International Spillovers of Monetary Policy: Conventional Policy vs. Quantitative Easing*

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This paper evaluates the popular view that quantitative easing exerts greater international spillovers than conventional monetary policies. To distinguish the effects of these policies, we use a term structure model to decompose longer-term bond yields into expected short-term interest rates and term premia. We find that expected short-term interest rates have larger spillover effects than term premia on the U.S. dollar. We also find that foreign yields are at least as sensitive to U.S. short rates as to term premia, and more so for emerging market economies. All told, our findings contradict the popular view that quantitative easing (which is generally thought to work by affecting term premia) exerts greater international spillovers than conventional monetary policies (which are generally thought to work through expected rates).

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1. Introduction

The years immediately following the global financial crisis (GFC) were marked by a heightened interest in the international spillovers of monetary policy, and in particular the spillovers of unconventional policies such as quantitative easing. Many observers asserted that the quantitative easing adopted by advanced economies after the GFC exerted greater cross-border effects on foreign financial conditions, such as exchange rates and interest rates, than conventional monetary policy operating through changes in policy interest rates. In consequence, quantitative easing was blamed for many challenges, such as appreciating currencies and too-easy credit conditions, faced by emerging market economies in that period.[1]

However, evidence for this view is scant, in part because it is difficult to estimate the spillover effects of quantitative easing (also known as balance sheet policies). Vector autoregression (VAR) analyses based on central bank balance sheet data generally suffer from severe identification problems, especially as much of the impact of balance sheet policies on asset prices takes place at the time of their announcement rather than during their subsequent implementation. Event studies focusing on the announcement effects of balance sheet policies on exchange rates or foreign interest rates avoid this pitfall, but the relative paucity of quantitative easing (QE) announcements in any one country reduces the statistical power of this approach.[2] Some event studies circumvent these problems by comparing the effects of all monetary policy announcements on foreign financial conditions in the pre- and post-GFC periods, on the assumption that pre-GFC policy actions were mainly conventional while post-GFC actions were mainly unconventional policies such as quantitative easing. However, it is almost impossible to know how much any change in announcement effects owes to changes in

[1] For example, Brazilian President Dilma Rousseff referred to quantitative easing as a "monetary tsunami" that was leading to currency wars. (See discussion in Bernanke 2015.)

[2] As a way to address identification problems associated with VAR and event studies, Rogers, Scotti, and Wright (2018) use a hybrid "external instruments" approach which supplements the VAR with information from event studies to strengthen the identification of policy shocks.

policy and how much it owes to the dramatic changes in the economic environment that followed the GFC.

This paper develops a novel approach to comparing the international spillovers of conventional and balance sheet policy that circumvents these concerns. We start by noting that longer-term bond yields can be decomposed into two components: the expected short-term interest rate over the period to maturity, and the term premium, which reflects compensation for the risk of holding the bond. In principle, conventional monetary policy is understood to affect bond yields and financial conditions more generally by affecting the current short-term interest rate and the expected path of short rates in the future. By comparison, balance sheet policy—in particular, purchases of longer-maturity bonds—is believed to act by altering the supply/demand balance in the bond market and thus affecting the term premium.

In practice, of course, there is evidence that conventional monetary policy can have an effect on the term premium and balance sheet measures can influence expected short rates. (See, for example, Bauer and Rudebusch 2014.) Even so, conventional monetary policy is generally targeted at the short rate and balance sheet policy is targeted at the term premium, so our mapping captures the primary focus of each type of policy action. By the same token, the forward guidance regarding interest rates or balance sheets that implicitly or explicitly accompanies policy announcements may also affect expected rates and term premia, so our research sheds light on spillovers from these policies as well.

Based on these considerations, we examine the impact of Federal Reserve monetary policy announcements during the period 2002 to 2019. Focusing on the change in U.S. 10-year Treasury yields during one-day windows around the announcement dates, we use term structure models to decompose these moves into changes in expected short-term interest rates and changes in term premia. We then examine the relative effects of changes in these two components of the 10-year Treasury yield on exchange rates and foreign bond yields. To our knowledge, our paper represents the first thorough and robust comparison of these effects, and we report several novel and significant findings.

First, we find that changes in expected interest rates after Federal Reserve announcements lead to substantially and significantly larger responses by the dollar exchange rate—whether measured against advanced-economy or emerging-market-economy currencies—than changes in term premia. Moreover, consistent with earlier research, we find that the sensitivity of the dollar to monetary policy announcements has risen since the GFC, but we add a new finding that most of this rise is due to an increased sensitivity of the dollar to expected interest rates rather than to term premia. Acknowledging that different methods for estimating term structure components may yield different estimates, we also show (in appendix tables) that our results are generally robust to alternative ways of calculating expected rates and term premia.

A second key finding of our paper is that changes in expected rates generally affect foreign bond yields at least as much as changes in term premia. We focus on a small group of foreign economies. For Germany and the United Kingdom, differences in the cross-border spillover effects of changes in U.S. expected interest rates and term premia are not large or statistically significant. For Canada, Korea, Mexico, and Brazil, however, the pass-through of changes in U.S. expected rates to foreign yields is greater than that from changes in U.S. term premia, and to a statistically significant extent. Notably, as in the case of exchange rates, foreign yields appear to have become more sensitive to U.S. monetary policy announcements after the GFC, and, again, in most cases that rise reflects a heightened sensitivity to U.S. expected rates rather than term premia.[3]

All told, our research suggests that changes in U.S. expected interest rates—whether stemming from conventional policy adjustments, forward guidance, or other forms of signaling—have been exerting effects on exchange rates and foreign financial conditions that are generally larger than the effects of changes in term premia, as might be caused by the Federal Reserve's quantitative easing. This contradicts the popular view that quantitative easing exerts greater international spillovers than conventional policy.

[3]When the window is enlarged to two days, our results for the primacy of expected rates in influencing exchange rates hold up, but expected rates and term premia now exert more similar effects on foreign yields. However, this may reflect the high correlation of yields across countries during periods between central bank announcements.

To be sure, as noted above, the dichotomy between conventional policy and balance sheet policy is not always clear-cut in practice: conventional policy actions may affect term premia (see Bhattarai and Neely 2016) and quantitative easing announcements are believed to often signal future policy rates, as suggested in Woodford (2012) and Bauer and Rudebusch (2014). However, we show that conventional policies during the pre-GFC period indeed mainly affected expected rates, while actions in the years immediately following the GFC, when policy rates were pinned near zero and balance sheet measures were more important, mainly affected term premia.

Moreover, our findings can help predict the effect of future monetary policies: actions geared toward affecting expected interest rates, such as changes in policy rates or forward guidance regarding rates, are likely to induce greater international spillovers than actions targeting term premia, such as balance sheet adjustments or forward guidance on future adjustments. A speech by the Federal Reserve's Lael Brainard (2017), which shows how different combinations of conventional and balance sheet normalization by the Federal Reserve can lead to different outcomes for U.S. and foreign economic activity, attests to the importance of this consideration for policymakers.

A final contribution of this paper to the literature is to show how the decomposition of changes in bond yields can be used not only to compare the spillovers of different types of policies by the central bank initiating the monetary action but also to examine how these spillovers are transmitted to the economy receiving the spillovers. Thus, we examine the impact of Federal Reserve (Fed) policy actions on expected interest rates and term premia embedded in German bond yields, and also examine the impact of European Central Bank (ECB) policy actions on expected interest rates and term premia embedded in U.S. Treasury bond yields. We find similar spillovers in both instances: Policy easings by the Fed have little effect on German expected interest rates but lead to substantial declines in German term premia; similarly, ECB policy easings have only small effects on U.S. expected rates but substantially depress U.S. term premia. Exactly what accounts for this pattern of results is beyond the scope of this paper but clearly merits further research.

The plan of the paper is as follows. Section 2 reviews the literature on monetary policy spillovers, focusing mainly on studies attempting to compare the effects of conventional policy and quantitative easing. Section 3 describes the methodology used for our event studies and decomposition of bond yields into expected rates and term premia. In Section 4, we analyze the effects of U.S. monetary policy on exchange rates, while Section 5 focuses on how U.S. policy actions affect foreign bond yields. Section 6 digs deeper into the transmission channels of these spillovers, examining how U.S. policy actions affect expected rates and term premia in Germany, and how ECB actions affect those same variables in the United States. Section 7 examines the robustness of our results to a number of alternative measures of yield-curve components, Treasury yields, and event windows, and Section 8 concludes.

2. Literature Review

There is a broad literature on the effects of conventional and unconventional monetary policy.[4] Most articles focus on the effects of these policy actions on domestic asset prices and economic activity. Fewer papers examine their impacts on foreign assets and economies—that is to say, examine the spillovers of conventional and unconventional monetary policies. However, even here, there have been a number of papers on this topic and the literature is growing rapidly.[5] Some of the papers in this area explore the spillover effects of unconventional policies, without explicitly comparing these effects with those of conventional policies. (See, among others, Chen et al. 2015, De los Rios and Shamloo 2017, Gagnon et al. 2017, Bhattarai, Chatterjee, and Park 2018, and Fratzscher, Lo Duca, and Straub 2018) Below, we review research in which more explicit attempts are made to compare spillovers from conventional and unconventional policy.

One approach to this issue focuses on model simulations to explore the different channels through which monetary policies spill over to foreign economies. For example, Alpanda and Kabaca (2015) develop a dynamic stochastic general equilibrium (DSGE) model to show that U.S. asset purchases that generate the same output effects

[4]Bhattarai and Neely (2016) provide a comprehensive survey on the empirical literature on U.S. unconventional monetary policy.

[5]See the survey by Claessens, Stracca, and Warnock (2016).

as conventional policies lead to larger international spillovers due to stronger portfolio balance effects.

However, most studies in this genre involve empirical analysis that is more closely focused on financial market effects. One approach here to is to use event studies—usually, the effect of Federal Open Market Committee (FOMC) announcements—to assess whether announcements of conventional policy actions have different effects on market variables than announcements of unconventional policies. Neely (2015) finds that Fed QE announcements have larger effects on the dollar and on foreign yields than non-QE announcements. However, this study does not control for the size of these announcements, as measured by their effects on domestic Treasury yields. Conversely, Ferrari, Kearns, and Schrimpf (2017), Curcuru, De Pooter, and Eckerd (2018), and Gilchrist, Yue, and Zakrajsek (2018) measure the size of the monetary policy action being announced by its impact on domestic sovereign yields, and then look at the sensitivity of foreign market asset prices to changes in those yields; for the most part, they find little difference in the response of the dollar and/or foreign yields to movements in domestic yields following QE-related and more conventional policy announcements. Bowman, Londono, and Sapriza (2015) likewise measure the responses of foreign sovereign yields to FOMC unconventional policy announcements; they find that these responses align well with the predictions of a model relating foreign yields to changes in U.S. yields, estimated over the period 2006–13. All told, these studies find little evidence that spillovers of monetary policy to foreign markets differ, depending on whether the policy actions are conventional or unconventional.

However, one concern posed by event studies of unconventional monetary policy announcements is that there have been relatively few of them, reducing the reliability of the estimates. A somewhat different approach is pursued by Glick and Leduc (2015), which uses all FOMC meeting statements, including those without any explicit policy announcements. They compare the effects on the dollar of FOMC statements prior to the GFC, which were by definition conventional, with effects of FOMC statements in the post-GFC era, which included QE and forward guidance; they show that monetary policy surprises had much larger effects on the value of the dollar in the post-GFC era. Curcuru (2017) and Ferrari, Kearns, and Schrimpf

(2017) also show that impact of monetary policy on exchange rates has grown significantly. Chen, Mancini-Griffoli, and Sahay (2014), Chari, Stedman, and Lundblad (2017), and Albagli et al. (2018) find that U.S. monetary policy spillovers to a range of emerging market asset prices and capital flows strengthened after the GFC. Rogers, Scotti, and Wright (2018) find a similar strengthening of spillovers from U.S. policy to asset prices in advanced foreign economies.

However, as noted in the introduction, comparing the effects of policy announcements before and after the GFC may not give a clear read on the comparison between unconventional versus conventional policies. First, post-GFC policy announcements were not exclusively unconventional; both conventional and unconventional policies were implemented by advanced-economy central banks in the post-GFC period.[6] Second, changes in the effect of monetary policy announcements after the GFC might have reflected the dramatic changes in the economic environment during that period, including steep declines in aggregate demand, heightened risk aversion and policy uncertainty, and declines in policy interest rates to zero or below.

Accordingly, as described in the introduction, in this paper we use term structure models to decompose yield changes surrounding FOMC meeting announcements into expected short rate and term premium components, and use these two components to compare the effects of conventional interest rate versus balance sheet policies. Our approach thus avoids the identification issues associated with comparisons of conventional and unconventional policy announcements or comparisons of pre- and post-GFC announcements.

Our research is the first both to associate components of the term structure with different types of monetary policy and to conduct a thorough and robust analysis of the spillovers of these term structure components. There are a number of other recent works touching on some aspects of this issue. An investment bank newsletter by Hatzius et al. (2017) briefly summarizes regression results showing that the dollar is more sensitive to expected rates than to term premia, but no description of estimation details (e.g., regression specification, sample range, robustness) is provided. Ferrari, Kearns, and Schrimpf

[6]For example, forward guidance on interest rates was used extensively in the post-crisis period by the FOMC and the ECB. The ECB also adopted a negative interest rate policy in 2014.

(2017) and Kearns, Schrimpf, and Xia (2018) look at spillovers to exchange rates and foreign yields, respectively, from changes in domestic yields following monetary policy announcements. However, they use only a rough proxy for term premia (changes in 10-year yields that are orthogonal to 2-year yields); they do not examine robustness with respect to other measures of term structure components; and, unlike our paper, they find broadly similar spillovers from changes in expected interest rates and term premia. Mehrotra, Moessner, and Shu (2019) analyze the effect of changes in U.S. yield-curve components on foreign yields, but they use monthly panel data rather than the event-study approach used in our paper, thus raising concerns about the identification of monetary policy shocks.

Other papers do not explicitly estimate shocks in expected short rate and term premia but instead construct measures which are related and have a similar interpretation. Chen, Mancini-Griffoli, and Sahay (2014) study the spillover effects of U.S. monetary policies on emerging markets by differentiating between "policy signal shocks" (which affect expectations of future short-term policy rates) and "market shocks" (which affect longer-term rates through a variety of channels); they find the former have larger effects on emerging market asset prices, consistent with our own results, as described below. Conversely, Stavrakeva and Tang (2015) study the linkage between monetary policy and exchange rate movements by separating quarterly exchange rate changes into a component that is related to policy rate differentials and a currency risk premium component (plus an expectation error term) which could arise from unconventional policy actions; they find that the importance of unconventional monetary policy for explaining exchange rate variations is larger while the importance of conventional monetary policy is lower in the post-GFC period. Similarly, Rogers, Scotti, and Wright (2016) identify the first principal component of the U.S. Treasury yield curve as an "LSAP shock" and the second principal component as a "forward-guidance shock," and find that the LSAP (large-scale asset purchase) shock exerts the stronger spillover effects, at least during the 2008–13 period covered in the study. Finally, a number of studies, including Bauer and Neely (2014), Albagli et al. (2018), and Rogers, Scotti, and Wright (2018), analyze how monetary policy actions affect expected interest rates and/or term premia in the economies *receiving* the spillovers, with mixed results.

3. Data and Methodology

3.1 Data Sources

For our event studies, we use data on daily changes in exchange rates and sovereign bond yields on FOMC and ECB meeting dates. We include meetings between January 2002 and December 2019, for 144 FOMC meetings and 196 ECB meetings. We present results for the entire sample and also two sub-samples, a pre- and post-GFC period. We define the meeting dates prior to September 2008 as the pre-GFC period, and the post-GFC period as meetings starting in September 2008. The sub-sample analysis will help us identify changes to the monetary policy transmission channels pre-crisis versus post-crisis. In other estimations, available upon request, we specified the post-GFC period to start in January 2010, so as to remove the most turbulent period of the GFC from the sample; this made little difference to the results.[7]

Most of our data are obtained from Bloomberg. We use daily closing values for exchange rates for the euro, Mexican peso, and Brazilian *real*, as well as benchmark government bond par yields for the United States, the United Kingdom, Canada, Germany, Korea, Mexico, and Brazil. We also use daily closing values of German zero-coupon yields at maturities of three months, six months, and 1 to 10 years from Bloomberg, and U.S. zero-coupon yields at similar maturities from the Federal Reserve Board.[8] We create two

[7]It would also be interesting to separately examine the period from December 2015 through February 2020, when policy interest rates had risen above zero and there was more scope for conventional monetary policy. However, there were too few observations during this period to yield meaningful results.

[8]The zero-coupon yields for the United States are derived using the methodology presented in Gürkaynak, Sack, and Wright (2006). We do not use the publicly available German zero-coupon yield data published by the Bundesbank, because the Bundesbank yields are as of noon CET, whereas the Bloomberg yields are as of market close (5:00 p.m. CET). Therefore we use the Bloomberg yields in order to maximize the overlap between the daily changes in German and U.S. yields, which are as of the U.S. close (5:00 p.m. ET). That said, using the Bundesbank yields does not materially change our results.

trade-weighted dollar indices, an advanced foreign economy (AFE) index and an emerging market economy (EME) index consisting of floating exchange rates.[9]

3.2 Design of Event Study

We use the event-study approach to examine the spillovers from FOMC policy announcements to dollar exchange rates and foreign yields. For each FOMC announcement day, we examine one-day changes in U.S. and foreign 10-year yields around policy announcements. This captures the reaction to *unexpected* news about policy actions; prior to the announcement, any policy actions expected by market participants will already be reflected in yields and other asset prices. For U.S. yields, we decompose these changes into changes in their respective expected short rate and term premium components using a term structure model (discussed below). We then use regression analysis to estimate the amount of spillover to the dollar and foreign yields from changes in U.S. expected short rates and term premia for FOMC announcements.[10] We also decompose German yields into their expected short rate and term premium components, and examine whether these two components react differently to FOMC policy surprises. Finally, we study how changes in the expected rate and term premium components of German yields following ECB announcements affect the two components of U.S. yields.

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[9]Although the Federal Reserve Board publishes indices for both advanced and emerging market economies using noon values, the timing and composition of these indices are not ideal for our exercise, so we make several adjustments. In order to better align the advanced economy exchange rate index with the 2:00 p.m. FOMC announcements, we construct our own version of the index using end-of-day values. Also, since several emerging market exchange rates are fixed and many exchange rates have stopped trading for the day at the time of the FOMC announcement, we construct our own emerging market economy index which includes only floating exchange rates and uses noon values.

[10]We use a robust regression approach in our study. The robust regression is based on the Huber loss function, which is less sensitive to outliers in data than the quadratic error loss function used for ordinary least square regression. The Huber loss function is quadratic for small values of regression fitting error, and linear for large values. So it is approximately a mixture of ordinary least square regression and absolute least deviation regression.

In our paper, we had to balance the costs and benefits of shorter versus longer event windows. On the one hand, shorter windows reduce the likelihood of other consequential developments taking place besides the central bank announcement. Thus, it is possible that a one-day window may be too wide and there could other important events (e.g., economic data releases) in addition to the central bank announcements within the window that would contaminate the reactions to central bank announcements; such events should not bias our estimates, but they could boost the standard errors and reduce statistical significance. On the other hand, our one-day window, while capturing the immediate effect of monetary policy shocks on yields and exchange dates, does not provide information about the persistence of these effects over longer periods of time.

Ultimately, we chose to focus on one-day changes around central bank announcements as an appropriate balancing of these competing objectives; moreover, it would have been impractical to utilize a shorter event window, because the zero-coupon yields needed to estimate the term structure models and thus calculate changes in expected rates and term premia for shorter windows are difficult to construct and less accurate. However, as discussed in Section 7 below, we do explore the effects of using a longer, two-day event window for yield changes.

To decompose changes in yields into their expected rates and term premium components, we fit an affine term structure model to U.S. zero-coupon yields and German zero-coupon yields, respectively.[11] There are several types of decomposition methods used in the literature. In this paper we opt for the method presented in Adrian, Crump, and Moench (2013) (hence, ACM) for its ease of computation. The ACM method assumes the yields are driven by five pricing factors that follow a VAR(1) process with Gaussian shocks, with the principal components of yield as the underlying factors. The model parameters can then be estimated using a three-step

[11] Term structure models are typically estimated on zero-coupon yields instead of par-coupon yields because the decomposition of long-term yields into expected short rates and term premia only holds exactly in zero-coupon yields. Therefore, the paper's results that use the term structure model decomposition are based on the zero yields, but elsewhere they are based on the par yield.

linear regression approach. In the first step, the pricing factors are regressed on the lagged factors to estimate the factor VAR(1) parameters and the factor shocks; in the second step, zero-coupon bond returns are regressed on these factor shocks to estimate their loadings or sensitivities, as well as on *lagged* pricing factors to estimate expected returns or risk premia; in the final step, risk premium parameters are estimated using a cross-sectional regression of these risk premia estimates on the factor loading estimates. The estimated model parameters allow us to decompose yields at any maturity into expected short rate and term premium components.[12] The ACM model produces estimates consistent with alternative measures of expected short rates and term premia based on simple measures of the yield-curve slope.[13] As shown in Table 1, the correlations between our ACM-model-based measures and these alternative measures of the 10-year expected short rates and term premia are very high.

The one-day changes in expected U.S. short rates and term premia of the 10-year yield generated by the ACM model around each FOMC announcement are shown in Figure 1. The conventional policy announcements during the pre-GFC period appear mainly to have affected expected rates. In contrast, policy actions in the years immediately following the GFC, when policy rates were pinned near zero and unconventional policy actions including balance sheet measures were more important, appear mainly to have affected term premia.

Table 2 quantifies this shift by reporting the ratio of the variance of changes in the U.S. yield-curve components (expected rates or term premia) following policy announcements to the variance of changes in the overall yield. The expected short rate accounted

[12]As in the original ACM paper, we estimate the model over available U.S. yield-curve data from 1961 to 2019 (and German data from 2002 to 2019). These samples are longer than the pre- and post-GFC samples used to estimate our spillover regressions. For highly persistent series such as interest rates, a long sample is required to precisely estimate the autoregressive parameters of the model factors; estimating the ACM model over the same pre- and post-GFC samples used in our spillover regressions would generate noisy and biased estimates of the yield-curve components.

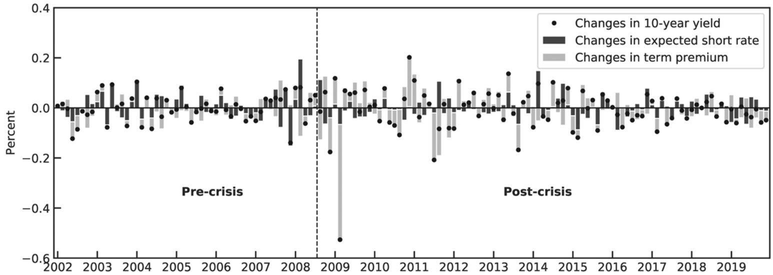
[13]This is similar to Ferrari, Kearns, and Schrimpf (2017), who use the 2-year yield and orthogonalized 10-year yield as proxies for the expected short rate and term premium.

Table 1. Correlation between Alternative Measures of U.S. Term Premia and Expected Short Rates

Correlation of Measures of U.S. Term Premia, Full Sample			
	Slope (10-Year Minus 2-Year)	Residual (10-Year on 2-Year)	ACM Model-Based Term Premium
Slope (10-Year Minus 2-Year)	1	0.746	0.807
Residual (10-Year on 2-Year)		1	0.97
ACM Model-Based Term Premium			1
Correlation of Measures of U.S. Expected Interest Rates, Full Sample			
		2-Year Yield	ACM Model-Based Expected Interest Rates
2-Year Yield		1	0.957
ACM Model-Based Expected Interest Rates			1

Note: The slope measure of term premium is defined as the difference between the 10-year and the 2-year Treasury yields, and the corresponding expected short rate is the yield on a 2-year Treasury. The residual measure is based on a regression of 10-year Treasury yields on 2-year Treasury yields. The term premium estimates are the residuals from this regression and the 2-year Treasury yields serve as expected short rates. The ACM model-based measures of term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013).

Figure 1. Changes in 10-Year Treasury Yield and Its Components on FOMC Meeting Dates



Note: The data are changes in a one-day window around FOMC announcement dates. The sample is from 2002 to 2019. The post-crisis period begins in September 2008. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013).

Table 2. Variance Ratios of U.S. 10-Year Yields' Expected Short Rate and Term Premium Components over 10-Year Yields

	Pre-GFC	Post-GFC
Expected Short Rates	0.98	0.23
Term Premia	0.55	0.94

Note: This table reports the ratio of the variance of changes following FOMC announcements in expected interest rates and term premia, respectively, relative to that of 10-year yields for the pre- and post-crisis samples. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013).

for most of the variance in overall yields in the pre-GFC period, while the term premium dominated yield movements in the post-GFC period. These results are again consistent with the view that conventional policy announcements in the pre-crisis period operated mainly through expected short rate, whereas in the latter period balance sheet policies affecting term premia gained importance. That said, both the figure and the table make clear that conventional policies had some apparent effect on term premia in the first period and that a combination of conventional and unconventional policies was affecting expected rates in the second period.

3.3 Data Timing Issues

As also noted above, our analysis is based on one-day changes around FOMC announcements, measured using end-of-day closing yield data as of U.S. eastern standard time (EST). German yields are as of 5:00 p.m. central European time (CET), which is either 11:00 a.m. or 12:00 p.m. U.S. EST time on the same day, depending on whether the daylight savings adjustment is in effect. This is before the usual FOMC policy announcement time of 2:00 p.m. Therefore, to capture the reaction of German and U.K. yields to FOMC policy announcements, we use changes in German and U.K. closing yields from the day of the FOMC announcement to the next day. In contrast, ECB announcements are typically at around 1:45 p.m. CET, which is 6:45 a.m. or 7:45 a.m. on the same day U.S. EST, so we use changes in U.S. and German closing yields from the day prior to the ECB announcement to the day of ECB announcement to capture the reaction of U.S. and German yields to ECB announcements.

As noted above, all exchange rate data are also end-of-day (U.S. EST) values except for the EME exchange rate index and South Korean won, which are recorded at 12:00 p.m. EST. Therefore, for these two exchange rates we use the change from the day of the FOMC announcement to the following day.

3.4 Econometric Analysis of Spillovers

We first study the spillover effects of FOMC policies on the dollar. Specifically, we run a set of regressions on FOMC announcement days of changes in the dollar exchange rates (FX) on changes in the U.S. 10-year par yield (Y_{US}):

$$dFX_{i,t} = \alpha_i + \beta_i dY_{US,t} + \epsilon_{i,t}, \tag{1}$$

where $i = \{$AFE, EME, EUR, KRW, MXN, and BRL$\}$.

To assess the spillover effects of the components of yields, we regress the changes in exchange rates on the changes in U.S. 10-year yield's expected short rate (SR) and term premium (TP) components:

$$dFX_{i,t} = \alpha_i + \beta_{1,i} dSR_{US,t} + \beta_{2,i} dTP_{US,t} + \epsilon_{i,t}. \tag{2}$$

We then run a similar set of regressions on FOMC announcement days of changes in foreign 10-year yields (Y_i) on changes in the U.S. 10-year yield to study the spillover effects of FOMC policies to foreign yields:

$$dY_{i,t} = \alpha_i + \beta_i dY_{US,t} + \epsilon_{i,t} \tag{3}$$

$$dY_{i,t} = \alpha_i + \beta_{1,i} dSR_{US,t} + \beta_{2,i} dTP_{US,t} + \epsilon_{i,t}, \tag{4}$$

where $i = \{$Germany, Canada, United Kingdom, Korea, Mexico, and Brazil$\}$.

We next drill down deeper into the spillover effects of the FOMC's policies on German yields, assessing how German expected policy rates and term premia react to FOMC announcements. We regress the German 10-year yield and its two components on the components of the U.S. 10-year yield:

$$dY_{Germany,t} = \alpha + \beta_1 dSR_{US,t} + \beta_2 dTP_{US,t} + \epsilon_{Germany,t} \tag{5}$$

$$dSR_{Germany,t} = \alpha + \beta_{1,SR} dSR_{US,t} + \beta_{2,SR} dTP_{US,t} + \epsilon_{SR,t} \tag{6}$$

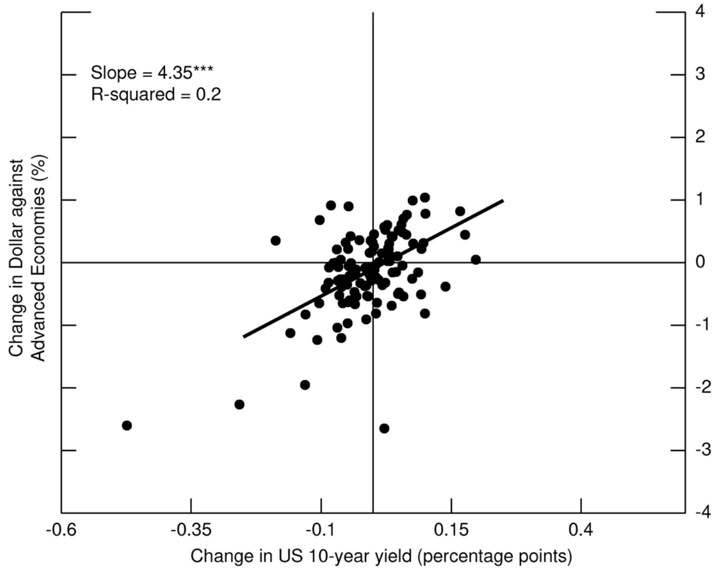
$$dTP_{Germany,t} = \alpha + \beta_{1,TP} dSR_{US,t} + \beta_{2,TP} dTP_{US,t} + \epsilon_{TP,t}. \tag{7}$$

We use an analogous analysis to assess the spillover from German to U.S. yields following ECB announcements. For all of our regressions we report heteroskedasticity-consistent standard errors.

4. Monetary Policy Effects on the U.S. Dollar Exchange Rate

Figure 2 illustrates our event study, with each dot corresponding to an FOMC announcement. The x-axis shows the change in the 10-year U.S. Treasury yield following the announcement, while the y-axis depicts the change in the AFE dollar index, where a positive move indicates dollar appreciation. The trend line through the data, estimated using Equation (1), suggests that a policy-induced 100 basis point change in 10-year bond yields led, on average, to a 4.35 percent increase in the AFE dollar index. Figure 3 shows a similar scatter plot for the EME dollar index, and the regression implies an index appreciation of 2.36 percent for a 100 basis point change in yields, on average. The relatively shallow slope of the EME

Figure 2. Changes in the Advanced Economy Dollar Index and U.S. 10-Year Treasury Yield on FOMC Announcement Days



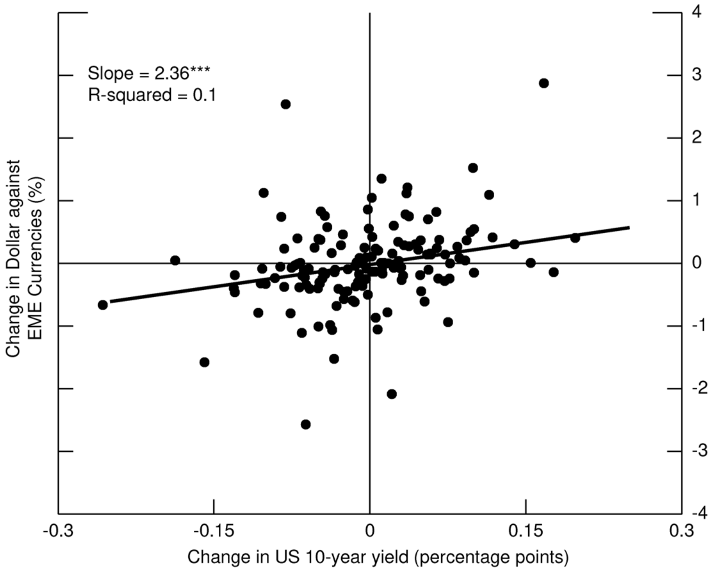
Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is from 2002 to 2019. The U.S. 10-year yield is the generic government bond yield from Bloomberg. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

index likely reflects active exchange rate management by some EM countries.

Further details on these relationships are provided in Tables 3A (AFEs) and 3B (EMEs), which also expands the analysis to our sample of bilateral exchange rates. The tables show the results of the estimation of Equations (1) and (2) for the full sample, pre-, and post-crisis periods. Looking down the first column of results, for most currencies we observe increased sensitivity in the post-crisis period. For example, the sensitivity of the euro jumps from 3.2 percent per 100 basis points in the pre-crisis period to 5.9 percent per 100 basis points in the post-crisis period. The observed increases in the sensitivities for the other currencies are of a similar magnitude.

We can use our yield-curve decomposition to separately examine the exchange rate effects of changes in the short rate and term

Figure 3. Changes in the Emerging Market Dollar Index and U.S. 10-Year Treasury Yield on FOMC Announcement Days



Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is from 2002 to 2019. The U.S. 10-year yield is the generic government bond yield from Bloomberg. Only floating rate EME currencies are included. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

premium. Figure 4 breaks down the effect of yields on the advanced economy index, which was shown in Figure 2, into the separate effects of expected interest rates and term premium. From the figures it appears that changes in short rates have a much larger effect on changes in the dollar. We can also see this in Table 3A, which reports the coefficient estimates from Equation (2), which includes both the short rate and term premium in the regression. The coefficient on the U.S. expected interest rate is reported in the third column of the table, and the term premium in the fourth column.[14] Looking across the columns, we observe that exchange rates always react more

[14] The difference between the multivariate regression results in this table and the univariate regressions in Figure 4 arises from correlation between changes in the U.S. expected short rate and term premium.

Table 3A. Regression Results for Exchange Rate Spillovers, FOMC Announcement Days, AFE

Dependent Variable Exchange Rate Changes	U.S. Explanatory Variables, Changes in:				
	10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
AFE Index					
Full Sample	4.353*** (0.583)				0.20
Pre-GFC	1.994 (1.368)				0.07
Post-GFC	4.793*** (0.657)				0.23
Full Sample		9.124*** (0.902)	2.41*** (0.549)	7.112***	0.32
Pre-GFC		1.823 (1.912)	−1.502 (2.829)	1.439	0.12
Post-GFC		11.619*** (1.028)	2.769*** (0.512)	8.331***	0.45
EUR					
Full Sample	5.26*** (0.612)				0.21
Pre-GFC	3.186*** (0.964)				0.12
Post-GFC	5.913*** (0.756)				0.27
Full Sample		8.944*** (0.991)	2.828*** (0.654)	5.726***	0.27
Pre-GFC		3.799*** (1.398)	1.04 (1.866)	1.464	0.09
Post-GFC		13.614*** (1.31)	3.512*** (0.653)	7.459***	0.43

Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is January 2002–December 2019. The pre-crisis sample is January 2002–August 2008. The post-crisis sample is September 2008–December 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). The 10-year yields are generic government bond yields from Bloomberg. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Significance of the t-test is a rejection of the hypothesis that the expected interest rate and term premium coefficients are the same.

Table 3B. Regression Results for Exchange Rate Spillovers, FOMC Announcement Days, EME

Dependent Variable Exchange Rate Changes	U.S. Explanatory Variables, Changes in: 10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
EME Index					
Full Sample	2.362*** (0.507)				0.10
Pre-GFC	1.251** (0.62)				0.07
Post-GFC	2.991*** (0.719)				0.12
Full Sample		5.112*** (0.883)	1.39** (0.583)	3.909***	0.13
Pre-GFC		1.793** (0.875)	0.436 (1.168)	1.151	0.07
Post-GFC		8.757*** (1.558)	1.54** (0.776)	4.482***	0.21
KRW					
Full Sample	3.221*** (0.698)				0.07
Pre-GFC	1.552** (0.781)				0.05
Post-GFC	3.899*** (0.935)				0.09
Full Sample		4.696*** (1.177)	2.612*** (0.778)	1.642	0.08
Pre-GFC		1.624 (1.058)	1.584 (1.423)	0.028	0.04
Post-GFC		9.444*** (2.001)	2.516** (0.997)	3.350***	0.13

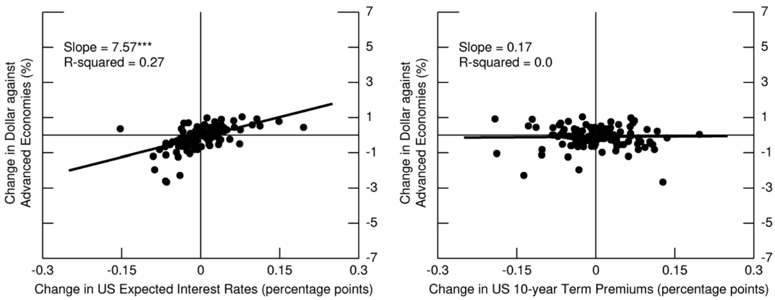
(*continued*)

Table 3B. (Continued)

Dependent Variable Exchange Rate Changes	U.S. Explanatory Variables, Changes in: 10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
MXN					
Full Sample	1.056 (0.672)				0.01
Pre-GFC	−1.961*** (0.717)				0.06
Post-GFC	2.641*** (1.021)				0.05
Full Sample		5.081*** (1.141)	0.234 (0.754)	3.938***	0.07
Pre-GFC		−1.725 (1.13)	−2.137 (1.509)	0.270	0.03
Post-GFC		10.185*** (1.847)	0.826 (0.92)	4.904***	0.20
BRL					
Full Sample	2.808*** (0.912)				0.04
Pre-GFC	1.266 (1.762)				0.01
Post-GFC	3.353*** (1.061)				0.07
Full Sample		6.507*** (1.555)	1.14 (1.03)	3.182***	0.07
Pre-GFC		1.891 (2.505)	−1.726 (3.344)	1.071	0.01
Post-GFC		9.811*** (2.03)	1.557 (1.012)	3.910***	0.16

Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is January 2002–December 2019. The pre-crisis sample is January 2002–August 2008. The post-crisis sample is September 2008–December 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). EME exchange rate index includes only floating rates. The 10-year yields are generic government bond yields from Bloomberg. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Significance of the t-test is a rejection of the hypothesis that the expected interest rate and term premium coefficients are the same.

Figure 4. Changes in the Advanced Economy Dollar Index and U.S. Expected Interest Rates and Term Premia on FOMC Announcement Days



Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is from 2002 to 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

strongly to changes in the expected interest rate. In addition, this difference is more pronounced in the post-crisis period, as the coefficient on the expected rate rises more after the crisis than the coefficient on the term premium. For example, when the dependent variable is changes in the euro, the coefficient on the expected short rates rises from 3.8 in the pre-crisis period to 13.6 in the post-crisis period, while the coefficient on the term premium rises only from 1.0 to 3.5. We also show the results of a t-test for equality of the coefficients on the expected short rate and term premium; for every currency the difference between the two coefficients is highly statistically significant in the post-crisis period, though not in the pre-crisis period.

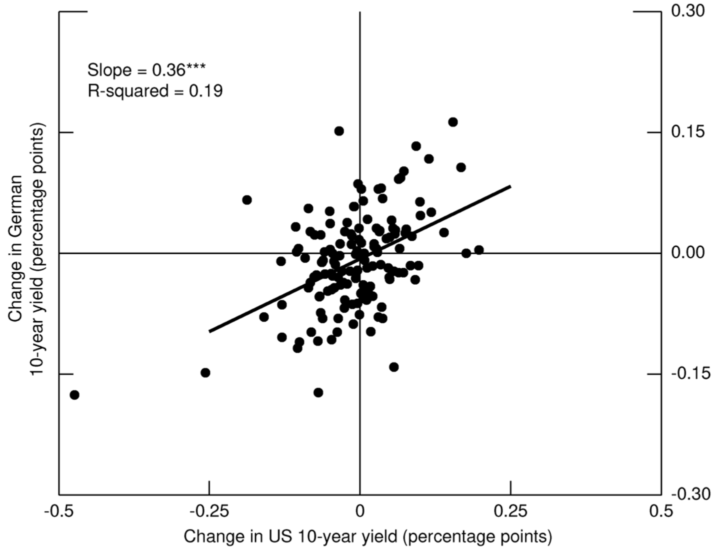
While the effect of the term premium on the exchange rate rises less (from pre- to post-GFC) than the effect of the expected short rate, it does rise. In fact, the effect of the term premium on the exchange rate appears to be solely a post-crisis phenomenon. In all the regressions, the coefficient on the term premium is not statistically significant in the pre-crisis period.

4.1 Discussion

Our finding that expected interest rates have larger spillover effects on the dollar than term premia may contradict conventional wisdom but should not be surprising. As noted earlier, the term premium represents compensation for the risk of holding a bond. Consider a rise in the term premium on U.S. Treasury bonds, for example, that reflects an increase in its perceived riskiness. Such a development should not boost the demand for dollar-denominated assets, and hence should not boost the value of the dollar, at least not to an extent commensurate with the effect of a rise in expected interest rates. Alternatively, consider a rise in the U.S. term premium that reflects a balance sheet action by the Federal Reserve, such as a reduction in its asset holdings. This action, by increasing the supply of dollar-denominated bonds, also would not be expected to boost the value of the dollar, or, again, not as much as a rise in expected interest rates.

Another question raised by our findings is why the dollar's sensitivity to monetary policy announcements, and especially its sensitivity to increases in expected interest rates, rose after the GFC. This latter result is especially surprising, considering that changes in expected interest rates became less important relative to term premia in the post-GFC period. Ferrari, Kearns, and Schrimpf (2017) conjecture that the higher sensitivity of the dollar to monetary policy may reflect structural changes such as the shift to unconventional monetary policy actions, which some argue are targeted at exchange rates given the compression of domestic interest rates. Another possibility the authors present is that the reduced liquidity and intermediation ability of dealers lead investors to shy away from inventory risk. However, Curcuru (2017) shows that the sensitivity of the dollar to interest rates does not rise smoothly over time but fluctuates widely. This suggests that the heightened sensitivity of the dollar in the post-GFC period may reflect particular macroeconomic circumstances rather than persistent structural changes. It may be that the pronounced economic uncertainties prevailing during and after the GFC led market participants to place extra weight on the information content of Fed announcements; Mehrotra, Moessner, and Shu (2019) find heightened spillovers during periods of greater uncertainty, while Stavrakeva and Tang (2018) find that Fed announcements triggered flight-to-safety flows during the GFC. All told, the reasons for the dollar's heightened sensitivity after the GFC to monetary policy, and especially to expected interest rates, merits further research, although conducting such analysis is beyond the scope of this current paper.

Figure 5. Changes in the German 10-Year Bund Yield and U.S. 10-Year Treasury Yield on FOMC Announcement Days



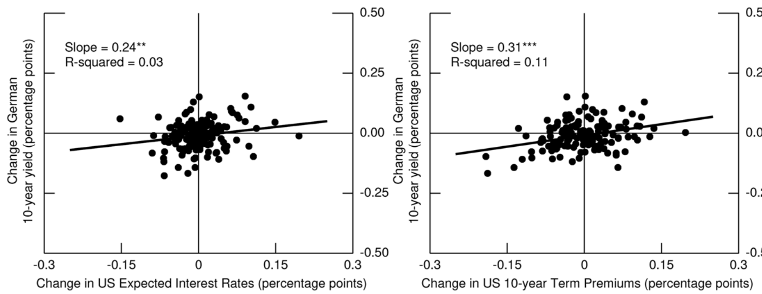
Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is from 2002 to 2019. The 10-year yields are the generic government bond yields from Bloomberg. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

5. Monetary Policy Spillovers to Foreign Yields

As noted in the introduction, quantitative easing has been criticized not only for exerting undue appreciation pressures on foreign currencies, but also for causing foreign financial conditions to loosen excessively. To assess this hypothesis, we examine the response of foreign interest rates in a number of important foreign economies to U.S. monetary policy announcements. Figure 5 repeats the event study shown in Figure 2 but examines the reaction of the German 10-year bund yield to changes in U.S. Treasury yields following FOMC announcements. It indicates that over the entire sample, a little more than a third of the post-announcement change in U.S. Treasury yields passed through to German yields.

How do conventional monetary policies compare with balance sheet policies in affecting German yields? Figure 6 breaks down the

Figure 6. Changes in the German 10-Year Bund Yield and U.S. Expected Interest Rates and Term Premia on FOMC Announcement Days



Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is from 2002 to 2019. The German 10-year yield is the zero-coupon yield from Bloomberg. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

spillover effect of U.S. yields on German yields into the separate effects of U.S. expected interest rates and term premium. It suggests that the effect of changes in U.S. term premia on German yields, on the right, is slightly stronger than the effect of changes in U.S. expected short rates. However, this result reverses when changes in U.S. expected interest rates and term premia are incorporated jointly, as shown in Table 4A, which presents the results of estimating Equations (3) and (4). Focusing first on the AFEs, they indicate that over the entire 2002–19 sample, changes in the U.S. expected rate had a larger effect on foreign yields than changes in the U.S. term premium. However, this difference is statistically significant only for Canada; moreover, for Germany and the United Kingdom, the U.S. term premium exerted the stronger effect in the pre-GFC period.

Table 4B addresses the three important EMEs discussed earlier: Korea, Mexico, and Brazil. In the pre-GFC period, except for Korea, the impact of U.S. Treasury yield components on these EME yields is not statistically significant and explains very little of their variation. Conversely, in the post-GFC period, U.S. yield components explain a material share of the movement in the EME yields. Moreover, for all three EMEs, the impact of expected interest rates is

Table 4A. Regression Results for Bond Yield Spillovers, FOMC Announcement Days, AFE

Dependent Variable 10-Year Yield Changes	U.S. Explanatory Variables, Changes in: 10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
AFE					
Germany					
Full Sample	0.358*** (0.057)				0.19
Pre-GFC	0.265** (0.11)				0.08
Post-GFC	0.373*** (0.061)				0.24
Full Sample		0.379*** (0.099)	0.363*** (0.066)	0.149	0.17
Pre-GFC		0.214 (0.149)	0.412** (0.199)	−0.982	0.07
Post-GFC		0.465*** (0.13)	0.359*** (0.065)	0.782	0.25
Canada					
Full Sample	0.595*** (0.02)				0.72
Pre-GFC	0.634*** (0.039)				0.69
Post-GFC	0.573*** (0.024)				0.75
Full Sample		0.722*** (0.039)	0.571*** (0.026)	3.569***	0.65
Pre-GFC		0.778*** (0.075)	0.539*** (0.1)	2.356**	0.55
Post-GFC		0.668*** (0.047)	0.576*** (0.023)	1.910*	0.71

(*continued*)

Table 4A. (Continued)

Dependent Variable 10-Year Yield Changes	U.S. Explanatory Variables, Changes in: 10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
United Kingdom					
Full Sample	0.375*** (0.063)				0.15
Pre-GFC	0.2* (0.115)				0.04
Post-GFC	0.456*** (0.074)				0.22
Full Sample		0.415*** (0.112)	0.366*** (0.074)	0.403	0.14
Pre-GFC		0.141 (0.153)	0.427** (0.205)	−1.385	0.07
Post-GFC		0.647*** (0.165)	0.402*** (0.082)	1.439	0.21

Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is January 2002–December 2019. The pre-crisis sample is January 2002–August 2008. The post-crisis sample is September 2008–December 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). The 10-year yields are generic government bond yields from Bloomberg. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Significance of the t-test is a rejection of the hypothesis that the expected interest rate and term premium coefficients are the same.

Table 4B. Regression Results for Bond Yield Spillovers, FOMC Announcement Days, EME

Dependent Variable 10-Year Yield Changes	U.S. Explanatory Variables, Changes in:				
	10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
EME					
Korea					
Full Sample	0.317***				0.21
	(0.039)				
Pre-GFC	0.305***				0.13
	(0.088)				
Post-GFC	0.327***				0.28
	(0.043)				
Full Sample		0.496***	0.248***	3.519***	0.23
		(0.066)	(0.043)		
Pre-GFC		0.466***	0.017	2.882***	0.17
		(0.119)	(0.16)		
Post-GFC		0.519***	0.276***	2.636***	0.31
		(0.09)	(0.044)		
Mexico					
Full Sample	0.28***				0.05
	(0.057)				
Pre-GFC	0.054				0.00
	(0.135)				
Post-GFC	0.36***				0.19
	(0.055)				
Full Sample		0.389***	0.243***	1.350	0.05
		(0.1)	(0.066)		
Pre-GFC		0.084	0.155	−0.285	0.00
		(0.186)	(0.248)		
Post-GFC		0.597***	0.276***	2.703***	0.19
		(0.114)	(0.056)		

(*continued*)

Table 4B. (Continued)

Dependent Variable 10-Year Yield Changes	U.S. Explanatory Variables, Changes in:				
	10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
Brazil					
Full Sample	0.434***				0.06
	(0.135)				
Pre-GFC	0.318				0.04
	(0.38)				
Post-GFC	0.459***				0.07
	(0.139)				
Full Sample		1.107***	0.198	3.694***	0.12
		(0.229)	(0.147)		
Pre-GFC		0.482	0.442	0.063	0.06
		(0.513)	(0.775)		
Post-GFC		1.442***	0.206	4.349***	0.17
		(0.268)	(0.139)		

Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is January 2002–December 2019. The pre-crisis sample is January 2002–August 2008. The post-crisis sample is September 2008–December 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). Brazil 10-year yield data begin January 4, 2006. The 10-year yields are generic government bond yields from Bloomberg. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Significance of the t-test is a rejection of the hypothesis that the expected interest rate and term premium coefficients are the same.

considerably greater than that of term premia, and to a statistically significant extent.

5.1 Discussion

Changes in U.S. expected interest rates appear to exert as much or more influence on foreign yields as changes in term premia. That U.S. expected rates have at least as strong an effect on foreign yields as term premia is not very surprising: Changes in either U.S. expected rates or term premia, by changing the rate of return on U.S. assets, should lead to similar changes in portfolio allocations that trigger similar movements in foreign yields. It is less clear why U.S. expected rates should exert significantly larger effects on foreign yields than changes in term premia, as is especially the case of the EMEs we studied. One possible explanation is that EME bonds are more risky and less substitutable with U.S. bonds than AFE bonds; therefore, there may be weaker portfolio rebalancing effects between U.S. and EME bonds, and this may manifest itself in weaker linkages through term premia. Another possibility is that EMEs are viewed as more likely to target their exchange rates than AFEs, so that changes in U.S. interest rates are expected to lead to greater policy responses by EMEs than AFEs.

Another question posed by these results, similar to those for the dollar, is why spillovers to foreign yields appear to be stronger in the post-crisis period, and, moreover, why this was so evident for expected rates, despite their reduced importance for changes in U.S. yields after FOMC announcements. As noted earlier, it may be that the greater uncertainties prevailing in the post-GFC era led market participants to make greater inferences from Fed actions. But, again, this remains an important question for future research.

The next section drills down a little deeper into the process by which U.S. yields affect foreign yields, and vice versa.

6. Channels of Yield Spillovers

6.1 Impact of U.S. Monetary Policies on German Yields, Expected Interest Rates, and Term Premia

So far, we have distinguished between expected interest rates and term premia in the economies originating the monetary policy shocks, that is, the United States. In this section, we deepen our understanding of the spillovers of these shocks by looking at how they affect the term structure components of the yields in the economies receiving these shocks. We focus on Germany, where a long history of liquid bond markets allows us to decompose German bond yields into expected interest rates and term premia.

Table 5 present the results of estimating Equations (5)–(7). The top set of results reproduces the results in Table 4 that link German 10-year yields to U.S. 10-year yields, but uses zero-coupon yields (which will be used to estimate term structure components, below) instead of par-coupon yields. The results are little changed from Table 4, confirming that changes in both the U.S. expected short rate and the U.S. term premium have significant, similar spillover effects on the German 10-year yield.

The middle section focuses on spillovers from Fed announcements to German expected interest rates. It indicates that changes in the U.S. 10-year yield, and in either of its two components, have essentially no spillover effects on the German expected interest rate. This suggests that market participants expect that the ECB would not adjust its policy rate in response to the FOMC's interest rate and balance sheet policies and their effects.

The bottom section of Table 5 focuses on spillovers to German term premia. Here, the results show that changes in the U.S. 10-year yield, as well as changes in both of its components, have pronounced effects. One explanation is that U.S. easing increases expectations for additional QE in the euro area, which lowers the German term premium. Alternatively, this spillover effect could arise as investors rebalance their portfolios in response to FOMC policy actions. For example, FOMC easing actions, whether through a rate cut or through an asset purchase program, lead to lower long-term yields in the U.S. and thus heightened investor demand for German bonds, which in turn leads to lower German term premia and yields.

6.2 Impact of ECB Monetary Policies on U.S. Yields, Expected Interest Rates, and Term Premia

So far in this paper, we have focused on international spillovers from U.S. monetary policy actions. However, in recent years, observers

Table 5. Regression Results for Spillovers on German 10-Year Yield and Its Components, FOMC Announcement Days

Dependent Variable Changes in:	U.S. Explanatory Variables, Changes in:				
	10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
German 10-Year Yield					
Full Sample	0.369*** (0.058)				0.17
Pre-GFC	0.294** (0.126)				0.07
Post-GFC	0.373*** (0.063)				0.24
Full Sample		0.377*** (0.099)	0.365*** (0.065)	0.108	0.18
Pre-GFC		0.21 (0.14)	0.44** (0.187)	−1.217	0.09
Post-GFC		0.463*** (0.131)	0.354*** (0.065)	0.800	0.24
German Expected Interest Rate					
Full Sample	−0.005 (0.018)				0.00
Pre-GFC	0.036 (0.054)				0.01
Post-GFC	−0.017 (0.018)				0.00
Full Sample		0.011 (0.03)	−0.01 (0.02)	0.625	0.00
Pre-GFC		0.042 (0.059)	0.033 (0.079)	0.111	0.01
Post-GFC		−0.008 (0.035)	−0.02 (0.017)	0.327	0.00

(*continued*)

Table 5. (Continued)

Dependent Variable Changes in:	U.S. Explanatory Variables, Changes in:				
	10-Year Yield	**Expected Interest Rate**	**Term Premium**	**SR = TP t-test**	**R-squared**
German Term Premium					
Full Sample	0.321*** (0.051)				0.16
Pre-GFC	0.187** (0.092)				0.07
Post-GFC	0.337*** (0.063)				0.19
Full Sample		0.292*** (0.082)	0.329*** (0.054)	−0.413	0.16
Pre-GFC		0.149 (0.094)	0.334*** (0.125)	−1.457	0.10
Post-GFC		0.397*** (0.135)	0.325*** (0.067)	0.522	0.19

Note: The data are changes in a one-day window around FOMC announcement dates. The full sample is January 2002–December 2019. The pre-crisis sample is January 2002–August 2008. The post-crisis sample is September 2008–December 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). The German 10-year yields are zero-coupon yields from Bloomberg. The U.S. 10-year yields are zero-coupon yields from the Federal Reserve Board. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Significance of the t-test is a rejection of the hypothesis that the expected interest rate and term premium coefficients are the same.

and policymakers have become increasingly attuned to the effect of foreign policies on U.S. financial conditions. In particular, foreign monetary easing is believed to be playing an important role in depressing U.S. long-term yields. To shed some light on these effects, we repeat the analysis above, but focusing on the effects of ECB announcements on U.S. yields. We use German yields as the benchmark for how ECB policies affect "domestic" (i.e., euro-area) financial conditions, and then examine how these pass through to U.S. yields following ECB announcements.

Our findings are presented in Table 6, which shows the results of estimating the equivalent of Equations (5)–(7) but for the spillover from German to U.S. bonds following ECB events. As with the spillover effects from FOMC monetary policies shown in the top section of Table 5, the top section of Table 6 shows that ECB monetary policy actions' spillover effects on U.S. yields are large, significant, and broadly comparable in the pre- and post-GFC periods.[15] Further, the spillover effects on U.S. yields from both types of ECB policies are broadly similar.

The rest of Table 6 show the responses of the U.S. 10-year yield's two components to ECB policy surprises. The middle section of the table shows the spillover results on the U.S. expected short rate. Unlike in the case with German expected short rates, we find that U.S. expected short rates do react somewhat to changes in German yields, especially their expected short rates component, but the effect is quite small. In contrast, the results in the bottom section of the table show that changes in the German 10-year yield, as well as changes in both of its components, have large and significant spillover effects on the U.S. term premium. These results are similar to the spillover effect of FOMC policies on the German term premium, shown in Table 5; as noted above, this spillover effect could reflect either portfolio balance channels or investor expectations of changes in Fed QE policy.

[15] The larger spillover coefficient from ECB announcements on U.S. yields than the corresponding spillover coefficient from FOMC announcements on German yields could be a result of the timing of the one-day event-study window that we use. Using a narrower two-hour event window, Curcuru, De Pooter, and Eckerd (2018) find similar spillover effects between the FOMC and ECB announcements.

Table 6. Regression Results for Bond Yield Spillovers, ECB Announcement Days

Dependent Variable Changes in:	German Explanatory Variables, Changes in:				
	10-Year Yield	Expected Interest Rate	Term Premium	SR = TP t-test	R-squared
U.S. 10-Year Yield					
Full Sample	0.759*** (0.057)				0.37
Pre-GFC	0.725*** (0.112)				0.27
Post-GFC	0.768*** (0.064)				0.42
Full Sample		0.829*** (0.091)	0.765*** (0.064)	0.688	0.37
Pre-GFC		0.815*** (0.145)	0.703*** (0.148)	0.664	0.27
Post-GFC		0.818*** (0.117)	0.778*** (0.07)	0.344	0.42
U.S. Expected Interest Rate					
Full Sample	0.103*** (0.038)				0.03
Pre-GFC	0.276*** (0.088)				0.09
Post-GFC	0.042 (0.041)				0.01
Full Sample		0.203*** (0.06)	0.063 (0.042)	2.268**	0.04
Pre-GFC		0.294*** (0.111)	0.267** (0.113)	0.210	0.09
Post-GFC		0.148** (0.072)	0.022 (0.043)	1.749*	0.02

(*continued*)

Table 6. (Continued)

Dependent Variable Changes in:	German Explanatory Variables, Changes in:				
	10-Year Yield	**Expected Interest Rate**	**Term Premium**	**SR = TP t-test**	**R-squared**
U.S. Term Premium					
Full Sample	0.637*** (0.057)				0.28
Pre-GFC	0.451*** (0.092)				0.18
Post-GFC	0.707*** (0.074)				0.33
Full Sample		0.560*** (0.092)	0.692*** (0.064)	−1.410	0.29
Pre-GFC		0.564*** (0.113)	0.408*** (0.116)	1.176	0.19
Post-GFC		0.501*** (0.132)	0.766*** (0.079)	−2.015**	0.35

Note: The data are changes in a one-day window around ECB announcement dates. The full sample is January 2002–December 2019. The pre-crisis sample is January 2002–August 2008. The post-crisis sample is September 2008–December 2019. Term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). The German 10-year yields are zero-coupon yields from Bloomberg. The U.S. 10-year yields are zero-coupon yields from the Federal Reserve Board. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. Significance of the t-test is a rejection of the hypothesis that the expected interest rate and term premium coefficients are the same.

6.3 Discussion

To summarize, policy easings (for example) by the Fed have little effect on German expected interest rates but lead to substantial declines in German term premia; similarly, ECB policy easings have fairly small effects on U.S. expected rates but substantially depress U.S. term premia. It is not clear why spillovers appear to mainly affect foreign term premia rather than expected short-term rates. One possibility is simply that policy easing in one country depresses the longer-term yields of the other country through standard portfolio balance effects, but market participants expect the recipient country's central bank to ignore this effect, so the expected rate path is left unchanged. Another possibility is that policy easing in one country both appreciates the currency of the recipient country while lowering its longer-term yields; with the contractionary effect of the currency appreciation offsetting the expansionary effect of the decline in yields, there is no need to the central bank to change its stance. But these are just conjectures, and more research in this area is needed.

7. Robustness Checks

7.1 Alternative Yield Decompositions

As noted earlier, there is no consensus approach to decomposing bond yields into their respective expected rates and term premium components. As a robustness check, we use two alternative decomposition methods and repeat our analysis of the spillovers to exchange rates and yields. More specifically, we use the two-year yield as a proxy for the expected short rate and pair it with two measures of the term spread—the difference between the 10-year and 2-year yield, and the residuals from a regression of the 10-year yield on the 2-year yield. As noted earlier, this is similar to Ferrari, Kearns, and Schrimpf (2017), who use the 2-year yield and orthogonalized 10-year yield as proxies for the expected short rate and term premium.

The appendix tables show that the results of our regressions of the dollar on term structure components estimated using the ACM method are generally robust to the other decomposition methods we employed. In all cases, the estimated sensitivity of the exchange rates to expected interest rates exceeds that of its sensitivity to the term premium, albeit not always to a statistically significant extent. In addition, our estimated yield-curve spillovers following both FOMC and ECB meetings using the ACM decompositions are generally similar to the estimates using the alternative decomposition methods.

7.2 Longer Event Window

To evaluate the persistence of the effects described in this paper, the appendix tables also present estimations based on two-day event windows—that is, the period after the policy announcement is lengthened by one day. By and large, the estimated spillovers of U.S. yield changes to exchange rates are a little smaller and, in the case of some EMEs, less statistically significant; this may reflect either some mean-reverting behavior in foreign exchange markets or the noise from other developments seeping into the event window. However, the central result of our research remains: expected short rates have a larger impact on exchange rates than term premia.

With the longer event window, estimated spillovers to foreign yields remain large and significant, although expected rates and term premia now exert more similar effects. This may well reflect the high correlation of yields across countries during periods between central bank policy announcements.

7.3 Two-Year Yield

So far we have focused on using changes of the 10-year yield and its ACM model components to measure monetary policy as, relative to shorter-term yields, term premia are likely to be important in 10-year yields. To get a clearer picture of how monetary policy is spilling over to foreign markets, we now measure monetary policy based on changes in the two-year yield and its ACM model components. As indicated in the last row of the appendix tables, spillovers to foreign markets from changes in two-year yields remain strong and statistically significant. However, the size of the spillovers from expected rates is smaller and those from term premia are larger; the effects of these components on exchange rates are now quite similar. These findings may reflect that term premia comprise a very small part of two-year yields, so that the decomposition method may not be precisely distinguishing term premia from expected rates.[16]

[16] In both pre- and post-crisis periods, expected rates in the estimated ACM model can explain about 90 percent of the movements in two-year yields on FOMC meeting dates.

8. Conclusion

In summary, we use models to decompose longer-term yields into expected short rate and term premium components and compare the spillover effects of different monetary policies by examining the impact of these two components on foreign financial conditions. Our paper represents the first thorough and robust comparison of these effects, and we report several novel and significant results. We find that changes in expected interest rates have larger effects on exchange rates than changes in term premia, and an increased sensitivity of the dollar to expected interest rates accounts for most of the rise in the overall sensitivity of the dollar to monetary policy following the global financial crisis. We also find that spillovers to foreign yields from expected interest rates are generally at least as large as those from term premia, especially for emerging market economies. To the extent that changes in expected rates primarily reflect conventional policy actions or forward guidance regarding policy rates, while changes in term premia primarily reflect balance sheet policies, these findings contradict the popular wisdom that balance sheet policies exert unusually large spillovers.

In this paper, we also drilled down deeper into the process by which monetary policy actions spill over to other economies. We found that U.S. policy actions exerted little effect on the expected interest rates embedded in German long-term yields but large effects on German term premia. In the other direction, we found that ECB announcements also had only small effects on U.S. expected interest rates but large effects on U.S. term premia. Exactly what accounts for this pattern of results is beyond the scope of this paper but clearly merits further research.

We have also used alternative decompositions of longer-term yields and performed additional robustness checks and found that our results broadly hold. That said, we caution that our findings are based on event studies and subject to the typical caveats associated with event studies. More research on this topic is needed.

Appendix. Regression Results Using Alternative Yield Decompositions, Window Lengths, and Bond Maturities

Table A.1. AFE Index on U.S. Interest Rate Decomposition on FOMC Announcement Days, Full Sample

		Intercept	Short Rate	Term Premium	SR = TP t-test	R-squared
10-Year Yield, 1-Day Window	ACM	−0.11**	9.12***	2.41***	7.11***	0.32
		(0.04)	(0.90)	(0.55)		
	Slope	−0.09**	6.42***	1.80**	4.78***	0.28
		(0.04)	(0.64)	(0.77)		
	Residual	−0.10**	6.07***	1.80**	3.95***	0.28
		(0.04)	(0.65)	(0.77)		
10-Year Yield, 2-Day Window	ACM	0.06	8.79***	1.46***	6.56***	0.22
		(0.06)	(1.24)	(0.54)		
2-Year Yield, 1-Day Window	ACM	−0.10**	7.17***	7.31***	−0.13	0.31
		(0.04)	(0.71)	(1.13)		

Note: The ACM model-based measures of term premia and expected short rates are constructed using the estimated affine term structure model of Adrian, Crump, and Moench (2013). The slope measure of 10-year term premium is defined as the difference between the 10- and the 2-year Treasury yields, and the corresponding expected short rate is the yield on a 2-year Treasury. The residual measure of 10-year term premium is based on a regression of 10-year Treasury yields on 2-year Treasury yields. The term premium estimates are the residuals from this regression and the 2-year Treasury yields serve as expected short rates. Heteroskedasticity-consistent standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Table A.2. EME Index on U.S. Interest Rate Decomposition on FOMC Announcement Days, Full Sample

		Intercept	Short Rate	Term Premium	SR = TP t-test	R-squared
10-Year Yield, 1-Day Window	ACM	−0.03 (0.04)	5.11*** (0.88)	1.39** (0.58)	3.91***	0.13
	Slope	−0.02 (0.04)	3.01*** (0.58)	1.38* (0.77)	1.81*	0.11
	Residual	−0.03 (0.04)	2.74*** (0.58)	1.38* (0.77)	1.34	0.11
10-Year Yield, 2-Day Window	ACM	−0.08 (0.05)	3.22*** (1.01)	0.08 (0.47)	3.30***	0.04
2-Year Yield, 1-Day Window	ACM	−0.02 (0.04)	3.52*** (0.69)	3.00*** (1.13)	0.43	0.11

Table A.3. German 10-Year Yield on U.S. Interest Rate Decomposition on FOMC Announcement Days, Full Sample

		Intercept	Short Rate	Term Premium	SR = TP t-test	R-squared
10-Year Yield, 1-Day Window	ACM	−0.01* (0.00)	0.38*** (0.10)	0.36*** (0.07)	0.15	0.17
	Slope	−0.01 (0.00)	0.30*** (0.07)	0.45*** (0.09)	−1.48	0.19
	Residual	−0.01** (0.00)	0.21*** (0.07)	0.45*** (0.09)	−2.05**	0.19
10-Year Yield, 2-Day Window	ACM	−0.01 (0.00)	0.50*** (0.07)	0.45*** (0.03)	0.80	0.51
2-Year Yield, 1-Day Window	ACM	−0.01* (0.00)	0.22*** (0.08)	0.68*** (0.13)	−3.29***	0.14

Table A.4. Korean 10-Year Yield on U.S. Interest Rate Decomposition on FOMC Announcement Days, Full Sample

		Intercept	Short Rate	Term Premium	SR = TP t-test	R-squared
10-Year Yield, 1-Day Window	ACM	−0.01*** (0.00)	0.50*** (0.07)	0.25*** (0.04)	3.52***	0.23
	Slope	−0.01*** (0.00)	0.38*** (0.04)	0.17*** (0.06)	3.13***	0.25
	Residual	−0.01*** (0.00)	0.35*** (0.04)	0.17*** (0.06)	2.32**	0.25
10-Year Yield, 2-Day Window	ACM	−0.01*** (0.00)	0.30*** (0.07)	0.21*** (0.04)	1.29	0.16
2-Year Yield, 1-Day Window	ACM	−0.01*** (0.00)	0.33*** (0.05)	0.51*** (0.08)	−2.04**	0.22

Table A.5. U.S. 10-Year Yield on German Interest Rate Decomposition on ECB Announcement Days, Full Sample

		Intercept	Short Rate	Term Premium	SR = TP t-test	R-squared
10-Year Yield, 1-Day Window	ACM	0.01** (0.00)	0.76*** (0.10)	0.76*** (0.07)	0.07	0.36
	Slope	0.01** (0.00)	0.70*** (0.06)	0.76*** (0.08)	−0.92	0.36
	Residual	0.01** (0.00)	0.43*** (0.05)	0.76*** (0.08)	−3.48***	0.36
10-Year Yield, 2-Day Window	ACM	0.01*** (0.00)	1.14*** (0.10)	0.94*** (0.07)	1.91*	0.49
2-Year Yield, 1-Day Window	ACM	0.01*** (0.00)	0.20*** (0.07)	1.69*** (0.16)	−7.92***	0.33

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