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# Measuring Monetary Policy Spillovers between U.S. and German Bond Yields<sup>1</sup>

by

Stephanie E. Curcuru  
Michiel De Pooter  
George Eckerd

April 2018

## Abstract

In this paper we estimate the magnitude of spillovers between bond markets in the U.S. and Germany following monetary policy communications by the FOMC and the ECB. The identification of policy-related co-movements following FOMC announcements, in particular, can be difficult because many foreign bond markets, including those in Germany, are closed at the time of the announcement. To address this issue we use intraday futures market data to estimate spillovers during a narrow and overlapping event window. We find that about half of the reaction in German domestic yields spills over to U.S. yields following ECB announcements, which is nearly identical to the spillover from U.S. yields to German Bund yields following FOMC announcements. This result contrasts with the conventional wisdom that FOMC announcements spill over to other countries but that there is not much effect in the other direction. We also find that spillover estimates are slightly higher in the post-crisis period, but that there is little difference in the spillover impact of conventional versus unconventional monetary policy. Our results based on futures prices differ noticeably from those using daily prices, which suggests that spillover estimates based on cash market data can be misleading.

Keywords: monetary policy, quantitative easing, interest rate differentials

JEL Codes: E5, F3.

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## **I. Introduction and Summary**

As monetary policy normalization is continuing in the United States and draws closer in other major advanced economies, market participants and policy makers alike are focused on the potential for cross-border monetary policy spillovers. Unlike spillovers from U.S. conventional and unconventional monetary policies to emerging market economies, which have been more studied extensively,<sup>2</sup> monetary policy spillovers between advanced foreign economies and the U.S. have received surprisingly little attention in the literature.

Spillovers between advanced economy sovereign bond markets in particular could be significant, both from and to U.S. yields. For example, on June 27, 2017, European Central Bank (ECB) President Mario Draghi stated at the Forum on Central Banking in Sintra, Portugal that “all the signs now point to a strengthening and broadening recovery in the euro area” and that “deflationary forces have been replaced by reflationary ones.” These comments were interpreted as signaling that the ECB was moving closer towards announcing a reduction in its pace of asset purchases. Accordingly, the German 10-year Bund yield increased 13 basis points on the day. Notably, ten-year U.S. Treasury yields also rose by 7 basis points on the day, reportedly in sympathy with the rise in German yields. These moves were reminiscent of the market reaction following the June 19, 2013 Federal Open Market Committee (FOMC) meeting when (then) Fed Chairman Ben Bernanke commented during the press conference that the FOMC might reduce the pace of purchases later in 2013 and end purchases in the middle of 2014 if economic conditions were to evolve as expected. The 10-year Treasury yield rose 17 basis points that day, while the 10-year Bund yield rose 11 basis points the following day, with the latter being attributed to spillovers from the FOMC communications the day before.

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<sup>2</sup> For examples of recent studies see Chen, Filardo, He, and Zhu (2011), Chen, Mancini-Griffoli, and Sahay (2014), and Bowman, Londono and Sapriza (2015).

In this paper we estimate the magnitude of spillovers between bond markets in the U.S. and Germany following notable monetary policy communications by the FOMC and the ECB.<sup>3,4</sup> The identification of policy-related co-movements following FOMC announcements, in particular, can be difficult because many foreign bond markets, including those in Germany, are closed at the time of the announcement. To address this issue, and in contrast to nearly all existing studies that rely on daily or multi-day changes in cash market yields to measure spillovers, we use intraday futures market data to estimate spillovers during a narrow and overlapping event window. Futures on Treasuries and Bunds are often at least as actively traded as the underlying cash instruments, but more importantly, futures have the benefit of longer trading hours which overcomes the issue of some cash markets being closed around announcements.

Summarizing our main results, we find that spillovers from ECB announcements to U.S. Treasury yields are significant. About half of the reaction in German domestic yields spills over to U.S. yields—a magnitude of impact that is nearly identical to that from FOMC announcements to German Bund yields. This result contrasts with the conventional wisdom that FOMC announcements spill over to other countries but that there is not much effect in the other direction. We also find that spillover estimates are slightly higher in the post-crisis period, but that there is little difference in the spillover impact of conventional versus unconventional

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<sup>3</sup> In other work, we look at a broader spillovers, including from monetary policy decisions by the Federal Reserve, European Central Bank, Bank of England, Bank of Japan, and the Bank of Canada, to a variety of asset prices. As discussed in Section II, we consider a range of FOMC and ECB communications, including pre-scheduled meetings but also notable speeches and interviews. While not all of these are formal “announcements”, we will generally refer to them as such throughout this paper to use a uniform term for all types of communications.

<sup>4</sup> Here we focus solely on measuring the magnitude and direction of spillovers. The reason for *why* and the mechanism of *how* spillovers occur is beyond the scope of this paper. For the interested reader, the channels through which changes in monetary policy expectations spill over between countries are discussed in Ammer, De Pooter, Erceg, and Kamin (2016), while Neely (2015) discusses a mechanism for spillovers through a portfolio balance model in the context of the FOMC’s LSAP announcements.

monetary policy. Finally, our results based on futures prices differ noticeably from those using daily prices. This strongly suggests that spillover estimates based on cash market data can be misleading.

## **II. Data and Empirical Approach**

Most existing studies that measure spillovers to and from the United States rely on using changes in yields on cash instruments at a daily frequency.<sup>5</sup> Estimates using cash instruments face at least two challenges. First, while U.S. Treasuries trade around ECB announcements (typically at 7:45am Eastern Time (ET) on Thursdays), standard pricing sources for German Bunds stop at noon ET, long before FOMC policy announcements (typically at 2:00pm ET on Wednesdays). Therefore, using same-day changes in German cash Bund yields will not capture the reaction to the FOMC announcement. Second, trying to circumvent this problem by using either lagged responses or changes calculated over multiple days is likely to introduce noise. Ideally the event window should be sufficiently narrow that it isolates only market movements directly associated with the monetary policy announcement, as a wider window will include unrelated market movements and weaken the identification of the spillover effect. For example, using a next-day or two-day window to capture the response in German Bund yields to FOMC announcements will also include the reaction to any data releases in both U.S. and Germany as well as other notable news over the wider window.<sup>6</sup>

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<sup>5</sup> See Gürkaynak and Wright, 2011; Hausman and Wongswan, 2011; Bauer and Neely, 2014; Neely, 2015; Curcuro et al. (2018).

<sup>6</sup> For example, immediately following the December 2017 FOMC meeting which concluded on a Wednesday, weekly jobless claims, retail sales, and PMI were released in the U.S. on Thursday while that same day a host of macroeconomic data were released in the euro area, including several country-specific inflation data for November as well as country-specific and euro-area aggregate PMIs for December. Moreover, the Norges Bank and the Bank of England held monetary policy meetings. Finally, the ECB itself also held its December monetary policy meeting which was followed by its customary monetary policy statement and ensuing press conference.

Using intraday data on yields derived from prices on futures contracts remedies the above-mentioned challenges when estimating spillovers. In particular, as shown in Figure 1, the primary trading hours of U.S. and German futures markets (the top two horizontal lines) are longer than those of their cash market equivalents (the bottom two lines) and encompass both ECB and FOMC announcements (the vertical lines and shaded periods).<sup>7</sup> Furthermore, futures contracts are often at least as actively traded as their underlying cash instruments, and prices remain tightly linked between the two markets, even amid significant volatility.<sup>8,9</sup> In addition, there is evidence that price discovery in U.S. Treasury markets, and even more so in German Bund markets, primarily takes place in futures markets (see Mizrach and Neely, 2008, and Upper and Werner, 2007, respectively).<sup>10</sup>

### *Data*

Our main analysis uses changes in intraday futures prices on 10-year U.S. Treasury and 10-year Bund securities during narrow windows around FOMC and ECB monetary policy

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<sup>7</sup> U.S. Treasury futures and German Bund futures are standardized contracts which trade during fixed trading hours on the CME and Eurex exchanges, respectively. In contrast, cash Treasuries and Bunds are traded over-the-counter. Although the latter can therefore technically transact at any time, there are somewhat “standard” trading hours which are reflected in the bottom two horizontal lines in Figure 1.

<sup>8</sup> This is reflected by the almost 97 percent correlation between 1-day changes in the yields estimated from price moves in the 10-year U.S. T-note contract and changes in cash market yields. Additionally, as described in the Joint Staff Report on the U.S. Treasury Market on October 15, 2014, Treasury cash and futures markets remained tightly linked even through the extreme 37 basis point round trip in 10-year US Treasury yields that day.

<sup>9</sup> Notional futures volumes regularly exceed those of comparable tenor on-the-run cash securities in both the Treasury and Bund markets, according to futures market data and reviews of cash market structure published by the Treasury Department and German Finance Agency.

<sup>10</sup> Rogers, Scotti and Wright (2014) use intraday futures prices to measure unconventional monetary policy surprises by the FOMC, ECB, the Bank of England and the Bank of Japan and the effects of these surprises on asset prices domestically and abroad. In particular, they use the first principal component of the change in futures-derived yields on 2-, 5- and 10- and 30-year Treasuries for the U.S. using either a 30- or 120-minute event window around each announcement. For the euro area, however, they do not use intraday changes in German Bund futures but instead use intraday changes in cash market spreads between yields on Italian 10-year government bonds and their German counterparts. Therefore, to our knowledge our analysis of spillovers between U.S. and German bond markets is the first to be fully based on futures data.

announcements. For comparison with previous studies, we also use a daily window using both cash and futures markets, and a 2-day window using the cash market.

Our sample of FOMC and ECB announcements starts in December 2005 and runs through the end of December 2017.<sup>11</sup> We include all regularly-scheduled FOMC and ECB meetings in our 2005-2017 sample, as well as the unscheduled FOMC meeting on January 22, 2008 and the coordinated unscheduled ECB and FOMC meetings on October 8, 2008. In addition, we also include dates where FOMC or ECB officials revealed notable information about future or ongoing asset purchases (AP) or forward guidance (FG). For these nonstandard events we relied on a combination of dates previously identified in other studies, and we updated the list to include events up until December 2017.<sup>12</sup> In sum, we identified 107 events for the United States (a combination of 99 FOMC meetings, 34 AP and 18 FG dates) and 159 events for the euro area (a combination of 134 ECB meetings, 45 AP and 11 FG dates).

Our (intraday) futures prices are from Thomson Reuters Tick History. The counterpart of the 10-year U.S. Treasury note is the U.S. 10-year T-Note futures contract. For 10-year German Bunds, the futures contract counterpart is the Euro-Bund futures contract traded on the Eurex exchange. We used changes during an event window from 15 minutes before to 1 hour 45 minutes after each announcement. For regular ECB and FOMC announcements this captures both the market reaction to the release of the statement as well as the reaction to the ensuing

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<sup>11</sup> We start with the December 2005 ECB and FOMC meetings because prior to November 20, 2005, trading hours for Bund futures on Eurex ran from 8am to 6pm local time (2am to noon ET) and did not encompass the same-day reaction to the release of FOMC statements. Starting November 20<sup>th</sup>, 2005 trading hours on Eurex were extended from 8am to 10pm local time (2am to 4pm ET), covering FOMC announcements.

<sup>12</sup> We included asset purchase and forward guidance event dates previously identified in Fawley and Neely (2013); Roger, Scotti, and Wright (2014); Altavilla, Carboni, and Motto (2015); Engen, Laubach and Reifschneider (2015).



press conference. For our results based on daily futures prices, we used 4pm ET as the daily close.<sup>13</sup>

For the analysis based on daily cash market changes, we use close-of-business bond yields on the benchmark 10-year Treasury and Bund securities, as reported on Bloomberg.<sup>14</sup> Because German cash bond markets are closed during most of our FOMC announcements, we record the daily change in German yields following an FOMC event as the change from the close on the FOMC event day  $t$  to the close on the following day, day  $t+1$ , whenever the announcement time falls after the close of cash Bund trading as shown in Figure 1. For earlier announcement times we record daily changes as  $t-1$  to  $t$ .

### *Futures-based yields*

To compare changes in futures prices across futures contracts to changes in cash bond yields we convert futures prices into yields using the standard bond price change to yield change conversion formula. Specifically, we divide the (negative of the) percent change in the futures price by the modified duration of the bond which is most likely to be delivered at expiration.<sup>15</sup>

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<sup>13</sup> Liquidity in German Bund futures drops dramatically between 3:55pm and 4:00pm ET, so we used prices at 3:55pm as the proxy for the closing price.

<sup>14</sup> Some studies have instead used U.S. constant maturity rates (see [www.federalreserve.gov/releases/h15/](http://www.federalreserve.gov/releases/h15/)). Our results using daily data were all but unchanged using constant maturity rates.

<sup>15</sup> At expiration, the seller of a U.S. T-note futures contract will deliver to the purchaser any U.S. Treasury note with maturity between 6½ and 10 years from a predefined delivery basket. Purchasers of a Euro-Bund futures contracts will be delivered a Bund with maturity between 8½ and 10½ years. Of note, in January 2016 the CME launched a new Ultra 10-year futures contract, which tracks the on-the-run 10-year cash security more closely due to the more constrained set of securities in its deliverables basket. However, we focus on the classic 10-year contract, as the traditional contract continues to dominate in terms of volume. One can also argue about whether monetary policy shocks affect the 6/7-year point differently than the 10-year tenor. However, because we are working in changes and not in levels we believe our results should not be affected.

The bond most likely to be delivered at contract expiration is referred to as the “cheapest-to-deliver” (CTD) bond.<sup>16</sup> We use Bloomberg to identify the CTD security for each contract.<sup>17, 18</sup>

### *Empirical Approach*

We determine the magnitude and significance of spillovers using a simple univariate regression approach based on intraday futures prices, daily futures prices, and daily cash yields. For spillovers to German yields following FOMC announcements, we use OLS to estimate the equation:

$$dY_{GE,t}^{w,m} = \alpha + \beta dY_{US,t}^{w,m} + \epsilon_t \quad (1)$$

where  $w$  is the window (2 hours, 1 day, 2 days) and  $m$  is the market (futures, cash). An analogous equation is used to estimate the spillover to U.S. yields following ECB announcements:

$$dY_{US,t}^{w,m} = \alpha + \beta dY_{GE,t}^{w,m} + \epsilon_t \quad (2)$$

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<sup>16</sup> See for more details <https://www.cmegroup.com/education/files/understanding-treasury-futures.pdf>

<sup>17</sup> A shortcut to converting changes in future prices to changes in yields would be to use a fixed duration. However, there is considerable variability in the duration of the CTD bond which is why we identify each individual CTD and its duration over time. In particular, the duration of the CTD bond for the U.S. T-note futures contract averages 6.02 for our sample period, but ranges from 5.56 to 6.81. For the Euro-Bund contract, the average is 7.82 with a range of 6.99 to 9.10.

<sup>18</sup> Futures contracts expire quarterly so we generally use the contract with the closest expiration at each date. However, active trading in a contract dwindles prior to expiration, so we roll forward to the next contract when it becomes more actively traded.

### III. Spillover Estimates

#### *Full sample estimates*<sup>19</sup>

Figure 2 provides an overview of our regression results for both FOMC announcements and ECB announcements.

There is clear evidence of spillovers from both FOMC and ECB announcements. In all panels the regression slope is positive and statistically significant. There are two important differences, however, between spillover estimates based on futures data and those based on daily cash yields. First, when measured using daily changes in cash market yields (the right panels), it appears that the pass-through from ECB policy announcements to U.S. yields would, surprisingly, be much larger than the pass-through from FOMC announcements to German yields. Second, the estimated reaction in the German cash market to FOMC events (top right panel) is much less precise, as is evident from the lower  $R^2$  and much wider confidence bands.

Table 1 shows the detailed regression results for the estimation of spillovers to German yields following FOMC announcements using equation (1). When measured using the change in futures prices in a narrow window around the FOMC announcement, the first column, the spillover coefficient,  $\beta$ , is estimated to be 0.45, which is statistically significant at the 1 percent level. The  $R^2$  of the regression is 0.88. We get roughly similar results when we widen the window by using the daily change in futures prices measured at 4pm each day, which is the close of the Euro-bund futures market (column 2). As shown in the second column, the estimate of  $\beta$  increases a bit to 0.49, but the precision of the estimates is reduced and the  $R^2$  falls to 0.71.

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<sup>19</sup> The results presented in the tables below are based on heteroscedasticity-robust standard errors. To check for robustness, we also estimated our equations using outlier-robust estimation, but this generally did not change the results significantly.

The spillover estimates arising from cash-market regressions, as typically used in the literature, are quite different. As shown in the third column, using 1-day changes in the cash market indeed introduces noise as the estimate of  $\beta$  is still quite significant, but noticeably lower at 0.31, and the  $R^2$  falls to just 0.22. The final column in the table shows the results using cash market yield changes over both the announcement day and the subsequent day, which some other studies have also used. Using 2-day changes leads to a much larger  $\beta$  estimate of 0.77 and a higher  $R^2$  than for one-day changes. However, because of the much wider window, this regression is more likely to pick up on the general (high) level of correlation between U.S. and German yields and less so on the specific spillovers from FOMC announcements to Bund yields.

Turning to spillovers from ECB announcements, Table 2 shows that the spillover to U.S. yields is at least as large as the spillover to German yields following FOMC announcements. The estimated  $\beta$  from equation (2) is 0.53 using changes in intraday futures prices in the 2-hour window around the event (column 1), and 0.57 using 1-day futures changes (column 2), although the  $R$  is lower than the corresponding equation for FOMC announcements. Using 1-day changes in cash market yields, the estimated  $\beta$  jumps noticeably to 0.77, but we would exercise caution in interpreting this result as suggesting that as much as three quarters of the domestic response in Bund yield due to ECB announcements spills over to Treasury yields. Although there is a 3-4 hour overlap in same-day trading hours for U.S. and German cash bond markets following ECB decision announcements and press conferences, this larger daily window introduces noise and captures co-movement for reasons other than from monetary policy announcements, such as the reaction to macroeconomic releases. Along that same line, results using 2-day cash market yield changes over both the announcement day and the subsequent day results in an even larger  $\beta$  estimate.

Taken together, the results in Tables 1 and 2 are in contrast to those from most previous studies which have found evidence of spillovers from U.S. to German yields following FOMC announcements, but not in the other direction following ECB announcements (see for example Ehrmann and Fratzscher, 2005; Rogers, Scotti, Wright, 2014). We instead find significant spillovers in *both* directions and these spillovers are of a very similar magnitude, with about half of the reaction in domestic yields spilling over to foreign yields. We attribute our much more symmetric results to the improved accuracy of our narrow-window identification strategy using futures data.<sup>20</sup>

#### *Pre- and Post-Crisis Estimates*

During the global financial crisis, both the FOMC and ECB lowered their key interest rates to zero, or even into negative territory in the case of the ECB. Moreover, both central banks introduced a range of unconventional monetary policies which could induce some variation in spillovers over time.<sup>21</sup> In Table 3 we re-estimate equations (1) and (2) over pre-crisis events (December 2005-June 2007) and post-crisis events (January 2010-December 2017) using intraday yield changes based on futures prices. As shown in the table, spillovers from FOMC announcements to German Bund yields are about the same pre- and post-crisis. Spillovers from ECB announcements are higher post-crisis, with the estimate of  $\beta$  increasing from 0.36 to 0.48 (and becoming more significant) and the  $R^2$  also increasing. Interestingly, the magnitude of monetary policy spillovers between U.S. and German yields are nearly identical in the post-crisis period; 0.47 for FOMC events, and 0.48 for ECB events.

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<sup>20</sup> Our results of two-way spillovers are in line with the results in Gürkaynak and Wright (2011) and Curcuru (2017) who also find evidence of monetary policy announcements abroad spilling over to U.S yields based on daily changes in overnight index swap contracts.

### *Conventional and Unconventional Policy Announcements*

In our final analysis, we use interaction dummy variables to identify differences in the magnitude of spillovers across the nature of announcements. In particular, as specified in the top lines of panels A and B of Figure 4, we distinguish regular communications from those associated with asset purchases (AP) and/or forward guidance (FG). Table 4 shows that for both FOMC and ECB events the marginal effect of the announcement of unconventional tools is minimal. The additional spillover from FOMC AP announcements,  $\beta_2$  in panel A, is statistically significant but small. The marginal spillover from ECB AP announcements, panel B, is also small and not statistically significant. Spillovers from both FOMC and ECB FG announcements are also insignificant.

### **IV. Conclusion**

In this paper we estimated spillovers between U.S. and German bond markets following monetary policy announcements by the FOMC and ECB. Using 1-day changes in cash market yields, a common approach used in previous studies, one might conclude that about one third of the reaction in domestic U.S. yields to FOMC announcements spills over to German Bund yields while three quarters of the reaction in German yields to ECB announcements spills over to Treasury yields. However, we judge these estimates to be inaccurate and therefore misleading. We argue for using intraday changes in futures-based yields. Doing so we find that spillovers are all but symmetric with about half of the reaction in domestic yields spilling over to foreign yields in either direction.

Our novel finding of significant spillovers from ECB monetary policy announcements to U.S. Treasury yields has several important implications. First, it provides evidence for the view that monetary policy actions by foreign central banks are an important driver behind movements in Treasury yields. Second, it shows that U.S. monetary policy cannot be conducted in isolation. As the FOMC continues to remove policy accommodation, it will need to take into account the eventual removal of policy accommodation abroad and the impact this will have on U.S Treasury yields and U.S. asset prices in general. In further work we plan to extend our spillover analysis to also account for announcements from other major central banks to see if the results from ECB spillovers generalize to other advanced foreign central banks.

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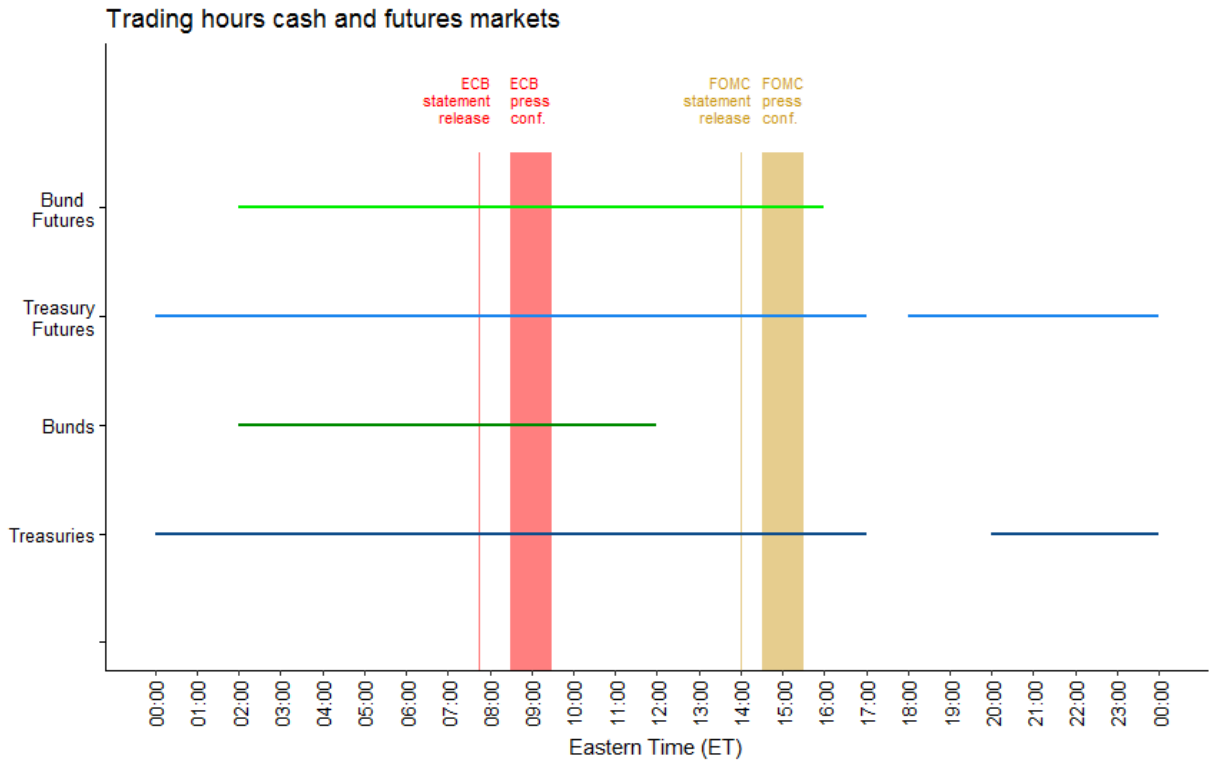
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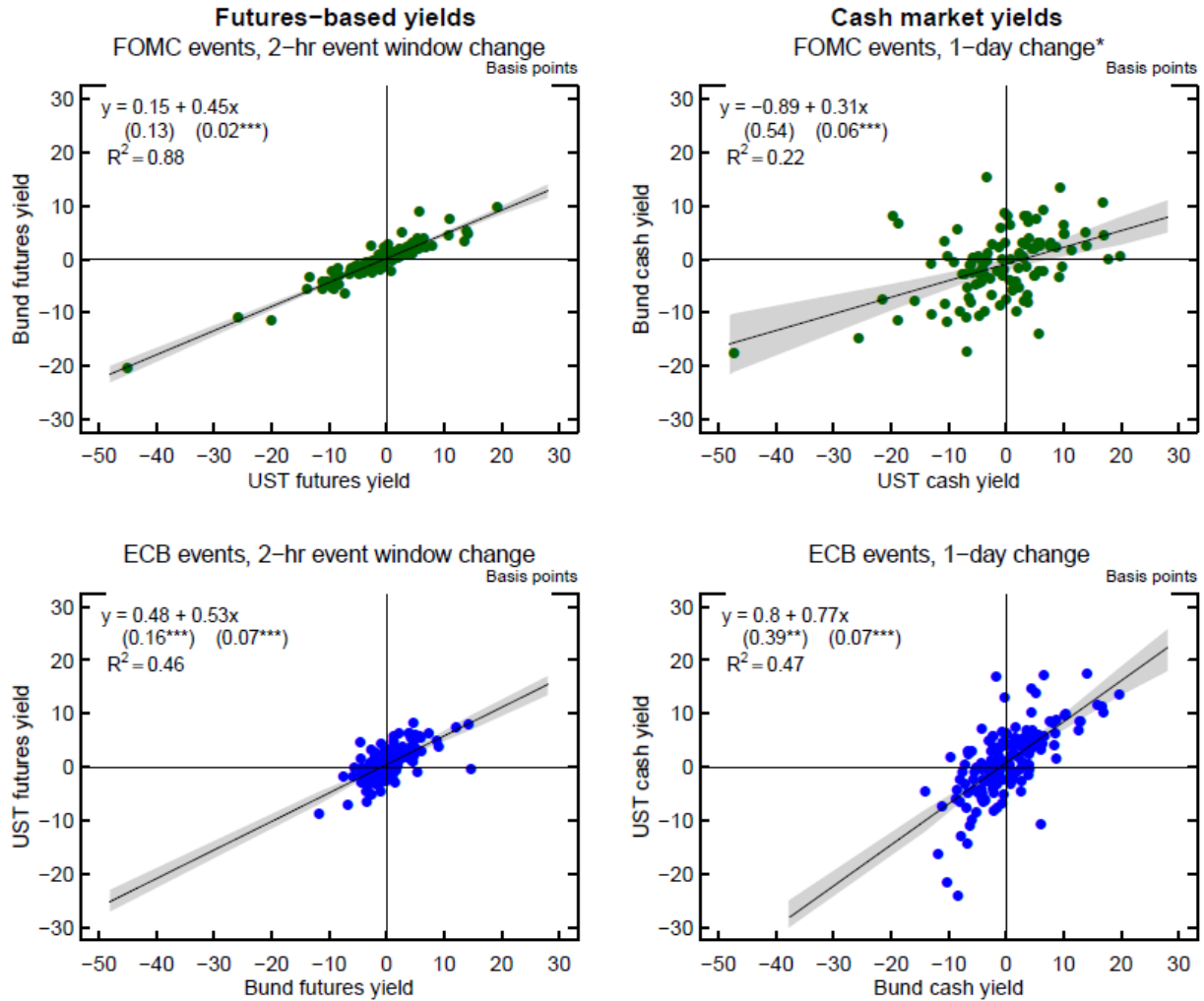
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## VI. Figures and Tables

**Figure 1: Trading hours in U.S. Treasury and German Bund cash and futures markets**



**Figure 2: Futures and Cash Market Reaction to FOMC and ECB Events**



\*German Bund yield changes for the following day for FOMC announcements which occur after the close of the German Bund cash market.

Note: The lines in the panels are the estimated regression lines from equations (1) and (2), and the shaded areas around the regression lines show the 95 percent confidence interval.

**Table 1: Spillover Estimates from FOMC Announcements to German Bund Yields**

$$dY_{GE,t}^{w,m} = \alpha + \beta dY_{US,t}^{w,m} + \epsilon_t$$

Window:	2 hours	1 day	1 day	2 days
Market:	Futures	Futures	Cash	Cash
$\beta$	0.45*** (27.55)	0.49*** (10.68)	0.31*** (5.38)	0.77*** (9.14)
$\alpha$	0.15 (1.16)	0.15 (0.48)	-0.89 (-1.66)	-1.57* (-1.84)
No. Obs.	107	107	107	107
R <sup>2</sup>	0.882	0.706	0.217	0.525

Notes: Sample includes all FOMC announcement days between December 2005 and December 2017. The regression is estimated using OLS with robust (White) standard errors. For the 1-day cash changes, when the FOMC announcement occurs after the close of trading in the German Bund market, the change in German Bund yields on the following day is used. The changes in futures prices are converted to yields using the methodology described in the text and are based on the movements in the most actively-traded futures contract. Robust *t*-statistics in parentheses. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

**Table 2: Spillover Estimates from ECB Announcements to U.S. Treasury Yields**

$$dY_{US,t}^{w,m} = \alpha + \beta dY_{GE,t}^{w,m} + \epsilon_t$$

Window:	2 hours	1 day	1 day	2 days
Market:	Futures	Futures	Cash	Cash
B	0.53*** (7.16)	0.57*** (8.15)	0.77*** (10.83)	0.85*** (10.00)
$\alpha$	0.48*** (2.91)	0.58 (1.43)	0.80** (2.08)	1.61*** (2.98)
No. Obs.	159	159	159	159
R <sup>2</sup>	0.464	0.403	0.469	0.524

Notes: See notes for Table 1. Sample includes all ECB announcement days between December 2005 and December 2017.

**Table 3: Sub-Period Results**

**Panel A: FOMC Events**  $dY_{GE,t}^{2hrs,futures} = \alpha + \beta dY_{US,t}^{2hrs,futures} + \epsilon_t$

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	12/2005-6/2007	1/2010-12/2017
$\beta$	0.44*** (14.05)	0.47*** (14.95)
$\alpha$	-0.01 (-0.04)	0.11 (0.72)
No. Obs.	13	70
R <sup>2</sup>	0.939	0.841

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**Panel B: ECB Events**  $dY_{US,t}^{2hrs,futures} = \alpha + \beta dY_{GE,t}^{2hrs,futures} + \epsilon_t$

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	12/2005-6/2007	1/2010-12/2017
$\beta$	0.36** (2.89)	0.48*** (6.08)
$\alpha$	0.28 (1.22)	0.42** (2.36)
No. Obs.	19	109
R <sup>2</sup>	0.333	0.502

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Notes: See notes for Table 1.

**Table 4: Spillovers by Announcement Type****Panel A: FOMC Events**

$$dY_{GE,t}^{2hrs,fut} = \alpha + \beta_1 dY_{US,t}^{2hrs,fut} + \beta_2 dY_{US,t}^{2hrs,fut} [1_{if AP=1}] + \beta_3 dY_{US,t}^{2hrs,fut} [1_{if FG=1}] + \epsilon_t$$

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	Baseline	AP Dummy	FG Dummy	AP and FG Dummy
$\beta_1$	0.45*** (27.55)	0.40*** (14.29)	0.45*** (15.63)	0.41*** (14.71)
$\beta_2$		0.08** (2.28)		0.09** (2.38)
$\beta_3$			-0.00 (-0.04)	-0.04 (-1.04)
$\alpha$	0.15 (1.16)	0.17 (1.31)	0.15 (1.12)	0.15 (1.13)
No. Obs.	107	107	107	107
Adjusted R <sup>2</sup>	0.880	0.885	0.879	0.886

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**Table 4 (cont.)****Panel B: ECB Events**

$$dY_{US,t}^{2hrs,fut} = \alpha + \beta_1 dY_{GE,t}^{2hrs,fut} + \beta_2 dY_{GE,t}^{2hrs,fut} [1_{if AP=1}] + \beta_3 dY_{GE,t}^{2hrs,fut} [1_{if FG=1}] + \epsilon_t$$

	Baseline	AP Dummy	FG Dummy	AP and FG Dummy
$\beta_1$	0.53*** (7.16)	0.49*** (4.13)	0.53*** (6.91)	0.49*** (4.07)
$\beta_2$		0.11 (0.87)		0.11 (0.87)
$\beta_3$			-0.01 (-0.07)	-0.03 (-0.18)
A	0.48*** (2.91)	0.47*** (2.79)	0.48*** (2.90)	0.46*** (2.77)
No. Obs.	159	159	159	159
Adjusted R <sup>2</sup>	0.461	0.463	0.457	0.459

Notes: See notes for Table 1. “AP” are ECB and FOMC communications that revealed information about asset purchases while “FG” are announcements about forward guidance.