amico and King (2013); Gilchrist and Zakrajšek (2013); Gilchrist et al. (2015); and Hanson and Stein (2015)). While employing a variety of empirical approaches, a common finding that emerges from these studies is that the unconventional policy measures employed by the FOMC since the end of 2008 have led to a significant reduction in Treasury yields and that this broad-based reduction in longer-term interest rates has been passed fully to lower borrowing costs for businesses and households.[5]

To gauge the impact of LSAPs beyond US borders, Neely (2015) employs an event-style methodology and finds that these unconventional policy actions substantially lowered the foreign exchange value of the US dollar and reduced longer-term yields yields for a small sample of advanced foreign economies; Chen et al. (2014) report similar results for emerging market economies. In a follow-up paper, Bauer and Neely (2014) use dynamic term structure models to parse out the extent to which the declines in foreign interest rates occurred through the signaling or portfolio rebalancing channels and find evidence that both channels were in operation. Our paper is also related to the recent work of Fratzscher et al. (2014) and Bowman et al. (2015); the former paper systematically analyzes the global spillovers of the Federal Reserve's asset purchase programs on a broad array of financial asset prices, while the latter study empirically quantifies the spillover effects of US unconventional policies on emerging market economies. The key takeaway of these two papers is that US unconventional monetary policy measures induced a significant portfolio reallocation among investors and led to a notable repricing of risk in global financial markets.[6]

In a recent paper, Albagli et al. (2018) document significant US monetary policy spillovers to international bond markets. They identify US monetary policy shocks as changes in the short-term US Treasury yields within two days of FOMC meetings, and they trace the effects of those changes on international bond yields using panel regressions. They document that spillovers to long-term foreign bond yields have increased substantially after the global financial crisis. The main difference with our study is that they analyze international bonds denominated in local currencies. As such, they provide evidence consistent with an exchange rate channel, according to which foreign central banks face a tradeoff between narrowing policy rate differentials, or experiencing currency movements against the US dollar. We, on the other hand, focus on the dollar-denominated sovereign bonds, and our US monetary policy shocks are much better identified because we use intraday high-frequency data to compute changes in short-term US Treasury yields in narrow windows bracketing FOMC announcements. The study by Gagnon et al. (2017) explores the direct effects and spillovers of unconventional monetary and exchange rate policies and finds that increases in US bond yields are associated with increases in foreign bond yields and stock prices, as well as with a depreciation of foreign currencies.

[5] Rogers et al. (2014), on the other hand, compares the efficacy of unconventional policy measures employed by the Bank of England, European Central Bank, and the Bank of Japan.

[6] The work of Bredin et al. (2010), Ehrmann et al. (2011), and Hausman and Wongswan (2011) documents the extent of spillovers in international bond markets resulting from the unanticipated changes in the conventional stance of US monetary policy.

Our paper is also related to the research based on small open economy models that feature foreign interest rate shocks and some form of financial market frictions (see Neumeyer and Perri, 2005; Uribe and Yue, 2006). These papers show that movements in sovereign credit spreads are an important driver of business cycles dynamics in emerging market economies and that these spreads are influenced importantly by fluctuations in the world interest rate, namely, the long-term US Treasury yield (see also Kamin and von Kleist, 1999; Eichengreen and Mody, 2010). The analysis of these papers, however, uses monthly or quarterly changes in long-term US interest rates to estimate the spillover effects of US monetary policy to international bond markets. An important advantage of our approach is that we use high-frequency data to more cleanly identify unanticipated changes in the stance of US monetary policy and to trace out the causal effect of these changes on sovereign credit spreads. Indeed, our empirical results, in contrast to the aforementioned studies, show that unanticipated changes in the stance of US monetary policy do not significantly affect sovereign credit spreads.

The outline for the reminder of the paper is as follows: Section 2 outlines our empirical methodology. In Section 3, we present our main results: subsection 3.1 discusses the construction of the dollar-denominated sovereign bond portfolios using bond-level data; subsection 3.2 contains the results that compare the effects of US monetary policy—across the different policy regimes—on yields of short- and long-duration sovereign bond portfolios and on yields of speculative- and investment-grade bond portfolios; subsections 3.3 and 3.4 present the results showing how US monetary policy affects sovereign bond credit spreads; and subsection 3.5 explores potential asymmetries of US monetary policy spillovers. Section 4 concludes.

2 Empirical Framework

This section outlines the empirical approach that is used to estimate the impact of US monetary policy on international bond markets during both the conventional and unconventional policy regimes. Central to our approach is the use of *intraday* data, from which we can directly infer monetary policy surprises associated with FOMC announcements. In combination with the daily data on foreign interest rates, these high-frequency policy surprises allow us to estimate the causal effect of US monetary policy actions on foreign bond yields.

Our analysis requires dating the two monetary policy regimes. The sample period underlying our analysis runs from January 2, 1992, to April 30, 2019. We divide this period into two distinct policy regimes: (*i*) a *conventional* monetary policy regime, a period in which the primary policy instrument was the federal funds rate; and (*ii*) an *unconventional* monetary policy regime, during which the funds rate has been stuck at the effective lower bound, and the FOMC primarily conducted monetary policy by altering the size and composition of the Federal Reserve's balance sheet and also by issuing various forms of forward guidance regarding the future trajectory for the federal funds rate.

As in Gilchrist et al. (2015), we assume that the unconventional policy regime began on November 25, 2008, and that prior to that day, the conventional policy regime was in effect. The unconventional policy regime ended on December 16, 2015, with the liftoff of the federal funds rate from its effective lower bound. Thus, the conventional US monetary policy regime is assumed to cover two non-overlapping periods: (i) from February 6, 1992 to December 15, 2008; and (ii) from December 17, 2015 to March 29, 2019, the end of our sample period. Virtually all of the 169 announcements during the conventional policy period followed regularly-scheduled FOMC meetings; only six were associated with the intermeeting policy moves.[7]

The standard analysis of how changes in the stance of conventional US monetary policy affect financial asset prices has historically relied on a single factor—the "target" surprise or the unanticipated component of the change in the current federal funds rate target (see, Kuttner (2001); Cochrane and Piazzesi (2002); and Bernanke and Kuttner (2005)). However, as shown by Gürkaynak et al. (2005), this characterization is incomplete, and another factor—that is, changes in the future policy rates that are independent of the current target rate—is needed to capture fully the effect of conventional monetary policy. This second factor, which is commonly referred to as a "path" surprise, is closely associated with the FOMC statements that accompany changes in the target rate and represents a communication aspect of monetary policy that assumed even greater importance after the target rate was lowered to its effective lower bound in December 2008.

To facilitate the comparison of the spillover effects from conventional and unconventional US monetary policy, we follow Hanson and Stein (2015) and Gertler and Karadi (2015), and assume that the change in the 2-year nominal US Treasury yield over a narrow window bracketing an FOMC announcement captures both aspects of US monetary policy. Under this assumption, the effect of unanticipated changes in the stance of US monetary policy on foreign interest rates can be inferred by estimating the following regression:

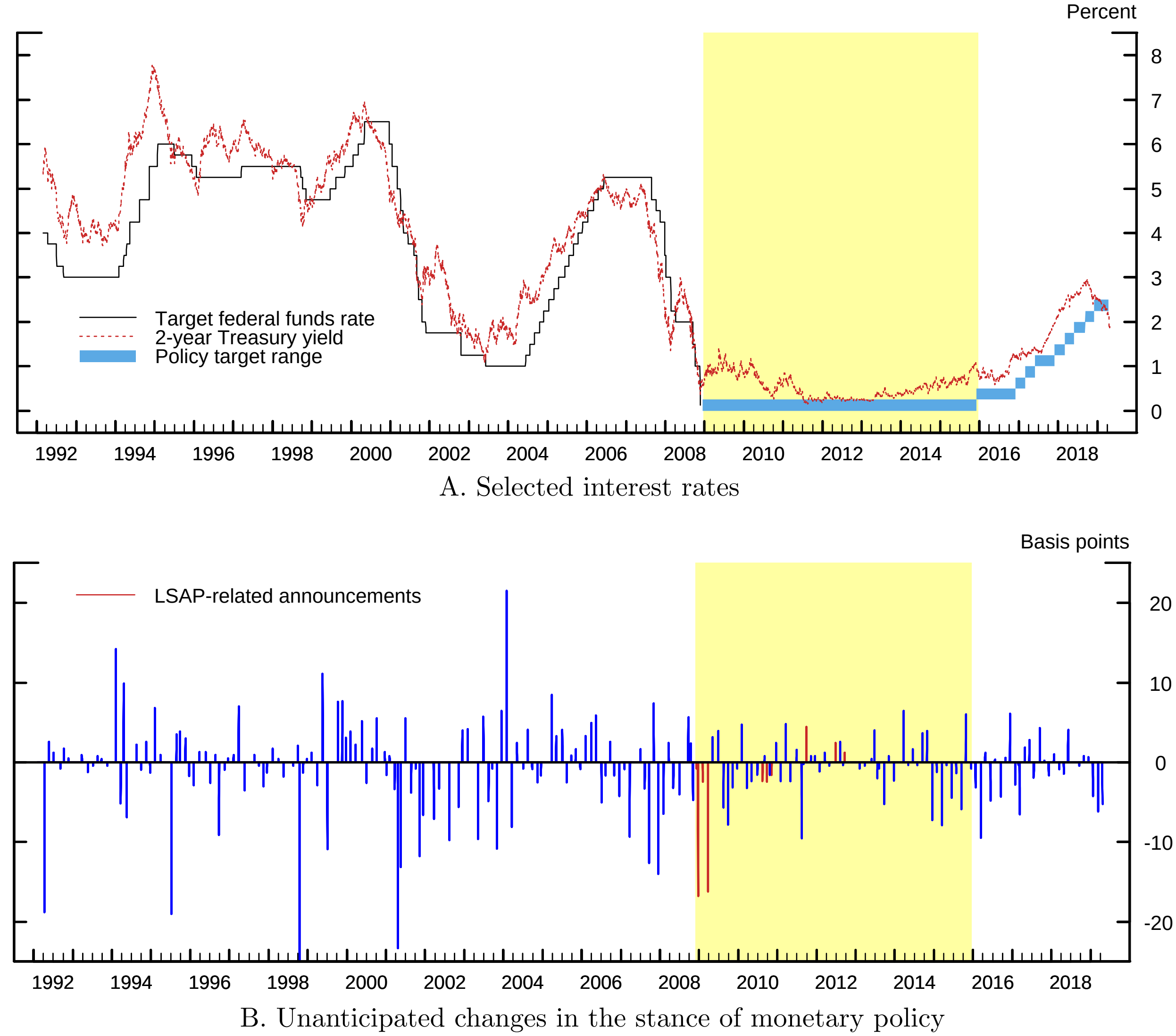
$$\Delta_h y^{(n)}_{i,t+h-1} = \alpha^{(n)}_i m^{US}_t + \epsilon^{(n)}_{i,t+h-1}, \tag{1}$$

where $\Delta_h y^{(n)}_{i,t+h-1}$ denotes an h-day change (from day $t-1$ to day $t+h-1$) bracketing an FOMC announcement on day t in the yield on an n-year sovereign bond of country i; m^{US}_t is the *intraday* change in the (on-the-run) 2-year nominal US Treasury yield over a narrow-window surrounding an FOMC announcement; and, $\epsilon^{(n)}_{i,t+h-1}$ is a stochastic disturbance capturing the information that possibly was released earlier in the day, and also noise from other financial market developments that took place through day $t+h-1$.

For the conventional US policy regime, we measure the unanticipated changes in the stance of monetary policy m^{US}_t using a *30-minute* window surrounding FOMC announcements (10 minutes before to 20 minutes after). However, the unconventional policy regime includes a number of

[7]As is customary, we excluded from the sample the announcement made on September 17, 2001, which was made when trading on major stock exchanges was resumed after it was temporarily suspended following the 9/11 terrorist attacks. The other six intermeeting moves occurred on April 18, 1994; October 15, 1998; January 3, 2001; April 18, 2001; January 22, 2008; and October 8, 2008. Most of the FOMC announcements took place at 2:15 p.m. (EST); however, announcements for the intermeeting policy moves were made at different times of the day. We obtained all of the requisite times from the Office of the Secretary of the Federal Reserve Board.

FIGURE 1 – The Stance of US Monetary Policy



NOTE: Sample period: daily data from 01/02/1992 to 03/29/2019. The black line and the shaded band in Panel A depict the stance of US monetary policy, while the red line shows the daily 2-year Treasury yield. Panel B depicts unanticipated changes in the stance of monetary policy, as measured by the narrow-window changes in the 2-year Treasury yield bracketing FOMC announcements (see the text for details). The shaded region represents the unconventional US monetary policy regime (see Table A-1 in the Data Appendix for the list of LSAP-related announcements).

key speeches/testimonies through which the policymakers elaborated on the various aspects of unconventional policy measures being employed by the FOMC. In these instances, we try to capture the information content of announcements that reflects the market participants' interpretation of the statements and speeches—as opposed to conveying information about the precise numerical value of the target funds rate—so we use a wider *60-minute* window bracketing an announcement (10 minutes before to 50 minutes after) to calculate the intraday changes in the 2-year US Treasury yield. The use of a 60-minute window to calculate the policy surprise m_t^{US} during this period should allow the market a sufficient amount of time to digest the news contained in announcements associated with unconventional policy measures.[8]

Panel A of Figure 1 shows the path of the target federal funds rate and the 2-year Treasury yield over the entire sample period. Our sample period is marked by substantial variation in shorter-term interest rates and contains a number of distinct phases of US monetary policy: The 1994–1995 tightening phase that followed the "jobless" recovery during the early-1990s; the tightening phase that preceded the bursting of the "tech bubble" in early 2001; the subsequent easing of policy in response to a rapid slowdown in economic activity and the emergence of substantial disinflationary pressures; the 2003–2004 period of very low interest rates; the gradual removal of monetary accommodation that commenced in the spring of 2004; the aggressive reduction in the target federal funds rate during the early stages of the 2007–2009 financial crisis; the 2009–2015 period when the federal funds rate was stuck at its effective lower bound; and the post-2015 period of policy normalization, as the FOMC begun to raise gradually the target federal funds rate from its effective lower bound.

Panel B depicts the sequence of monetary policy surprises—that is, the value of m_t^{US}—associated with the FOMC's actions during this period. During the conventional policy regime, the largest (absolute) policy surprises are associated with the intermeeting policy actions. As shown by the red spikes, the largest (absolute) surprises during the unconventional policy regimes correspond to the early LSAP announcements. For both policy regimes under consideration, we estimate equation (1) by OLS. As noted above, implicit in this approach is the assumption that movements in the 2-year Treasury yield in narrow windows bracketing FOMC announcements are entirely due to the unanticipated changes in the stance of US monetary policy. By any measure, this is a reasonable assumption because we are virtually certain that no other important economic news was released within that interval of time.[9]

[8] To separate the effect of balance sheet policies from other forms of unconventional policy, we also consider a subsample of the unconventional policy period that excludes the 12 announcements listed in Table A-1, which are most closely identified with the asset purchase programs. These results are available from the authors upon request.

[9] It is possible that other economic or political news or policy actions by foreign central banks might coincide with the US monetary policy shocks, especially during the unconventional policy regime; see Greenlaw et al. (2018) for a detailed analysis of major news events on the day when the US bond market had a big move during the unconventional policy regime. However, as documented by Albagli et al. (2018), while US monetary policy news is not always the only event moving US Treasury yields on FOMC announcement days, this is the case much more often than not—the overlap frequency between FOMC meetings and all other major country events is only about seven percent at the daily frequency. Our measure of US monetary policy surprises is based on yield changes over the 30- or 60-minute window bracketing FOMC announcements and thus is even less affected by such news. In our case, the impact of other news on international bond markets gets impounded in the error terms of our regressions, which would affect the precision of our estimates but not their consistency.

3 US Monetary Policy and Sovereign Bond Yields

3.1 Data Sources and Methods

To abstract from the policy-induced movements in exchange rates that confound the response of yields on foreign bonds denominated in local currencies, our paper focuses on sovereign debt denominated in US dollars. To that purpose, we downloaded from Thompson Reuters Datastream daily secondary market prices of dollar-denominated sovereign bonds issued by 95 countries (see Table A-2 in Appendix A for further details).[10] The data set includes the bond characteristics such as the issuance and maturity dates, issue amount, coupon structure, as well as the daily time series of prices.

The micro-level aspect of our data allows us to compute bond yields at the security level. We then construct portfolios of such dollar-denominated bond yields based on various bond characteristics, such as duration and credit risk. We use these portfolios to estimate the response of foreign yields to US monetary policy. To understand the economic implications of these estimates, we are also interested in estimating the extent to which such yields respond more or less than matched-duration US Treasury yields. Such a comparison tells us the extent to which credit spreads, and hence sovereign risk, respond to US monetary policy.

Importantly, because we construct bond yields from the underlying micro data on individual bond prices, we can construct credit spreads that are free of the duration mismatch, which is a common problem in many of the standard credit spread indexes. Specifically, in our analysis, we follow the methodology outlined in Gilchrist and Zakrajšek (2012) and construct a synthetic US Treasury security that exactly replicates the cash-flows of the corresponding sovereign debt instrument.

Formally, we consider a dollar-denominated sovereign bond k (issued by country i) that at time t is promising a sequence of cash-flows denoted by $\{C(s) : s = 1, 2, \dots, S\}$.[11] The price of this bond at time t is given by

$$P_{it}[k] = \sum_{s=1}^{S} C(s)D(t_s),$$

where $D(t) = \exp(-r_t t)$ denotes the discount function in period t. To calculate the price of the corresponding synthetic US Treasury security—as denoted by $P_t^{US}[k]$—we discount the cash-flow sequence $\{C(s) : s = 1, 2, \dots, S\}$ using continuously-compounded zero-coupon US Treasury yields in period t, which are obtained from the daily estimates of the US Treasury yield curve based on the methodology of Gürkaynak et al. (2007). The resulting price $P_t^{US}[k]$ can then be used to calculate the yield—denoted by $y_t^{US}[k]$—of a hypothetical US Treasury security with exactly the same cash-

[10] As can be seen from Table A-2, a significant proportion of our sample of sovereign bonds is accounted for by securities issued by Israel. To ensure that our results were not unduly influenced by the over-representation of Israeli securities in our sample, we re-did the analysis by excluding these securities from the sample. All the empirical results, however, were essentially the same, both qualitatively and quantitatively, as those reported below.

[11] The cash-flow sequence $\{C(s) : s = 1, 2, \dots, S\}$ consists of the regular coupon payments and the repayment of the principle at maturity.

Table 1 – Selected Sovereign Bond Characteristics
(*Dollar-Denominated Bonds*)

Bond Characteristic	Mean	StdDev	Min	P50	Max
No. of bonds per country	18.40	47.64	1	8	454
Maturity at issue (years)	15.06	8.39	1.34	10.25	33
Term to maturity (years)	8.22	6.35	1	6.68	30
Duration (years)	6.05	3.54	0.91	5.51	18.87
Par amount ($millions)[a]	564.83	879.62	1.09	57.27	11,209
Sovereign credit rating (Moody's)	-	-	Ca	A1	Aaa
Coupon rate (pct.)	4.62	3.27	0.00	5.00	13.63
Nominal yield to maturity (pct.)	4.97	2.98	0.11	4.46	36.57
Credit spread (bps.)	224	255	−50	142	3,000

Note: Sample period: daily data from 01/02/1992 to 03/29/2019. No. of bonds = 1,748; No. of countries = 95; Observations = 1,888,320; see Table A-2 in the Data Appendix for the list of countries included in the sample. All reported statistics are based on trimmed data (see the text for details).
[a] The par amount issued is deflated by the US CPI (2005 = 100).

flows as the underlying sovereign bond. The resulting credit spread $s_{it}[k] = y_{it}[k] - y_t^{US}[k]$, where $y_{it}[k]$ denotes the yield of the sovereign bond k, is therefore free of the bias that would occur if the spreads had been computed simply by matching the sovereign yield to the estimated yield of a US Treasury security of the same maturity.

Table 1 contains the summary statistics for the key characteristics of bonds in our sample.[12] An average country in our sample has more than 18 sovereign bond issues outstanding at any point in time. However, this distribution is skewed significantly to the right by a few countries that have a very large number of issues trading in the secondary market at a point in time. In fact, the median country has only eight such issues trading in any given day.

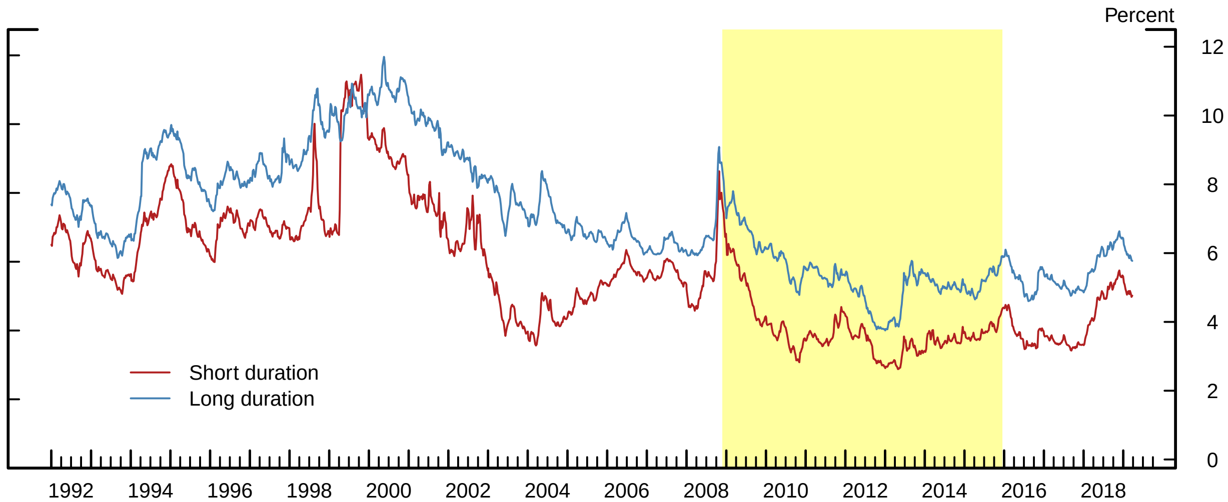
The size distribution of the sovereign bond issues is similarly skewed, with the range running from $1.1 million to more than $11 billion. The maturity of these debt instruments is fairly long, with the average maturity at issue of about 15 years. In terms of default risk—at least as measured by the Moody's sovereign credit ratings—our sample spans a significant portion of the credit-quality spectrum. However, at "A1," the median observation is well within the investment-grade category. An average sovereign bond in our sample has an expected return of 224 basis points more than a comparable US Treasury security, while the standard deviation of 255 basis points is indicative of the wide range of credit qualities in our sample.

3.2 Sovereign Bond Portfolios Yields

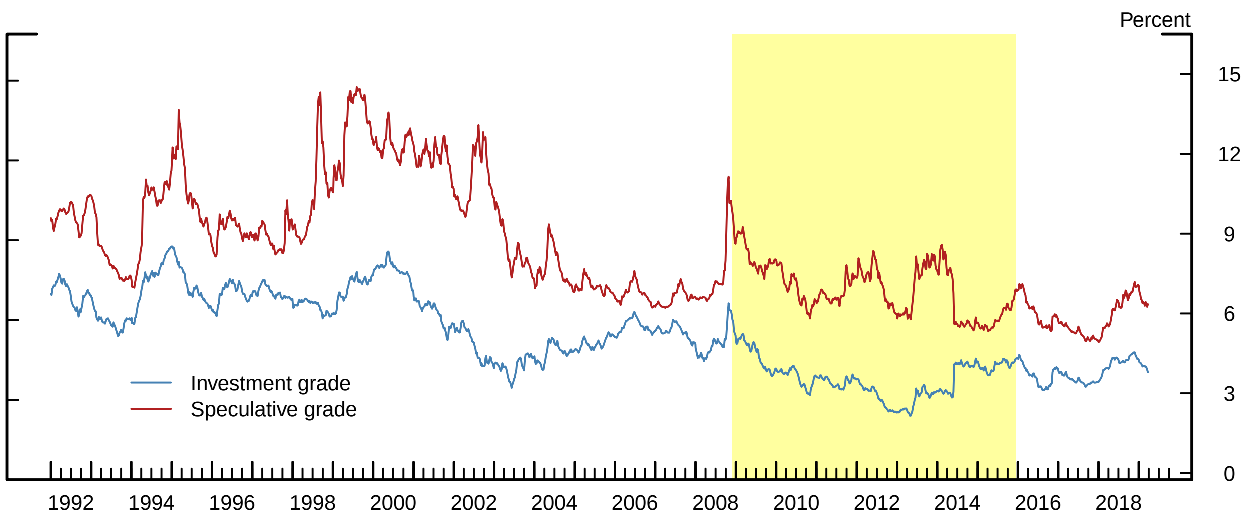
We exploit the cross-sectional heterogeneity of our data by constructing sovereign bond portfolios. All of the portfolios are weighted by the market value of the underlying bond issues in the previous

[12]To ensure that our results are not driven by a small number of extreme observations, we have eliminated observations with credit spreads of less that -50 basis points and more than $3,000$ basis points. In addition, we dropped from our sample very small sovereign debt issues (par value of less than $1 million in 2005 dollars) and all observations with a remaining term-to-maturity of less than one year or more than 30 years.

Figure 2 – Sovereign Bond Yields



A. By duration



B. By credit risk

Note: Sample period: weekly averages of daily data from 01/02/1992 to 03/29/2019. In Panel A, the two lines depict the yields on portfolios of dollar-denominated sovereign bonds of short (< 5 years) duration and long (≥ 5 years) duration. In Panel B, the two lines depict the yields on portfolios of dollar-denominated sovereign bonds with an investment- and speculative-grate ratings. The shaded region represents the unconventional US monetary policy regime.

day. The portfolios are constructed based on bond-specific characteristics that reflect both maturity and credit risk. To construct duration-specific portfolios, we sort bonds into short and long duration categories, based on whether the bond's duration (on day $t-1$) is above or below five years, a cutoff corresponding roughly to the median duration in our sample. To construct portfolios based on credit risk, we sort bonds based on whether the issuing country has a speculative- or investment-grade sovereign credit rating (on day $t-1$). The daily portfolio yields are then computed as weighted

Table 2 – The Effect of US Monetary Policy on Sovereign Bond Yields
(*h-day Changes in Duration-Based Bond Portfolio Yields*)

	Conventional MP[a]		Unconventional MP[b]	
Regressor	SD	LD	SD	LD
A. 2-day changes ($h = 2$)				
m_t^{US}	0.93***	0.85***	1.27***	1.19***
	(0.11)	(0.17)	(0.25)	(0.28)
$\Pr > E_p$[c]	<.01	<.01	<.01	<.01
R^2	0.23	0.17	0.27	0.25
B. 6-day changes ($h = 6$)				
m_t^{US}	1.21***	1.25***	1.46***	1.53**
	(0.21)	(0.32)	(0.48)	(0.58)
$\Pr > E_p$[c]	<.01	<.01	0.01	<.01
R^2	0.10	0.10	0.16	0.13

Note: The dependent variable is $\Delta_h y_{t+h-1}$, an h-day change (from day $t-1$ to day $t+h-1$) bracketing an FOMC announcement on day t in the specified bond portfolio yield: SD = portfolio of short duration (< 5 years) sovereign bonds; and LD = portfolio of long duration (≥ 5 years) sovereign bonds. The explanatory variable in all specifications is m_t^{US}, an FOMC-induced surprise in the 2-year US Treasury yield. All specifications include a constant (not reported) and are estimated by OLS. Heteroskedasticity-consistent asymptotic standard errors are reported in parentheses: * $p < .10$; ** $p < .05$; and *** $p < .01$.
[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019).
[b] 65 FOMC announcements (12/16/2008–12/16/2015).
[c] p-value for the Doornik and Hansen (2008) test of the null hypothesis of normality of the OLS residuals.

averages of security-level yields, using market values of individual bond issue in the previous day as weights. While finer gradations are possible, our sorting captures the salient differences that we observe in the data, while maintaining a significant number of bonds in each portfolio.

The solid line in Panel A of Figure 2 depicts the sovereign bond yields across the short- and long-duration bond portfolios; the same information for the investment- and speculative-grade bond portfolios is shown in Panel B.[13] Clearly there is considerable time-series variation in the bond yields of our sovereign bond portfolios. Panel A shows that sovereign bonds with long duration have higher yields than the yields in the short-duration portfolio, except during late 1990s and in 2008, when yields in both portfolios spiked to similar levels. Panel B shows that speculative-grade bonds carry a substantially higher yield than their investment-grade counterparts. This difference reflects the additional risk premium for bonds with a lower credit rating, as well as possible differences in liquidity between investment- and speculative-grade sovereign securities.

We begin by discussing the effect of a US monetary policy surprises on sovereign yields. In the conventional monetary policy regime, a tightening of US policy is associated with rising US short-term rates and a flattening of the yield curve. In contrast, in the unconventional regime, a tightening

[13]For visual purposes, we smoothed the data by taking weekly averages of the daily bond yields.

of US policy is associated with a steepening of the yield curve, as short rates are anchored at their effective lower bound. Thus, a natural starting point is to document the extent to which US monetary policy affects foreign yields across the maturity spectrum.

Specifically, we use OLS to estimate the following regression specification:

$$\Delta_h y_{p,t+h-1} = \alpha_p m_t^{US} + \epsilon_{p,t+h-1},$$

where $\Delta_h y_{p,t+h-1}$ denotes an h-day in the sovereign bond portfolio yield associated with short- and long-duration sovereign bonds (i.e., p = SD (short duration) and p = LD (long duration)). The h-day yield change is calculated as the change in yield from day $t-1$ to day $t+h-1$, where the yield is quoted at the market closing time of the relevant country. Given the our sample of countries covers many different time zones—and thus closing times differ across countries—we compute the h-day yield changes from day $t-1$ to day $t+h-1$, which ensures that the US policy surprise occurred within that time interval. Our baseline horizon is two days (i.e., $h = 2$), but given the potentially illiquid nature of sovereign bonds, which would lead to a delayed yield response to US monetary policy announcements, we also consider the effect of policy surprises at the 6-day horizon (i.e., $h = 6$).

Table 2 presents the results for our duration based bond portfolios. Panel A shows the results for the 2-day changes, and Panel B shows results for the 6-day changes. According to the entries in Panel A of the table, US monetary policy shocks impact sovereign bond yields across the duration spectrum. The estimates imply that a monetary policy action that raises the 2-year Treasury yield by 100 basis points leads to increases in dollar-denominated sovereign bond yields that are slightly less than 100 basis points during the conventional policy regime and somewhat more than 100 basis points during the unconventional regime. The results, however, do not imply significant differences in responses across the duration spectrum.

Regression using the 6-day changes (Panel B) produce slightly bigger estimates. In our view, this increased responsiveness likely reflects relative illiquidity of the dollar denominated sovereign bond market. Again, the estimated effects are very similar across the duration spectrum and imply larger point estimates of response coefficient during the unconventional policy regime relative to the conventional regime, though these differences are not statistically significant. In broad terms, the results in Table 2 imply a robust response of sovereign yields to US monetary policy and capture a "level" effect, whereby sovereign yields are rising one-for-one with a policy-induced increase in the US 2-year Treasury yield. In addition, we do not observe substantial differences in response across the two monetary policy regimes.

It is worth noting that Albagli et al. (2018) find that US monetary policy spillovers to long-term foreign yields have increased substantially after the global financial crisis. However, they study international bonds denominated in local currencies and provide evidence consistent with an exchange rate channel, according to which foreign central banks face a tradeoff between narrowing policy rate differentials, or experiencing currency movements against the US dollar. Our analysis focuses on the dollar-denominated sovereign bonds, an asset class where the exchange rate channel

Table 3 – The Effect of US Monetary Policy on Sovereign Bond Yields
(*h-day Changes in Credit-Risk-Based Bond Portfolio Yields*)

	Conventional MP[a]		Unconventional MP[b]	
Regressor	IG	SG	IG	SG
A. 2-day changes ($h = 2$)				
m_t^{US}	0.75***	1.07***	1.27***	1.13***
	(0.10)	(0.19)	(0.20)	(0.41)
$\Pr > E_p$[c]	<.01	<.01	<.01	<.01
R^2	0.25	0.15	0.38	0.12
B. 6-day changes ($h = 6$)				
m_t^{US}	0.77***	1.91***	1.60***	1.09
	(0.14)	(0.49)	(0.36)	(0.92)
$\Pr > E_p$[c]	<.01	<.01	<.01	0.01
R^2	0.10	0.09	0.23	0.03

Note: The dependent variable is $\Delta_h y_{t+h-1}$, an h-day change (from day $t-1$ to day $t+h-1$) bracketing an FOMC announcement on day t in the specified bond portfolio yield. IG = portfolio of sovereign bonds with an investment-grade credit rating; and SG = portfolio of sovereign bonds with a speculative-grade credit rating. The explanatory variable in all specifications is m_t^{US}, an FOMC-induced surprise in the 2-year US Treasury yield. All specifications include a constant (not reported) and are estimated by OLS. Heteroskedasticity-consistent asymptotic standard errors are reported in parentheses: * $p < .10$; ** $p < .05$; and *** $p < .01$.
[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019).
[b] 65 FOMC announcements (12/16/2008–12/16/2015).
[c] p-value for the Doornik and Hansen (2008) test of the null hypothesis of normality of the OLS residuals.

does not have a direct effect.

The estimates of the spillover effects on sovereign bonds with different durations reflect not only the impact of the US monetary policy on the yield curve, but also the effects of policy changes on the risk premiums. To examine whether lower credit quality portfolios respond more or less than higher credit quality portfolios, we now consider the sovereign yield response for the portfolios sorted by credit risk. Table 3 reports OLS estimates of the coefficients measuring the effect of a US monetary policy surprise on sovereign bond yields of portfolios with speculative- and investment-grade credit ratings (i.e., $p =$ IG (investment grade) and $p =$ SG (speculative grade)). Panel A of Table 3 shows the results at the 2-day horizon, and Panel B reports the results for the 6-day horizon.

In comparison to the portfolios sorted by duration, sorting by credit risk implies much larger differences in yield responses across credit risk categories and across monetary policy regimes. Specifically, during the conventional policy regime, the response coefficient on the portfolio of investment-grade sovereign bonds is 0.75, implying that lower risk sovereign bond yields respond significantly less than one-for-one to policy-induced changes in the 2-year US Treasury yield. In contrast, the response coefficient on the portfolio of speculative-grade sovereign bonds is much larger, especially at the 6-day horizon; in that case, our estimates imply that a US monetary policy action that raises the 2-year Treasury yield by 100 basis points leads to an increase of almost

200 basis points in the speculative-grade bond portfolio yield.

During the unconventional policy regime, however, this pattern reverses itself, as yields on speculative-grade sovereign bonds appear less responsive to US monetary policy, compared with yields on investment-grade sovereign bonds. Likely reflecting the smaller sample size, the response coefficients based on this sample period are estimated with considerably less precision, especially for the 6-day changes in speculative-grade sovereign bond yields. Moreover, the clear pattern that speculative-grade sovereign bond yields are more responsive to US monetary policy than their investment-grade counterparts that was seen during the conventional policy regime no longer appears to hold during the unconventional US monetary policy regime.

3.3 Sovereign Credit Spreads

The above analysis showed that during the conventional US monetary policy regime, yields on speculative-grade sovereign bonds responded more to monetary policy shocks than the yields on investment-grade sovereign bonds and that this pattern no longer held during the unconventional regime. These findings suggest that, at least during conventional policy regime, US monetary policy may have a strong impact on sovereign risk, especially for emerging market economies, which most often fall into the speculative-grade credit rating category.

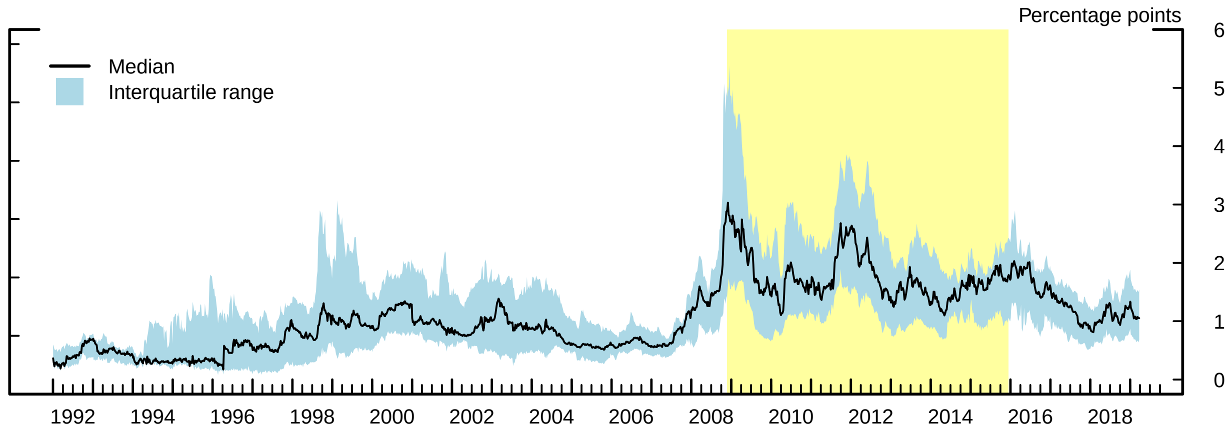
To formally analyze this issue, we now exploit our rich micro-level data to construct duration-matched portfolios of corresponding US Treasury securities, once again conditional on the sovereign's credit rating. The difference between these portfolio yields provides a measure of the spread on the sovereign yield relative to the yield on US Treasuries with matched payout characteristics. The solid line in Panel A of Figure 3 depicts the cross-sectional median of sovereign credit spreads across the investment-grade country portfolios, while the shaded band represents the corresponding interquartile range; the same information for the speculative-grade country portfolios is shown in Panel B.[14]

Clearly there is considerable cross-sectional and time-series variation in the sovereign bond portfolios in both credit rating categories. Sovereign credit spreads for riskier countries spiked up during the Mexican peso crisis that started in December 1994, as investors fled, not only Mexico, but emerging markets in general. In contrast, the jump in spreads during the Asian financial crisis in mid-1997 was noticeably less severe. The Russian financial crisis during the late summer of 1998 also led to "financial contagion," in the sense that sovereign spreads of speculative-grade countries increased sharply. Note that during these international financial crises, credit spreads on dollar-denominated sovereign bonds issued by countries with an investment-grade rating barely budged.

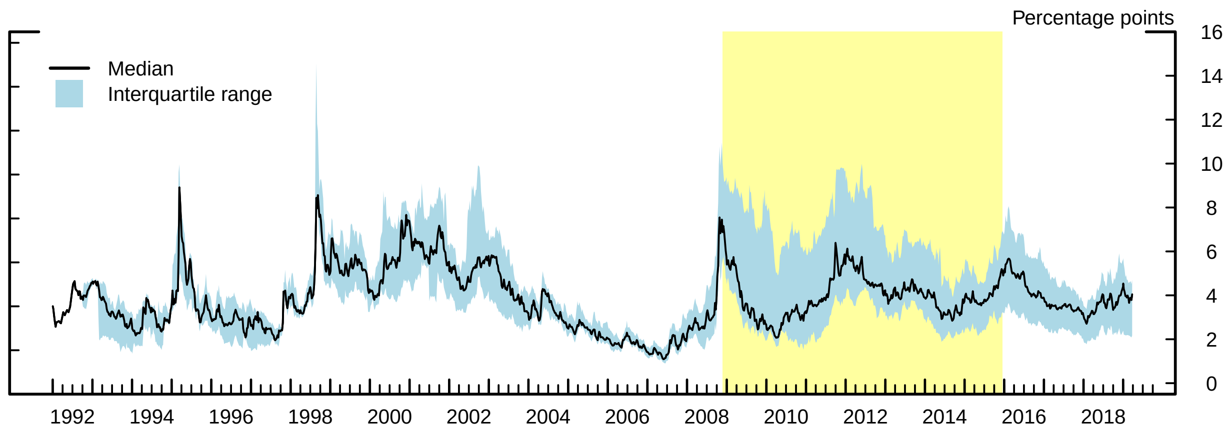
The collapse of Lehman Brothers on September 15, 2008, an event that sparked a world-wide financial panic, sent spreads sharply higher for both investment- and speculative-grade sovereign credits. Consistent with previous international financial crises, the cross-sectional dispersion of

[14] Again, for visual purposes, we smoothed the data by taking weekly averages of the daily country-specific portfolio spreads.

Figure 3 – Sovereign Credit Spreads



A. Investment-grade sovereign credits



B. Speculative-grade sovereign credits

Note: Sample period: weekly averages of daily data from 01/02/1992 to 03/29/2019. The solid line in Panel A depicts the median credit spread across country-specific portfolios of dollar-denominated sovereign bonds with an investment-grade credit rating, while the shaded bands denotes the corresponding interquartile (P75–P25) range. Panel B shows the same information for countries with a speculative-grade sovereign credit rating. The shaded region represents the unconventional US monetary policy regime.

credit spreads also widened significantly and remained high in both credit rating categories for the remainder of our sample period. The effects of the European debt crisis that started at the end of 2009 and intensified in early 2010 and thereafter are especially evident in the elevated and volatile investment-grade sovereign spreads, as it took some time for the periphery eurozone countries at the center of the crisis to be downgraded to "junk" status. Especially during this period, the impact of US unconventional monetary policy on advanced and emerging market economies became a hotly debated topic in global and national policy circles.

We begin the analysis by discussing the effect of a US monetary policy surprise on sovereign yields and the yields for the matched US Treasury portfolios. Specifically, we use OLS to estimate

Table 4 – The Effect of US Monetary Policy on Sovereign Credit Risk
(*2-day Changes in Bond Portfolio Yields*)

	Conventional MP[a]		Unconventional MP[b]	
Dependent Variables	m_t^{US}	R^2	m_t^{US}	R^2
Sovereign bond yield – IG	0.75***	0.25	1.27***	0.38
	(0.10)		(0.20)	
Sovereign bond yield – SG	1.07***	0.15	1.13***	0.18
	(0.19)		(0.41)	
US Treasury yield – IG	0.69***	0.16	1.24***	0.27
	(0.10)		(0.27)	
US Treasury yield – SG	0.53***	0.10	1.41***	0.28
	(0.12)		(0.31)	
Memo: Credit spread response[c]				
Credit spread – IG	0.05		0.03	
	(0.09)		(0.28)	
Credit spread – SG	0.53***		−0.28	
	(0.18)		(0.48)	

Note: In each specification, the dependent variable is a 2-day change (from day $t-1$ to day $t+1$) bracketing an FOMC announcement on day t in the specified bond portfolio yield: IG = portfolio of sovereign bonds with an investment-grade credit rating; and SG = portfolio of sovereign bonds with a speculative-grade credit rating. US Treasury (IG/SG) corresponds to a 2-day change in the yield on the portfolio of synthetic US Treasury securities of identical duration as the sovereign bonds in the (IG/SG) portfolios. The entries denote the OLS estimates of the portfolio-specific response coefficients to m_t^{US}, an FOMC-induced surprise in the 2-year US Treasury yield. All specifications include a constant (not reported). Heteroskedasticity-consistent asymptotic standard errors are reported in parentheses: * $p < .10$; ** $p < .05$; and *** $p < .01$.

[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019).

[b] 65 FOMC announcements (12/16/2008–12/16/2015).

[c] The response of the sovereign credit spreads for the IG and SG credit risk categories is computed as the difference between the estimated response of sovereign bond yields and the estimated response of US Treasury yields in the matched portfolio of US Treasuries in that credit risk category.

the following system of equations:

$$\begin{aligned}\Delta_h y_{p,t+h-1} &= \alpha_p m_t^{US} + \epsilon_{p,t+h-1};\\ \Delta_h y^{US}_{p,t+h-1} &= \beta_p m_t^{US} + \nu_{p,t+h-1},\end{aligned}$$

where $\Delta_h y_{p,t+h-1}$ denotes an h-day change (from day $t-1$ to day $t+h-1$) in the sovereign bond portfolio yield associated with credit quality $p =$ SG (speculative grade) and $p =$ IG (investment grade), and $\Delta_h y^{US}_{p,t+h-1}$ is the corresponding h-day change in the yield on a matched portfolio of US Treasuries. The response of the sovereign credit spreads to US monetary policy surprises may then be directly inferred from the difference in response between these two portfolio yields; that is, $\alpha_p - \beta_p$, for $p =$ SG and IG.

Table 4 documents the effect of a policy-induced increase in the 2-year US Treasury yield on the 2-day changes in the speculative and investment-grade sovereign bond portfolio yields and their matched US Treasury equivalents. We again conduct a separate analysis across the conventional and unconventional US monetary policy regimes. According to the entries in the table, a conventional policy induced increase in the 2-year US Treasury yield of 100 basis points leads to an increase of 107 basis points in the speculative-grade bond portfolio yield and an increase of 75 basis points in the investment-grade bond portfolio yield; both of these effects are statistically significant at the 1 percent level.

Over the same two days, the respective yields on matched portfolios of US Treasuries are estimated to increase 53 basis points for the speculative-grade portfolio and 69 basis points for the investment-grade portfolio. The implied credit spread response is thus 53 basis points for the speculative-grade portfolio and a mere 5 basis points for the investment-grade portfolio. The standard errors associated with these responses imply that the credit spread response for speculative-grade bonds is statistically different from zero at the 5 percent significance level, while the response for investment-grade bonds is statistically indistinguishable from zero. Thus, during the conventional policy regime, a US monetary policy easing that induces a decline in the 2-year US Treasury yield of 100 basis points narrows credit spreads on speculative-grade sovereign bonds by about 50 basis points, but has essentially no effect on credit spreads on investment-grade sovereign bonds. These results are consistent with the notion that US monetary policy has a direct impact on global asset prices by reducing foreign investment-grade yields one-for-one with US Treasury yields and has an additional impact by reducing the credit risk premiums on speculative-grade sovereign bonds.

The right side of the table reports analogous results for the unconventional policy regime. Again, we observe an economically important and statistically significant response in the 2-day change of both sovereign and matched US Treasury portfolio yields to the US monetary policy surprise. Consistent with our previous findings, the size of the response of both the sovereign yields and the yields on comparable US Treasuries is substantially greater than those we obtain during the conventional policy regime. During the unconventional regime, a US monetary policy easing reduces longer-term yields by more than short-term yields. Hence, this finding reflects the fact that portfolios of US Treasury securities with matched payout characteristics to speculative- and investment-grade sovereign bonds are of significantly longer duration than the 2-year US Treasury note.

Taking the difference of responses between the sovereign bond yields and the matched US Treasury yields again allows us to infer the response of the credit spread on dollar-denominated sovereign bonds to an unanticipated change in the unconventional stance of US monetary policy. In contrast to the conventional policy regime, there is no statistically significant decline in the credit spread on speculative-grade sovereign bonds during the unconventional policy regime. The response of the credit spread for investment-grade sovereign bonds is again zero, both economically and statistically. Thus, during the unconventional policy regime, US monetary policy has a direct effect on both speculative- and investment-grade sovereign debt by reducing yields on comparable US Treasury securities that are then transmitted one-for-one to yields on dollar-denominated sovereign bonds but has no additional impact via a reduction in sovereign credit risk.

Given the potentially illiquid nature of dollar-denominated sovereign bonds, which would likely

Table 5 – The Effect of US Monetary Policy on Sovereign Credit Risk
(*6-day Changes in Bond Portfolio Yields*)

	Conventional MP[a]		Unconventional MP[b]	
Dependent Variables	m_t^{US}	R^2	m_t^{US}	R^2
Sovereign bond yield – IG	0.77***	0.10	1.60***	0.23
	(0.14)		(0.36)	
Sovereign bond yield – SG	1.91***	0.09	1.09	0.03
	(0.49)		(0.90)	
US Treasury yield – IG	0.49***	0.05	1.39***	0.18
	(0.14)		(0.22)	
US Treasury yield – SG	0.38**	0.02	1.67***	0.23
	(0.15)		(0.21)	
Memo: Credit spread response[c]				
Credit spread – IG	0.29***		0.21	
	(0.09)		(0.38)	
Credit spread – SG	1.53***		−0.59	
	(0.47)		(0.87)	

Note: In each specification, the dependent variable is a 6-day change (from day $t-1$ to day $t+5$) bracketing an FOMC announcement on day t in the specified bond portfolio yield: IG = portfolio of sovereign bonds with an investment-grade credit rating; and SG = portfolio of sovereign bonds with a speculative-grade credit rating. US Treasury (IG/SG) corresponds to a 6-day change in the yield on the portfolio of synthetic US Treasury securities of identical duration as the sovereign bonds in the (IG/SG) portfolios. The entries denote the OLS estimates of the portfolio-specific response coefficients to m_t^{US}, an FOMC-induced surprise in the 2-year US Treasury yield. All specifications include a constant (not reported). Heteroskedasticity-consistent asymptotic standard errors are reported in parentheses: * $p < .10$; ** $p < .05$; and *** $p < .01$.

[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019).

[b] 65 FOMC announcements (12/16/2008–12/16/2015).

[c] The response of the sovereign credit spreads for the IG and SG credit risk categories is computed as the difference between the estimated response of sovereign bond yields and the estimated response of US Treasury yields in the matched portfolio of US Treasuries in that credit risk category.

lead to a delayed yield response to US monetary policy announcements, we now consider the effect of a US monetary policy surprise using 6-day changes in the sovereign bond portfolio yields and the yields on the matched portfolios of US Treasuries. These results are summarized in Table 5.

During the conventional policy regime, the response of speculative-grade sovereign yields shows a substantially greater response at the 6-day horizon (1.91) than at the 2-day horizon (1.07). In contrast, the response of investment-grade sovereign yields is essentially the same at both horizons. This suggests that there is some price discovery that takes place over this horizon or that it takes several days for illiquidity in the speculative-grade segment of the sovereign debt market to dissipate. In addition, the response of the yields on the matched portfolios of US Treasury securities shows attenuation at the 6-day horizon relative to the 2-day horizon. Consequently, when we allow for the longer horizon, the response of credit spreads to a conventional US monetary policy surprise becomes larger in absolute value, and it is statistically significant for both speculative- and investment-grade sovereign bonds. A policy-induced decline of 100 basis points in the 2-year US Treasury yield now implies a narrowing of credit spreads on speculative-grade sovereign bonds of about 150 basis points and a reduction of about 30 basis points in credit spreads on investment-grade sovereign bonds. Note that both of these estimates are statistically significant at the 1 percent level.

These findings likely reflect the confluence of two factors. First, a decline in international risk-free interest rates could lead to narrower sovereign credit spreads because it improves the creditworthiness of riskier countries. Second, international investors' attempts to enhance portfolio returns in a low interest rate environment—by increasing their credit risk exposure—could also put downward pressure on credit spreads on sovereign debt issued by riskier countries. While intuitive, our results stand in sharp contrast to those from the earlier literature, which found than an *increase* in US shorter-term interest rates led to a *narrowing* of sovereign credit spreads, especially for the emerging market economies (see Kamin and von Kleist, 1999; Eichengreen and Mody, 2010; Uribe and Yue, 2006). Importantly, these papers uses monthly or quarterly changes in US interest rates to estimate the spillover effects of US monetary policy to international bond markets. Our analysis, in contrast, highlights the importance of using high-frequency data to identify the unanticipated changes in the conventional stance of US monetary policy and to trace out the causal effect of these changes on sovereign credit spreads.

During the unconventional policy regime, our coefficient estimates imply a modest increase in the response of both the speculative- and investment-grade sovereign yields at the 6-day horizon compared with the 2-day horizon. In contrast, there is a substantially more pronounced response of portfolio yields on comparable US Treasuries over the 6-day horizon relative to the 2-day horizon. The combination of these two forces again implies no statistically significant effect of a US monetary policy surprise on sovereign credit spreads during the unconventional policy regime. These estimates reinforce the finding that US monetary policy easings do not lead to a statistically significant narrowing of sovereign credit spreads during the unconventional policy regime.

Although, we do not offer a full explanation for why the response of sovereign credit spreads to US monetary policy differs across the conventional and unconventional policy regimes, we suggest two possible reasons why there may be attenuation of the response of credit spreads to unconventional policy actions. The first is the recognition that there is a substantially greater cross-country dispersion in sovereign credit spreads during the unconventional regime (see Figure 3). This heightened dispersion suggests that country-specific idiosyncratic factors may have played a larger role in determining sovereign credit risk during this period. This may then imply an attenuation of the response of sovereign credit spreads to unconventional US monetary policy measures.

A second concern, discussed in Greenlaw et al. (2018), is the fact that unconventional monetary policy primarily relies on forward guidance to convey its policy stance. Implementation of monetary policy through forward guidance may lead to greater scope for policy announcements to convey both the policy stance, as well as the monetary authority's perception of the state of the economy. To the extent that rising yields capture positive views conveyed by the monetary authority regarding the state of the economy, we expect to see an increase in risky asset prices in response to rising US Treasury yields during announcement periods. Such a mechanism also implies an attenuation of the response of sovereign credit spreads to policy-prompted increases in US Treasury yields on

FOMC announcement days.

3.4 Micro-Level Sovereign Credit Spreads

To further examine the response of sovereign credit spreads to US monetary policy actions, we now consider estimates based on the micro-level data, which allows us to directly control for potential liquidity concerns by including an interaction between the monetary policy surprise and bond characteristics that likely influence liquidity premiums. In addition to explicitly controlling for observable liquidity characteristics, the panel data analysis may be viewed as providing the equivalent of an equally-weighted portfolio analysis.

Formally, we estimate the following regression specification:

$$\begin{aligned}\Delta_h s_{i,t+h-1}[k] = \beta_{SG} m_t^{US} \times \mathbf{1}[\text{RTG}_{i,t-1} \in \text{SG}] + \beta_{IG} m_t^{US} \times \mathbf{1}[\text{RTG}_{i,t-1} \in \text{IG}] \\ + \boldsymbol{\theta}' \mathbf{x}_{i,t}[k] \times m_t^{US} + \epsilon_{i,t+h-1}[k],\end{aligned} \tag{2}$$

where $\Delta_h s_{i,t+h-1}[k] \equiv \Delta_h y_{it}[k] - \Delta_h y_t^{US}[k]$, is the h-day change in the credit spread on sovereign bond k (issued by country i); $\mathbf{1}[\text{RTG}_{i,t-1} \in p]$ is an indicator variable that equals 1 if country i's sovereign credit rating at $t-1$ falls into the $p = \text{SG}$ and IG credit-rating category; and, $\mathbf{x}_{i,t}[k]$ is a vector of (pre-determined) bond characteristics that may influence the liquidity of the bond issue k. Specifically, $\mathbf{x}_{i,t}[k]$ consists of $\ln \text{PAR}_i[k]$, $\ln(1 + \text{AGE}_{i,t}[k])$, $\ln(1 + \text{COUP}_i[k])$, and $\ln \text{DUR}_{i,t}[k]$, where $\text{PAR}_i[k]$ is the inflation-adjusted size of the sovereign bond issue, $\text{AGE}_{i,t}[k]$ is the age (in days) of the issue, $\text{COUP}_i[k]$ is the fixed coupon rate, and $\text{DUR}_{i,t}[k]$ is the bond's duration. These characteristics are interacted with the policy surprise m_t^{US} and thus control for the fact that a portion of the credit spread response may reflect movements in liquidity premium that is a function of the specified bond characteristics.[15]

Table 6 reports the estimated effects of monetary policy on both the 2- and 6-day changes in sovereign credit spreads. Consistent with the view that some part of the credit spread response may be attributed to a liquidity premium that varies with issue size and other bond characteristics, the panel-data estimates imply a smaller response of credit spreads to US monetary policy surprises during the conventional regime relative to those obtained from the aggregate portfolio analysis. The estimate of the response coefficient on the 2-day changes in speculative-grade credit spreads (Panel A) declines from an estimated value of 0.53, when estimated at the portfolio level, to about 0.35 when estimated using the bond-level data. Similarly, the estimate of the response coefficient on the 6-day changes in speculative-grade credit spreads (Panel B) falls from 1.53 to about 0.9, though it remains highly statistically significant.

In summary, the panel-data estimates reported in Table 6 do not change our earlier conclusion that conventional US monetary policy actions have an economically and statistically significant

[15] As before, we estimate equation (2) by OLS. To take into account cross-sectional dependence in the disturbance term $\epsilon_{i,t+h-1}[k]$ arising from the fact that our sample consists of FOMC announcement days only, as well as the fact that error terms of bonds issues by the same country are likely to be correlated, we report asymptotic standard errors clustered across time (t) and countries (i) computed according to Cameron et al. (2011).

Table 6 – The Effect of US Monetary Policy on Sovereign Credit Risk
(*h-day Changes in Bond-Level Credit Spreads*)

	Conventional MP[a]			Unconventional MP[b]		
Regressor	(1)	(2)	(3)	(4)	(5)	(6)
A. 2-day changes ($h = 2$)						
$\beta_{IG} m_t^{US} \times \mathbf{1}[\text{RTG}_{i,t-1} \in \text{IG}]$	−0.01	0.06	0.07	−0.21	−0.20	−0.19
	(0.06)	(0.09)	(0.09)	(0.16)	(0.21)	(0.22)
$\beta_{SG} m_t^{US} \times \mathbf{1}[\text{RTG}_{i,t-1} \in \text{SG}]$	0.36**	0.37**	0.37**	−0.37	−0.39	−0.42
	(0.15)	(0.15)	(0.15)	(0.34)	(0.27)	(0.28)
Bond-specific controls	N	Y	Y	N	Y	Y
Country FE	N	N	Y	N	N	Y
$\Pr > W$[c]	<.01	0.03	0.03	0.39	0.07	0.05
R^2	0.01	0.01	0.02	0.01	0.01	0.02
B. 6-day changes ($h = 6$)						
$\beta_{IG} m_t^{US} \times \mathbf{1}[\text{RTG}_{i,t-1} \in \text{IG}]$	0.19**	0.21	0.21	−0.10	−0.06	−0.05
	(0.09)	(0.22)	(0.21)	(0.17)	(0.20)	(0.24)
$\beta_{SG} m_t^{US} \times \mathbf{1}[\text{RTG}_{i,t-1} \in \text{SG}]$	0.96***	0.88**	0.93**	−0.50	−0.53	−0.56
	(0.34)	(0.38)	(0.37)	(0.60)	(0.39)	(0.42)
Bond-specific controls	N	Y	Y	N	Y	Y
Country FE	N	N	Y	N	N	Y
$\Pr > W$[c]	0.02	0.01	<.01	0.42	0.05	0.05
R^2	0.02	0.02	0.06	0.01	0.01	0.01

Note: The dependent variable is $\Delta_h s_{i,t+h-1}[k]$, an h-day change (from day $t-1$ to day $t+h-1$) bracketing an FOMC announcement on day t in the credit spread on sovereign bond k issued by country i. The explanatory variables are m_t^{US}, a US policy-induced surprise in the 2-year US Treasury yield, interacted with the country's sovereign credit rating indicator: SG = speculative grade and IG = investment grade. In columns (2), (3), (5) and (6), the response coefficients on m_t^{US} are evaluated at the sample mean of the bond-specific characteristics. All specifications include a constant (not reported) and are estimated by OLS. Robust asymptotic standard errors reported in parentheses are clustered in the i and t dimensions (see Cameron et al., 2011): * $p < .10$; ** $p < .05$; and *** $p < .01$.

[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019). No. of bonds = 992; No. of countries = 80; and Observations = 27,890.

[b] 65 FOMC announcements (12/16/2008–12/16/2015). Panel dimensions: No. of bonds = 1,237; No. of countries = 89; and Observations = 36,546.

[c] p-value for the test of the null hypothesis that the response coefficients on m_t^{US} are equal across the SG and IG credit risk categories.

effect on speculative-grade sovereign credit spreads. These estimates also confirms our above finding that US monetary policy actions during the unconventional regime had no effect, on average, on sovereign credit spreads.

3.5 Asymmetric Spillovers of US Monetary Policy

An important concern among policymakers across the globe is the extent to which an easing of monetary policy may lead to increased risk taking in the form of compression of spreads on risky debt. This concern became especially acute in the years immediately following the 2008–09 global financial crisis, a period marked by a surge in capital flows to emerging market economies. At that time, a number of policymakers, academic economists, and financial market participants argued that these flows were contributing to loose financial conditions, excessive credit growth, and undesired exchange rate appreciation in the recipient countries. Because those flows were occurring against a backdrop of aggressive expansion of balance sheets by central banks in major advanced economies, a popular narrative emerged, which argued that these unconventional monetary policy measures were an especially important driver of capital flows to emerging market economies.

According to this view, one should therefore observe a differential effect between monetary policy easings and tightenings. In particular, one would expect an easing of US monetary policy to result in a larger move in credit spreads on speculative-grade sovereign bonds relative to a policy tightening of equal size. To examine whether US monetary tightenings and easings have an asymmetric effect on international bond markets, we split our policy surprises based on their sign—that is, positive vs. negative—and then re-estimate the response of portfolio yields to those two shocks, denoted by $m_t^{US,(+)}$ and $m_t^{US,(-)}$. Tables 7 and 8 present our findings regarding whether the conventional and unconventional US monetary policy actions have asymmetric effects on sovereign bond credit spreads at the 2- and 6-day horizons, respectively.

As shown in Table 7, during the conventional policy regime, the 2-day change in yields for both speculative- and investment-grade bond portfolios respond significantly more to a monetary tightening then to a monetary easing. However, the yields on synthetic US bond portfolios also display a similarly heightened response to monetary policy tightenings. Consequently, the resulting effect on credit spreads is the same regardless of the direction of a policy move. Notably, the point estimates for the response of credit spreads on speculative-grade bonds are unchanged across tightening and easing actions and are entirely in line with the 50 basis point response documented in Table 4. During the unconventional policy regime, only monetary policy easings have a significant effect on either sovereign yields or their US matched portfolio equivalents. This in part reflects the fact that unanticipated policy tightenings were relatively infrequent during the unconventional policy regime. Again, there is no evidence to suggest that monetary policy has asymmetric effects on international bond markets.

The results for the 6-day horizon reported in Table 8 reinforce this conclusion. We again find that policy tightenings have substantially larger effects on sovereign yields than policy easings of the same magnitude. As before, we find that the credit spread response for speculative-grade sovereign

Table 7 – The Asymmetric Effects of US Monetary Policy on Sovereign Credit Risk
(2-day Changes in Portfolio Bond Yields)

	Conventional MP[a]			Unconventional MP[b]		
Dependent Variables	$m_t^{US,(+)}$	$m_t^{US,(-)}$	R^2	$m_t^{US,(+)}$	$m_t^{US,(-)}$	R^2
Sovereign bond yield – IG	1.30***	0.45***	0.29	1.15*	1.31***	0.38
	(0.27)	(0.10)		(0.65)	(0.23)	
Sovereign bond yield – SG	1.54***	0.81***	0.15	1.19	1.12**	0.12
	(0.35)	(0.22)		(1.47)	(0.43)	
US Treasury yield – IG	1.12***	0.46***	0.18	0.74	1.40***	0.29
	(0.21)	(0.15)		(0.77)	(0.33)	
US Treasury yield – SG	1.03***	0.26*	0.13	0.66	1.64***	0.27
	(0.23)	(0.15)		(0.84)	(0.37)	
Memo: Implied credit spread response[c]						
Credit spread – IG	0.17	−0.01		0.41	−0.09	
	(0.19)	(0.11)		(0.73)	(0.34)	
Credit spread – SG	0.51	0.54**		0.53	−0.53	
	(0.43)	(0.21)		(1.76)	(0.49)	

Note: In each specification, the dependent variable is a 2-day change (from day $t-1$ to day $t+1$) bracketing an FOMC announcement on day t in the specified bond portfolio yield: IG = portfolio of sovereign bonds with an investment-grade credit rating; and SG = portfolio of sovereign bonds with a speculative-grade credit rating. US Treasury (IG/SG) corresponds to a 2-day change in the yield on the portfolio of synthetic US Treasury securities of identical duration as the sovereign bonds in the (IG/SG) portfolios. The entries denote the OLS estimates of the portfolio-specific response coefficients to $m_t^{US,(+)}$ and $m_t^{US,(-)}$, a positive and negative FOMC-induced surprises in the 2-year US Treasury yield, respectively. All specifications include a constant (not reported). Heteroskedasticity-consistent asymptotic standard errors are reported in parentheses: * $p < .10$; ** $p < .05$; and *** $p < .01$.

[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019).

[b] 65 FOMC announcements (12/16/2008–12/16/2015).

[c] The response of the sovereign credit spreads for the IG and SG credit risk categories is computed as the difference between the estimated response of sovereign bond yields and the estimated response of US Treasury yields in the matched portfolio of US Treasuries in that credit risk category.

Table 8 – The Asymmetric Effects of US Monetary Policy on Sovereign Credit Risk
(6-day Changes in Portfolio Bond Yields)

	Conventional MP[a]			Unconventional MP[b]		
Dependent Variables	$m_t^{US,(+)}$	$m_t^{US,(-)}$	R^2	$m_t^{US,(+)}$	$m_t^{US,(-)}$	R^2
Sovereign bond yield – IG	1.33***	0.48***	0.12	1.86	1.52***	0.23
	(0.41)	(0.15)		(1.25)	(0.39)	
Sovereign bond yield – SG	2.49***	1.61**	0.10	−0.75	1.66*	0.05
	(0.72)	(0.77)		(3.15)	(0.88)	
US Treasury yield – IG	1.01***	0.21	0.06	2.04**	1.19***	0.19
	(0.34)	(0.17)		(0.90)	(0.31)	
US Treasury yield – SG	1.05***	0.03	0.06	2.10**	1.54***	0.23
	(0.35)	(0.17)		(0.94)	(0.31)	
Memo: Implied credit spread response[c]						
Credit spread – IG	0.32	0.27**		−0.18	0.34	
	(0.25)	(0.10)		(0.95)	(0.47)	
Credit spread – SG	1.44*	1.58**		−2.85	0.12	
	(0.83)	(0.75)		(2.89)	(0.86)	

Note: In each specification, the dependent variable is a 6-day change (from day $t-1$ to day $t+5$) bracketing an FOMC announcement on day t in the specified bond portfolio yield: IG = portfolio of sovereign bonds with an investment-grade credit rating; and SG = portfolio of sovereign bonds with a speculative-grade credit rating. US Treasury (IG/SG) corresponds to a 6-day change in the yield on the portfolio of synthetic US Treasury securities of identical duration as the sovereign bonds in the (IG/SG) portfolios. The entries denote the OLS estimates of the portfolio-specific response coefficients to $m_t^{US,(+)}$ and $m_t^{US,(-)}$, a positive and negative FOMC-induced surprises in the 2-year US Treasury yield, respectively. All specifications include a constant (not reported). Heteroskedasticity-consistent asymptotic standard errors are reported in parentheses: * $p < .10$; ** $p < .05$; and *** $p < .01$.

[a] 169 FOMC announcements (02/06/1992–12/15/2008 and 12/17/2015–03/20/2019).

[b] 65 FOMC announcements (12/16/2008–12/16/2015).

[c] The response of the sovereign credit spreads for the IG and SG credit risk categories is computed as the difference between the estimated response of sovereign bond yields and the estimated response of US Treasury yields in the matched portfolio of US Treasuries in that credit risk category.

bonds is economically large and statistically significant across both easing and tightening policy actions. Nonetheless, we find no difference in the size of the response for speculative-grade credit spreads to policy easings versus tightenings, with both estimates implying a 150 basis point change in speculative-grade credit spreads in response to a 100 basis point policy-induced increase in the 2-year US Treasury yield.

Another way to examine this question is to ask whether the credit spread differential between speculative- and investment-grade sovereign bonds responds more during monetary tightenings relative to easings. This can be seen by computing the differential response of the credit spreads on investment- vs. speculative-grade sovereign bonds. The 6-day change results reported in Table 8 imply the same point estimates for both investment- and speculative-grade bond portfolios across monetary easings and tightenings. Specifically, the point estimates of 150 basis points for speculative-grade bonds and 30 basis points for investment-grade bonds imply that the credit curve widens by 120 basis points in response to a monetary tightening and narrows by the same amount in response to a monetary easing. Therefore, we see no evidence of credit spread compression in this dimension either.

All told, these results clearly imply that during the conventional policy regime, US monetary policy causes an economically important change in credit spreads for speculative-grade sovereign credits that is on the order of 50 basis points—for a 100 basis point policy-induced change in the 2-year US Treasury yield—over a 2-day horizon and 150 basis points over a 6-day horizon. But we find no evidence to suggest an asymmetric effect across policy easings versus policy tightenings. We interpret this evidence as inconsistent with the view that US monetary policy has asymmetric effects on international bond markets through a risk-taking channel that leads to spread compression on risky sovereign in response to looser US monetary policy.

4 Conclusion

Our analysis of US monetary policy spillovers employs a large micro-level data set at the daily frequency, consisting of almost 1,800 individual dollar-denominated sovereign securities traded in the secondary market, which were issued by more than 90 countries since the early 1990s. Using this rich data set, we analyze how US monetary policy affects sovereign bond portfolio yields—where portfolios are defined by duration or credit risk—as well as bond-level credit spreads. We also compare the effects of conventional US monetary policy actions with those of the unconventional measures employed after the target federal funds rate hit the effective lower bound. By focusing on the dollar-denominated sovereign bonds, we abstract from the confounding effects of policy-induced movements in exchange rates and thus directly quantify the spillover effects of US monetary policy on international bond markets through the so-called financial channel that is an important determinant of sovereign credit risk.

According to our findings, foreign bond yields are highly responsive to unanticipated changes in the stance of US monetary policy during both the conventional and unconventional policy regimes. Conventional US monetary policy is transmitted very effectively to both shorter- and longer-duration yields on dollar-denominated sovereign bonds. The spillover effects of conventional US monetary policy across the portfolios of different durations are much more uniform compared with the unconventional policy regime. Overall, the extent of spillovers from the US unconventional monetary policy actions to foreign bond yields is, on balance, roughly similar to that estimated for the conventional policy regime.

We also document that conventional US monetary policy actions have an economically large and statistically significant effect on credit spreads of dollar-denominated debt of countries with a speculative-grade credit rating. Specifically, credit spreads on risky sovereign debt are estimated to narrow significantly in response to an unanticipated US policy easing during the conventional regime. In contrast, sovereign credit spreads for investment-grade countries do not respond to conventional US monetary policy. During the unconventional policy regime, an unanticipated easing of US monetary policy induces a decline in sovereign bond yields that is commensurate with that of yields on a portfolio of comparable US Treasuries. Furthermore, our analysis indicates that the unconventional policy actions undertaken by the FOMC during the 2008–15 period did not affect, on average, the level of sovereign credit spreads across the credit quality spectrum. Lastly, we find no evidence that US monetary policy tightenings and easings have an asymmetric effect on foreign bond yields. This finding cast doubt on the popular notion that US monetary easings lead to excessive risk-taking in international bond markets.

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Appendices – For Online Publication

A Data Appendix

Table A-1 – LSAP-Related Unconventional Monetary Policy Actions

Date	Time[a]	FOMC[b]	Highlights
11/25/2008	08:15	N	Announcement that starts LSAP-I.
12/01/2008	08:15	N	Announcement indicating potential purchases of Treasury securities.
12/16/2008	14:20	Y	Target federal funds is lowered to its effective lower bound; statement indicating that the Federal Reserve is considering using its balance sheet to further stimulate the economy; first reference to forward guidance: "... economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time."
01/28/2009	14:15	Y	"Disappointing" FOMC statement because of its lack of concrete language regarding the possibility and timing of purchases of longer-term Treasuries.
03/18/2009	14:15	Y	Announcement to purchase Treasuries and increase the size of purchases of agency debt and agency MBS; also, first reference to extended period: "interests rates are likely to remain low for an extended period."
08/10/2010	14:15	Y	Announcement that starts LSAP-II.
09/21/2010	14:15	Y	Announcement reaffirming the existing reinvestment policy.
11/03/2010	14:15	Y	Announcement of additional purchases of Treasury securities.
09/21/2011	14:15	Y	Announcement of the Maturity Extension Program (MEP).
06/20/2012	12:30	Y	Announcement of continuation of the MEP through end of 2012.
09/13/2012	12:30	Y	Third "calendar-based" forward guidance: "likely maintain the Federal funds rate near zero at least through mid-2015." In addition, first forward guidance regarding the pace of interest rates after lift-off: "likely maintain low rates for a considerable time after the economic recovery strengthens," and announcement of LSAP-III (flow-based; $40 billion per month of agency MBS).
12/12/2012	12:30	Y	Announcement of an increase in LSAP-III (from $40 billion to $85 billion per month); first "threshold-based" forward guidance: maintain the funds rate near zero for as long as unemployment is above 6.5%, inflation (1–2 years ahead) is below 2.5%, and long-term inflation expectations remain well-anchored.

[a] All announcements are at Eastern Standard Time.

[b] Y = an announcement associated with a regularly-schedule FOMC meeting; N = an intermeeting policy announcement.

Table A-2 – Sample Composition

Country Name	Country Code	Start Date	End Date	No. of Bonds	Obs.
United Kingdom	GBR	07/30/2009	03/06/2013	7	2,636
Austria	AUT	05/19/2004	05/30/2014	15	10,258
Belgium	BEL	01/02/1992	03/29/2019	23	28,624
Denmark	DNK	07/30/2009	05/30/2014	8	2,976
Italy	ITA	01/02/1992	03/29/2014	50	59,319
Netherlands	NLD	02/24/2012	05/30/2014	4	1,986
Norway	NOR	01/02/1992	04/12/1996	2	1,990
Sweden	SWE	01/02/2001	03/29/2019	54	29,119
Canada	CAN	02/14/2012	03/29/2019	5	2,078
Japan	JPN	01/02/1992	05/30/2014	75	92,718
Finland	FIN	01/02/1992	03/29/2019	29	25,979
Greece	GRC	05/24/1994	09/12/2011	21	9,406
Iceland	ISL	01/02/2001	05/30/2014	6	3,902
Ireland	IRL	01/02/1992	07/14/2009	6	8,550
Portugal	PRT	09/08/1999	03/29/2019	5	5,367
Spain	ESP	09/23/1992	05/30/2014	15	13,720
Turkey	TUR	05/05/1992	03/29/2019	45	61,581
Australia	AUS	07/30/2009	05/30/2014	1	1,208
New Zealand	NZL	01/02/1992	05/30/2014	10	15,203
South Africa	ZAF	12/12/1994	03/29/2019	18	28,796
Argentina	ARG	10/01/1992	03/29/2019	29	23,548
Bolivia	BOL	10/29/2012	03/29/2019	6	2,190
Brazil	BRA	04/18/1994	03/29/2019	33	62,820
Chile	CHL	10/16/2001	03/29/2019	8	8,379
Colombia	COL	10/11/1996	03/29/2019	24	48,541
Costa Rica	CRI	07/30/2009	03/29/2019	9	9,066
El Salvador	SLV	10/25/2002	03/29/2019	7	8,302
Guatemala	GTM	06/06/2012	05/30/2014	4	1,638
Honduras	HND	03/15/2013	05/30/2014	4	834
Mexico	MEX	03/01/1993	03/29/2019	30	43,750
Panama	PAN	03/11/1997	03/29/2019	15	27,731
Paraguay	PRY	01/25/2013	03/29/2019	4	2,988
Peru	PER	11/26/2002	03/29/2019	9	17,068
Uruguay	URY	11/18/2005	03/29/2019	6	6,813
Venezuela	VEN	01/02/1992	03/29/2019	29	46,946
Bahamas	BHS	11/20/2009	05/30/2014	4	2,446
Barbados	BRB	01/02/2001	05/30/2014	5	2,078
Bermuda	BMU	07/20/2010	05/30/2014	6	3,292
Jamaica	JAM	12/19/2001	03/29/2014	10	15,355
Trinidad & Tobago	TTO	01/02/2009	03/29/2019	5	2,904
Cayman Islands	CYM	11/24/2009	05/30/2014	2	2,255
South Korea	KOR	04/09/1998	03/29/2019	62	66,626
Cyprus	CYP	01/29/1998	06/25/2001	1	854
Lebanon	LBN	06/02/2014	03/29/2019	15	12,194
Israel	ISR	03/10/2000	03/29/2019	454	492,385
Bahrain	BHR	06/02/2014	03/29/2019	14	13,162
Jordan	JOR	11/12/2010	03/29/2019	10	7,799
Quatar	QAT	04/09/2009	03/29/2019	27	27,873
Kuwait	KWT	03/20/2017	03/29/2019	4	2,032
Saudi Arabia	SAU	10/26/2016	03/29/2019	18	6,898
Oman	OMN	06/15/2016	03/29/2019	16	7,648
Iraq	IRQ	06/02/2014	03/29/2019	5	3,782
Egypt	EGY	07/02/2001	03/29/2019	25	16,834
Sri Lanka	LKA	11/04/2010	03/29/2019	21	18,445
Hong Kong, China	HKG	07/22/2004	07/31/2013	2	4,516

Table A-2 – Sample Composition (continued)

Country Name	Country Code	Start Date	End Date	No. of Bonds	Obs.
India	IND	02/25/2004	05/30/2014	14	13,163
Indonesia	IDN	03/10/2004	03/29/2019	63	75,691
Malaysia	MYS	05/28/1999	07/14/2010	2	4,505
Pakistan	PAK	02/12/2004	03/29/2019	11	12,507
Philippines	PHL	11/23/1996	03/29/2019	25	44,461
Thailand	THA	12/23/2005	09/28/2012	1	1,694
Viet Nam	VNM	11/03/2005	03/29/2019	6	8,629
Angola	AGO	11/12/2015	03/29/2019	6	2,576
Ghana	GHA	07/26/2013	03/29/2019	10	7,666
Gabon	GHA	06/02/2014	03/29/2019	2	2,414
Ethiopia	ETH	12/11/2014	03/29/2019	2	2,148
Kenya	KEN	06/24/2014	03/29/2019	6	3,466
Ivory Coast	CIV	03/03/2015	03/29/2019	4	2,934
Nigeria	NGA	02/16/2017	03/29/2019	14	3,834
Morocco	MAR	11/12/2012	03/29/2019	2	3,148
Senegal	SEN	05/06/2011	03/29/2019	7	3,627
Namibia	NAM	11/03/2011	05/30/2014	2	1,282
Zambia	ZMB	06/02/2014	03/29/2019	4	4,246
Fiji	FJI	07/30/2009	05/30/2014	2	1,083
Belarus	BLR	08/03/2010	05/30/2014	2	1,792
Albania	ALB	11/01/2010	05/30/2014	1	894
Azerbaijan	AZE	06/02/2014	03/29/2019	4	3,196
Georgia	GEO	10/06/2010	05/30/2014	3	1,946
Kazakhstan	KAZ	12/11/1996	03/29/2019	13	13,183
Bulgaria	BGR	04/10/2002	01/14/2014	2	5,884
Russian Federation	RUS	11/22/1996	03/29/2019	37	51,946
People's Republic of China	PRC	07/05/1996	03/29/2019	8	7,419
Ukraine	UKR	11/20/2001	03/29/2019	55	43,950
Latvia	LVA	06/16/2011	05/30/2014	6	3,344
Hungary	HUN	02/03/2005	03/29/2019	9	12,911
Lithuania	LTU	10/15/2009	03/29/2019	9	15,017
Mongolia	MNG	12/05/2012	03/29/2019	4	3,898
Croatia	HRV	02/12/1997	03/29/2019	13	20,577
Slovenia	SVN	07/25/1996	03/29/2019	11	7,419
Slovakia	SVK	06/02/2014	03/29/2019	2	2,414
Poland	POL	06/30/1995	03/29/2019	11	19,366
Serbia	SRB	07/15/2013	03/29/2019	7	5,904
Romania	ROU	02/07/2012	03/29/2019	10	12,018

Note: No. of bonds = 1,748; No. of countries = 95; Obs. = 1,888,320. Bonds in default are excluded.