Unconventional Monetary Policy, (A)Synchronicity and the Yield Curve

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ABSTRACT

This paper examines unconventional monetary policy (UMP) spillovers to the United States, exploiting the asynchronous timing of policy normalization to shed light on the term structure implications of UMP divergence. Using high frequency data, I find that spillovers to the U.S. increase during UMP and strengthen during asynchronous normalization. Using a shadow rate term structure model, I find that spillovers to the U.S. manifest through term premia, particularly at the effective lower bound. Identifying target, forward guidance, and Quantitative Easing (QE) shocks suggests term premium effects arise from QE and forward guidance, while target shocks do not generate spillovers. I find further that spillovers (particularly to term premia) increase as debt available for purchase by the private sector decreases.

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1 Introduction

The speed of economic recovery in the aftermath of the Global Financial Crisis (GFC) differed markedly among advanced economies, leading to increasingly divergent monetary conditions by the end of 2019. While the Euro area, Japan, and to a more limited extent the United Kingdom increased their unconventional monetary stimulus through 2019, the United States began monetary policy normalization in 2015, and subsequently saw a gradual inversion of the domestic yield curve. These dynamics fueled extant interest in the process of exiting from unconventional monetary policy (UMP) and in the role of monetary policy spillovers in explaining patterns of domestic and foreign asset prices at and away from the effective lower bound (ELB).[1] The implications of UMP divergence for the efficacy of monetary policy are not well understood. On the one hand, coordinated policy actions are thought to be particularly potent. On the other, shifts in monetary policy in an environment of large interest rate differentials can lead to outsized market responses (Forbes 2019).

While abundant research documents spillovers from the Federal Reserve's monetary policy to other economies, the effects of other central banks' policies on the United States have received limited study despite an evolving policy landscape. [2] This paper documents the magnitude of cross-border spillovers to the United States from the ECB, the Bank of Japan, and the Bank of England. In addition, I exploit the Fed's asynchronous shift away from unconventional monetary policy, or a return to short-rate-based monetary policy, to understand the implications of this policy divergence for domestic and international transmission.

I focus on three key questions. First, how does domestic and foreign monetary policy at the effective lower bound differ from conventional periods in its effect on the shape of the US term structure? Second, what role do term premia play in domestic and international transmission compared to more conventional channels? Finally, how do spillover dynamics change

[1] Although the term "spillovers" could be used to denote the impact of foreign policy on any number of variables, throughout the text I use "spillovers" to refer to the effect of one central bank's monetary policy surprises on another country's sovereign yield curve.

[2] For spillovers from the Federal Reserve, see for example Krishnamurthy and Vissing Jorgensen (2011), Bauer and Rudebusch (2014), Neely (2015), Fratzscher et al. (2018), Christensen and Rudebusch (2012), Gagnon et al. (2011), Hamilton and Wu (2012), D'Amico and King (2013), and Wright (2012). A small but growing body of literature treats spillover effects from the ECB. Fratzscher et al. (2016), Falagiarda et al. (2015), Bluwstein and Canova (2016) explore the effects of the ECB's asset purchase programs on emerging and non-euro European markets, while Georgiadis and Gräb (2015), and Curcuru et al. (2018) examine spillovers from ECB monetary policy on advanced economy assets.

when unconventional monetary policy conditions diverge?

To answer these questions, I use high frequency identification to extract monetary policy surprises from futures contracts on the dates of monetary policy announcements in the manner of Kuttner (2001), Gürkaynak et al. (2005) and others. I take a novel approach incorporating contemporaneous advanced economy monetary policy and macroeconomic news surprises to jointly examine the effects of foreign policy on the term structure of US yields. Controlling for these concurrent surprises on the dates of monetary policy announcements decreases news contamination in the absence of intraday data and enables direct comparisons between central banks. To evaluate the influence of policy synchronicity, I separate the sample into three distinct periods based on whether 1.) a central bank is pursuing unconventional monetary policies and 2.) they are in sync at the effective lower bound. In so doing, my paper differs from others comparing the time-varying spillovers of the four largest central banks, which to date address differential effects between the pre- and post-crisis periods only.

Focusing first on the term structure itself, I find that spillovers to the United States not only shift from short maturities to long ones at the effective lower bound, but that they also increase in overall magnitude. Moreover, these spillovers grow further in the period of asynchronous monetary policy normalization. Contravening a focus in the spillover literature on the Federal Reserve, I find that the ECB and Bank of England generate substantial spillovers to the long end of the US yield curve (e.g., Ehrmann and Fratzscher 2005; Fratzscher et al. 2016; Brusa et al. 2020; Mueller et al. 2017; Rogers et al. 2014).[3] Notably, I find that each central bank's measured spillovers in the post-Lehman era actually derive in large part from increases following the start of monetary policy divergence. Using local projections, I find that the impact is persistent up to a month.

Second, to pinpoint the importance of the term premium for international transmission,

[3]Throughout this paper, I follow Bernanke (2009) and others and define quantitative easing as a central bank balance sheet expansion focused on the mix of loans and securities that the central bank holds, with explicit consideration on the effect this composition of assets affects credit conditions. This definition distinguishes the experience of the ECB from the Fed, the Bank of England, and the Bank of Japan. In contrast to these other central banks, the ECB's balance sheet expansion during its early crisis response mainly reflects its increased intermediation role and the growth of its lending to banks, which play a crucial part in financing the Euro area's private sector. While the other central banks orchestrated the growth of their balance sheets as part of their policies of quantitative easing, in the case of the ECB, the discretion of commercial banks and their need for refinancing drove balance sheet expansion. The contraction of the ECB's balance sheet that began in 2012 reflected the banks' declining need for liquidity following the reduction in financial fragmentation in the Euro area (de Sola Perea and Van Nieuwenhuyze, 2014).

I decompose the zero coupon bond yield into an expected path of short rates and a term premium using the shadow rate term structure model (SRTSM) of Wu and Xia (2016).[4] Results from this yield decomposition suggest that, in almost every case and time period, the term premium drives the bulk of spillovers where they appear. I find that these term premium spillovers are strongest in the period of asynchronous monetary policy normalization both in absolute terms (i.e., compared to term premium spillovers in other subsamples) and in comparison to the expected path of short rates. I find, consistent with a portfolio balance channel of transmission, that the effect of foreign monetary policy shocks on US term premia rises when the availability of local sovereign bonds for purchase by the private sector (or free float) falls. By contrast, the expected path of short rates drives (modest) spillovers in the pre-crisis period, which diminish in periods of unconventional monetary policy. Using a simple version of Jarocinski and Karadi's (2018) separation of monetary policy shocks from central bank information effects, I show that spillovers to US Treasuries would have been even larger in the absence of growth news shocks.

The strength of the term premium channel underscores the uniqueness of unconventional monetary policy both in terms of spillovers and in driving domestic interest rate pass-through.[5] Both domestic and international transmission channels map onto the maturity structure of interest rate pass-through: periods of unconventional monetary policy correspond to a larger impact on the long end of the yield curve through term premia, while periods of conventional monetary policy largely act on shorter interest rates through expectations of future policy rates. However, normalization only partially reestablishes conventional channels in US domestic monetary policy; this speaks to the degree to which UMP is no longer "unconventional" in the sense that it remains in the expected central bank tool kit.

An abundant literature on the international impact of US quantitative easing programs on a number of asset classes contrasts its effects with those of conventional monetary policy.[6]

[4]The choice of a shadow rate term structure model with daily data further distinguishes this paper from the existing literature by taking into account the influence of the effective lower bound on the expected path of short rates (Kearns et al. 2020; Rogers et al. 2014; Shah 2022).

[5]Periodically throughout the paper, I use the term "pass-through" to denote the effect of domestic monetary policy surprises on the domestic sovereign yield curve.

[6]For example, Neely (2015), Wright (2012), Fratzscher et al. (2018), Bauer and Neely (2014), and Rogers et al. (2018) find that QE's international impact distinguishes unconventional from conventional monetary policy, Curcuru et al. (2018b) find that QE does not exert larger international spillovers. Mueller et al. (2017) document that a trading strategy that is short in the U.S. dollar and long in other currencies exhibits larger excess returns on days

However, the nearest neighbors of this paper compare the magnitude of sovereign bond yield spillovers from unconventional monetary policy among multiple advanced economy central banks. While the literature agrees in finding evidence of spillovers from the Federal Reserve, disagreement arises as to whether it plays a unique role in doing so. While Rogers et al. (2014), Fratzscher et al. (2018) and Shah (2022) find that the Federal Reserve uniquely propagates cross-border yield curve spillovers, Rogers et al. (2018), Kearns et al. (2020) Curcuru et al. (2018a), and Zhang (2022) find a role for other advanced economy central banks, particularly the ECB, in influencing long-term bond yields internationally.

Previous work has shown that other advanced economy central banks generate larger spillovers to the U.S. yield curve at the ELB (see e.g. Miranda-Agrippino and Tenova (2021)). This paper goes a step further in providing evidence that these large spillovers emanate from the portfolio balance channel since 1.) they largely affect term premia rather than expected short rates and 2.) they are larger when there is a more limited effective supply of own-country government bonds. Thus, spillovers grow in times when unconventional monetary policy is out-of-sync in part because the domestic availability of safe, long duration assets takes time to recover. To my knowledge, this is the first paper to document changes in these international mechanisms through the process of unwinding, with a focus on spillovers to the United States.

While conventional monetary policy generates small spillovers that are concentrated in the short end of the yield curve, unconventional monetary policy and its unwinding uniquely generate conditions under which central banks may face challenges in implementing independent monetary policy, due to its impact on long-term bond yields. A unilateral or asynchronous exit from unconventional monetary policy thus has the potential to flatten or invert the domestic yield curve, while monetary policy normalization has the potential to impact the effectiveness of ongoing LSAPs in other countries. In the absence of spillovers, both LSAPs and normalization may be more effective domestically because of the potential for international (rather than domestic) portfolio balance effects. In light of the unique conditions gen-

with scheduled Federal Reserve announcements—a pattern which is shared only by the Bank of Japan. Examining excess equity returns, Brusa et al. (2020) find that there is an equity premium associated with Fed announcement days that is not shared by any other central bank. A vast literature documents the impact of monetary policy spillovers on bank lending channels (See for example Hofmann and Takáts 2015; Bruno and Shin 2015; Cetorelli and Goldberg 2012; Morais et al. (2019)).

erated by the ELB and the likelihood it will bind repeatedly in the future, the timing, overlap, and intensity of unconventional monetary policies among the largest advanced economy central banks warrants specific attention.

The paper proceeds as follows. Section 2 briefly describes the transmission mechanisms of conventional and unconventional monetary policy. Section 3 presents stylized facts from the data to motivate the main approach. Section 4 presents the baseline model for estimating the effects of monetary policy surprises on zero coupon bond yields, including the decomposition of these yields into a rational expectations-implied path of short rates and a term premium to test their relative importance in monetary policy transmission. Section 5 presents further evidence on the channels of pass-through to term premia in greater depth and discusses a number of robustness checks. Section 6 concludes and outlines future directions for research.

2 Motivation: Spillovers at the effective lower Bound

Over long stretches of history, central banks have largely conducted monetary policy by buying and selling short-term debt and, in most instances, target short-term interest rates. However, at the effective lower bound, the availability of cash as an asset prevents stimulus from decreasing the short-term policy rate indefinitely below zero. Beyond the effective lower bound of interest rates, central banks pursue policies such as direct lending, liquidity provision to key credit markets, and large-scale asset purchases, with some variations. These large-scale asset purchases, coupled with forward guidance regarding the path of policy, aim specifically to lower long-term interest rates through heavier management of expectations and adjustments to term premia.[7] Thus, to distinguish between conventional and unconventional monetary policy channels, it is convenient and common to consider the yield on an n-period risk-free bond as the average level of short-term interest rates over the maturity of the bond and a term premium:

$$Y_t^{(n)} = \mathbf{E}[\bar{Y}_{t,t+n}|I_t] + YTP_t^{(n)} \tag{1}$$

[7] Bernanke, Ben S. (19 November 2013) *Communication and Monetary Policy*. Retrieved from https://www.federalreserve.gov/newsevents/speech/bernanke20131119a.htm

where $\mathbf{E}[\bar{Y}_{t,t+n}|I_t]$ is the average short-term rate expected to prevail over the period t to $t+n$ (that is, the component of the yield that would drive yield variation if the expectations hypothesis were to hold exactly), and $YTP_t^{(n)}$ is a maturity-specific term premium. The term premium captures the additional required compensation for holding a long-term bond (duration risk), subsuming the price and amount of interest rate risk, inflation risk, and macroeconomic growth risk. Monetary policy enacted through policy rates operates chiefly via the expected path of short-term interest rates, as compensation for maturity risk shrinks to zero with the maturity of the bond (Hamilton 2009; Sims and Wu 2020). However, unconventional monetary policy influences both terms of (1), either by signaling the central bank's intention to keep interest rates low over longer horizons, thereby reducing $\mathbf{E}[\bar{Y}_{t,t+n}|I_t]$, or by removing duration risk from the market (decreasing $YTP_t^{(n)}$).

Homing in on the first term of (1), expansionary forward guidance lowers the expected path of interest rates by communicating the central bank's intention to keep interest rates low (or to pursue ongoing asset purchases), committing often to a specific time horizon or level of fundamentals. However, large-scale asset purchases also contribute to the force of forward guidance by acting as a commitment mechanism. Growing and maintaining the balance sheet signals low future interest rates in the sense that a central bank that has purchased a large quantity of long-dated assets when interest rates are low stands to see the value of its portfolio decline when interest rates begin to climb (Fawley and Neely 2013). This "signaling" channel carries the potential generate international spillovers through conventional means like international bank balance sheets, exchange rates, or the current account.

However, as the maturity of an asset increases, the expected path of short interest rates explains less of the yield, in part because uncertainty increases with the horizon. For this reason, monetary policy at the effective lower bound also aims at decreasing term premia. While expansionary forward guidance can support the reduction of term premia by limiting inflation and interest rate risk, central banks can also directly target longer term interest rates by purchasing long duration assets, thereby reducing the effective supply of such assets raising their prices, lowering their yields, and decreasing the duration risk associated with holding them. As investors rebalance their portfolios in response to large scale asset purchases, the prices of the assets they acquire rise as well, decreasing their respective yields through the term premium and potentially prompting further rebalancing. "Restricted" or preferred habitat investors at home and abroad can amplify this portfolio balancing channel by purchasing additional long-dated assets, even as their prices rise in order to balance long-dated obligations on their balance sheets or to search for yield.[8] In this way, an expansionary monetary policy shock with strong portfolio balance effects has the potential to decrease *international* term premia.

Financial center monetary policy can also generate changes in global yields by revealing information about the state of the economy. While central banks release information purposefully through forward guidance, policy actions also contain information regarding policy makers' level of confidence in economic fundamentals. In practice, central bank policy rates and sovereign bond yields can be correlated internationally for various reasons, especially among countries with close economic ties. These can emerge through trade flows, or they can comprise information flows that manifest through business cycle comovement (see, for example, Kose et al. (2003) and Baxter and Kouparitsas (2005)). That is, foreign monetary policy reveals information on the state of the global economy to which the marginal investor expects the domestic central bank to react. For example, while an episode like the "Taper Tantrum" of 2013 may increase yields by signaling an increase in the path of US interest rates, it also suggests optimism on the part of the FOMC regarding the state of the US economy. This might, in turn, be expected to benefit the global economic outlook, raising yields via projected future growth and, in turn, expected real interest rates. Such informational spillovers can manifest through the expected path of short rates (average path) as well as term premia (volatility) through a "confidence" channel.[9]

Due to its focus on long-term interest rates, unconventional monetary policy stands to generate larger financial spillovers, and asynchronous normalization of monetary policy has the potential to shape the term structure of normalizing and non-normalizing economies. The next section discusses challenges inherent to identifying cross-country spillovers from uncon-

[8] Shin (2017) provides an illuminating example of long-term bond yield amplification through the duration balancing activities of German insurance firms.

[9] Conversely, central banks in countries facing expansionary financial spillovers may therefore be expected by the marginal investor to *withdraw* stimulus in the face of increased liquidity from abroad. We would expect the same reaction by central banks if expansionary monetary conditions abroad generally engender expansionary domestic demand conditions through a trade channel.

ventional monetary policy, while Section 4 presents solutions for identification.

3 Stylized Facts: Inference via Heteroskedasticity

The baseline analysis of this paper utilizes daily data on bond yields and interest rate futures to jointly estimate the spillover effects of monetary policy surprises among the four central banks, controlling for macroeconomic news surprises. Daily data is not only more accessible, but it also possesses some informational advantages over intraday data. First, using intraday data increases the risk of excluding information through leaks that limit the "firmness" of the announcement time, particularly in international contexts. Similarly, intraday windows cut off slow market reactions without guaranteeing sole influence from the announcement of interest. Similarly, futures markets retain a higher risk of "dead quotes" for windows wherein the assets of interest do not turn over often due to lack of liquidity. This issue is particularly acute in international contexts.

However, the choice of daily data also poses challenges for identification. To expand on this and to motivate my approach, I examine monetary policy spillovers in an assumption-light fashion, testing for the *presence* of spillovers between the US, the UK, the Euro area, and Japan with an inference via heteroskedasticity-type exercise in the spirit of Rigobon (2003). These straightforward estimates suggest some tentative conclusions about the presence of spillovers and highlights the importance of considering them jointly. In particular, these results underline some challenges of the event study approach for uniquely identifying monetary policy from the Bank of England and ECB using daily data, due to an abundance of concurrent monetary policy surprises. Given that more than 25 percent of BOE and ECB announcement days within the sample are shared, this represents a non-trivial barrier to identification.

3.1 Methodology

In a regression framework, one can express an asset price's relationship to monetary policy as

$$\Delta y_{i,t} = \begin{cases} \alpha_i + \beta MP_t^j + \epsilon_{i,t} & t = Announcement\ day \\ \alpha_i + \epsilon_{i,t} & t = Non-announcement\ day, \end{cases}$$

where $\Delta y_{i,t}$ is the change in the asset return in question for market i at time t, and MP_t^j is the monetary policy surprise originating from country j at time t (or in the case of a domestic monetary policy surprise, $i = j$). This setup requires only that returns during announcement windows would have the same distribution as those during non-announcement windows in the absence of central bank announcements. Taking the variance of returns on announcement and non-announcement days separately, we see that the following holds:

$$\begin{aligned} \Delta y_{i,t}^{(a)} &= \alpha_i + \beta MP_t^j + \epsilon_{i,t} && (2) \\ var(\Delta y_{i,t}^{(a)}) &= \beta^2 var(MP_t^j) + var(\epsilon_{i,t}) \\ \Delta y_{i,t}^{(n)} &= \alpha_i + \epsilon_{i,t} && (3) \\ var(\Delta y_{i,t}^{(n)}) &= var(\epsilon_{i,t}) \end{aligned}$$

In order to test the null hypothesis that $\beta = 0$, one need only test whether the variance of returns on announcement days equals that on non-announcement days:

$$var(\Delta y_{i,t}^{(a)}) = \beta^2 var(MP_t^j) + var(\Delta y_{i,t}^{(n)}) \quad (4)$$
$$var(\Delta y_{i,t}^{(a)}) > var(\Delta y_{i,t}^{(n)}) \implies \beta \neq 0$$

Note that the above holds regardless of the sign of β. To test the equality of return variances on announcement versus non-announcement days, I use the Brown-Forsythe test, comprising the F-statistic from an analysis of variance on absolute deviations from the median. As opposed to a test of mean squared deviations (such as an F-test), the Brown-Forsythe test is robust to non-normal data such as financial returns. Testing the difference in variances provides an initial picture of monetary policy spillovers without leaning heavily on many assumptions.

The sample of returns consists of daily data from September 4, 2004, to January 1, 2020.[10] For this exercise, I collect data on government bond yields at maturities of one, three, five, seven and ten years from the respective central banks' websites. Because responses to the Global Financial Crisis and turbulence surrounding the euro often elicited unscheduled policy decisions from all central banks in the sample, announcement days include both scheduled and unscheduled events. The Federal Reserve's websites supplies the majority of announcement dates; I take additional unscheduled dates from Rogers et al. (2014) and Chari et al. (2021).

In an event study framework, identification requires the exclusion of announcement days with overlapping meetings or macroeconomic news events. While announcements from the ECB, the Bank of England, and the Bank of Japan seldom overlap with those from the Federal Reserve, important exceptions occur, especially in the period during which central banks responded to the GFC. Appendix Table 1a shows the count of announcements by subsamples, including the count of overlapping meeting days. [11] The ECB and Bank of England dates overlap frequently throughout the sample. To highlight the informational content of these concurrent announcement dates, I test the response of asset returns to shared ECB/Bank of England dates separately from those with a single central bank announcement. In such concurrent instances, I define an announcement date as one on which *both* the Bank of England and the ECB release a monetary policy announcement.

Due to the geographic dispersion of these markets, I adjust the timing ascribed to each announcement to reflect trading hours and the time difference between source and recipient countries. For example, an FOMC announcement concluded at 2:45pm on date t may not affect Japanese bond yields until trading begins at 8:45am (GMT+9) on day $t+1$. For this reason, I measure announcement effects from the US to other countries in the sample as the daily difference in yields from t to $t+1$, whereas the impact of the ECB, Bank of England, and Bank of Japan on the US are measured as the daily difference of US yields from $t-1$ to t. Appendix

[10] The sample dates match those used in the baseline, which reflects the availability of zero coupon bond yield data from the ECB.

[11] For example, on March 18, 2009, the FOMC and Bank of Japan both announced asset purchase programs. On this date, the US 10-year bond yield exhibited the largest single day drop from 1987 to the time of this writing.

Table 1b provides a summary of timing conventions between the four markets.

3.2 Results

Table 2 displays the results. Statistically significant results ($\leq$ 10 percent) are expressed as the ratio of standard deviations on announcement days to those on non-announcement days:

$$\frac{\sigma_i^{a_j}}{\sigma_i^n} - 1, \tag{5}$$

where j is the central bank generating a monetary policy announcement and i is the recipient market. Blank cells represent results insignificant at the 10 percent level. Finally, cells with red text denote spillovers from combined ECB/Bank of England dates that do not exhibit spillovers from either Bank of England or ECB announcements individually.

Several patterns stand out. First, these central banks influence their own yield curves at every maturity. In terms of spillovers, the UK and Euro area's monetary policies exhibit the most consistent connection, impacting each other's term structure at every maturity. In line with much of the extant literature, the results in Table 2 suggest that the FOMC generates spillovers to the Euro area and the UK, while no central bank in the sample generates unilateral spillovers to the US. This result aligns with some of the current literature addressing cross-country spillovers to the United States from other central banks (Ehrmann and Fratzscher 2005; Rogers et al. 2014; Shah 2022; Mueller et al. 2017; Brusa et al. 2020). Unique within the sample, the Bank of Japan does not appear to generate spillovers to the bond yields of any of the other markets in the sample, nor does Japan appear to receive detectable spillovers.

Notably, however, when I consider dates that contain both an ECB and a Bank of England announcement, these concurrent events increase the volatility of medium and longer-dated US yields. In this case, Bank of England and ECB monetary policies are not separately identified, but the receptiveness of US yields to these concurrent shocks suggest a shortcoming in measuring unilateral spillovers from the ECB or Bank of England using daily data in a univariate event study framework.

Beyond the preliminary and intuitive documentation of spillovers among these advanced economy central banks, this stylized fact from the data suggests that shared dates among these central banks matter for identification, especially in the case of the ECB and the Bank of England. The conservative approach embodied in this exercise leaves important information underutilized, and thus the impact of some central banks in the sample appears less well identified. These concerns motivate the main approach of the paper, to which I turn next.

4 Baseline Estimation

The previous section highlighted some potential pitfalls of identifying monetary policy surprises using daily data.[12] In this section, the baseline analysis captures the full impact of monetary policy surprises while addressing these obstacles in analyzing the influence of asynchronous monetary policy normalization on spillovers.

4.1 Data

This paper follows the high frequency identification (HFI) literature pioneered by Cook and Hahn (1989), Kuttner (2001), Cochcrane and Piazzesi (2002), Gürkaynak et al. (2005), and others. Early work in this literature often defined a monetary policy surprise (in the United States) as the daily difference in the implied yield on a Fed Funds futures contract on a date with some Federal Reserve activity. This approach requires some adjustments, however, for international applications and for the effective lower bound.

First, aside from case of the Federal Reserve, no futures market instruments track the other central banks' policy rates directly. Each of these markets does, however, have an active interbank lending market with its own Interbank Offered Rate. 24 month ahead futures contracts on the three-month Euro Interbank Offered Rate (Euribor), Sterling London Interbank Offered Rate (Sterling Libor), and Euroyen Tokyo Interbank Offered Rate (Euroyen Tibor) are all traded continuously throughout the sample and maintain variation at the ELB (see Figure 1). Because these interbank rates are strongly influenced by current expectations of future policy rates, overnight futures contracts can act as close substitutes for a contract based explicitly on the policy.[13]

[12] See Nakamura and Steinsson (2018) and Curcuru et al. (2018a) for more work in this area.

[13] Bernoth and Von Hagen (2004), for example, find that the three month Euribor futures rate is an unbiased predictor of Euro area policy rate changes.

Further complicating identification, variation in the price of Fed Funds futures contracts decreased considerably at the effective lower bound. From December 2008 until December of 2015, the FOMC announced no changes to the target Fed Funds rate, and in much of that period, the FOMC worked to maintain the message that the policy rate would continue near zero. To account for this issue, I use the 24 month-ahead Eurodollar futures contract instead of Fed Funds futures in the spirit of Gertler and Karadi (2018), which alleviates the issue of attenuation apparent in the Fed Funds Futures data. The use of Eurodollar futures also brings the monetary policy measure for the FOMC in line with measures for the other central banks. Thus, I use the daily change in the yields implied by these overnight interbank interest rate futures prices (Eurodollar, Euribor, Euroyen and Short Sterling) as my measure of the surprise element contained in announcements by each respective central bank. The majority of included central bank announcement dates in the sample come from central bank websites. However, as in the previous exercise, I also include additional unscheduled dates.

Although attenuation does not appear to pose a problem in the sample period for the chosen contracts, time varying volatility of any short term interest rate into and away from the effective lower bound may still be a concern (see Figures 1a - 1d). To this end, and in recognition of quantitative easing's explicit goal of influencing longer-term interest rates, I include several robustness checks using variations of longer dated assets.[14] For ease of interpretation, I normalize monetary policy surprises to one standard deviation.

In the baseline regressions and to estimate the shadow rate term structure model, I use zero coupon bond yield data gathered from central banks. The Federal Reserve publishes daily data on US zero coupon bond yields from Gürkaynak, Sack, and Wright (2007).[15] To give a more complete picture of term structure adjustments, I estimate the impact of monetary policy surprises on yields with maturities of 1, 3, 5, 7, and 10 years. As in the previous section, the sample spans September 4, 2004, to January 1, 2020.

To extract the term premium and expected path of short rates from the term structure,

[14]A suitable futures contract on a medium duration bond is not available for all sample countries. Contracts for Japan and the UK (5-year JGB futures and Medium Gilt futures) do not have an adequately long trading history, and no futures contract exists for a generic European bond yield. In the case of Japan, trade in 5-year JGB futures ceased entirely from June of 2002 to January of 2008, while in the case of the UK, Medium Gilt Futures did not launch until November of 2009.

[15]https://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html

I use the shadow rate term structure model of Wu and Xia (2016). Many papers in the literature on monetary policy spillovers utilize Gaussian affine term structure models (GATSM) to estimate term premia. However, because these models assume the short rate to be linear in Gaussian factors, GATSMs place a positive probability on negative nominal interest rates and, therefore, are less well-suited to a binding effective lower bound. By contrast, the SRTSM used here is a latent factor model where the state variables have Gaussian dynamics, but the short rate has a shadow rate interpretation. Following Black (1995), the shadow rate class of term structure models represents the policy rate as the maximum of the effective lower bound and a shadow interest rate reflecting the value of the short rate if it could move freely below zero. The nonlinearity introduced by this representation makes such models difficult to estimate beyond one factor. However, Wu and Xia (2016) propose an analytical representation for the forward rate that makes a nonlinear term structure model tractable in empirical estimation for multiple factors. Having estimated the expected path of short rates for the US, I calculate the term premium as a residual in accordance with Eqn. 1.

As mentioned above, this paper uses daily data to identify a monetary policy surprise in order to capture as much of the asset price's reaction as possible. In measuring the informational impact of monetary policy surprises, too narrow a window may miss part of the monetary policy surprise, but too wide a window risks the inclusion of non-monetary news. To retain the information of the announcement while reducing noise from other concurrent events, I control for macroeconomic news surprises from systemic economies using the Citigroup Economic Surprise Index (CESI) for Japan, the Euro area, the UK, and the US, in addition to controlling for concurrent monetary policy announcements. The CESI tracks how economic data compare to expectations, rising when economic data exceed economists' consensus forecasts and falling when data come in below forecast estimates.[16] In order to ensure that monetary policy surprises enter the regressions only through the futures-implied measures, I orthogonalize these news shocks to the monetary policy surprise measures. Finally, the bilateral nominal exchange rate in local currency per unit of foreign currency controls for

[16]Indices are defined as weighted historical standard deviations of data surprises (actual releases vs. Bloomberg survey median) and are calculated daily in a rolling three-month window. The weights of economic indicators are derived from relative high-frequency spot FX impacts of one standard deviation data surprises. The indices also employ a time decay function to replicate the limited memory of markets.

the influence of currency-based arbitrage on announcement days.

4.2 Empirical Approach

Given my interest in what might be considered different global monetary policy phases, I partition the sample by synchronicity at the effective lower bound. For each central bank, I define the period of conventional monetary policy (CMP) from the start of the sample to the Fed's adoption of quantitative easing. The second period begins in Nov. 25, 2008 and ends on May 22, 2013. [17]

Beginning the period of asynchronous monetary policy normalization, the next subsample begins with the "Taper Tantrum" of May 22, 2013, when then-FOMC Chair Ben Bernanke first suggested the FOMC's intention to taper US large-scale asset purchases. From this point on, I consider the United States to have begun normalizing monetary policy. Thus, from May 22, 2013 the three foreign central banks in the sample continued expansionary monetary policy at the ELB, while the Fed began to tighten, bringing it out of sync with the other central banks. I consider each switch as a potential "critical juncture" and run piecewise regressions for each of the central banks individually, of the following form:

$$\Delta y^{(n)}_{US,t} = \alpha + \sum_k \gamma^j_k D_k MP^j_t + \sum_i \psi_i MP^i_t + \theta_1 S^j_t + \sum_i \theta_i S^i_t + \phi_1 \Delta e^j_t + \sum_i \phi_i \Delta e^i_t + \psi \Delta VIX_t + \epsilon_{it} \quad (6)$$

$$MP^j_t = \begin{cases} Y_{j,t} - Y_{j,t-1} & t = Announcement_j \\ 0 & Otherwise, \end{cases}$$

where $y^{(n)}_{US,t}$ is either the zero coupon yield on an n-year Treasury, the average expected path of short rates in the United States from t to $t+n$ ($\mathbf{E}[\bar{Y}_{t,t+n}|I_t]$), or the term premium ($YTP^{(n)}_t$) on an n-year bond at time t. j indexes one of the three non-US central banks per equation, while t indexes days with an announcement from central bank j. D_k refers to dummy variables equal to one in each of the aforementioned policy phases (k = {CMP, UMP, Async }),

[17] I contrast here entry in response to the GFC with the ECB's initiation of quantitative easing in response to the deterioration of real economic conditions in the Euro area after the initial recovery of financial markets from the GFC.

while MP_t^j is the monetary policy surprise emanating from the central bank in focus, and MP_t^i is the sequence of monetary policy shocks from the other three central banks. This last term controls for any announcements that overlap with announcements from central bank j.[18]

In calculating the monetary policy surprise, $Y_{j,t}$ is the implied yield on the short futures contract in use for central bank j. $\Delta e_t^{US,j}$ is the daily change in the exchange rate (LC/FC), and S_t^{JP}, S_t^{US}, S_t^{EU}, and S_t^{UK} are the orthogonalized CESI for Japan, the US, the Euro area, and the UK, respectively. Finally, to control for changes in risk and risk aversion, I include daily changes in the VIX. To avoid excessive influence of outliers, I estimate parameters by robust regression, using M-estimator of Huber (1981).

4.3 Results

Figure 2 summarize the main results and Tables 4 - 9 display parameter values and standard errors. Eestimates include effects at 1-, 3-, 5-, 7-, and 10-year maturities; however, I largely limit discussion in the text to maturities of 1, 5, and 10 years for ease of exposition. Before turning to the baseline (piecewise) regressions and to provide a useful contrast, I document first the broad patterns in the full sample, shown in Table 4.

The full sample results suggest significant effects of Federal Reserve policy shocks on U.S. Treasury rates and statistically significant but small spillovers from other central bank policy shocks to U.S. Treasuries, which differ little across maturities. We observe in Table 4 that the ECB generates the largest spillovers, although both the ECB and Bank of England surprises elicit U.S. term structure adjustments in both the term premium and in expected short rates. This latter pattern maps onto the results noted in Section 3, wherein only concurrent ECB/BoE monetary policy announcements appear to elicit a US yield response. Japan does not appear to generate spillovers detectable in the full sample.

Breaking the data into subsamples based on synchronicity at the ELB, some additional nuance emerges. Figure 2 condenses the results of the baseline regressions to allow for easier comparison between the sources of monetary policy surprises and between the channels of transmission. Tables 7 - 9 show the results for both yields and the yield decomposition with

[18] For example, the estimate for ECB spillovers includes only days with an ECB announcement, but a non-negligible number of those days also have announcements from other central banks.

parameter values for controls and standard errors.

Figure 2, row 1 summarizes the estimated impact of domestic monetary policy surprises on yields, term premia, and expected short rates respectively. As in the full sample, domestic effects dominate those of spillovers in all subsamples in terms of magnitude. However, the loading of monetary policy surprises by maturity differs by subsample for both domestic monetary policy effects and spillover effects, reflecting changing channels of transmission. [19]

Domestically, expansionary monetary policy surprises decrease yields all along the domestic yield curve, but the "shape" of the loading pattern differs at and away from the effective lower bound, consistent with other results in the literature. In the pre-crisis period, the impact of monetary policy decreases with the maturity of the bond, in line with the conduct of conventional monetary policy. In this subsample, an expansionary monetary policy surprise decreases the 1-year zero coupon bond yield at a rate 50 percent higher that of the 10-year yield. The Federal Reserve exhibits domestic pass-through to the 10-year bond yield at 5.1 basis points, a bit higher than point estimates from Gürkaynak et al. (2005).[20]

Related to decreasing pass-through by maturity, this period also exhibits a strongly dominant domestic role for the expected path of short rates, which decreases monotonically with maturity. In fact, in line with results from Nakamura and Steinsson (2018), the term premium does not appear to strongly influence domestic bond yields at any maturity in the pre-crisis period. What small effect the term premium does have on bond yields runs counter to the force exerted by the expected path of short rates. That is, an expansionary monetary policy surprise increases the term premium, indicating that market participants anticipate future growth, inflation or interest rate volatility, or a combination thereof, in the face of an expansionary FOMC surprise.

In the US, domestic patterns of interest rate pass-through shift with the onset of US quantitative easing. During this initial period of synchronous quantitative easing, the effect of US monetary policy increases with the maturity of the bond, which aligns with the stated goals of the FOMC's unconventional monetary policy and fits with other results observed in the

[19]To compare subsample coefficients statistically, Appendix Tables 10a - 10c display tests for equality of coefficients for each component.

[20]Gürkaynak et al. (2005) find that a 25 basis point expansionary monetary policy surprise caused 10-year yields to fall about 10 basis points. Given that a one standard deviation shock is 9.7 basis points, a 25 basis point shock would translate into a 13.9 basis point change in the 10 year yield.

literature (Christensen and Rudebusch (2012); Shah (2022); Rogers et al. (2018); Georgiadis and Gräb (2015); and Neely (2015), for example). During this period, a one standard deviation loosening surprise induced a 8 basis point change in the 10-year US bond yield on average.[21] The domestic impact of FOMC monetary policy peaks along the yield curve at the 7-year bond yield in the initial period of quantitative easing, compared to the 3-year yield in the period of conventional monetary policy and the 5-year yield during asynchronous normalization. In the context of interest rate normalization, this implies that monetary policy exerted decreasing influence over domestic long-term bond yields as the Federal Reserve normalized US monetary policy in the years following the taper tantrum. We observe this in the transition from dominant term premium effects to dominant expected short rate effects over the periods in sequence.

The decomposition of ECB spillovers to the US (Figure 2, row 2) reveals a marked departure from the magnitudes estimated in the full sample. In particular, ECB spillovers to the US during and after the GFC increase substantially. Moreover, spillovers to the United States mirror transmission channels from the FOMC in each of the subsamples. That is, the expected short rate channel drives (modest) spillovers in the pre-crisis period, whereas the term premium takes on additional importance for spillovers in the periods of US and Euro area quantitative easing. In the periods of quantitative easing, spillovers from ECB monetary policy announcements to US long-term bond yields in particular increase. One explanation for the greater spillovers in the normalization period relative to the initial LSAP period could be that this period coincides with the ECB's first purchases of government securities of member countries in a form analogous to the other central banks in the sample. However, Figure 2, row 3 shows that the Bank of England also propagated greater spillovers in the normalization period, despite having initiated LSAPs earlier, in 2009.

Spillovers from the Bank of England appear smaller than with those from the ECB, although they are still statistically significant. Unlike the ECB, spillovers from Bank of England surprises decrease in magnitude in the synchronous period of unconventional mone-

[21]To provide some context, the announcement of QE1 on November 25, 2008, was associated with a 26.5 basis point drop in the implied yield on the three month ahead Eurodollar futures contract and a 19.2 basis point drop in the implied yield from the 5-year Treasury bond futures contract. Across the three FOMC announcement dates from November 25 to December 16, 2008, the cumulative drop in these implied yields was 55 basis points and 53.3 basis points, respectively.

tary policy, although they do tilt toward the long end of the yield curve. This decrease in yield spillovers can be attributed to opposing impacts on the expected path of short rates and term premia—while expansionary BoE surprises lowered term premia, they increased expected short rates. A Bank of England monetary policy surprise exhibits its largest impact in the periods of asynchronous normalization, which increases with maturity and acts primarily through the term premium. Adding up the spillovers in rows 2 and 3 shows that during the Federal Reserve's policy normalization period, monetary policy shocks from the Bank of England and ECB had a combined effect on 10-year U.S. yields that overshadows the 6.5 basis point effect of the Federal Reserve's own policy tightening (2.5 and 4.3 BP respectively) Thus, spillovers from Bank of England and ECB monetary policies potentially offset the effect of Federal Reserve policy normalization on U.S. longer-term rates, neutralizing the transmission of domestic monetary policy to long-term interest rates. A simple back of the envelope calculation suggests that, in the absence of these spillovers, US ten year yields would have been about a percentage point higher by the end of 2019.

Spillovers from Bank of Japan (Figure 2, row 4) generally lack statistical significance or else are vanishingly small, reflecting low co-movement with the other economies in general. This low historical co-movement suggests that U.S. and Japanese sovereign bonds are not close substitutes. Alternatively, although the influence of monetary policy on carry trade activity lies beyond the scope of this paper, it is reasonable to posit that expansionary Japanese monetary policy might increase the attractiveness of in yen relative to other currencies, decreasing the price and increasing the yield of other safe assets in a manner than outweighs portfolio rebalancing or signaling effects.

Turning to the effect of control variables, foreign macroeconomic news does not generate statistically discernible yield changes on announcement days, although this analysis certainly does not rule out the influence of foreign economic developments on US bond yields in general. Among exchange rates, only the USD/EUR price has a statistically significant effect on announcement days. Here, an appreciation Euro on announcement days is associated with a decrease in US bond yields. In some specifications, a depreciation of the British pound is associated with a decrease in yields. Consistent with flight to safety effects, the yields of US bonds across the yield curve decrease when the VIX rises.

In summary, in the pre-crisis period, spillovers to the United States were generally small across maturities and more relevant for Treasuries with shorter maturities. In the synchronous UMP period, spillovers to the United States strengthened from the ECB. In the period of U.S. monetary policy normalization, characterized by the highest degree of policy asynchronicity, spillovers increased from both the ECB and Bank of England. Tables 10a - 10c show that these differences between phases of monetary policy are nearly all statistically significant at conventional levels. Together, these results suggest that asynchronous normalization was indeed, on net, consistent with lower long-term yields than would otherwise have prevailed from the FOMC tightening domestic policy.

4.4 Persistence of Monetary Policy Surprises

While point estimates from the baseline provide valuable information regarding the immediate effect of monetary policy on asset prices, the economic significance of monetary policy surprises emerges in part from their persistence. To characterize the persistence of spillovers, I extend the baseline using local projection methods (Jordà 2005; Stock and Watson 2018). While it is common in the literature on monetary policy transmission to use vector autoregression to document the persistence of shocks, these models have a number of drawbacks for the identification of cross-border monetary policy surprises.[22] Local projection methods allow the inclusion of multiple monetary policy surprises and macroeconomic news shocks without raising concerns of parameter proliferation and without imposing additional assumptions over the baseline model. Specifically, I estimate the following:

$$\Delta y^{(10)}_{US,t+h} \quad = \quad \alpha + \sum_j \gamma_{j,h} MP_{j,t} + \sum_{k=0}^{K} \theta_k x_t + \sum_{k=1}^{K} \sum_k \phi_k \Delta e^{i,j}_t + \psi \Delta VIX_t + \delta Fri + \epsilon_{it} \quad (7)$$

where $h = 0, \ldots, H$ is the estimation horizon and x_t represents the vector of news controls. I plot impulse responses to a horizon of 25 event days, defined as any day with a central bank announcement. $\gamma_{j,h}$ represents the average monetary policy pass-through to the US ten year bond yield from central bank j spillovers (or domestic passthrough, in the case that j = US).

[22] See, for example, Rogers et al. (2014); Rogers et al. (2018); Gertler and Karadi (2015); and Bluwstein and Canova (2016)

Although local projection methods confer a number of benefits in the current context, they tend to produce jagged impulse responses that can be difficult to interpret. To smooth excess variability of the estimator, I apply a compound moving median smoother to the estimated series $\hat{\gamma}_j = \{\hat{\gamma}_{j,0} \ldots \hat{\gamma}_{j,H}\}$.[23]

Due to the unique role long-term bond yields play in the conduct of unconventional monetary policy, I limit my discussion to the persistence of monetary policy pass-through to 10-year zero coupon bond yields. In terms of subsample periods, I contrast here the full sample results to those from the asynchronous period, as this latter period exhibits the largest spillovers in static estimates. Figures 3 and 4 depict the persistence of domestic monetary policy surprises, plotting the smoothed path of the parameter estimates with smoothed 90% and 95% confidence bands. As in the baseline, monetary policy surprises are normalized to a one standard deviation loosening.

Overall, while the *magnitudes* of spillovers increase in the asynchronous subsample period compared to the full sample, their persistence does not change drastically. Nevertheless, interesting distinctions do arise in comparing the central bank/recipient pairs to one another in terms of persistence. Domestic passthrough from US monetary policy to 10 year Treasury yields persists over the 25 day period, converging slowly to zero. In comparison, spillovers to the ECB and Bank of England, while larger in the asynchronous subsample, generally last one to two weeks before becoming statistically insignificant. As in the static estimates, spillovers from the Bank of Japan are not significant over any horizon.

4.5 Policy Decomposition

Another strand of the literature on the identification of monetary policy shocks supports the notion that a multidimensional monetary policy surprise more fully explains asset price movements. Therefore, following the work of Gürkaynak, Sack, and Swanson (2005), Swanson (2021) and Rogers et al (2018), and in explicit recognition of the changing mechanisms of monetary policy over time, I also consider three separate measures of monetary policy surprises constructed as follows.

[23] In particular, I first apply a 3-spline moving median smoother with repetition to convergence, followed by a Hanning linear binomial smoother.

First, I extract the surprise component of the decision about the target rate based on the change in yield on the one-month ahead OIS futures contracts on the dates of monetary policy announcements, which I label the "target surprise". Next, I take the residual from a regression of the announcement day change in the implied yield on the 24 month ahead futures contracts on the three-month Euro Interbank Offered Rate onto the target surprise and label this the "forward guidance surprise". Finally, I take the residual from a regression of the announcement day change in the 10 year bond futures onto the target and forward guidance surprises. This "LSAP surprise" is intended to capture changes in long-term interest rates that are associated with announcements related to large-scale asset purchases. As large scale purchases begin strictly after November 2008 for each case except for Japan, I restrict this monetary policy surprise measure to equal zero before then as in Swanson (2021) and Rogers et al. (2018). Figure 5 displays the decomposition for each central bank over time, and Appendix Table 11 displays summary statistics. As in the baseline, surprises are normalized to a one-standard deviation loosening.

This exercise expands the baseline in the following manner:

$$\Delta y_{US,t}^{(n)} = \alpha + \sum_j \gamma_1^j target_t^j + \sum_j \gamma_2^j fg_t^j + \sum_j \gamma_3^j D_k lsap_t^j + X_t' \theta_i + \epsilon_{it} \tag{8}$$

Where X_t is a transposed vector of controls identical to the baseline and t is indexed to central bank j's announcement days. In the interest of brevity, I limit my discussion to estimated spillovers to one- and ten-year yields.

Given the multidimensional nature of the monetary policy surprise, the results provide a map between the domestic pass-through and spillovers (Table 12). We see in the domestic results in Figure 2 that the decomposition reflects changes in the maturity structure of domestic pass-through. That is, target surprises dominate one year yields, forward guidance surprises affect both short and long rates, and LSAP shocks dominate 10-year yields. Turning to spillovers, LSAP surprises generate the largest international spillovers, and pass-through of the baseline monetary policy shock to domestic 10-year yield peaks, in most cases, in the asynchronous period. Thus, even with the relatively short maturity of the instrument underlying the unidimensional monetary policy measure in the baseline, the baseline monetary policy shock still largely captures announcement day comovement in long duration yields. These spillovers arise in large part through term premia, which also maps onto a similar finding in the baseline.

Interestingly, forward guidance surprises load onto international 10 year yields at a rate which does not differ drastically from LSAP surprises. It stands to reason that, once unconventional tools came into wide use during the GFC, forward guidance reaches permanently further into the yield curve. Thus, the extra impulse to long term spillovers generating subsample changes in the baseline emanate from surprises that reach the long end of the domestic curve. These forward guidance and LSAP surprises show up primarily, although not exclusively, in term premia.

Target shocks, unsurprisingly, do not strongly spill over into ten-year yields, and are more prevalent in the pre-crisis period, explaining the dearth of observed monetary policy spillovers in the pre-crisis baseline. These manifest almost exclusively through the path of expected short rates.

Taken together, these results suggest taking into account the cross-country nature of unconventional monetary policy through the lens of time varying regimes provides a more nuanced image of international spillovers, but also of domestic pass-through. Spillovers from unconventional monetary policy appear to change with both the domestic response and the comparative policy stance of other markets. While spillovers increase during periods of heavy multilateral large scale asset purchases, asynchronous normalization has engendered the largest cross-country spillovers from monetary policy, implying that measured spillovers sampling the post-crisis period result in part from the increase in spillovers during normalization.

5 Extensions and Robustness

What is it, then, about the period of normalization that drives these patterns? This section explores a number of candidate channels, including the effective supply of safe sovereign assets, elevated uncertainty, asymmetric reactions to monetary policy shocks, and central bank information effects.

5.1 Testing the Confidence Channel: News, Uncertainty and Risk Aversion

Given the provenance of monetary policy cycles in differing macroeconomic, financial and political conditions over time, we might surmise that changes in spillovers result from changes in sentiment regarding global economic conditions. Recent literature on the information channel of monetary policy transmission argues that central banks affect asset prices via agents' beliefs not only about policy, but about the path of the economy (Leombroni et al. 2021; Nakamura and Steinsson 2018; Melosi et al. 2017; Jarocinski and Karadi 2018). This information falls into two broad categories. First, central banks can produce "Odyssean" forward guidance in the form of information about the path of policy. In the baseline analysis, results obtained using the expected path of short rates provides evidence regarding the importance of this transmission channel for international spillovers. However, as mentioned previously in reference to the confidence channel of monetary policy transmission, the central bank also generates "Delphic" information, wherein the announcement reveals news about the state of the economy. If, for example, the central bank enacts a more aggressive rate cut than expected or communicates a longer cycle than expected, agents may infer that the central bank possesses better information on downside growth risks and update their beliefs accordingly.[24]

Standard theory predicts that an expansionary announcement characterized only by information about the path of policy (without Delphic effects) should lead to a stock price rally through discount and dividend channels; that is, we would expect negative co-movement of surprises and equity returns (as in Bernanke and Kuttner 2005). In turn, if market participants extract information suggesting a weaker outlook for economic or financial conditions, stock prices would rise less or even fall on reduced expectations of cash flows or of higher risk. Thus, looser monetary policy that is accompanied by a decrease in stock returns (positive co-movement) indicates diminished economic or financial conditions. Thus, the sign of high-frequency co-movement of stocks and the implied yields on futures contracts can help disentangle events with strong risk premium implications versus no (or weak) risk premium implications.

In the context of spillovers, Delphic news shocks can propagate via two potential channels. The first mirrors that for domestic asset prices, but is two-fold. That is, bad news gleaned

[24]See Leombroni et al. 2021 for an in-depth discussion of the mechanism.

from monetary policy decreases yields through downward revisions to growth expectations. These revisions, in turn, should drive a lower path of expected future interest rates. On the other hand, downside risk to economic growth should increase risk premia, so to the (albeit modest) extent that these sovereign bonds are subject to a risk premium, this would increase yields on expansionary events if the information effect dominates. The second channel reflects flight to safety—increased risk revealed from monetary policy should induce capital to flow toward other safe assets, compressing their yields.

To test for the presence of risk-induced effects, I use a simplified version of Jarocinski and Karadi's (2018) decomposition method, separating surprises with positive equity return co-movement using a dummy variable indicating a "risk-off" days. For each market, I use Fama/French excess returns (Rm - Rf) and test interaction effects one pair at a time to economize on parameters. Regressions take two separate forms to account for spillovers. In the first set of specifications, a "risk-off" day indicator function takes a value of 1 on announcement days characterized by positive equity return co-movement in the same country as the monetary policy surprise in question. For example, when considering risk premium effects from the ECB, I look for positive co-movement with the equity return in the Euro area.

$$\Delta y_{US,t}^{(n)} = \alpha + \beta_1 \mathbb{1}[r_{i,t} \times MP_t^i > 0] + \beta_2 MP_t^i + \beta_3 \mathbb{1}[r_{i,t} \times MP_t^i > 0] * MP_t^i + \dots \\ + \sum_j \gamma_j MP_t^j + X_t' \theta_i + \epsilon_{it} \quad (9)$$

Where $y_{it}^{(n)}$ is either the yield on the n-year Treasury bond or the expected path of short rates over an n-year horizon. In this and the next specification, X_t is a transposed vector of controls identical to the baseline. In this exercise, i is the domestic market/central bank, i is the foreign central bank of interest, and j indexes the other central banks in the sample.

In the second set of specifications, the indicator function takes a value of 1 on announcement days characterized by positive equity return co-movement in the same country as the sovereign bond of interest. Thus, when considering risk premium effects on the US 10 year yield from the ECB, I look for positive co-movement between the ECB surprise and the equity return in the United States.

$$\Delta y^{(n)}_{US,t} = \alpha + \beta_1 \mathbb{1}[r_{US,t} \times MP^i_t > 0] + \beta_2 MP^i_t + \beta_3 \mathbb{1}[r_{US,t} \times MP^i_t > 0] * MP^i_t + \dots$$
$$+ \sum_j \gamma_j MP^j_t + X'_t \theta_i + \epsilon_{it} \quad (10)$$

Tables 13 and 14 display the results. Spillovers from the ECB, the Bank of England and the Bank of Japan all exhibit some statistically significant risk component. The sign of the impact indicates announcements containing a risk-off component exert smaller spillovers compared to those without, indicating that these announcements generate smaller downward revisions of growth and interest rates and/or flight to safety flows.

In the context of the current study, the question naturally arises as to whether these risk shocks contribute to increased spillovers in periods of unconventional monetary policy.[25] Given the positive sign on the "risk-off" interaction, an increase in spillovers explained by the effect of news would require the prevalence of these types of shocks to fall. To comment on the time variation in risk-based spillovers, I plot measured monetary policy surprises against changes in the Fama/French returns in each of the baseline subsamples (See Figures 6 - 7). If risk-based spillovers explain increased spillovers to ten year yields in the asynchronous period, we should expect fewer of these comovement surprises in later subsamples compared to the pre-crisis period.

Put differently, if monetary policy surprises with a strong risk-off component diminish in the latter subsamples, the plots should show decreased pairings in the first and third quadrants, with a fit line less positively sloped compared to other periods. In fact, we observe just the opposite. In each each case, either the fit line becomes less negatively sloped in the asynchrous period or it remains similar to the previous period. Thus, spillovers appear to have increased during US monetary policy normalization *in spite* of news effects, and therefore the incidence of central bank information shocks does not appear to explain increased spillovers.

Rather than central bank news driving increased spillovers, it could be instead that the period of asynchronous monetary policy was marked by a differential risk environment with

[25]For example, Leombroni et al. (2021) find that risk premium shocks in the Euro area rise in importance in the context of the European debt crisis.

attendant impacts of the size of spillovers. Gorodnichenko and Ray (2017) show, for example, that local supply effects of Treasury demand shocks are most obvious during periods of elevated risk. That is, LSAPs are less likely to be “spot” effective when the risk bearing capacity of arbitrageurs is high. While it is not feasible in this context to test whether spillovers are maturity-specific, a related question lay in the degree to which uncertainty and/or risk aversion affects the size of spillovers. To that end, I repeat the previous exercise, conditioning the impact of the monetary policy shock on the VIX index. Table **??** suggests that uncertainty and/or risk aversion as measured by option-implied volatility does not alter the size of spillovers much, and therefore largely cannot explain the baseline pattern of results.

5.2 Asymmetric Responses: Contractionary Versus Expansionary Surprises

Another candidate explanation arises from the distribution of contractionary versus expansionary surprises in the various subsamples. That is, if expansionary surprises generate larger spillovers than contractionary ones, we should expect periods marked by a prevalence of expansionary surprises to produce larger spillovers. To test for these asymmetric effects, I run the following specification, testing one interaction at a time:

$$\Delta y^{(n)}_{US,t} = \alpha + \beta_1 MP^j_t + \beta_2 \mathbb{1}[MP^j_t < 0] + \beta_3 \mathbb{1}[MP^j_t < 0] * MP^j_t + \sum_k \gamma_k MP^k_t + \theta^i_1 S^i_t + \sum_j \theta_j S^j_t + \sum_j \phi_j \Delta e^{i,j}_{t-1} + \psi \Delta VIX_t + \delta Fri + \epsilon_{it} \quad (11)$$

Where $\mathbb{1}[MP^j_t < 0]$ is an indicator function equal to one where the monetary policy surprise takes a negative value (i.e., an expansionary surprise). As in the previous exercise, i indicates the domestic market/central bank, j is the foreign central bank of interest, and k indexes the other two central banks in the sample. When estimating domestic risk premium effects, k indexes all three foreign central banks.

Table 17 shows that yields do not in general react differently to expansionary monetary policy surprises compared to contractionary ones from the ECB. On the other hand, US One year yields do appear to react more to expansionary surprises from the Federal Reserve and the Bank of England. One year yields also appear to respond more to contractionary surprises from the BoJ. Spillovers to ten year yields do not appear to differ comparing expansionary to contractionary shocks, although they do appear to react more to contractionary shocks from the FOMC. Although the responses to expansionary versus contractionary shocks differ on the short end of the yield curve, shocks do not appear to be overwhelmingly contractionary or expansionary in most subsamples for most of the Central Banks. In Table 18, we see that contractionary shocks are more prevalent from the ECB in the pre-crisis period, whereas expansionary shocks are more prevalent from the Bank of Japan in the period of asynchronous normalization. Thus, it appears that the asymmetric reactions do not drive the baseline results.

5.3 The Portfolio Balance Channel and Duration Risk

When the ECB implemented the public sector purchase program (PSPP) in March of 2015, policy makers explained the accompanying fall in yields in terms not only of a reduction of duration risk, but also the "creation of scarcity" (Cœuré 2015). This speaks directly to the portfolio balance channel of asset purchases, in which the preferences of habitat investors for the relative safety and liquidity of advanced economy sovereign bonds causes these assets' prices (and those of their closest substitutes) to rise because they cannot easily be replaced (Vayanos and Vila 2009). Empirical evidence on this front suggests that the net supply of debt can indeed explain domestic yields (e.g., Krishnamurthy and Vissing-Jorgensen 2011; Hamilton and Wu 2012; Greenwood and Vayanos 2014; Wolcott 2020; Blattner and Joyce 2021). As shown in Figure 8, the amount of UK and German sovereign debt available for purchase by the private sector has fallen steadily since the start of the sample, reaching about a third of outstanding debt by Jan 2020. This section explores the degree to which the public's access to safe sovereign assets affects the size of monetary policy spillovers.

In this context, "free float" reflects the quantity of government bonds available for purchase by the domestic private sector after accounting for central bank purchases. To explore the relationship between float and monetary policy shocks, I interact the proportion of government debt that is available for private domestic purchase (expressed as z-scores) with monetary policy shocks from the respective central banks in the sample. Each central bank's shock is matched to its own government's free float, with two caveats. First, the data needed to calculate total free float across the Euro area in its entirety is not publicly accessible. Thus, I use German Bund free float from Bloomberg as a proxy for the Euro area. Second, free float data for Japan is also not available and, without a proxy, I omit Japan from this exercise. With this data in hand, we have the following:

$$\Delta y^{(n)}_{US,t} = \alpha + \beta_1 MP^i_t + \beta_2 FF^i_{t-q} + \beta_3 FF^i_{t-q} * MP^i_t + \sum_j \gamma_j MP^j_t + \sum_k \theta_k S^k_t + \sum_k \phi_k \Delta e^{k,US}_t + \phi \Delta VIX_t + \delta Fri + \epsilon_{it} \quad (12)$$

Where FF^i_{t-q} is the z-score of country i's free float in the previous quarter, MP^i_t is the monetary policy shock from country i (whose announcement days constitute the sample), j indexes central banks not including i, and k indexes all central banks in the regression. Free float enters with a lag, owing to its lower frequency. Due to the central role of preferred habitat investors in the determination of the term premium in particular, I repeat the exercise with term premia and the path of expected short rates as the dependent variable.

Table 19 displays the results. We see first in Table 19a columns 1-3 that spillovers from the ECB do indeed fall when German free float rises, particularly in intermediate and longer-dated yields. Consulting columns 4-6, it appears that this effect runs entirely through the term premium, in line with the mechanisms of the portfolio balancing channel. In contrast, the availability of government bonds to the public does not influence spillovers to the expected path of short rates except at the short end, where it adds to (modest) spillovers.

The case of the Bank of England, shown in Table 19b is less clear-cut and relies on the yield decomposition. While the effect of yield spillovers conditional on the amount of free float is not statistically significant, it does carry the expected sign. Consulting the decomposition, spillovers to US term premia do fall further in response to the Bank of England monetary policy shock when UK free float is low. As in the case of the ECB, monetary policy conditional on free float does not appear to impact the expected path of short rates. Combined with the contribution of the expected path of short rates to yield effects overall, this helps to explain the statistically insignificant impact of the conditional monetary policy shock on yields.

As demonstrated in Figure 20, these same patterns hold when I replace the own-market float with the GDP-weighted average float of the four markets. Taken together, these results suggest a role for portfolio balance behavior in driving spillovers from ECB and BoE monetary policy to US yields.

5.4 Compound Monetary Policy Surprise Measure

While I have chosen futures contracts for their comparability across markets, my monetary policy measure differs from some of the recent literature in monetary policy shock identification in that it does not extract changes in the cross-section of maturities (Kiley 2014; Rogers et al. 2014; Rogers et al. 2018; Shah 2022). Monetary policy surprises derived from the cross-section of yields have the advantage of subsuming policies aimed at different maturities in the yield curve. Such compound measures summarize the overall stance of monetary policy both at and away from the effective lower bound. Therefore, as a robustness check, I repeat the exercise described in Equation 2 with the terms MP_i and MP_j now comprising the announcement-day change in the first principal component of 2-month and 24 month-ahead OIS futures, with the implied yield on 10-year bond futures in the respective central banks' markets, normalized to a one standard deviation loosening. However, this approach falls short in that there is no generic Euro area ten year bond futures contract. As a proxy for Euro area bond futures, I use ten year Bund futures.[26] Comparing Figure 9, which summarizes the results, with Figure 2 suggests that the patterns observed in the baseline do not shift markedly when using a compound monetary policy measure.

6 Concluding Remarks and Directions for Future Research

In this paper, I utilize high frequency identification, a shadow rate term structure model, piecewise regressions, and local projection methods to identify the effect of monetary policy spillovers to and from advanced economies engaged in unconventional monetary policy across the yield curve over time. I provide evidence for the existence of heightened spillovers to the US from the UK, Japan, and the Euro area during the period of asynchronous monetary policy normalization, with the most persistent spillovers arising during the period of asynchronous monetary policy normalization.

[26] Alternative specifications using 10 year generic Euro area sero coupon bond yields from the ECB produce similar results.

Results suggest that these central banks' programs of unconventional monetary policy compressed long-term bond yields in each other's markets primarily through the term premium, indicating the dominance of portfolio balance and confidence channels of transmission over signaling. In particular, I find that advanced economy spillovers to US long term yields have increased with the rise of two phenomena: wide scale adoption of unconventional monetary policy among advanced economies and the accompanying decrease in the availability of safe, long-duration assets.

The mechanisms of unconventional monetary policy that distinguish it from conventional monetary policy imply unique challenges to the withdrawal of monetary stimulus, particularly in the presence of spillovers. Long-term bond yields compressed during the period of unconventional monetary policy may be less upwardly sensitive to conventional policy given the role of term premia in determining long-term interest rates, especially in an environment marked by scarcity of safe assets. In the face of ongoing quantitative easing in other systemic, advanced economies, this implies that normalizing central banks conduct monetary policy primarily by exerting pressure on the expected path of short-rates (which is diminishing in maturity) compared to periods of quantitative easing, while international spillovers have the potential to exert force in the opposite direction on the term premium (which increases with maturity) (Hamilton 2009).

Asynchronicity of unconventional monetary policy in these systemically important markets makes the cross-country spillovers that I document particularly salient. For example, the evidence presented here suggests that US monetary policy normalization preceding the COVID-19 crisis effectively exerted contractionary monetary policy on European bond yields. This implies that the ECB would have needed to withdraw its stimulus more slowly (or even increase it) in order to keep credit conditions from tightening more than intended when it ultimately halts its asset purchases. From another angle, in the absence of international portfolio balance effects, domestic long-term bond yields would be more responsive to quantitative easing. Once again, as of writing, these countries find themselves at the point of normalizing monetary policy. Central banks do well to acknowledge the impact of spillovers on the shape of the sovereign yield curve, which makes monetary policy more or less effective.

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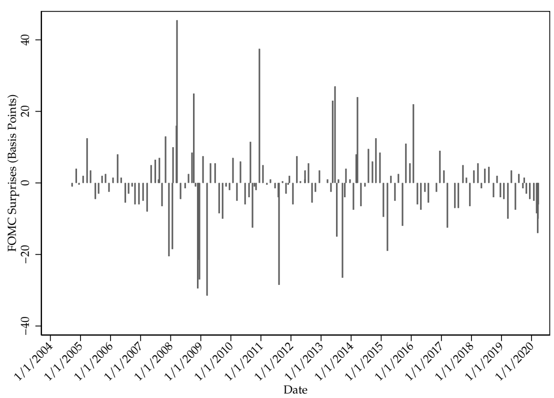
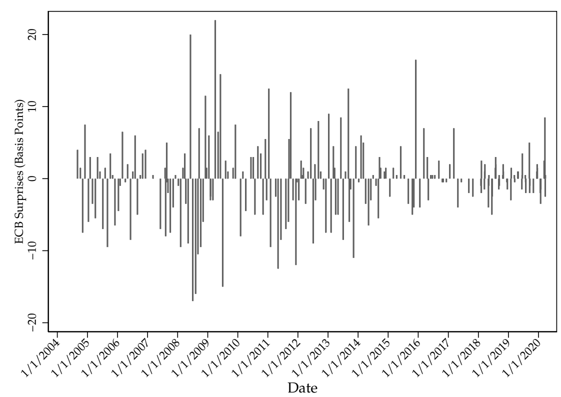
7 Appendix A: Figures

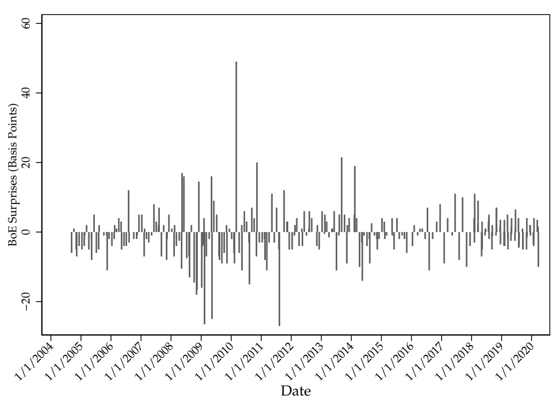
Figure 1: Monetary Policy Surprises Measured with Interbank Futures



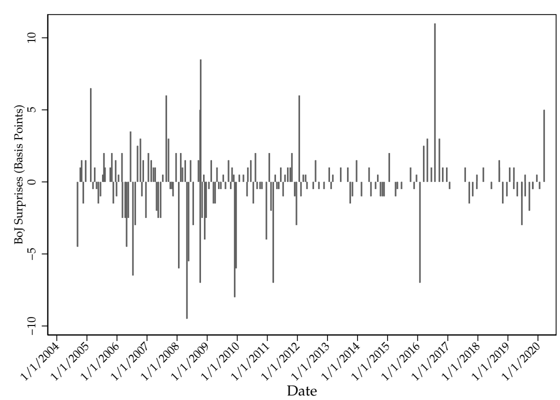
(a) FOMC



(b) ECB



(c) Bank of England

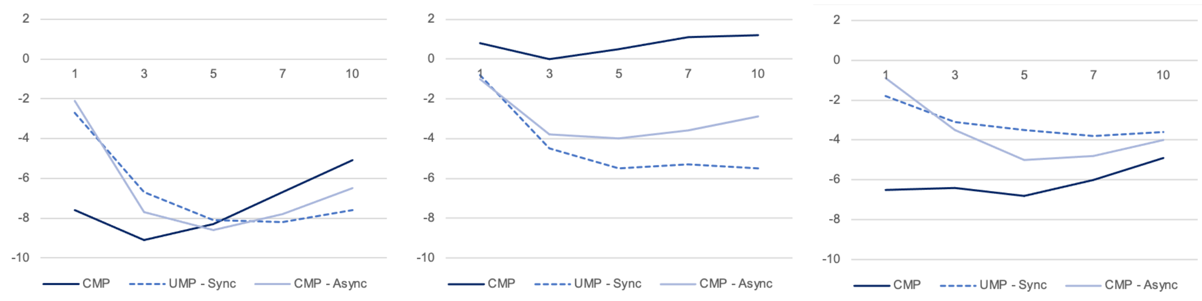


(d) Bank of Japan

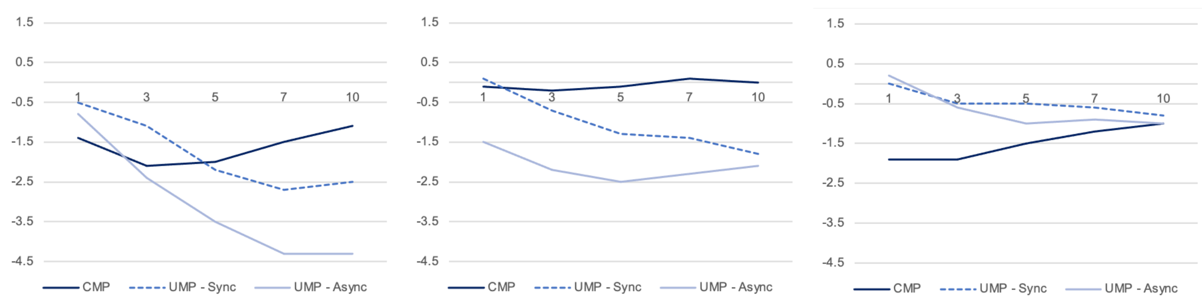
Figure 1 shows the open to close change in the implied yield on the 24 month ahead futures contract based on the three-month (1a) Eurodollar on FOMC announcement days, (1b) Euribor on ECB announcement days, (1c) Short Sterling on BoE announcement days, and (1d) Euroyen Tibor on BoJ announcement days.

Figure 2: Effect of a One St. Dev. Monetary Policy Loosening Surprise on US Yields

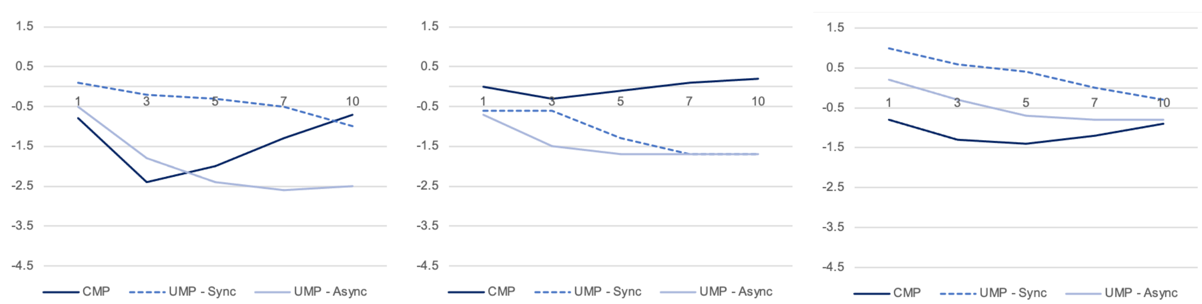
(a) Yields (b) Term Premium (c) Expected Short Rate



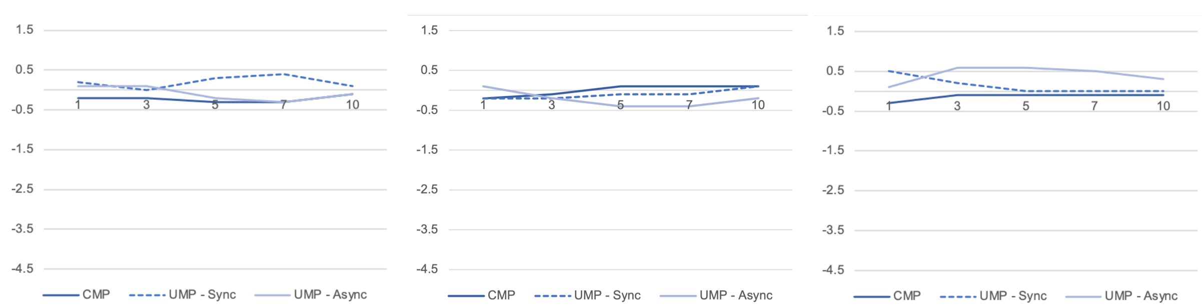
i. Federal Reserve



ii. European Central Bank

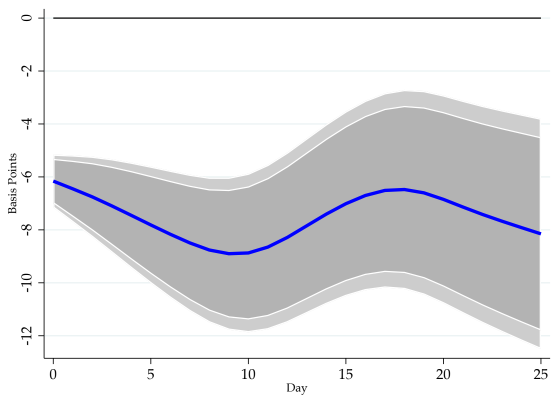


iii. Bank of England

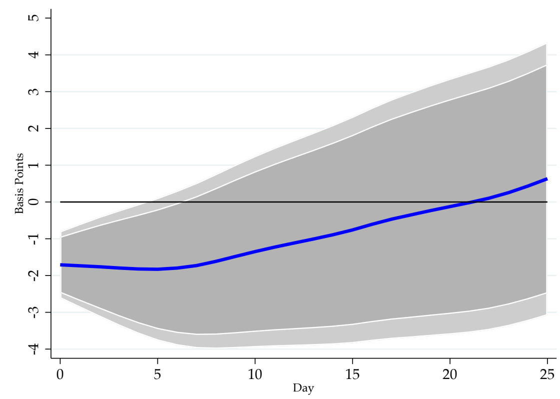


iv. Bank of Japan

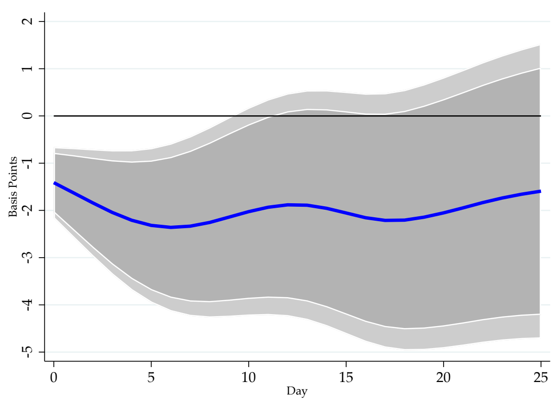
Figure 2 summarizes the results of daily piecewise regressions where the dependent variable is the change in zero coupon bond yields for maturities of 1, 3, 5, 7, and 10 years. The monetary policy shock is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks. Monetary policy measures are normalized to be a ten basis point loosening, where standard deviations are calculated by sub-sample. All control variables from the baseline are included in the regression and appear in the appendix.



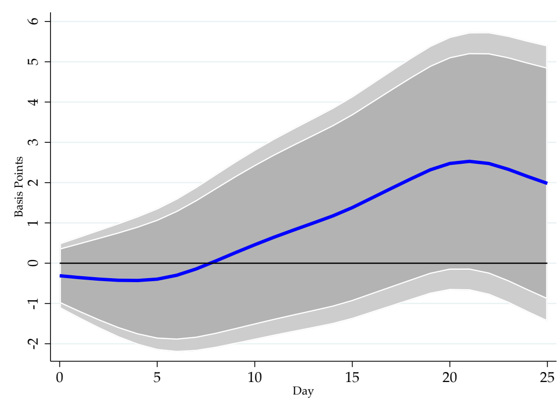
(a) FOMC



(b) ECB



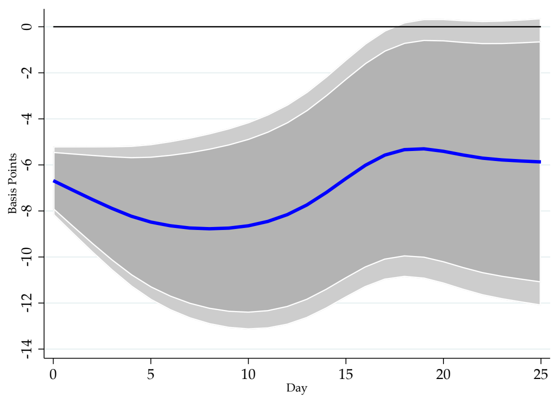
(c) BOE



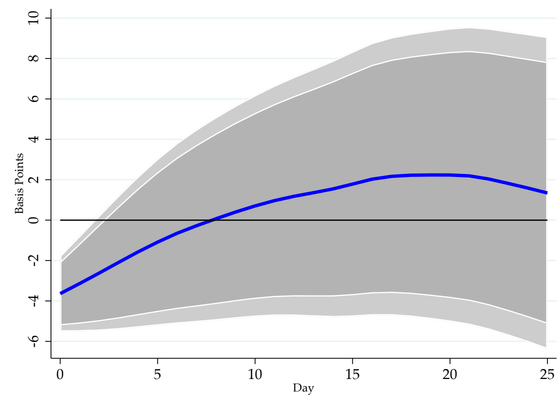
(d) BOJ

Figure 3: Effect of a one standard deviation Expansionary Surprise on Domestic 10 Year Bond, Full Sample

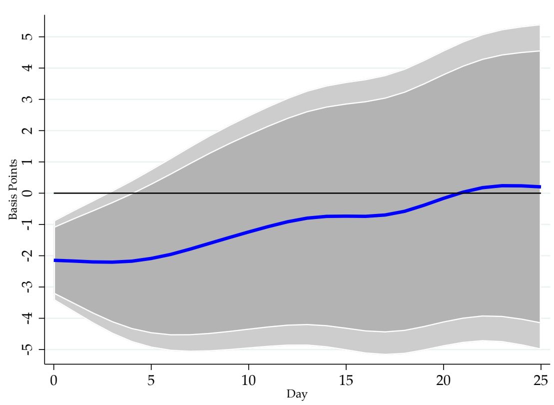
Figure 3 summarizes the results of daily local projections in the full sample where the dependent variable is the change in the domestic 10 year zero coupon bond from 0 to 25 days after the date of a domestic monetary policy announcement. The impulse variable is the daily change in the implied yield for the 18 month ahead futures contract on the (a.) Eurodollar (Fed), (b.) Euribor (ECB), (c.) Short Sterling (BoE) and (d.) Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks. Monetary policy measures are normalized to be a one standard deviation loosening. Thick blue lines show the path of the smoothed estimate for the path of $\hat{\gamma}_{i,0}, \ldots, \hat{\gamma}_{i,25}$ using a compound moving median smoother. The dark and light gray areas indicate smoothed confidence intervals at 95% and 90% confidence intervals, respectively.



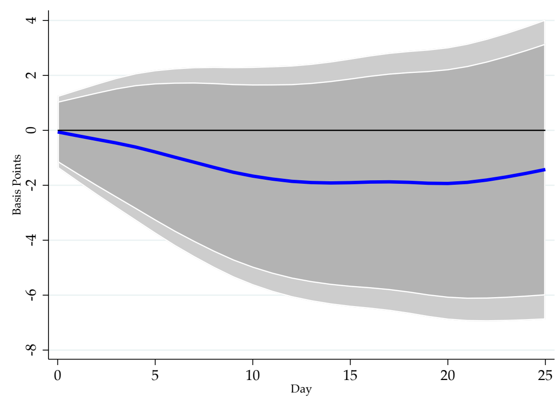
(a) FOMC



(b) ECB



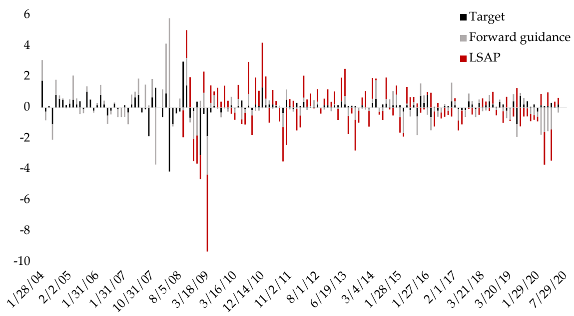
(c) BOE



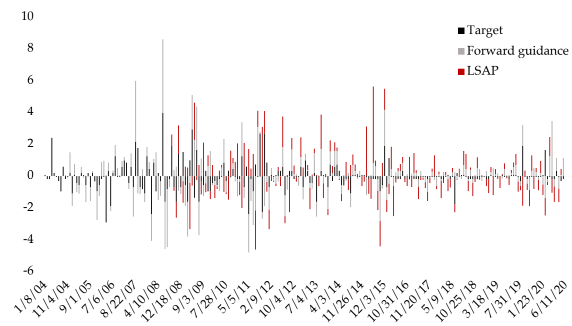
(d) BOJ

Figure 4: Effect of a one standard deviation Expansionary Surprise on Domestic 10 Year Bond, Asynchronous Normalization

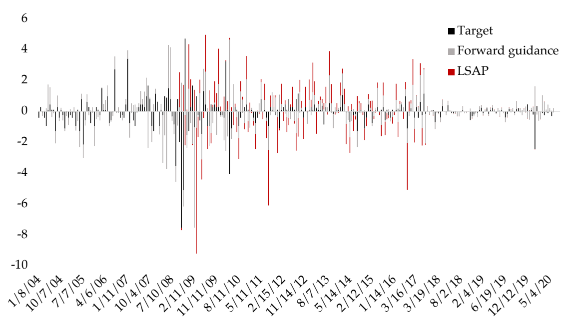
Figure 4 summarizes the results of daily local projections in the asynchronous normalization subsample period, where the dependent variable is the change in the domestic 10 year zero coupon bond from 0 to 25 days after the date of a domestic monetary policy announcement. The impulse variable is the daily change in the implied yield for the 18 month ahead futures contract on the (a.) Eurodollar (Fed), (b.) Euribor (ECB), (c.) Short Sterling (BoE) and (d.) Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks. Monetary policy measures are normalized to be a one standard deviation loosening. Thick blue lines show the path of the smoothed estimate for the path of $\hat{\gamma}_{i,0}, \ldots, \hat{\gamma}_{i,25}$ using a compound moving median smoother. The dark and light gray areas indicate smoothed confidence intervals at 95% and 90% confidence intervals, respectively.



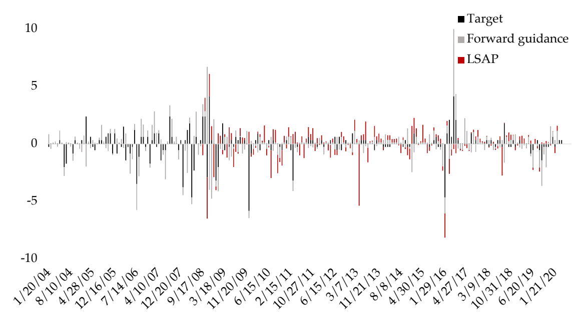
(a) Federal Reserve



(b) European Central Bank



(c) Bank of England



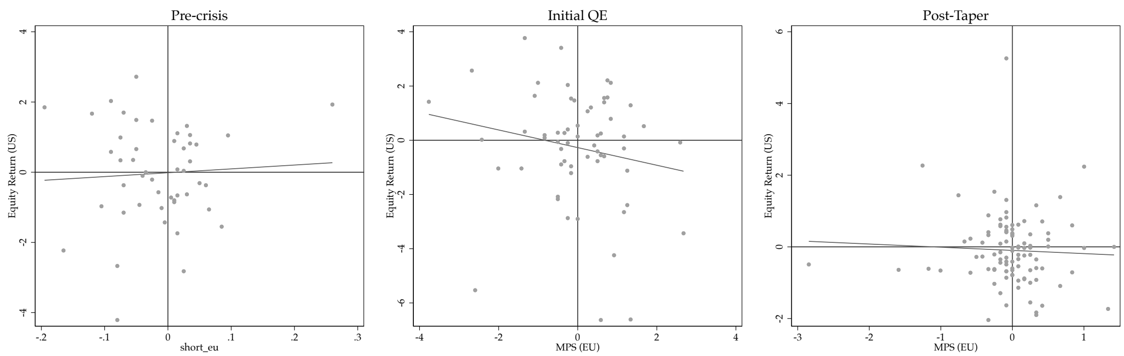
(d) Bank of Japan

Figure 5: Three-part Monetary Policy Surprise Measure

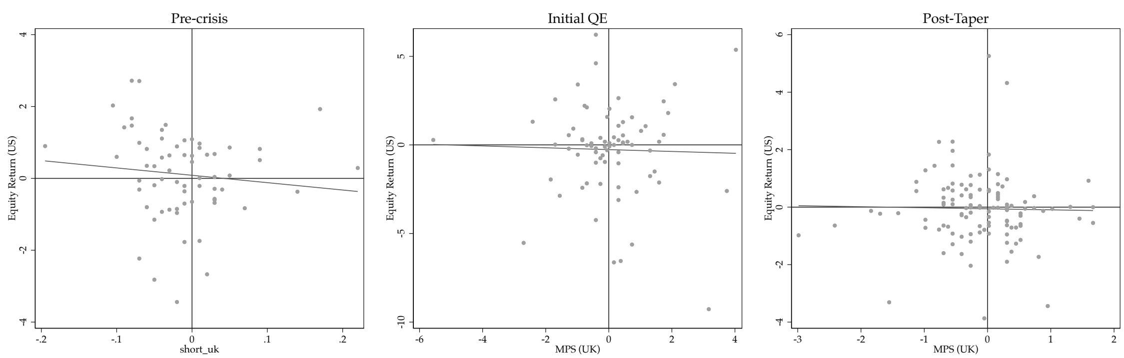
Figure 5 shows "Target", "Forward Guidance" and "LSAP" shocks for the FOMC, ECB, Bank of England and Bank of Japan. For each central bank's announcement day, target shocks comprise the surprise component of the decision about the target rate based on the change in yield on the one-month ahead OIS futures contracts. Forward guidance shocks contain the residual from a regression of the announcement day change in the 24 month ahead futures contracts on the three-month Euro Interbank Offered Rate onto the target surprise. LSAP shocks comprise residual from a regression of the announcement day change in the implied yield on 10-year bond futures onto the target and forward guidance surprises.

Figure 6: Positive Co-movement Days, ECB & BOE Announcements against Domestic Equity Returns

(a) ECB



(b) BOE



(c) BOJ

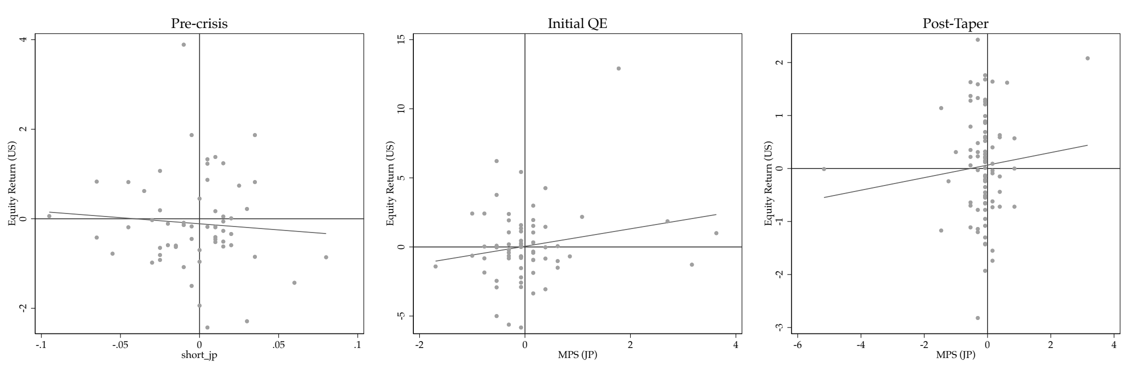
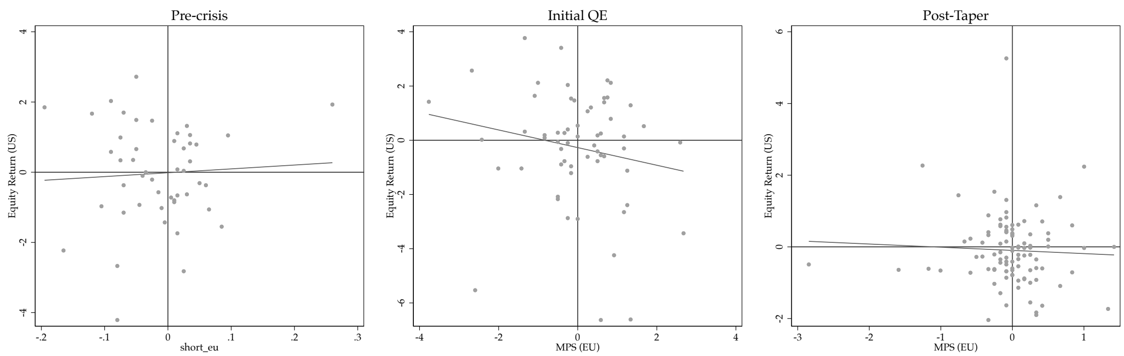
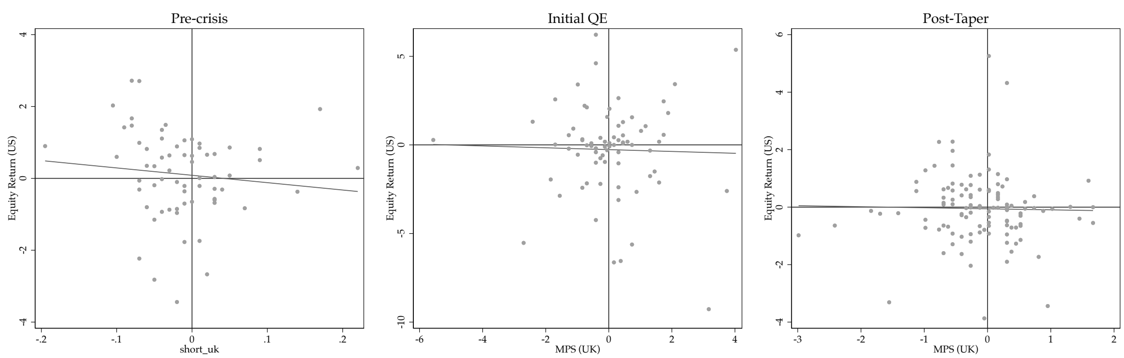


Figure 7: Positive Co-movement Days, ECB & BOE Announcements against US Equity Returns

(a) ECB



(b) BOE



(c) BOJ

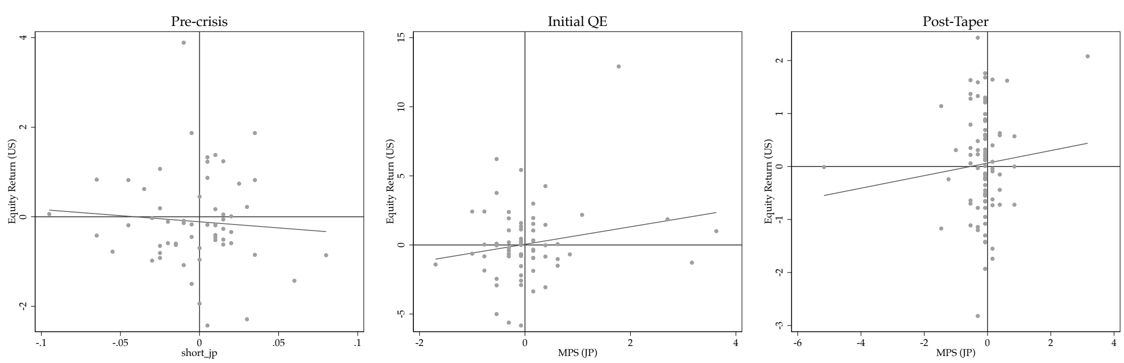
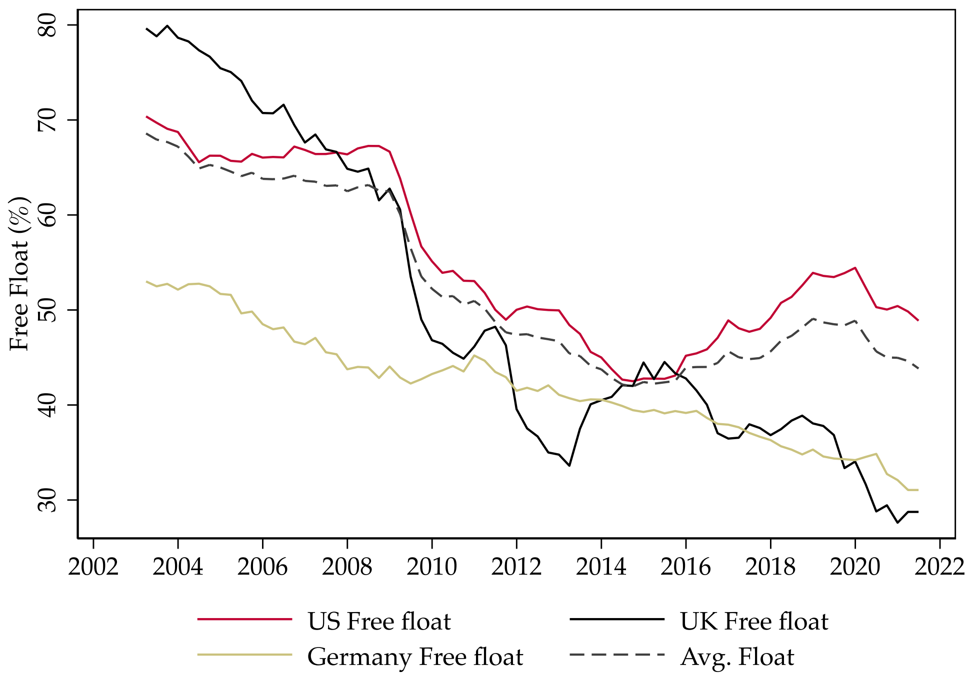
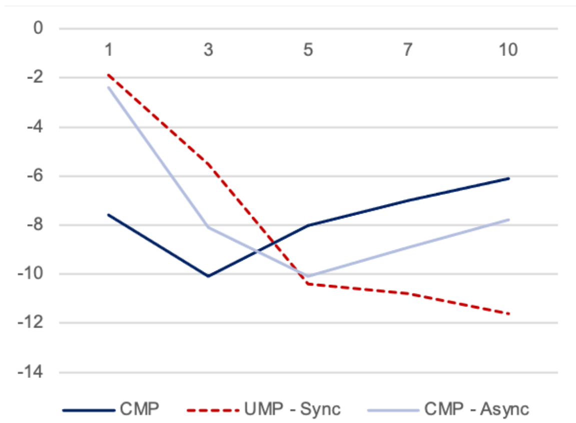
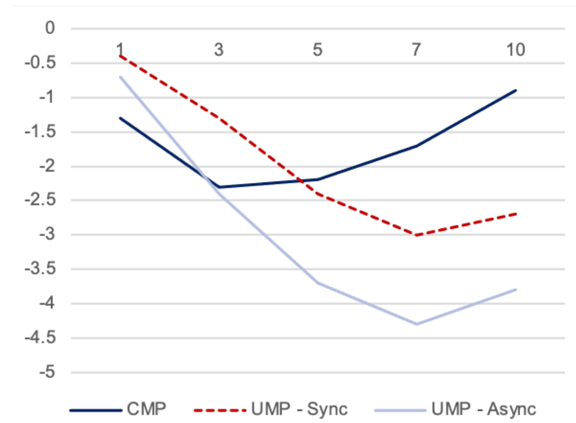


Figure 8: Sovereign Bond Free Float

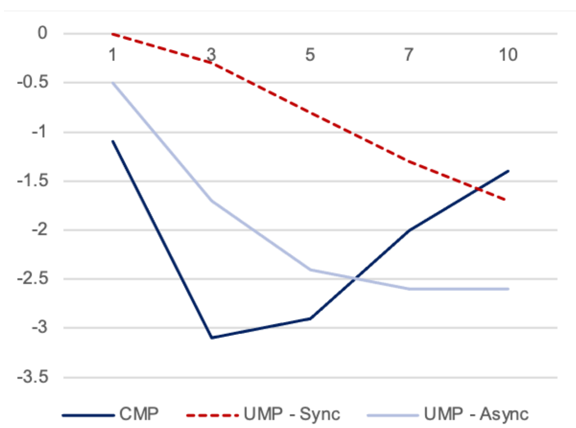




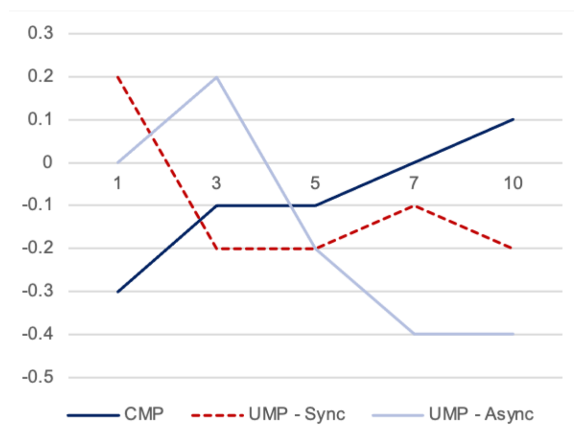
(a) Federal Reserve



(b) European Central Bank



(c) Bank of England



(d) Bank of Japan

Figure 9: Monetary Policy Surprises Measured with PCA

Figure 9 summarizes the results of daily piecewise regressions where the dependent variable is the change in zero coupon bond yields for maturities of 1, 5, and 10 years. The monetary policy shock is the daily change in the first principal component of the 2-month, 24-month ahead OIS futures and and 10-year futures implied yields in the respective central bank's markets on monetary policy meeting days. Monetary policy measures are normalized to be a one standard deviation loosening. All control variables from the baseline are included in the regression and their point estimates appear in the appendix.

8 Appendix B: Tables

Table 1: Monetary Policy Sample Counts and Market Timing Conventions

Central Bank	Full Sample	Pre-crisis	US QE	Post-Taper	EU QE
FOMC	162	86	42	40	23
ECB	244	116	60	53	30
BoE	275	135	74	58	32
BoJ	259	125	67	52	28
ECB or BoE	406	198	100	94	60
ECB and BoE	113	60	34	17	2

(a) Count of Announcement Days

Source	Recipient Market			
	US	UK	Euro area	Japan
FOMC	$t-1, t$	$t, t+1$	$t, t+1$	$t, t+1$
BoE	$t-1, t$	$t-1, t$	$t-1, t$	$t, t+1$
ECB	$t-1, t$	$t-1, t$	$t-1, t$	$t, t+1$
BoJ	$t-1, t$	$t-1, t$	$t-1, t$	$t-1, t$

(b) Timing of Asset Price Changes

Table 2: Inference via Heteroskedasticity

Panel A: 1 Year Yields

	EUR	JPY	UK	US
ECB	0.421***		0.134*	
BOJ		0.249*		
BOE			0.352***	
FOMC	0.448***		0.188**	0.36***
BOE & ECB	0.769***		0.526***	

Panel B: 5 Year Yields

	EUR	JPY	UK	US
ECB	0.36***		0.154**	
BOJ		0.116*		
BOE			0.32***	
FOMC	0.337***		0.479***	0.441***
BOE & ECB	0.429***		0.189**	0.154**

Panel C: 10 Year Yields

	EUR	JPY	UK	US
ECB	0.267***		0.184***	
BOJ		0.136*		
BOE	0.117*		0.333***	
FOMC	0.388***		0.402***	0.392***
BOE & ECB	0.187**			0.179**

Table 2 summarizes the results of a Brown-Forsythe test for equality of variance across the full sample of zero coupon bond yield changes for maturities of 1, 5, and 10 years on announcement days compared to non-announcement days. Columns represent the central bank generating potential surprises. Rows indicate recipient markets. Empty cells indicate results which are not significant at the 10% level (minimum). Cells with text in red indicate yields for which the ECB and BoE monetary policy surprise is not identified, but where joint days generate a statistically significant response. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3: Monetary Policy Surprise Summary Statistics by Subsample

(a) Summary Statistics: Interbank Interest Rate Futures Measure

Central	Full Sample		Pre-crisis		Initial QE		Intra-QE		EAPP	
Bank	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
FOMC	-0.16	8.66	1.54	9.05	-0.95	9.35	0.53	2.88	-1.46	5.81
BoE	-1.58	7.23	-1.17	7.57	-1.55	7.19	-1.44	4.44	-0.28	4.29
ECB	-0.35	6.27	-0.58	8.11	-0.07	6.45	-0.28	3.21	0.10	3.60
BoJ	-0.08	2.29	-0.14	2.87	-0.34	1.71	0.08	0.60	0.34	2.24

(b) Summary Statistics: 2-Year Yield Measure

Central	Full Sample		Pre-crisis		Initial QE		Intra-QE		EAPP	
Bank	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
FOMC	0.11	6.93	1.90	8.71	-1.09	5.58	1.02	4.16	-1.48	5.56
BoE	-1.19	5.51	-1.16	5.76	-1.14	5.66	-0.71	3.89	-0.46	4.01
ECB	-1.24	6.04	-0.41	5.66	-2.22	7.42	-0.56	5.09	-0.58	2.66
BoJ	-0.04	1.37	0.03	1.10	-0.20	1.16	0.06	0.51	0.13	1.54

Table 4: Response of Yields to a 1 St. Dev. Monetary Policy Surprise, Full Sample

	Y1	Y3	Y5	Y7	Y10
FOMC	-3.4***	-7.7***	-8.3***	-7.6***	-6.5***
	(0.191)	(0.180)	(0.238)	(0.292)	(0.340)
ECB	-0.8***	-1.7***	-2.3***	-2.5***	-2.2***
	(0.157)	(0.288)	(0.329)	(0.364)	(0.378)
BOE	-0.2	-0.8***	-1.2***	-1.4***	-1.5***
	(0.145)	(0.256)	(0.304)	(0.318)	(0.332)
JP	0.0	-0.2	-0.2	-0.2	-0.0
	(0.154)	(0.264)	(0.292)	(0.312)	(0.340)
US CESI	0.1*	0.0	-0.0	-0.1	-0.0
	(0.031)	(0.029)	(0.039)	(0.046)	(0.055)
JP CESI	0.0	-0.0	-0.0	0.0	0.0
	(0.021)	(0.035)	(0.039)	(0.041)	(0.046)
EU CESI	0.0	0.0	0.0	0.0	0.0
	(0.024)	(0.044)	(0.051)	(0.056)	(0.058)
UK CESI	0.0	-0.0	-0.0	0.0	0.0
	(0.021)	(0.037)	(0.044)	(0.046)	(0.048)
Friday	-0.9	0.6	1.8	3.0**	3.8**
	(0.967)	(0.911)	(1.207)	(1.423)	(1.723)
USD/EUR	-0.3	5.3*	7.4**	9.6**	9.6*
	(2.835)	(2.672)	(3.543)	(4.252)	(5.057)
USD/GBP	1.1	-1.5	-1.4	-2.0	-2.0
	(1.371)	(1.292)	(1.712)	(2.040)	(2.443)
USD/JPY	0.9	-1.1	-0.7	-1.0	0.8
	(1.799)	(1.696)	(2.251)	(2.700)	(3.221)
R^2: Fed	0.771	0.944	0.918	0.872	0.795
R^2: ECB	0.278	0.399	0.439	0.392	0.389
R^2: BOE	0.251	0.232	0.284	0.305	0.294
R^2: BOJ	0.481	0.482	0.438	0.422	0.542

Table 4 summarizes the results of daily regressions where the dependent variable is the change in zero coupon bond yields for maturities of 1, 3, 5, 7 and 10 years. MPS is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks. Monetary policy measures are normalized to be a one standard deviation loosening. Full results, including control variables, are shown in the Internet Appendix. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5: Response of Term Premia to a 1 St. Dev. Monetary Policy Surprise, Full Sample

	YTP1	YTP3	YTP5	YTP7	YTP10
FOMC	-0.7***	-3.6***	-3.6***	-3.4***	-2.9***
	(0.148)	(0.252)	(0.305)	(0.359)	(0.387)
ECB	-0.1	-0.6***	-0.7***	-0.7***	-0.7**
	(0.121)	(0.196)	(0.247)	(0.250)	(0.261)
BOE	-0.4***	-0.9***	-1.1***	-1.2***	-1.2***
	(0.103)	(0.171)	(0.213)	(0.230)	(0.242)
JP	-0.1	-0.1	-0.0	-0.0	0.1
	(0.097)	(0.166)	(0.204)	(0.225)	(0.247)
US CESI	-0.0	-0.1	-0.1	-0.0	-0.0
	(0.024)	(0.041)	(0.050)	(0.058)	(0.063)
JP CESI	0.0	0.0	0.0	0.0	0.0
	(0.013)	(0.022)	(0.027)	(0.030)	(0.033)
EU CESI	0.0	0.0	0.0	0.0	0.0
	(0.018)	(0.030)	(0.038)	(0.038)	(0.040)
UK CESI	-0.0*	-0.0	-0.0	-0.0	0.0
	(0.015)	(0.025)	(0.031)	(0.033)	(0.035)
Friday	0.4	1.2	1.8	2.4	2.9
	(0.749)	(1.277)	(1.545)	(1.819)	(1.958)
USD/EUR	4.2*	5.9	10.4**	9.3*	9.2
	(2.198)	(3.748)	(4.534)	(5.338)	(5.745)
USD/GBP	-0.5	-1.3	-2.6	-2.4	-2.4
	(1.062)	(1.811)	(2.190)	(2.579)	(2.775)
USD/JPY	0.1	-1.4	-1.7	-0.9	1.1
	(1.396)	(2.381)	(2.887)	(3.399)	(3.659)
R^2: Fed	0.299	0.680	0.633	0.542	0.469
R^2: ECB	0.266	0.304	0.325	0.432	0.448
R^2: BOE	0.201	0.264	0.282	0.282	0.268
R^2: BOJ	0.148	0.492	0.550	0.556	0.492

Table 5 summarizes the results of daily regressions where the dependent variable is the change in term premia for maturities of 1, 3, 5, 7 and 10 years. MPS is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks. Monetary policy measures are normalized to be a one standard deviation loosening. Full results, including control variables, are shown in the Internet Appendix. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6: Response of Expected Future Short Rates to a 1 St. Dev. Monetary Policy Surprise, Full Sample

	Y1	Y3	Y5	Y7	Y10
FOMC	-3.4***	-7.7***	-8.3***	-7.6***	-6.5***
	(0.191)	(0.180)	(0.238)	(0.292)	(0.340)
ECB	-0.8***	-1.7***	-2.3***	-2.5***	-2.2***
	(0.157)	(0.288)	(0.329)	(0.364)	(0.378)
BOE	-0.2	-0.8***	-1.2***	-1.4***	-1.5***
	(0.145)	(0.256)	(0.304)	(0.318)	(0.332)
JP	0.0	-0.2	-0.2	-0.2	-0.0
	(0.154)	(0.264)	(0.292)	(0.312)	(0.340)
US CESI	0.1*	0.0	-0.0	-0.1	-0.0
	(0.031)	(0.029)	(0.039)	(0.046)	(0.055)
JP CESI	0.0	-0.0	-0.0	0.0	0.0
	(0.021)	(0.035)	(0.039)	(0.041)	(0.046)
EU CESI	0.0	0.0	0.0	0.0	0.0
	(0.024)	(0.044)	(0.051)	(0.056)	(0.058)
UK CESI	0.0	-0.0	-0.0	0.0	0.0
	(0.021)	(0.037)	(0.044)	(0.046)	(0.048)
Friday	-0.9	0.6	1.8	3.0**	3.8**
	(0.967)	(0.911)	(1.207)	(1.423)	(1.723)
USD/EUR	-0.3	5.3*	7.4**	9.6**	9.6*
	(2.835)	(2.672)	(3.543)	(4.252)	(5.057)
USD/GBP	1.1	-1.5	-1.4	-2.0	-2.0
	(1.371)	(1.292)	(1.712)	(2.040)	(2.443)
USD/JPY	0.9	-1.1	-0.7	-1.0	0.8
	(1.799)	(1.696)	(2.251)	(2.700)	(3.221)
R^2: Fed	0.771	0.944	0.918	0.872	0.795
R^2: ECB	0.278	0.399	0.439	0.392	0.389
R^2: BOE	0.251	0.232	0.284	0.305	0.294
R^2: BOJ	0.481	0.482	0.438	0.422	0.542

Table 6 summarizes the results of daily regressions where the dependent variable is the change in expectations hypothesis-implied yields for maturities of 1, 3, 5, 7 and 10 years. MPS is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks. Monetary policy measures are normalized to be a one standard deviation loosening. Full results, including control variables, are shown in the Internet Appendix. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7: Response of Yields to a 1 St. Dev. Monetary Policy Surprise

	Y1	Y3	Y5	Y7	Y10
FOMC, Pre	-7.6***	-9.1***	-8.3***	-6.7***	-5.1***
	(0.401)	(0.479)	(0.588)	(0.522)	(0.622)
FOMC, UMP	-2.7***	-6.7***	-8.1***	-8.2***	-7.6***
	(0.260)	(0.311)	(0.380)	(0.466)	(0.555)
FOMC, A-sync	-2.1***	-7.7***	-8.6***	-7.8***	-6.5***
	(0.279)	(0.334)	(0.408)	(0.501)	(0.596)
ECB, Pre	-1.4***	-2.1***	-2.0***	-1.5***	-1.1**
	(0.236)	(0.432)	(0.490)	(0.527)	(0.542)
ECB, UMP	-0.5**	-1.1***	-2.2***	-2.7***	-2.5***
	(0.221)	(0.403)	(0.457)	(0.492)	(0.506)
ECB, A-sync	-0.8**	-2.4***	-3.5***	-4.3***	-4.3***
	(0.375)	(0.686)	(0.778)	(0.836)	(0.861)
BOE, Pre	-0.8***	-2.4***	-2.0***	-1.3*	-0.7
	(0.305)	(0.540)	(0.637)	(0.677)	(0.705)
BOE, UMP	0.1	-0.2	-0.3	-0.5	-1.0**
	(0.189)	(0.335)	(0.393)	(0.418)	(0.435)
BOE, A-sync	-0.5*	-1.8***	-2.4***	-2.6***	-2.5***
	(0.280)	(0.496)	(0.581)	(0.618)	(0.643)
BOJ, Pre	-0.2	-0.2	-0.3	-0.3	-0.1
	(0.230)	(0.389)	(0.428)	(0.454)	(0.510)
BOJ, UMP	0.2	-0.0	0.3	0.4	0.1
	(0.323)	(0.546)	(0.601)	(0.637)	(0.716)
BOJ, A-sync	0.1	0.1	-0.2	-0.3	-0.1
	(0.316)	(0.534)	(0.588)	(0.624)	(0.700)
US CESI	0.1**	-0.0	-0.0	-0.0	-0.0
	(0.025)	(0.030)	(0.037)	(0.045)	(0.054)
JP CESI	0.0	-0.0	-0.0	-0.0	0.0
	(0.021)	(0.036)	(0.040)	(0.042)	(0.047)
EU CESI	0.0	0.0	0.0	0.0	0.0
	(0.024)	(0.045)	(0.051)	(0.054)	(0.056)
UK CESI	-0.0	-0.0	-0.0	-0.0	0.0
	(0.021)	(0.037)	(0.044)	(0.046)	(0.048)
Friday	-0.9	0.9	1.8	3.1**	4.0**
	(0.785)	(0.938)	(1.147)	(1.405)	(1.671)
USD/EUR	-1.4	4.3	8.2**	9.4**	10.5**
	(2.380)	(2.845)	(3.478)	(4.240)	(5.045)
USD/GBP	0.3	-1.5	-1.5	-1.9	-2.1
	(1.125)	(1.344)	(1.643)	(2.013)	(2.396)
USD/JPY	2.2	-1.2	-0.6	-0.3	1.2
	(1.485)	(1.777)	(2.177)	(2.662)	(3.168)
VIX	-0.0	-0.3***	-0.6***	-0.8***	-0.9***
	(0.070)	(0.084)	(0.102)	(0.124)	(0.148)
R^2: Fed	0.847	0.925	0.911	0.880	0.804
R^2: ECB	0.337	0.407	0.436	0.416	0.467
R^2: BOE	0.263	0.351	0.303	0.291	0.289
R^2: BOJ	0.481	0.484	0.438	0.422	0.541

Table 7 summarizes the results of daily piecewise regressions where the dependent variable is the change in domestic zero coupon bond yields for maturities of 1, 3, 5, 7 and 10 years. The independent variable of interest is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks, normalized to a 1 St. Dev. loosening. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8: Response of Term Premia to a 1 St. Dev. Monetary Policy Surprise

	YTP1	YTP3	YTP5	YTP7	YTP10
FOMC, Pre	0.8***	0.0	0.5	1.1*	1.2*
	(0.246)	(0.411)	(0.564)	(0.622)	(0.689)
FOMC, UMP	-0.8***	-4.5***	-5.5***	-5.3***	-5.5***
	(0.220)	(0.367)	(0.503)	(0.555)	(0.614)
FOMC, A-sync	-1.0***	-3.8***	-4.0***	-3.6***	-2.9***
	(0.236)	(0.394)	(0.541)	(0.596)	(0.661)
ECB, Pre	-0.1	-0.2	-0.1	0.1	-0.0
	(0.178)	(0.289)	(0.360)	(0.376)	(0.405)
ECB, UMP	0.1	-0.7***	-1.3***	-1.4***	-1.8***
	(0.167)	(0.270)	(0.336)	(0.351)	(0.378)
ECB, A-sync	-1.5***	-2.2***	-2.5***	-2.3***	-2.1***
	(0.283)	(0.459)	(0.572)	(0.597)	(0.642)
BOE, Pre	-0.0	-0.3	-0.1	0.1	0.2
	(0.218)	(0.361)	(0.447)	(0.479)	(0.508)
BOE, UMP	-0.6***	-0.6***	-1.3***	-1.7***	-1.7***
	(0.135)	(0.223)	(0.276)	(0.296)	(0.314)
BOE, A-sync	-0.7***	-1.5***	-1.7***	-1.7***	-1.7***
	(0.200)	(0.329)	(0.408)	(0.437)	(0.464)
BOJ, Pre	-0.2	-0.1	0.1	0.1	0.1
	(0.145)	(0.249)	(0.304)	(0.335)	(0.370)
BOJ, UMP	-0.2	-0.2	-0.1	-0.1	0.1
	(0.203)	(0.350)	(0.427)	(0.470)	(0.519)
BOJ, A-sync	0.1	-0.2	-0.4	-0.4	-0.2
	(0.199)	(0.342)	(0.417)	(0.460)	(0.508)
US CESI	-0.0	-0.1**	-0.1	-0.0	-0.0
	(0.021)	(0.036)	(0.049)	(0.054)	(0.060)
JP CESI	0.0	0.0	0.0	0.0	0.0
	(0.013)	(0.023)	(0.028)	(0.031)	(0.034)
EU CESI	0.0	0.0	0.0	0.0	0.0
	(0.018)	(0.030)	(0.037)	(0.039)	(0.042)
UK CESI	-0.0	-0.0	0.0	0.0	0.0
	(0.015)	(0.025)	(0.031)	(0.033)	(0.035)
Friday	0.6	1.7	2.5	3.0*	3.4*
	(0.662)	(1.106)	(1.516)	(1.672)	(1.852)
USD/EUR	4.8**	5.1	6.2	7.6	7.4
	(1.998)	(3.337)	(4.577)	(5.047)	(5.589)
USD/GBP	-0.1	-0.9	-1.1	-1.6	-1.5
	(0.949)	(1.585)	(2.173)	(2.396)	(2.654)
USD/JPY	0.8	-1.2	-0.6	0.0	2.7
	(1.254)	(2.095)	(2.873)	(3.169)	(3.509)
VIX	-0.0	-0.3***	-0.3**	-0.5***	-0.4**
	(0.059)	(0.098)	(0.134)	(0.148)	(0.164)
R^2: Fed	0.457	0.731	0.665	0.594	0.552
R^2: ECB	0.294	0.324	0.372	0.450	0.315
R^2: BOE	0.277	0.258	0.314	0.336	0.307
R^2: BOJ	0.157	0.493	0.557	0.561	0.494

Table 8 summarizes the results of daily piecewise regressions where the dependent variable is the change in term premia for maturities of 1, 3, 5, 7 and 10 years. The independent variable of interest is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks, normalized to a 1 St. Dev. loosening. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 9: Response of Expected Short Rates to a 1 St. Dev. Monetary Policy Surprise

	SR1	SR3	SR5	SR7	SR10
FOMC, Pre	-6.5***	-6.4***	-6.8***	-6.0***	-4.9***
	(0.477)	(0.486)	(0.335)	(0.260)	(0.297)
FOMC, UMP	-1.8***	-3.1***	-3.5***	-3.8***	-3.6***
	(0.426)	(0.435)	(0.300)	(0.232)	(0.193)
FOMC, A-sync	-0.9**	-3.5***	-5.0***	-4.8***	-4.0***
	(0.458)	(0.466)	(0.321)	(0.249)	(0.206)
ECB, Pre	-1.9***	-1.9***	-1.5***	-1.2***	-1.0***
	(0.299)	(0.302)	(0.295)	(0.277)	(0.242)
ECB, UMP	-0.0	-0.5*	-0.5*	-0.6**	-0.8***
	(0.279)	(0.282)	(0.276)	(0.258)	(0.226)
ECB, A-sync	0.2	-0.6	-1.0**	-0.9**	-1.0**
	(0.474)	(0.480)	(0.468)	(0.439)	(0.384)
BOE, Pre	-0.8**	-1.3***	-1.4***	-1.2***	-0.9***
	(0.360)	(0.337)	(0.325)	(0.313)	(0.290)
BOE, UMP	1.0***	0.6***	0.4*	0.0	-0.3
	(0.223)	(0.209)	(0.202)	(0.195)	(0.180)
BOE, A-sync	0.2	-0.3	-0.7**	-0.8***	-0.8***
	(0.330)	(0.309)	(0.299)	(0.288)	(0.267)
BOJ, Pre	-0.3	-0.1	-0.1	-0.1	-0.1
	(0.299)	(0.291)	(0.267)	(0.244)	(0.220)
BOJ, UMP	0.5	0.2	0.0	-0.0	-0.0
	(0.420)	(0.408)	(0.375)	(0.342)	(0.309)
BOJ, A-sync	0.1	0.6	0.6	0.5	0.3
	(0.411)	(0.399)	(0.367)	(0.335)	(0.303)
US CESI	0.1**	0.0	0.0	0.0	0.0
	(0.041)	(0.042)	(0.029)	(0.022)	(0.019)
JP CESI	-0.0	-0.0	-0.0	-0.0	-0.0
	(0.028)	(0.027)	(0.025)	(0.022)	(0.020)
EU CESI	-0.0	-0.0	0.0	0.0	0.0
	(0.031)	(0.031)	(0.030)	(0.029)	(0.025)
UK CESI	0.0	-0.0	-0.0	-0.0	-0.0
	(0.025)	(0.023)	(0.022)	(0.022)	(0.020)
Friday	-1.0	-0.1	0.1	0.4	0.6
	(1.284)	(1.310)	(0.903)	(0.699)	(0.581)
USD/EUR	-8.4**	-6.0	-2.3	-0.5	0.3
	(3.875)	(3.953)	(2.725)	(2.110)	(1.762)
USD/GBP	1.2	0.9	-0.3	-0.6	-0.4
	(1.840)	(1.878)	(1.295)	(1.003)	(0.833)
USD/JPY	2.5	2.8	0.4	-0.0	0.9
	(2.428)	(2.474)	(1.706)	(1.321)	(1.099)
VIX	0.1	0.1	-0.1*	-0.1**	-0.1*
	(0.114)	(0.116)	(0.080)	(0.062)	(0.052)
R^2: Fed	0.675	0.739	0.884	0.919	0.907
R^2: ECB	0.295	0.365	0.403	0.344	0.392
R^2: BOE	0.201	0.255	0.307	0.305	0.317
R^2: BOJ	0.140	0.311	0.413	0.461	0.483

Table 9 summarizes the results of daily piecewise regressions where the dependent variable is the change in the expected path of short rates over 1, 5, and 10 years. The independent variable of interest is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of the respective central banks, normalized to a 1 St. Dev. loosening. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 10a: Test for Equality of Coefficients between Break Points, Yields

	Y1	Y3	Y5	Y7	Y10
Fed: CMP = UMP	0.00	0.00	0.78	0.04	0.00
Fed: UMP = Asynch	0.12	0.03	0.39	0.62	0.16
Fed: CMP = UMP = Asynch	0.00	0.00	0.68	0.11	0.01
ECB: CMP = UMP	0.00	0.08	0.72	0.08	0.04
ECB: UMP = Asynch	0.45	0.09	0.13	0.11	0.06
ECB: CMP = UMP = Asynch	0.01	0.11	0.20	0.01	0.00
BOE: CMP = UMP	0.01	0.00	0.03	0.33	0.74
BOE: UMP = Asynch	0.11	0.01	0.00	0.01	0.05
BOE: CMP = UMP = Asynch	0.03	0.00	0.01	0.03	0.09
BOJ: CMP = UMP	0.29	0.82	0.38	0.32	0.80
BOJ: UMP = Asynch	0.77	0.83	0.57	0.41	0.79
BOJ: CMP = UMP = Asynch	0.53	0.89	0.68	0.59	0.96

Table 10a shows the p-values from a two-way Wald test for equality of coefficients between sub-sample periods.

Table 10b: Test for Equality of Coefficients between Break Points, Term Premia

	YTP1	YTP3	YTP5	YTP7	YTP10
Fed: CMP = UMP	0.00	0.00	0.00	0.00	0.00
Fed: UMP = Asynch	0.49	0.21	0.06	0.04	0.01
Fed: CMP = UMP = Asynch	0.00	0.00	0.00	0.00	0.00
ECB: CMP = UMP	0.36	0.19	0.01	0.00	0.00
ECB: UMP = Asynch	0.00	0.00	0.06	0.21	0.65
ECB: CMP = UMP = Asynch	0.00	0.00	0.00	0.00	0.00
BOE: CMP = UMP	0.02	0.42	0.02	0.00	0.00
BOE: UMP = Asynch	0.74	0.03	0.47	0.99	0.97
BOE: CMP = UMP = Asynch	0.04	0.03	0.02	0.00	0.01
BOJ: CMP = UMP	0.90	0.72	0.73	0.82	0.97
BOJ: UMP = Asynch	0.31	0.98	0.62	0.63	0.68
BOJ: CMP = UMP = Asynch	0.51	0.90	0.65	0.73	0.86

Table 10b shows the p-values from a two-way Wald test for equality of coefficients between sub-sample periods.

Table 10c: Test for Equality of Coefficients between Break Points, Expected Short Rates

	SR1	SR3	SR5	SR7	SR10
Fed: CMP = UMP	0.00	0.00	0.00	0.00	0.22
Fed: UMP = Asynch	0.38	0.00	0.00	0.00	0.00
Fed: CMP = UMP = Asynch	0.00	0.00	0.00	0.00	0.01
ECB: CMP = UMP	0.00	0.01	0.02	0.12	0.78
ECB: UMP = Asynch	0.96	0.36	0.09	0.15	0.37
ECB: CMP = UMP = Asynch	0.00	0.02	0.04	0.21	0.67
BOE: CMP = UMP	0.00	0.00	0.00	0.00	0.02
BOE: UMP = Asynch	0.22	0.07	0.02	0.02	0.07
BOE: CMP = UMP = Asynch	0.00	0.00	0.00	0.00	0.05
BOJ: CMP = UMP	0.06	0.32	0.68	0.83	0.71
BOJ: UMP = Asynch	0.19	0.03	0.01	0.01	0.01
BOJ: CMP = UMP = Asynch	0.16	0.08	0.02	0.01	0.01

Table 10c shows the p-values from a two-way Wald test for equality of coefficients between sub-sample periods.

Table 11: Summary Stats, Three-Part Monetary Policy Surprises

Period	MPS	FOMC	ECB	BoE	BoJ
Precrisis	Target	-0.10	-0.04	0.03	-0.07
		(1.38)	(1.33)	(1.03)	(1.16)
	Forward Guidance	0.32	-0.03	-0.10	0.02
		(1.42)	(1.25)	(1.03)	(0.9)
UMP (Synchronous)	Target	-0.14	0.09	0.06	-0.11
		(0.92)	(1.23)	(1.03)	(0.93)
	Forward Guidance	-0.20	-0.18	-0.11	-0.08
		(0.82)	(1.31)	(1.34)	(0.51)
	LSAP	0.04	0.13	0.00	-0.05
		(1.48)	(1.27)	(1.59)	(1.35)
UMP (Asynchronous)	Target	0.07	-0.03	0.07	0.07
		(0.46)	(0.54)	(0.42)	(0.77)
	Forward Guidance	-0.09	0.11	0.12	0.04
		(0.69)	(0.54)	(0.65)	(0.93)
	LSAP	-0.06	-0.04	-0.02	0.08
		(0.79)	(1.05)	(0.74)	(0.85)

Table 11 provides summary statistics of three part monetary policy shocks suggested by Swanson (2018). For each central bank's announcement day, target shocks comprise the surprise component of the decision about the target rate based on the change in yield on the one-month ahead OIS futures contracts. Forward guidance shocks contain the residual from a regression of the announcement day change in the 2-year bond zero coupon bond yield onto the target surprise. LSAP shocks comprise residual from a regression of the announcement day change in the 7-year zero coupon bond yield onto the target and forward guidance surprises.

Table 12: The Impact of a One St. Dev. Monetary Policy Surprise on US Yields, Expected Short Rates and Term Premia (Alt. Measure: Three-Part Surprise)

		ECB		BoE		BoJ		FOMC	
MPS		Y1 US	Y10 US	Y1 US	Y10 US	Y1 US	Y10 US	Y1 US	Y10 US
Target	Yield	-0.27	-0.31	-0.42***	0.45	-0.01	0.06	-4.25***	0.08
	Exp. Short Rate	-0.41**	-0.29	-0.53***	-0.16	-0.03	-0.05	-5.38***	-2.01***
	Term Premium	-0.00	0.15	0.19*	0.65***	-0.09	0.05	0.66***	4.89***
Forward Guidance	Yield	-0.73***	-1.45***	0.03	-1.49***	0.41***	0.21	-2.11***	-5.94***
	Exp. Short Rate	-0.87***	-0.82***	0.61***	-0.41***	0.31	0.20	-1.91***	-3.70***
	Term Premium	-0.03	-0.95***	-0.58***	-1.06***	-0.10	0.23	-0.75***	-2.91***
LSAP	Yield	-0.15	-1.81***	-0.34**	-2.17***	-0.11	-1.08**	0.25	-6.33***
	Exp. Short Rate	-0.02	-0.31*	-0.05	-0.40**	0.02	-0.31	1.88***	-0.53***
	Term Premium	-0.26**	-1.19***	-0.36***	-1.89***	-0.03	-0.74**	-1.52***	-5.81***

Table 12 summarizes the results of daily piecewise regressions where the dependent variable is the change in (i) zero coupon bond yields for maturities of 1 and 10 years, (ii) the path of the expected short rate over the life of the bond, and (iii) the term premium relevant for the US. Measures of the expected short rate and the term premium are estimated using a shadow rate term structure model from Wu and Xia (2016). The independent variables of interest are target, forward guidance, and LSAP shocks from the the FOMC, BoE, BoJ and ECB. Monetary policy measures are normalized to be a one standard deviation loosening. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 13: Risk-off Announcement Days and Bond Yields

(a) Own-Market Equity Return Co-movement Days

	i. Federal Reserve			ii. ECB		
VARIABLES	(1) Y1	(2) Y5	(3) Y10	(1) Y1	(2) Y5	(3) Y10
Sign(MP_i) = Sign(R_i)	-0.3	-0.4	-0.4	0.6**	0.4	0.5
	(0.39)	(0.48)	(0.70)	(0.27)	(0.57)	(0.66)
MP_i	-4.2***	-8.5***	-6.5***	-0.8***	-2.4***	-2.3***
	(0.28)	(0.36)	(0.53)	(0.18)	(0.37)	(0.43)
Interaction (MP on RP days)	2.0*** (0.46)	0.3 (0.59)	-0.1 (0.86)	0.1 (0.35)	0.1 (0.73)	0.6 (0.84)

	iii. Bank of England			iv. Bank of Japan		
VARIABLES	(9) Y10 US	(10) Y10 UK	(11) Y10 EU	(13) Y10 US	(14) Y10 UK	(15) Y10 EU
Sign(MP_i) = Sign(R_i)	0.1	0.2	-0.0	-0.1	-0.1	-0.4
	(0.28)	(0.55)	(0.63)	(0.32)	(0.58)	(0.67)
MP_i	-0.5**	-2.9***	-2.4***	0.2	0.2	0.4
	(0.23)	(0.45)	(0.52)	(0.18)	(0.33)	(0.37)
Interaction (MP on RP days)	0.6** (0.29)	2.5*** (0.59)	1.8*** (0.67)	-1.3*** (0.39)	-2.1*** (0.70)	-2.1** (0.81)

(b) Cross-Market Equity Return Co-movement Days

	i. ECB			ii. Bank of England			iii. Bank of Japan		
VARIABLES	(1) Y1	(2) Y5	(3) Y10	(4) Y1	(5) Y5	(6) Y10	(7) Y1	(8) Y5	(9) Y10
Sign(MP_i) = Sign(R_i)	0.4*	1.2**	1.3**	0.1	1.2**	1.1*	-0.1	-0.1	-0.2
	(0.27)	(0.55)	(0.63)	(0.27)	(0.56)	(0.63)	(0.32)	(0.59)	(0.71)
MP_i	-1.0***	-2.6***	-2.7***	-0.4**	-2.7***	-2.2***	-0.0	-0.9	-0.3
	(0.20)	(0.42)	(0.48)	(0.20)	(0.40)	(0.45)	(0.30)	(0.56)	(0.67)
Interaction (MP on RP days)	0.6** (0.31)	0.7 (0.63)	1.7** (0.72)	0.8*** (0.28)	2.2*** (0.58)	1.4** (0.65)	0.1 (0.37)	1.1 (0.68)	0.7 (0.81)

Table 13 summarizes the results of daily piecewise regressions where the dependent variable is the change in n-year zero coupon bond yields in the US, UK, Euro area and Japan. The independent variable is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of respective central banks. The regression interacts these monetary policy surprises with an indicator variable equal to one on announcement dates on which interest rate futures markets and equity returns moved in the same direction. Panel A shows the results where the equity market is in the home economy (*i*), while Panel B shows results where the equity market is in the US (*j*). Monetary policy measures are normalized to be a one standard deviation loosening. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 14: Risk-off Announcement Days and the Expected Path of Short Rates (SR)

(a) Own-Market Equity Return Co-movement Days

	i. Federal Reserve			ii. ECB		
VARIABLES	(1) SR1	(2) SR5	(3) SR10	(1) SR1	(2) SR5	(3) SR10
Sign(MP_i) = Sign(R_i)	-0.9	-0.0	-0.2	0.6	0.6*	0.4
	(0.67)	(0.39)	(0.22)	(0.36)	(0.33)	(0.28)
MP_i	-4.1***	-5.4***	-4.3***	-0.6**	-0.9***	-0.9***
	(0.49)	(0.28)	(0.16)	(0.24)	(0.22)	(0.18)
Interaction	2.1***	0.1	0.5*	-0.8*	-0.3	-0.2
(MP on RP days)	(0.80)	(0.47)	(0.27)	(0.46)	(0.43)	(0.35)

	iii. Bank of England			iv. Bank of Japan		
VARIABLES	(9) SR1	(10) SR5	(11) SR10	(13) SR1	(14) SR5	(15) SR10
Sign(MP_i) = Sign(R_i)	0.1	-0.1	-0.0	1.0**	0.3	0.1
	(0.33)	(0.30)	(0.26)	(0.41)	(0.36)	(0.30)
MP_i	0.1	-0.6**	-0.7***	0.3	0.2	0.1
	(0.27)	(0.25)	(0.21)	(0.23)	(0.20)	(0.17)
Interaction	0.8**	0.7**	0.5*	-1.4***	-1.6***	-1.3***
(MP on RP days)	(0.35)	(0.32)	(0.28)	(0.50)	(0.44)	(0.36)

(b) Cross-Market Equity Return Co-movement Days

	i. ECB			ii. Bank of England			iii. Bank of Japan		
VARIABLES	(1) SR 1	(2) SR 5	(3) SR 10	(4) SR 1	(5) SR 5	(6) SR 10	(7) SR 1	(8) SR 5	(9) SR 10
Sign(MP_i) = Sign(R_i)	0.2	0.6*	0.6**	-0.1	0.2	0.4	0.1	0.2	0.2
	(0.34)	(0.35)	(0.27)	(0.32)	(0.30)	(0.26)	(0.42)	(0.38)	(0.30)
MP_i	-1.0***	-1.0***	-1.1***	-0.1	-0.9***	-0.8***	-0.5	-0.7*	-0.6*
	(0.26)	(0.26)	(0.21)	(0.23)	(0.22)	(0.19)	(0.40)	(0.36)	(0.29)
Interaction	0.8**	0.5	0.3	1.1***	1.2***	0.9***	0.6	1.0**	0.7**
(MP on RP days)	(0.39)	(0.39)	(0.31)	(0.33)	(0.31)	(0.27)	(0.48)	(0.43)	(0.35)

Table 14 summarizes the results of daily piecewise regressions where the dependent variable is the change in n-year expectations hypothesis-implies bond yield in the US, UK, Euro area and Japan. The independent variable is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of respective central banks. The regression interacts these monetary policy surprises with an indicator variable equal to one on announcement dates on which interest rate futures markets and equity returns moved in the same direction. Panel A shows the results where the equity market is in the home economy (i), while Panel B shows results where the equity market is in the US (j). Monetary policy measures are normalized to be a one standard deviation loosening. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 16: Effect of MP Surprises on 10-year Yields Conditional on Option Implied Volatility

	(1) FOMC	(2) ECB	(3) BOE	(4) BOJ
FOMC	-5.750***	-3.784	-6.105***	-10.73***
	(-7.16)	(-1.31)	(-3.07)	(-9.09)
vix	-0.00388	0.143***	0.202***	-0.0126
	(-0.08)	(3.03)	(4.48)	(-0.31)
FOMC × vix	-0.0308			
	(-1.03)			
ECB	-15.22***	-2.398***	-1.426***	-3.985*
	(-2.69)	(-2.97)	(-2.78)	(-1.91)
BOE	4.268***	-0.319	-2.415***	-1.571
	(2.65)	(-0.62)	(-3.68)	(-1.08)
BOJ	-0.400	-5.332	2.778**	1.262*
	(-0.47)	(-1.48)	(2.02)	(1.76)
ECB × vix		0.0137		
		(0.45)		
BOE × vix			0.0254	
			(1.11)	
BOJ × vix				-0.0774**
				(-2.35)
Constant	-10.47***	1.585	1.679	-2.028
	(-2.68)	(0.44)	(0.48)	(-0.53)
Observations	137	208	249	207

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16 summarizes the results of daily piecewise regressions where the dependent variable is the change in 10 year zero coupon bond yields in the US. The independent variable of interest is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of respective central banks. The regression interacts these monetary policy surprises with the VIX index. Monetary policy measures are normalized to be a one standard deviation loosening.

Table 17: Effect of Monetary Policy Surprises on Option Implied Volatility

	FOMC		BoE		ECB		BoJ	
	VIX	MOVE	VIX	MOVE	VIX	MOVE	VIX	MOVE
Pre-crisis	1.039***	1.197**	-0.063	0.236	0.090	-0.561**	0.131	-0.266
	(0.216)	(0.533)	(0.136)	(0.301)	(0.139)	(0.280)	(0.098)	(0.240)
Sync UMP	-0.336	-3.227***	0.019	-0.173	0.243*	-0.664**	0.161	0.302
	(0.210)	(0.511)	(0.085)	(0.188)	(0.128)	(0.260)	(0.137)	(0.333)
Async UMP	-0.273	-2.069***	0.038	-0.195	-0.102	-0.808*	0.061	0.816**
	(0.219)	(0.527)	(0.123)	(0.269)	(0.213)	(0.430)	(0.137)	(0.333)
ECB	1.324	-2.901	0.299***	-0.372*			-0.070	-1.686*
	(1.052)	(4.838)	(0.099)	(0.219)			(0.391)	(0.951)
BoE	0.103	1.713			0.116	0.284	0.129	0.208
	(0.560)	(1.364)			(0.120)	(0.252)	(0.278)	(0.685)
BoJ	0.413*	1.882**	0.163	-1.904**	0.268	-3.868**		
	(0.248)	(0.898)	(0.257)	(0.777)	(0.415)	(1.720)		
CESI US	-0.018	-0.055	0.003	0.028	-0.004	0.011	0.002	-0.073**
	(0.020)	(0.048)	(0.011)	(0.024)	(0.018)	(0.036)	(0.013)	(0.032)
CESI Euro area	-0.003	-0.013	0.021*	0.003	0.007	0.005	0.005	0.013
	(0.013)	(0.032)	(0.012)	(0.028)	(0.014)	(0.030)	(0.009)	(0.023)
CESI UK	-0.004	-0.020	-0.033***	-0.010	-0.037**	0.086***	-0.006	-0.003
	(0.014)	(0.035)	(0.009)	(0.021)	(0.015)	(0.031)	(0.008)	(0.018)
CESI Japan	0.013	-0.076	0.001	-0.024	-0.010	0.002	0.010	0.052**
	(0.019)	(0.054)	(0.009)	(0.020)	(0.012)	(0.024)	(0.009)	(0.021)
Friday	-0.594	1.279			-0.566	-3.464***	-0.258*	0.367
	(0.623)	(1.494)			(0.648)	(1.303)	(0.152)	(0.370)
Δ VIX		0.529***		0.552***		0.494***		0.260***
		(0.131)		(0.065)		(0.073)		(0.085)
FOMC			-0.892**	-0.273	-1.273**	-0.023	-0.379*	-5.011***
			(0.384)	(1.012)	(0.542)	(1.392)	(0.206)	(0.500)
Constant	-0.417***	-1.611***	-0.135**	-0.247*	-0.164**	-0.262	-0.006	-0.105
	(0.121)	(0.295)	(0.060)	(0.132)	(0.080)	(0.164)	(0.075)	(0.182)
R2	0.27	0.47	0.15	0.26	0.13	0.28	0.05	0.40
N	139	137	256	254	211	209	216	216

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 17: Asymmetric Responses to Expansionary Monetary Policy Surprises

	(1) Y1	(2) Y10	(3) Y1	(4) Y10	(5) Y1	(6) Y10	(7) Y1	(8) Y10
MPS (US)	-2.765***	-7.247***	-3.073**	-4.354	-4.152***	-2.388	-5.429***	-13.83***
	(-7.53)	(-10.85)	(-2.60)	(-1.60)	(-4.95)	(-1.01)	(-10.97)	(-12.29)
1[FOMC<0]=1	-0.0438	1.172						
	(-0.09)	(1.33)						
1[FOMC<0]=1 × MPS (US)	-1.880***	2.311**						
	(-3.47)	(2.35)						
MPS (EU)	2.789*	-14.01**	-0.699**	-0.719	-0.334	-1.954***	-1.179	-1.800
	(1.70)	(-2.56)	(-2.16)	(-0.97)	(-1.50)	(-3.79)	(-1.33)	(-0.89)
MPS (UK)	1.242	4.464***	-0.284	-0.580	0.459*	-1.070*	-0.0525	-1.382
	(1.48)	(2.90)	(-1.32)	(-1.18)	(1.78)	(-1.77)	(-0.08)	(-0.95)
MPS (JP)	-0.700	2.925*	0.975	-4.928	1.480**	0.603	-0.542**	0.903*
	(-1.66)	(1.79)	(0.67)	(-1.47)	(2.58)	(0.34)	(-2.32)	(1.70)
Friday	-0.725	3.651**	-0.0186	-8.949***	0	0	0.511	-0.469
	(-0.78)	(2.16)	(-0.02)	(-3.48)	(.)	(.)	(1.46)	(-0.59)
Δ VIX	0.0219	-0.872***	-0.172***	-1.215***	-0.166**	-0.609***	-0.419***	-1.096***
	(0.27)	(-5.89)	(-2.85)	(-8.79)	(-2.57)	(-4.08)	(-5.09)	(-5.85)
1[ECB<0]=1			-0.0551	2.047**				
			(-0.15)	(2.40)				
1[ECB<0]=1 × MPS (EU)			-0.145	-0.847				
			(-0.33)	(-0.83)				
1[BOE<0]=1					0.441	2.777***		
					(1.16)	(3.16)		
1[BOE<0]=1 × MPS (UK)					-0.804**	1.343		
					(-2.06)	(1.48)		
1[BOJ<0]=1							-0.164	1.549
							(-0.39)	(1.62)
1[BOJ<0]=1 × MPS (JP)							0.985**	-0.909
							(2.41)	(-0.98)
Constant	-2.650	-11.31***	3.900**	-0.616	-1.082	-0.681	-0.244	-0.949
	(-1.28)	(-3.02)	(2.50)	(-0.17)	(-0.71)	(-0.19)	(-0.14)	(-0.25)
Observations	138	136	208	208	249	248	208	208

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 17 summarizes the results of daily piecewise regressions where the dependent variable is the change in 10 year zero coupon bond yields in the US, UK, Euro area and Japan. The independent variable of interest is the daily change in the implied yield for the year-ahead futures contract on the Eurodollar (Fed), Euribor (ECB), Short Sterling (BoE) and Euroyen Tibor (BoJ) on monetary policy meeting days of respective central banks. The regression interacts these monetary policy surprises with an indicator variable equal to one on announcement dates marked by expansionary surprises, $\mathbb{1}[MP_t^j < 0] * MP_t^j$. Monetary policy measures are normalized to be a one standard deviation loosening.

Table 18: Test of Period Means, Contractionary versus Expansionary Shocks

Central Bank	Period	$\lvert MPS < 0\rvert$	$\lvert MPS > 0\rvert$	$Pr(T < t)$	$Pr(\lvert T\rvert > \lvert t\rvert)$	$Pr(T > t)$
FOMC	Pre-crisis	0.08	0.06	0.77	0.45	0.23
	UMP	0.05	0.07	0.20	0.40	0.80
	Async	0.06	0.06	0.52	0.96	0.48
ECB	Pre-crisis	0.04	0.07	0.0459**	0.0918*	0.95
	UMP	0.06	0.05	0.65	0.70	0.35
	Async	0.02	0.02	0.81	0.37	0.19
BoE	Pre-crisis	0.05	0.05	0.77	0.45	0.23
	UMP	0.06	0.07	0.41	0.81	0.59
	Async	0.04	0.03	0.85	0.30	0.15
BoJ	Pre-crisis	0.02	0.02	0.22	0.43	0.78
	UMP	0.01	0.01	0.55	0.89	0.45
	Async	0.01	0.00	1.00	0.003***	0.0015***

Table 18 summarizes the results of a simple t-test for equality of means comparing the absolute value of contractionary monetary policy shocks ($\mathbb{1}[MP_t^j > 0] * MP_t^j$) to that of expansionary monetary policy shocks ($\mathbb{1}[MP_t^j < 0] * MP_t^j$) by subsample. *, **, and *** denote results significant at the 10, 5, and 1 percent level, respectively.

Table 19: Spillovers of MP Surprises Conditional on Sovereign Bond Free Float

(a) European Central Bank

	(1) Y1	(2) Y5	(3) Y10	(4) YTP1	(5) YTP5	(6) YTP10	(7) SR1	(8) SR5	(9) SR10
FOMC	-3.093***	-6.537***	-4.643*	-1.072	-0.928	-0.222	-4.716***	-5.204***	-3.594***
	(1.164)	(2.454)	(2.646)	(0.696)	(1.805)	(1.994)	(1.243)	(1.506)	(1.199)
BoE	-0.238	-0.623	-1.255***	-0.525***	-0.782**	-1.043***	0.824***	-0.138	-0.522**
	(0.209)	(0.441)	(0.476)	(0.158)	(0.325)	(0.359)	(0.283)	(0.271)	(0.216)
ECB	-0.766***	-2.583***	-2.432***	-0.207	-1.273***	-1.353***	-0.551**	-0.807***	-0.955***
	(0.172)	(0.363)	(0.392)	(0.131)	(0.267)	(0.295)	(0.234)	(0.223)	(0.178)
Germany Free float	-0.145	-0.910	-1.398*	0.0348	-0.302	-0.531	-0.221	-0.502	-0.532
	(0.336)	(0.708)	(0.763)	(0.255)	(0.521)	(0.575)	(0.456)	(0.434)	(0.346)
ECB × Germany Free float	-0.127	-1.094*	-1.826***	-0.425**	-1.389***	-1.308***	0.828**	0.263	-0.130
	(0.264)	(0.556)	(0.600)	(0.201)	(0.409)	(0.452)	(0.359)	(0.341)	(0.272)
Observations	208	208	208	209	208	208	209	208	208

(b) Bank of England

	(1) Y1	(2) Y5	(3) Y10	(4) YTP1	(5) YTP5	(6) YTP10	(7) SR1	(8) SR5	(9) SR10
FOMC	-4.561***	-4.073*	-1.976	-0.594	0.777	1.305	-3.836***	-5.520***	-2.375**
	(0.850)	(2.195)	(2.383)	(0.611)	(1.500)	(1.715)	(1.023)	(0.940)	(0.935)
BoE	-0.183	-1.288***	-1.654***	-0.467***	-1.148***	-1.133***	0.354**	-0.375**	-0.547***
	(0.147)	(0.313)	(0.340)	(0.105)	(0.214)	(0.245)	(0.177)	(0.162)	(0.133)
UK Free float	-0.536*	-0.261	-0.370	0.171	0.325	0.157	-0.551	-0.309	-0.453*
	(0.294)	(0.630)	(0.684)	(0.212)	(0.430)	(0.492)	(0.354)	(0.326)	(0.268)
BoE × UK Free float	0.0479	-0.232	-0.527	-0.334**	-0.686**	-0.752**	0.145	0.0453	-0.0874
	(0.195)	(0.415)	(0.451)	(0.140)	(0.284)	(0.324)	(0.234)	(0.216)	(0.177)
ECB	-0.439**	-1.655***	-1.892***	-0.263*	-0.936***	-1.071***	-0.121	-0.0956	-0.524***
	(0.221)	(0.472)	(0.512)	(0.159)	(0.323)	(0.369)	(0.266)	(0.245)	(0.201)
Observations	249	248	248	249	248	248	249	249	248

(c) Federal Reserve

	(1) Y1	(2) Y5	(3) Y10	(4) YTP1	(5) YTP5	(6) YTP10	(7) SR1	(8) SR5	(9) SR10
FOMC	-3.278***	-8.514***	-6.527***	-0.524***	-3.547***	-2.808***	-3.076***	-5.288***	-4.160***
	(0.187)	(0.256)	(0.379)	(0.162)	(0.329)	(0.416)	(0.280)	(0.199)	(0.116)
US Free float	0.0739	-0.508	-0.0873	0.346	0.0828	0.142	0.166	-0.116	-0.175
	(0.244)	(0.329)	(0.486)	(0.211)	(0.429)	(0.542)	(0.365)	(0.259)	(0.151)
FOMC × US Free float	1.353***	-0.269	-0.00769	-0.287*	-0.669**	-0.454	2.542***	0.233	0.0234
	(0.170)	(0.238)	(0.351)	(0.148)	(0.300)	(0.380)	(0.255)	(0.181)	(0.106)
BoE	1.190	3.963***	4.381***	0.544	2.616*	3.032*	1.039	1.790**	1.763***
	(0.812)	(1.108)	(1.636)	(0.712)	(1.444)	(1.826)	(1.228)	(0.873)	(0.503)
ECB	2.050	-8.783**	-15.56***	-6.336**	-13.78***	-15.38**	9.602**	5.141*	0.272
	(1.577)	(3.880)	(5.731)	(2.495)	(5.123)	(6.479)	(4.304)	(3.059)	(0.978)
Observations	138	136	136	137	136	136	137	137	138

Table 19 summarizes the results of daily piecewise regressions where the dependent variable is the change in 1-, 5-, and 10-year zero coupon US bond yields. The independent variable of interest is the daily change in the implied yield for the 24 month-ahead futures contract on the Euribor (ECB) and Short Sterling (BoE) on monetary policy meeting days of respective central banks. The regression interacts these monetary policy surprises with domestic free float (German free float in the case of the ECB). Monetary policy measures are normalized to be a one standard deviation loosening. All controls from the baseline are included in the regressions: bilateral exchange rate against the USD, Friday dummy, news surprises and the VIX. Standard errors are shown in parenthesis. *, **, and *** denote results significant at the 10, 5, and 1 percent level, respectively.

Table 20: Spillovers of MP Surprises Conditional on Average Sovereign Bond Free Float

(a) European Central Bank

	(1) Y1	(2) Y5	(3) Y10	(4) YTP1	(5) YTP5	(6) YTP10	(7) SR1	(8) SR5	(9) SR10
FOMC	-3.018**	-6.142**	-4.255	-0.857	-0.924	-0.402	-4.901***	-5.157***	-3.470***
	(1.172)	(2.471)	(2.758)	(0.720)	(1.790)	(2.026)	(1.217)	(1.452)	(1.193)
BoE	-0.335	-0.570	-0.102	-0.402**	-0.0620	-0.376	0.618**	0.122	-0.539**
	(0.210)	(0.444)	(0.495)	(0.164)	(0.322)	(0.364)	(0.277)	(0.261)	(0.214)
ECB	-0.673***	-2.459***	-2.731***	-0.392***	-1.583***	-1.688***	-0.321	-0.810***	-0.879***
	(0.172)	(0.363)	(0.405)	(0.134)	(0.263)	(0.297)	(0.227)	(0.213)	(0.175)
Avg. Float	0.00228	-0.0938	-0.577	0.227	-0.00846	-0.187	-0.123	-0.170	-0.142
	(0.211)	(0.445)	(0.497)	(0.165)	(0.322)	(0.365)	(0.279)	(0.262)	(0.215)
ECB × Avg. Float	0.439***	-0.418	-1.130***	-0.438***	-1.196***	-1.257***	0.831***	0.469**	0.183
	(0.165)	(0.349)	(0.389)	(0.129)	(0.253)	(0.286)	(0.218)	(0.205)	(0.168)
Observations	208	208	208	209	208	208	209	208	208

(b) Bank of England

	(1) Y1	(2) Y5	(3) Y10	(4) YTP1	(5) YTP5	(6) YTP10	(7) SR1	(8) SR5	(9) SR10
FOMC	-4.345***	-4.062*	-2.124	-0.580	0.725	1.298	-3.777***	-5.491***	-4.481***
	(0.829)	(2.185)	(2.384)	(0.611)	(1.493)	(1.717)	(1.012)	(0.927)	(0.786)
BoE	-0.158	-1.320***	-1.581***	-0.466***	-1.156***	-1.091***	0.387**	-0.401**	-0.539***
	(0.143)	(0.313)	(0.342)	(0.106)	(0.214)	(0.246)	(0.175)	(0.160)	(0.136)
Avg. Float	-0.573***	-0.266	-0.0719	0.202	0.366	0.318	-0.560**	-0.492**	-0.424**
	(0.213)	(0.465)	(0.507)	(0.157)	(0.318)	(0.366)	(0.260)	(0.238)	(0.202)
BoE × Avg. Float	-0.0365	-0.316	-0.431	-0.256**	-0.577**	-0.663**	0.0181	-0.00536	-0.0946
	(0.158)	(0.345)	(0.376)	(0.116)	(0.236)	(0.271)	(0.193)	(0.177)	(0.150)
ECB	-0.409*	-1.613***	-1.896***	-0.272*	-0.938***	-1.047***	-0.109	-0.0753	-0.407**
	(0.216)	(0.472)	(0.515)	(0.159)	(0.322)	(0.371)	(0.264)	(0.241)	(0.205)
Observations	249	248	248	249	248	248	249	249	249

(c) Federal Reserve

	(1) Y1	(2) Y5	(3) Y10	(4) YTP1	(5) YTP5	(6) YTP10	(7) SR1	(8) SR5	(9) SR10
FOMC	-3.225***	-8.484***	-6.516***	-0.560***	-3.523***	-2.763***	-3.056***	-5.225***	-4.186***
	(0.188)	(0.251)	(0.379)	(0.161)	(0.327)	(0.413)	(0.278)	(0.197)	(0.115)
Avg. Float	0.00739	-0.520	0.00819	0.353	0.132	0.219	0.100	-0.124	-0.211
	(0.279)	(0.369)	(0.558)	(0.239)	(0.487)	(0.615)	(0.413)	(0.293)	(0.171)
FOMC × Avg. Float	1.516***	-0.273	-0.0872	-0.319*	-0.912***	-0.722*	2.736***	0.379*	0.0890
	(0.189)	(0.258)	(0.390)	(0.163)	(0.331)	(0.418)	(0.281)	(0.200)	(0.116)
BoE	0.994	3.945***	4.408***	0.590	2.725*	3.136*	0.724	1.734**	1.800***
	(0.815)	(1.086)	(1.642)	(0.706)	(1.437)	(1.816)	(1.220)	(0.867)	(0.499)
ECB	2.555	-8.746**	-15.62***	-6.492***	-14.12***	-15.67**	10.82**	5.377*	0.154
	(1.578)	(3.802)	(5.749)	(2.471)	(5.097)	(6.440)	(4.272)	(3.035)	(0.966)
Observations	138	136	136	137	136	136	137	137	138

Table 20 summarizes the results of daily piecewise regressions where the dependent variable is the change in 1-, 5-, and 10-year zero coupon US bond yields. The independent variable of interest is the daily change in the implied yield for the 24 month-ahead futures contract on the Euribor (ECB) and Short Sterling (BoE) on monetary policy meeting days of respective central banks. The regression interacts these monetary policy surprises with domestic free float (German free float in the case of the ECB). Monetary policy measures are normalized to be a one standard deviation loosening. All controls from the baseline are included in the regressions: bilateral exchange rate against the USD, Friday dummy, news surprises and the VIX. Standard errors are shown in parenthesis. *, **, and *** denote results significant at the 10, 5, and 1 percent level, respectively.