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To What Degree and through Which Channel Do Central Banks Other Than the Federal Reserve Cause Spillovers?

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Abstract:
Spillovers play a crucial role in driving monetary policy around the world. The literature focuses predominantly on spillovers from the Federal Reserve. Less attention has been paid to spillovers from other central banks. I measure the degree to which 20 central banks cause spillovers. I show that central banks in medium- to high-income countries cause spillovers to medium- to long-term interest rates in similar countries through a bond-pricing channel. These effects are narrower than spillovers from the Federal Reserve, which also affect emerging markets, short-term interest rates, and other assets. However, they are still pronounced. Fourteen central banks other than the Federal Reserve cause significant spillovers: the central banks of Australia, Canada, Czechia, the eurozone, Japan, Mexico, Norway, New Zealand, Poland, Romania, South Korea, Sweden, Switzerland, and the United Kingdom. Consequently, the Federal Reserve causes only one-fifth of the spillovers to 10-year interest rates, and the United States is the recipient of large spillovers. My results imply that central banks, especially the Federal Reserve, are affected by greater spillovers than is commonly believed, and that non-Fed central banks cause spillovers through a bond-pricing channel.

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1 Introduction

Federal Reserve actions have been shown to spill over into other countries (Chen, Griffoli, and Sahay, 2014; Georgiadis, 2016; Gilchrist, Yue, and Zakrajšek, 2019) and even to cause a global financial cycle (Miranda-Agrippino and Rey, 2020). Spillovers modify other countries' interest rates and can require them to adjust their domestic interest rate policy. Therefore, other countries face significant interference when setting their monetary policy (Hofmann and Takáts, 2015). This is true even for countries with independent monetary policy and a floating interest rate (Rey, 2016). Some papers look at spillovers from other countries' central banks, particularly from the European Central Bank, but the consensus is that these spillovers are small (Mueller, Tahbaz-Salehi, and Vedolin, 2017; Brusa, Savor, and Wilson, 2020; Ca'Zorzi et al., 2021; Kawai, 2015; Kearns, Schrimpf, and Xia, 2020).

In this paper, I investigate which central banks other than the Federal Reserve cause monetary policy spillovers and through which channel. These are important questions for two reasons. First, the United States is thought to play a dominant role in propagating monetary policy spillovers (Mueller, Tahbaz-Salehi, and Vedolin, 2017; Brusa, Savor, and Wilson, 2020; Ca'Zorzi et al., 2021). If instead other central banks also cause large spillovers, the degree to which countries face interference when setting monetary policy may be significantly understated in the existing literature. Second, there has been discussion about the degree to which Federal Reserve spillovers could "spill back" into the United States through the global business cycle and how policy-makers should take this into account (Rajan, 2016; Yellen, 2019; Breitenlechner, Georgiadis, and Schumann, 2021). However, if other central banks cause large spillovers into US interest rates, this implies that the Federal Reserve needs to also take into account direct spillovers from other central banks as well as indirect "spillbacks."

Using a panel of 20 countries/zones, I determine the degree to which monetary policy spills over from each of the 20 countries/zones into every other country/zone in the panel and to measures of the average interest rate in other developed and emerging countries/zones. To study this question, I have compiled high-frequency interest rate data for each country/zone in the panel dating back as far as 1996. To identify a monetary policy spillover, I measure how changes in interest rates in the source country/zone in a window around its monetary policy event affects interest rates in a similar window in the recipient country/zone. In my main specification, the window I consider when measuring the interest rate spans from as early as one hour before a monetary policy event to as late as one hour after the event. I also show that the results are similar when measured from as early as 20 minutes before to as late as 20 minutes after a monetary policy event. For this study, I have compiled monetary policy events—releases of statements and minutes from central bank meetings—for each country/zone in the panel.

There are large spillovers from many countries/zones into medium-term and long-term interest rates. I show that 14 central banks other than the Federal Reserve show evidence of monetary policy spillovers into the average 10-year interest rate in other developed countries/zones: the central banks of Australia, Canada, Czechia, the eurozone, Japan, Mexico, Norway, New Zealand, Poland, Romania, South Korea, Sweden, Switzerland, and the United Kingdom. For example, a 1 basis point rise in the 10-year interest rate around monetary policy events raises the average interest rate in other developed countries/zones by 0.14 basis points when the monetary policy event and accompanying interest rate increase are in Australia, 0.19 basis points when they're in Canada, 0.23 basis points when in Switzerland, 0.60 basis points when in the eurozone, 0.19 basis points when in the United Kingdom, and 0.17 basis points when in Sweden. When the event and rate increase are in the United States, the average interest rate in other developed countries/zones rises 0.50 basis points. These seven countries/zones show p-values of less than 0.001. The United States explains only 18.8 percent of spillovers into the 10-year interest rate. I also find strong though somewhat smaller spillovers from other central banks into two-year interest rates. The United States explains 40.3 percent of spillovers into the two-year interest rate as a result. To my knowledge, my paper is the first to assess the share of spillovers caused by a wide range of countries/zones and to show that medium-term and long-term interest rate spillovers are not primarily driven by the United States.

That being said, I find that other central banks do not generally cause significant spillovers into either short-term interest rates or emerging markets, unlike the Federal Reserve. The Fed causes the largest spillovers into short-term maturities. A 1 basis point rise in the six-month US interest rate around monetary policy events raises six-month interest rates in other developed countries/zones by 0.26 basis points on average. This compares with 0.14 basis points for such an interest rate rise in the eurozone and 0.05 basis points for the United Kingdom, which are the only other countries/zones to cause spillovers into six-month rates. The United States is also the only country/zone with a p-value of less than 0.001. The Federal Reserve causes large interest rate spillovers into emerging markets. Increases of 1 basis point in 2-year and 10-year US interest rates around monetary policy events raise average emerging-market interest rates by 0.45 and 0.41 basis points, respectively. No other central bank causes significant spillovers to emerging markets for a range of maturities.

I also investigate bilateral spillovers across a wide range of countries/zones. Notably, I show that there are significant spillovers from many countries into interest rates in the United States and the eurozone. The standard view in the literature is that the Federal Reserve is the primary source of monetary policy spillovers. Therefore, while the United States may be affected by spillbacks from Federal Reserve policy changes, it does not need to worry about spillovers from monetary policy changes at other central banks. I show this is not true. Instead, US interest rates are significantly affected by spillovers from many other countries/zones. A 1 basis point rise in the 10-year interest rate in Australia, Canada, Switzerland, the eurozone, the United Kingdom, and Sweden around monetary policy events raises the 10-year US interest rate by 0.1, 0.25, 0.22, 0.74, 0.19, and 0.10 basis points, respectively. The eurozone also experiences substantial spillovers. A 1 basis point rise in the 10-year interest rate in Canada, Switzerland, Czechia, the United Kingdom, Sweden, and the United States raises 10-year eurozone interest rates by 0.21, 0.28, 0.14, 0.27, 0.19, and 0.40 basis points, respectively. All of these coefficients have a p-value of less than 0.001. This implies that the Federal Reserve and the European Central Bank are also buffeted by spillovers.

Spillovers have lasting effects. One concern may be that the spillover effects are temporary and dissipate immediately after monetary policy events. I therefore look at how monetary policy events in source countries/zones affect interest rates in recipient countries/zones 24 hours, 48 hours, 72 hours, and one week after the monetary policy events. For the eight countries/zones with the most significant spillovers, I find the coefficient estimates remain the same or grow throughout this period. Therefore, there appears to be substantial evidence that spillovers have lasting effects. The fact that many spillover effects grow may indicate that it takes market participants time to process these effects.

Other central banks cause spillovers into corporate interest rates but not into other asset markets, unlike those of the Federal Reserve. I investigate the response of corporate interest rates to monetary policy events in other countries/zones. I find that a 1 basis point rise in interest rates around monetary policy events in the eight countries/zones with the most significant spillovers causes at least a 0.1 basis point (and often much larger) rise in interest rates for AAA-rated US corporate bonds. I find similar effects for other types of corporate bonds, and these effects remain after one week. Therefore, the spillovers affect the rate at which both governments and firms can borrow, leading to real, lasting effects for recipient economies. That being said, compared with other central banks, the Federal Reserve appears to have broader effects on other asset prices. A rise in US interest rates causes stock prices in other developed countries, stock prices in emerging markets, gold prices, and silver prices all to fall. All of these coefficients have a p-value of less than 0.001. No other central bank shows such significant effects on other asset prices and no other central bank affects as wide a range of assets.

I verify my results in other ways. Even though I use a high-frequency approach, one concern might be that within the time frame I consider, there could be positive comovement between interest rates in the source country/zone and those in the recipient countries for reasons other than monetary policy changes in the source country/zone. Therefore, I consider an alternative specification where I test whether spillovers still exist after controlling for comovement. I show comovement has little effect on my results. I also show my results hold across different subsets of years for the 1996–2022 period. And I demonstrate that measuring changes in interest rates using alternative nonparametric windows or with the parametric Nelson-Siegel approach yields very similar estimates.

I investigate the determinants of monetary policy spillovers. I demonstrate that a large component of the degree to which the Federal Reserve causes spillovers comes from changes in beliefs about the path of short-term US interest rates, whereas for other central banks this channel is less important, and the primary driver of spillovers is changes in the long-term part of the yield curve. I show that among all countries/zones, the greatest determinant of whether a country/zone's central bank will cause spillovers into long-term interest rates is that country/zone's gross domestic product (GDP). This reflects the fact that only medium/high-income countries/zones' central banks appear to cause spillovers and that spillovers from larger countries/zones' central banks are stronger. I investigate the determinants of bilateral spillovers, that is, why some countries/zones' central banks cause spillovers that are larger for certain recipient countries/zones than for others. For the Federal Reserve, I find both cultural and economic ties between the United States and other countries are important in determining the size of spillovers, whereas I find only cultural factors determine the size of spillovers from other central banks.[1] I also note that certain countries with very close links appear to have particularly strong bilateral spillovers—notably Australia and New Zealand, and Norway and Sweden.

Based on all of my results, I argue that central banks other than the Federal Reserve appear to cause spillovers through a bond-pricing channel. When a developed country/zone central bank lowers its interest rates, it makes comparable bonds in other developed countries/zones more appealing, which can raise their prices and lower their yields, all else being equal. Investors wish to transfer their money to similar assets, so spillovers primarily affect developed countries/zones, especially those with cultural links to the source country. This bond-pricing effect is likely to be stronger for long-term bonds whose interest rates are not pinned down as much as short-term bonds by expected interest rates, which explains why non-Fed central banks primarily cause spillovers into medium-term and long-term interest rates. This also explains why changes in the longer-term part of the source country's/zone's yield curve cause spillovers to a greater degree compared with changes to the short-term part of the yield curve. Corporate interest rates are likely to experience spillovers through these effects because they are, to a large extent, determined by sovereign bond interest rates. Conversely, information effects whereby changes in monetary policy at one central bank convey information about the path of monetary policy at another central bank can be ruled out as a channel for spillovers. Information effects can be ruled out because they would cause spillovers into short-term interest rates primarily, but the

[1] I capture economic ties by the share of exports from the source country/zone to the recipient country/zone and cultural ties by the religious similarity between the source and the recipient.

data do not show such changes. On the other hand, the Federal Reserve causes additional spillovers—into emerging markets, short-term interest rates, and a wide range of other assets—so the Federal Reserve appears to cause spillovers through a wider range of channels.

My paper most relates to the limited literature that compares the degrees to which different central banks cause spillovers. Many papers assess how different countries/zones are affected by spillovers from a single central bank, typically the Federal Reserve; however, few papers compare the degrees to which different central banks cause monetary policy spillovers. Ca'Zorzi et al. (2021) examine monetary policy spillovers from the Federal Reserve and the European Central Bank through high-frequency identification and a Bayesian vector autoregression (VAR) approach. They find spillovers from both but stronger effects from the Federal Reserve. Kawai (2015) compares the long-term response of emerging-economy stock prices and exchange rates to US and Japanese quantitative easing and suggests the United States has stronger effects. Stedman (2019) uses daily interest rate data to compare the magnitudes of monetary policy spillovers caused by the United States, the eurozone, the United Kingdom, and Japan during the period of quantitative easing and finds large spillovers from the United States into the other central banks and limited spillovers from the eurozone and the United Kingdom into the United States. Curcuru, De Pooter, and Eckerd (2018) conversely find spillovers from the European Central Bank into US interest rates that are similar to the spillovers from the Federal Reserve into European interest rates. Kearns, Schrimpf, and Xia (2020) look at intraday interest rate spillovers from the United States, the eurozone, the United Kingdom, and Japan into a wide range of countries/zones and find that the Federal Reserve causes large spillovers, that the spillovers from the European Central Bank have intensified over time, and that the spillovers from the Bank of England and the Bank of Japan are small. Mueller, Tahbaz-Salehi, and Vedolin (2017) and Brusa, Savor, and Wilson (2020) argue that the Federal Reserve causes uniquely strong monetary policy spillovers because Federal Reserve announcements are associated with the greatest risk premia in currencies (Mueller, Tahbaz-Salehi, and Vedolin (2017)) and equities (Brusa, Savor, and Wilson (2020)) but do not directly measure spillovers. To the best of my knowledge, my paper is the first that compares the sizes of interest rate spillovers from a wide range of central banks to examine the degree to which each central bank explains total spillovers. My paper is also the first to argue that non-Fed central banks primarily cause spillovers through the bond-pricing channel, unlike the Federal Reserve, which causes spillovers through multiple channels.

This paper ties into a broader literature looking at the drivers of the global financial cycle. Miranda-Agrippino and Rey (2020) argue that a key factor driving the global financial cycle is US monetary policy. In Miranda-Agrippino and Rey (2021), they expand this analysis to other central banks and argue that the European Central Bank also plays a role but to a lesser degree than the Federal Reserve, and that the People's Bank of China is important in determining the global trade and global commodity cycles. Boehm and Kroner (2020) argue that the current economic situation in the United States, and not the response of US monetary policy to it, plays an important role in driving the global financial cycle. Cerutti, Claessens, and Rose (2019) instead argue that the global financial cycle, measured through capital flows, does not appear to be driven by observables in a central country such as the United States. My paper implies that central banks other than the Federal Reserve may play a role in driving the global financial cycle.

My paper also relates to a strand of the literature looking at the differential impact of monetary policy spillovers on recipient countries/zones. Using a high-frequency identification method, Albagli et al. (2019) and Gilchrist, Yue, and Zakrajšek (2019) analyze the magnitudes of spillovers from US monetary policy into international bond markets using local-denominated bonds (Albagli et al. (2019)) and dollar-denominated bonds (Gilchrist, Yue, and Zakrajšek (2019)). Degasperi, Hong, and Ricco (2020) show that a US monetary policy tightening has large contractionary effects on both developed and emerging markets. Chen, Griffoli, and Sahay (2014) find that emerging-market countries with weaker fundamentals, such as lower GDP growth, are more affected by monetary policy spillovers from the Federal Reserve. Georgiadis (2016) compares the sizes of Federal Reserve spillovers and finds that spillovers have larger effects on advanced economies but also particularly pronounced effects on Russia, the Baltics, Greece, Ireland, and Luxembourg. These papers mostly look just at the degree to which spillovers from US monetary policy affect recipient countries. In this paper, I instead look at how spillovers from many source countries/zones affect many recipient countries/zones. I find that a monetary policy tightening from a developed- country/zone central bank other than the Federal Reserve is more likely to spill over into advanced economies. To my knowledge, this paper is also the first to analyze which factors determine the degree to which a country/zone will cause spillovers.

Section 2 explains the empirical approach. In section 3, I examine which countries/zones' central banks cause monetary policy spillovers; I break down the degree to which different countries/zones explain total spillovers, examine the magnitudes of spillovers across different assets, and verify these results with a variety of robustness checks. Section 4 analyzes which part of the source country's/zone's yield curve is primarily responsible for driving spillovers and the factors that determine which countries/zones cause/receive spillovers. In section 5, I summarize the differences between spillovers from the Federal Reserve and other central banks and discuss which channel drives spillovers from other central banks. Section 6 concludes.

2 Empirical Approach

I use a high-frequency approach around monetary policy events to identify spillovers. I look at a panel of 20 countries/zones.[2] I investigate how monetary policy shocks in each of the countries/zones in the panel spill over into the other 19 countries/zones.[3] I also look at how monetary policy shocks in each of the countries in the panel spill over on average into the other developed/emerging countries/zones.

2.1 Data

My analysis requires two types of data for each of the 20 countries/zones: (1) high-frequency data on interest rates and (2) dates and times of monetary policy events.

The interest rate data are primarily from Refinitiv, which offers intraday tick data from 1996 onward. I am able to construct high-frequency changes in interest rates and measure spillovers for 20 countries/zones. Ten are developed as defined by MSCI: Australia, Canada, the eurozone, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The other 10 are emerging as defined by MSCI: Brazil, China, Czechia, Hungary, Israel, Mexico, Poland, Romania, South Africa, and South Korea.[4] I measure the interest rate in the eurozone using German bonds. The bond data incorporate data from benchmark bonds

[2]These countries/zones appeared to offer the highest-quality high-frequency intraday interest rate data through Refinitiv.

[3]Note that I do this wherever possible. For some pairs of countries/zones, it is not possible because their time zones do not line up, and so monetary policy events in the source country take place at times when interest rate data in the recipient country/zones are not available.

[4]The data availability varies by country, but at the very least, I am able to assess the degree to which central banks in these countries/zones cause spillovers into the average 10-year rate in other developed countries/zones.

(for example, the closest one-, two-, three-, five-, or ten-year bond where the bond changes over time) and non-benchmark bonds (for example, a specific bond expiring on a specific day). Refinitiv has restrictions on bond price data for the United States, so I also incorporate GovPX data up to 2013. These data include intraday price data for all US bonds.[5]

I compile the dates and times of monetary policy meetings from several sources. My primary source is Bloomberg. I augment and verify this information with data directly from national central bank websites and from two other websites that also provide details on central bank release dates.[6] Most of the monetary policy events I use are releases of statements immediately following monetary policy committee meetings. Some countries/zones also release the meeting minutes after the release of the statement; I include these minutes where they are available.[7] I reconcile the results from the different sources and adjust appropriately for time zone differences. Table 1 summarizes the monetary policy events for which I have times and dates. The sample includes releases for 3,748 monetary policy meetings and 1,012 monetary policy meeting minutes.

Table 1: Monetary Policy Event Details

Country	Num. Meetings	Num. Minutes	Start Year
Australia	263	155	1998
Brazil	204	26	1999
Canada	166	0	2001
China	91	0	2006
Czechia	236	96	1997
Eurozone	277	1	1999
Hungary	223	72	2004
Israel	200	25	2003
Japan	318	148	1998
Mexico	150	56	2005
New Zealand	169	0	1999
Norway	180	0	1999
Poland	199	14	2004
Romania	120	12	2006
South Africa	118	0	2001
South Korea	147	12	2008
Sweden	128	62	2000
Switzerland	74	0	2004
United Kingdom	272	152	1997
United States	213	181	1996

The table shows the number of events available for each country/zone in my panel. The number of meetings is the number of events announcing the decision at a monetary policy committee meeting, typically through a statement following the meeting. The number of minutes is the number of events relating to the release of minutes from a monetary policy committee meeting after some time has passed following the meeting. Source: Bloomberg.

[5]GovPX data include pricing data on all US government bonds. In this sense, they actually provide greater coverage than the Refinitiv bond data, which cover only some bonds. However, the GovPX data are available only for the United States, and I do not have access to data from after 2013. GovPX provides only limited information on each bond, so I combine this with information from the Center for Research in Security Prices (CRSP) on the bond type and maturity date by matching the CUSIPs of the bonds.

[6]The websites are `www.investing.com` and `www.centralbanknews.info`.

[7]Unlike some papers (for example, Cieslak and Schrimpf (2019)), I do not include speeches by central bank governors or other events because these are difficult to time correctly and would increase the frequency of clashes with events in other countries/zones.

2.2 Primary Specification

I am interested in measuring the relationship in equation (1). I regress the change in the interest rate, which is represented as I, in the recipient country/zone r for maturity m around time t on the change in the interest rate in the source country/zone s for maturity m around time t. To identify how a change in interest rates in country/zone s due to a monetary policy event in country/zone s spills over into country/zone r's interest rate, I apply a high-frequency identification approach. Therefore, I run the regression only for periods when there was a monetary policy event in country/zone s. By using a narrow enough window around the monetary policy event in country/zone s, I hope to reduce the influence of confounding factors. I run equation (1) separately for different sources, different recipients, and different maturities.

$$\Delta I_{r,m,t} = \alpha_{s,r,m} + \beta_{s,r,m}\Delta I_{s,m,t} + u_{r,s,m,t}|\text{MP event in zone s} \tag{1}$$

I use a relatively simple regression structure to determine the strength of spillovers. Unlike many of the other authors studying spillovers, I do not take factors of a variety of asset prices and reshape them to obtain a measure of the change in yield, because the bond price data I use allow me to look directly at the change in the yield curve at a given maturity, rather than having to adjust derivatives price data. I primarily look at regressions in which the independent and dependent variable interest rates are measured at the same maturity, because this allows for the easy comparison of spillovers, and because spillovers seem likely to be strongest across similar maturities. I also consider regressions with different interest rate maturities for the dependent and independent variables. Some recent papers challenge the method of identification through monetary policy surprises (Bauer and Swanson 2020, Sastry 2021, Cotton 2022a). However, these critiques apply to the case where the dependent variable is measured at low frequency but not to the case I consider, where the dependent variable is measured in a high-frequency window. Indeed, as Bauer and Swanson 2020 points out, in the case I consider, the monetary policy surprise effects can be considered directly without any additional decomposition (along the lines of Jarociński and Karadi 2020, Andrade and Ferroni 2021, Miranda-Agrippino and Ricco 2021) that would reduce the efficiency of the regression and also potentially be difficult to perform across a wide range of countries/zones.

I consider a narrow window around monetary policy events in the source country/zone to aid identification. I examine interest rates from one hour to 10 minutes before the meeting, taking the earliest interest rate available. I look at interest rates from one hour to 10 minutes after the meeting, taking the latest interest rate available. I want to ensure that events from large central banks that could change interest rates substantially do not take place within the same window as other monetary policy events in my sample. Therefore, I drop events that are within 70 minutes of a monetary policy event in Australia, Canada, China, the eurozone, Japan, Norway, New Zealand, Sweden, Switzerland, the United Kingdom, or the United States.[8]

I consider alternative windows, which yield similar results. One concern may be that the window I consider is still too wide and could allow for other factors to drive interest rates in both the source and recipient zones. Therefore, I also restrict the measurement of interest rates to up to 20 minutes before and 20 minutes after the event. This yields similar results. A second concern may be that the results are only temporary. Therefore, I consider a wider window, where I look at how interest rates in recipient countries/zones respond up to one week after the monetary policy event. With a wider window, the significance unsurprisingly diminishes, but

[8]These are the countries/zones in my sample that are in the MSCI developed-country index, except that I replace Hong Kong with China.

the coefficient estimates increase, perhaps reflecting that markets take time to process spillovers.

One potential concern with the primary specification is that interest rates for similar countries/zones may comove at a high frequency for reasons other than monetary policy spillovers. In this case, a significant coefficient in equation (1) could reflect this comovement rather than a spillover. Fortunately, it is possible to test for the existence of spillovers while controlling for such comovement. The test assumes that any spillovers are due to comovement, removes this comovement, and then checks for spillovers. I explain how I implement this alternative specification in appendix A.

2.3 Interest Rate Measures

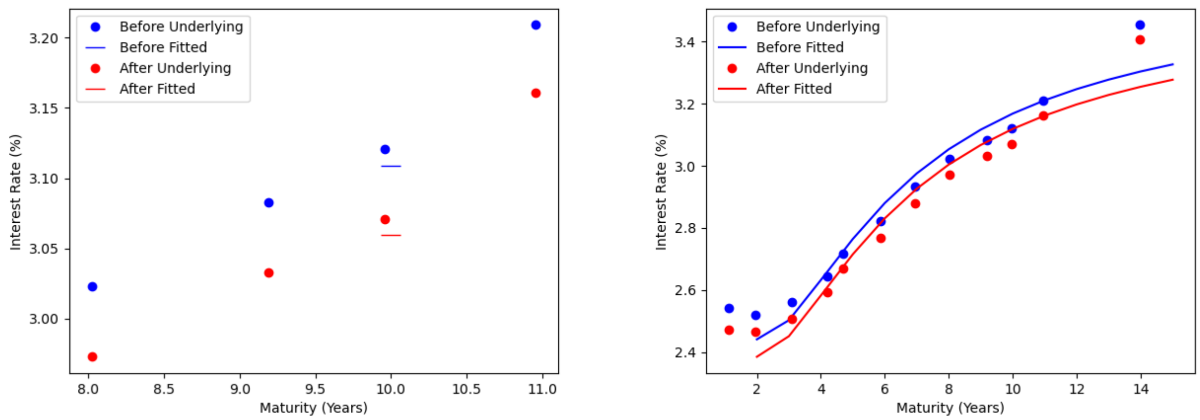
For my high-frequency identification approach, I need to measure interest rates before and after a monetary policy event. I take several preliminary steps to clean the interest rate data. Crucially, I consider only bonds for which I have data both before and after the event so that I do not compare distinct bonds that could have different rates for other reasons. The interest rate data are based on indicative quotes submitted by banks, that is, the price that bonds would be currently traded for at these banks. I drop any quote that is the same as the previously submitted quote to avoid the possibility that quotes have not been updated. Note that interest rates are measured very precisely, and interest rate quotes are constantly changing, so it is very unlikely that they would remain exactly the same even if a monetary policy announcement were unsurprising. There are occasional other issues with quotes, including random large rate deviations. Therefore, I include only bond data points that show a change similar to interest rate changes for other bonds around the same monetary policy event.[9]

I primarily apply a nonparametric approach to estimate the change in the interest rate for a given maturity. In the nonparametric approach, I compute the rate change for a given maturity by taking the average change in bonds with a maturity in a window close to the desired maturity.[10] For example, to compute the change in the ten-year rate for a bond with a ten-year window, I would compute the average change in bond prices for bonds with a maturity of more than seven years and less than ten years. A second approach I use involves estimating the yield curve parametrically through the Nelson and Siegel (1987) method. With this second approach, I restrict the underlying data to bonds with maturities of less than 15 years, because I do not want bonds with very long-term maturities to shift the yield curve, as is possible with simple parametric estimates of the yield curve. Figure 1 shows the estimation of the yield curve under both methods for Australia on

[9]For each monetary policy event and country/zone, I obtain a list of bond interest rates before and after the monetary policy event and their corresponding maturities. I then go through each list and remove the outliers. I drop any bonds for which the change in the bond price from before to after the meeting is greater than 1 percentage point, that is, when interest rates change by 1 percentage point or more from before to after a meeting, which would be an extremely large monetary policy shock. I drop cases where only a single bond is available for a specific meeting. For comparison with each bond, I find another bond with similar maturity for that country/zone: I compare the bond with the lowest maturity to the bond with the second-lowest maturity, the bond with the highest maturity to the bond with the second-highest maturity, and other bonds with the mean of the two bonds with the closest lower and higher maturity. I drop the bond if the interest rate of the comparison bond is more than 5 percentage points different either before or after the meeting. If a bond changes by more than 0.2 percentage points and the sign of the change in the comparison bond is different, then I drop it. If a bond changes by more than 0.2 percentage points, and the comparison bond changes by less than one-quarter of this magnitude, then I drop it. If a bond changes by more than 0.3 percentage points, and the comparison bond changes by less than one-third of this magnitude, then I drop it. If a bond changes by more than 0.4 percentage points, and the comparison bond changes by less than one-half of this magnitude, then I drop it. I repeat the process of removing outliers until there are no more outliers (in case there happen to be two large bond changes next to each other). I drop any bonds that show a rate of exactly 0 percent, which was an issue occasionally. For non-benchmark bonds with a starting maturity of more than one year, I stop considering such bonds once the bond has a maturity of less than six months, because prices for longer-term bonds become inaccurate close to their maturity.

[10]One other option would be to just take the benchmark bond for a given maturity. However, for most monetary policy events, I have obtained data for many bonds, so the nonparametric approach, which looks at the average change in multiple bonds, allows me to obtain a more refined measure of the change in the interest rate.

Figure 1: Yield Curve Fit for Australia on 5/7/2013



(a) Nonparametric Approach

(b) Nelson-Siegel Approach

The figure shows the different methods for constructing the yield curve for Australia on May 7, 2013, when the policy rate fell from 3 percent to 2.75 percent. The left sub-figure shows the estimation of the five-year interest rate with a two-year window. The right sub-figure shows the estimation with the Nelson-Siegel parametric approach. Sources: Bloomberg, Refinitiv.

May 7, 2013, when the policy rate fell from 3 percent to 2.75 percent. Figure 1a shows the estimation with the nonparametric approach for the ten-year interest rate for bonds with a maturity of more than seven years and less than thirteen years. There are four bonds with data available both before and after the monetary policy event in the seven-to-thirteen-year window. The dots show the before and after interest rates, while the horizontal lines show the means of these rates. The difference between the blue and red horizontal line reflects the change in the five-year interest rate found through the nonparametric method. Figure 1b shows the estimation using the Nelson-Siegel method. This incorporates all bonds (with a maturity of less than 15 years). With this structural approach, interest rates for one maturity could potentially mechanically affect the measurement of interest rates for another maturity, so I primarily use the nonparametric approach in this paper. However, I find the choice of yield curve does not affect the results in practice.

I also construct measures of the average change in the interest rates of other developed and emerging country/zones. I look at the change in other developed countries/zones; that is, if I am looking at spillovers from a source country into developed countries/zones, then I do not include the source country/zone in the developed measure, even if it is developed. I also exclude Japan for the developed country/zone measure because its interest rates move much less than those of other developed countries/zones due to its unique stability at the zero lower bound. [11]

[11]One issue with the measure is that depending on the time of day of the monetary policy release, certain countries/zones are more or less likely to be represented because interest-rate data for a country/zone are more available during that country's business hours. Consequently, I also show the impact of spillovers on specific countries/zones as a comparison.

3 Which Central Banks Cause Spillovers?

3.1 Impact on Global Interest Rates

In this section, I explore the degree to which different central banks cause monetary policy spillovers. I start by looking at the magnitude of spillovers from each source country/zone in the sample to average interest rates in other developed and emerging markets excluding the source country/zone. Table 2 shows the impact of spillovers from developed countries/zones as classified by MSCI, with each column showing the impact of the spillover from a different country/zone. The first three panels respectively look at the spillovers into the six-month, two-year, and ten-year rates for developed countries/zones. In the first panel/column, I therefore look at a regression of the average change in the six-month rate for developed countries/zones excluding Australia on the change in Australia's six-month rate at one-hour before and after monetary policy events in Australia. The number of points varies for different maturities because not all monetary policy events have interest-rate data available for each maturity/source/recipient. I do not show regressions with fewer than 10 points available.

Central banks from developed countries/zones other than the United States cause large spillovers to medium-term and long-term interest rates but smaller spillovers to short-term interest rates. Panel A of Table 2 shows the average spillover from the six-month interest rate. The United States causes the strongest six-month spillovers. A 1 basis point rise in the six-month rate in the United States is associated with a rise of 0.26 basis point in the six-month rate in other developed countries/zones. The eurozone and the United Kingdom also cause significant but smaller spillovers. Panel B shows the average spillovers from an increase in the two-year interest rate. Australia, Canada, Switzerland, the eurozone, the United Kingdom, Norway, Sweden, and the United States all cause significant spillovers to interest rates in other developed countries/zones. That being said, the United States shows the strongest effect for two-year rates. A 1 basis point rise in the two-year rate in the United States is associated with a rise of 0.50 basis points in the two-year rate in other developed countries/zones. The next-strongest effect is a 0.28 basis points rise, from an increase in the eurozone two-year rate. Panel C shows the results for the 10-year interest rate. All developed central banks in the panel cause significant spillovers, and the magnitudes of spillovers from non-Federal Reserve central banks are larger than for the lower maturities. The largest spillovers come from the eurozone—a 1 basis point rise in the 10-year rate in the eurozone is associated with a rise of 0.60 basis points in the global 10-year rate. Indeed, the size of spillovers from every country/zone increases relative to the size of spillovers associated with shorter maturities, often markedly, except for the spillovers from the United States, the size of which remains the same. The regressions are well identified, with t-statistics greater than 5 for many countries/zones, greater than 10 for the eurozone and the United Kingdom, and greater than 20 for the United States.[12] As I discuss further in section 5, central banks other than the Federal Reserve may cause larger spillovers to long-term interest rates because spillovers come from the bond-pricing channel, which affects long-term bonds more than short-term bonds.

I also look at regressions with alternative maturity structures. So far, I have discussed regressions in which the changes in interest rates around the monetary policy events are measured at the same maturity for both the source and recipient countries/zones. In Panels D through F, I instead look at regressions in which the

[12] By comparison, Albagli et al. (2019) estimate that a 1 basis point rise in US short-term rates during monetary policy meetings increases long-term rates in other developed countries by 0.43 basis points. The authors use daily data and look at only spillovers from US monetary policy.

Table 2: Spillovers from Developed Countries/Zones into Developed and Emerging Rates

Source	AUS	CAN	CHE	ECB	GBR	JPN	NOR	NZL	SWE	USA
Panel A: Dependent: ΔI_{6m} Developed Average (excluding Source)										
ΔI_{6m}	0.05	0.03	0.06	0.14**	0.05**		0.01	-0.03	0.05	0.26***
	(0.04)	(0.02)	(0.03)	(0.05)	(0.02)		(0.02)	(0.03)	(0.03)	(0.04)
N	164	105	37	91	221		80	110	55	270
Panel B: Dependent: ΔI_{2y} Developed Average (excluding Source)										
ΔI_{2y}	0.08***	0.06***	0.10***	0.28***	0.12***	0.11	0.05**	0.01	0.06***	0.50***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.02)	(0.12)	(0.02)	(0.02)	(0.02)	(0.02)
N	359	160	45	149	279	236	97	140	135	368
Panel C: Dependent: ΔI_{10y} Developed Average (excluding Source)										
ΔI_{10y}	0.14***	0.19***	0.23***	0.60***	0.19***	0.18*	0.09**	0.05*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.08)	(0.03)	(0.02)	(0.02)	(0.02)
N	386	161	45	150	279	232	114	130	149	373
Panel D: Dependent: ΔI_{2y} Developed Average (excluding Source)										
ΔI_{6m}	0.08**	0.05***	0.07**	0.28***	0.05***		0.06**	0.01	0.05*	0.57***
	(0.03)	(0.01)	(0.02)	(0.05)	(0.01)		(0.02)	(0.02)	(0.03)	(0.03)
N	172	105	37	91	224		80	123	55	325
Panel E: Dependent: ΔI_{10y} Developed Average (excluding Source)										
ΔI_{6m}	0.03	0.05**	0.05*	0.20**	0.06***		0.04*	0.01	0.03	0.42***
	(0.02)	(0.02)	(0.02)	(0.06)	(0.02)		(0.02)	(0.01)	(0.02)	(0.03)
N	178	105	37	91	224		80	122	55	327
Panel F: Dependent: ΔI_{10y} Developed Average (excluding Source)										
ΔI_{2y}	0.06***	0.06***	0.09**	0.23***	0.11***	0.26*	0.05*	0.02	0.07***	0.47***
	(0.01)	(0.01)	(0.03)	(0.04)	(0.02)	(0.11)	(0.02)	(0.01)	(0.01)	(0.02)
N	364	160	45	149	279	237	97	140	135	370
Panel G: Dependent: ΔI_{6m} Emerging Average										
ΔI_{6m}	-0.17	0.00	-0.26*	-0.00	-0.40***		-0.04	-0.05	-0.08	0.13*
	(0.12)	(0.05)	(0.12)	(0.16)	(0.10)		(0.08)	(0.06)	(0.08)	(0.06)
N	58	92	34	84	192		69	54	52	174
Panel H: Dependent: ΔI_{2y} Emerging Average										
ΔI_{2y}	0.02	0.03	0.05	0.04	-0.07	-0.44	-0.03	0.14*	0.03	0.45***
	(0.05)	(0.02)	(0.05)	(0.09)	(0.06)	(0.24)	(0.04)	(0.06)	(0.03)	(0.08)
N	270	158	45	138	257	164	91	90	135	222
Panel I: Dependent: ΔI_{10y} Emerging Average										
ΔI_{10y}	0.02	0.04	-0.04	0.23*	0.03	0.46**	0.06	0.11	0.18**	0.41***
	(0.07)	(0.04)	(0.08)	(0.10)	(0.06)	(0.14)	(0.06)	(0.09)	(0.06)	(0.05)
N	288	161	45	143	257	162	108	90	148	269

The table shows spillovers from the developed countries/zones (as classified by MSCI) in my panel to average interest rates in developed and emerging countries (excluding the source). Each cell represents a single regression of the change in the developed/emerging rate on the change in the source country/zone rate where the source country/zone is given in the column. The first three and last three panels respectively look at spillovers into the six-month, two-year, and ten-year rates in developed and emerging countries/zones. The middle three panels look at regressions where the interest rate maturity of the independent variable differs from that of the dependent variable. The changes in the six-month, two-year, and ten-year interest rates are measured by the average change in zero- to one-year, one- to three-year, and seven- to thirteen-year bonds, respectively. The changes in the dependent/independent interest rates are measured using the standard one-hour time frame before and after monetary policy events. I exclude Japan in regressions where the independent variable is measured at the six-month maturity because it was at the zero lower bound throughout the sample period. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

maturities for the source and recipient countries/zones differ. In Panel D, I look at regressions of the change in the two-year interest rate in other developed countries/zones on the change in the six-month interest rate in the source country/zone. In Panels E and F, I look at regressions of the change in the ten-year interest rate on the change in the six-month interest rate and two-year interest rate, respectively. For the Federal Reserve, I find very strong significant effects across each of these regressions. However, for other central banks, I find weaker but still significant spillovers into two-year and ten-year interest rates when looking at the monetary policy surprise to shorter-term maturities in the source country/zone. I examine this result in more detail in section 5, where I show that changes in the later part of the yield curve are primarily driving the spillovers into long-term interest rates from non-Fed central banks but not spillovers from the Federal Reserve. Therefore, looking at monetary policy surprises to shorter-term interest rates from non-Fed central banks seems to miss part of the spillovers into longer-term interest rates in other countries/zones.

The United States is the only developed country that shows clear monetary policy spillovers into emerging market interest rates. Panels G, H, and I of table 2 show the spillovers from developed countries into emerging markets for six-month, two-year, and ten-year interest rates, respectively. The United States causes significant spillovers into emerging markets at each of these maturities and with a high degree of significance for the two-year and ten-year regressions. No other country/zone shows significant monetary policy spillovers into emerging market interest rates at more than one maturity. Again, as I discuss further in section 5, this seems to be because other central banks cause spillovers through the bond-pricing channel. When a central bank lowers its interest rates, this potentially makes similar bonds in other countries/zones more appealing, causing their prices to rise and the yields to follow. This effect most likely will raise prices and lower yields for bonds in similar, developed countries/zones as opposed to emerging-market bonds.

Relatively developed emerging markets also show spillovers into other countries/zones. The spillovers from emerging countries (as classified by MSCI) to average interest rates in developed and other emerging countries/zones are given in table 3 and follow the same convention as the first three and the last three panels in table 2. No emerging countries show significant spillovers into the six-month or two-year rate in developed countries/zones.[13] However, five countries show significant spillovers into the 10-year rate in developed countries/zones: Czechia, Mexico, Poland, Romania, and South Korea. All of these countries are relatively developed and/or have close connections to developed countries/zones. The GDP per capita of these countries in 2020 was 22.7, 8.3, 15.7, 12.9, and 31.5 thousand dollars per capita, respectively, compared with 63.5, 43.2, and 40.3 in the United States, Canada, and the United Kingdom, respectively. Mexico has close links to the United States and Canada, while Czechia, Poland, and Romania are members of the European Union but not part of the eurozone. China, Czechia, Poland, and South Korea also demonstrate significant spillovers into interest rates in other emerging markets but for only one maturity each.[14]

3.2 Share of Global Spillovers

The United States is responsible for a majority of the spillovers into interest rates at shorter maturities but only a small share of the spillovers into long-term interest rates. Table 4 captures each central bank's share of spillovers caused to the average interest rate in (other) developed countries/zones. I measure a country/zone's

[13]Israel was upgraded by MSCI from emerging to developed in 2010, but it was considered emerging during the earlier part of my sample.

[14]It may seem surprising that China does not demonstrate a greater degree of spillover; however, China follows quite a different interest rate policy, and I have few observations of monetary policy events there.

Table 3: Spillovers from Emerging Countries into Developed and Emerging Rates

Source	BRA	CHN	CZE	HUN	ISR	KOR	MEX	POL	ROU	ZAF
Panel A: Dependent: ΔI_{6m} Developed Average										
ΔI_{6m}		-0.01	-0.00	-0.01	-0.01		-0.02	-0.01	-0.01	-0.01
		(0.03)	(0.01)	(0.05)	(0.03)		(0.03)	(0.01)	(0.03)	(0.01)
N		10	158	14	42		28	101	47	26
Panel B: Dependent: ΔI_{2y} Developed Average										
ΔI_{2y}	0.00	-0.02	0.01	-0.01	0.00	-0.04	-0.00	0.00	-0.01	0.01
	(0.07)	(0.04)	(0.02)	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)
N	10	19	182	157	106	134	71	160	76	99
Panel C: Dependent: ΔI_{10y} Developed Average										
ΔI_{10y}	-0.05	-0.06	0.12***	-0.01	0.02	0.10*	0.03*	0.05*	0.03*	0.02
	(0.06)	(0.08)	(0.03)	(0.02)	(0.02)	(0.04)	(0.01)	(0.02)	(0.01)	(0.01)
N	13	31	187	168	112	118	178	181	75	107
Panel D: Dependent: ΔI_{6m} Emerging Average (excluding Source)										
ΔI_{6m}			-0.07	0.05	-0.20		-0.07	0.05	0.03	0.19
			(0.06)	(0.18)	(0.24)		(0.11)	(0.03)	(0.11)	(0.11)
N			121	13	39		24	78	39	23
Panel E: Dependent: ΔI_{2y} Emerging Average (excluding Source)										
ΔI_{2y}		0.28*	0.15*	-0.06	-0.00	0.48**	0.01	-0.01	-0.01	-0.00
		(0.12)	(0.07)	(0.04)	(0.03)	(0.18)	(0.02)	(0.04)	(0.03)	(0.02)
N		17	174	156	107	113	68	158	76	98
Panel F: Dependent: ΔI_{10y} Emerging Average (excluding Source)										
ΔI_{10y}		0.01	-0.02	0.01	-0.03	0.03	0.03	0.17***	-0.04	0.05
		(0.13)	(0.08)	(0.03)	(0.04)	(0.12)	(0.04)	(0.04)	(0.03)	(0.03)
N		29	186	168	113	108	162	180	75	107

The table shows spillovers from the emerging countries/zones (as classified by MSCI) in my panel into average interest rates in developed and emerging countries (excluding the source). Each cell represents a single regression of the change in the developed/emerging rate on the change in the source country/zone rate where the source country is given in the column. The six panels respectively look at spillovers into the six-month, two-year, and ten-year rates in developed and emerging countries/zones. The changes in the six-month, two-year, and ten-year interest rates are measured by the average change in zero- to one-year, one- to three-year, and seven- to thirteen-year bonds, respectively. The changes in the dependent/independent interest rates are measured using the standard one-hour time frame before and after monetary policy events. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Regressions with less than 10 observations are dropped. Sources: Bloomberg, GovPX, Refinitiv.

Table 4: Share of Spillovers

	AUS	CAN	CHE	CZE	ECB	GBR	KOR	JPN	MEX	NOR	NZL	POL	ROU	SWE	USA
A. ΔI_{6m} Developed (All)					30.7	11.4									58.0
B. ΔI_{2y} Developed (All)	6.1	4.7	7.7		22.9	9.6				3.9				4.8	40.3
C. ΔI_{10y} Developed (All)	5.1	7.0	8.6	4.3	22.5	7.3	3.8	6.7	1.0	3.5	1.8	2.0	1.2	6.5	18.8
D. ΔI_{6m} Developed (p $<$ 0.001)															100.0
E. ΔI_{2y} Developed (p $<$ 0.001)	6.4	4.9	8.1		23.8	9.9								5.0	41.9
F. ΔI_{10y} Developed (p $<$ 0.001)	6.4	8.8	10.8	5.4	28.1	9.1								8.1	23.4

This table shows the share of spillovers by maturity. To compute this, I divide the coefficient for a source country in table 2 and table 3 by the sum of all significant coefficients and multiply by 100. Non-significant coefficients are set to zero, and coefficients that can be explained by comovement are dropped. I do this for each maturity separately. Rows A, B, and C correspond to the share of spillovers of each source country/zone into the six-month, two-year, and ten-year interest rates, respectively. Rows D, E, and F are similar except I include only coefficients with a p-value of less than 0.001. Sources: Bloomberg, GovPX, Refinitiv.

spillover share using its coefficient in Panel C of table 2 and table 3.[15] The eurozone and the United Kingdom cause spillovers into the average six-month interest rate in other developed countries/zones; however, the United States causes by far the largest share of spillovers at 58 percent. More countries/zones cause spillovers into the two-year developed-country/zone rate, so the United States explains a smaller share of 40.3 percent, but this is still a plurality. Many countries/zones cause significant and large spillovers into the average 10-year interest rate in other developed countries/zones, so the United States explains only 18.8 percent of spillovers into the 10-year rate. I also repeat the exercise in rows D, E, and F for only countries/zones that have particularly well-identified coefficients, that is, a p-value of <0.001 in Panel C of table 2 and table 3. This yields similar patterns. Therefore, the United States seems to cause a large share of short-term spillovers but a much smaller share of long-term spillovers.

3.3 Impact on Individual Countries/Zones

In table 5, I present results on spillovers into individual developed countries/zones. The source country/zone is given in the row index, and the recipient country/zone is given in the column index. The source countries/zones I consider are the countries/zones that showed significant spillovers into the 10-year rate in developed countries/zones, that is, all 10 developed countries/zones plus five emerging countries: Czechia, Mexico, Poland, Romania, and South Korea. In this table as well as tables that follow, I highlight the eight source countries/zones that show the most significant spillovers in yellow, that is, that countries/zones that have coefficients with a p-value of less than 0.001 in table 2 and table 3. Each cell of the table represents a regression of the change in the recipient country/zone's 10-year interest rate on the change in the source country/zone's 10-year interest rate around monetary policy events in the source country/zone. The brackets under the coefficients give the standard errors and the number of observations in the regression. I also report the average spillovers into developed country/zones in the final column.[16] The monetary policy events in Canada, the eurozone, Sweden, Switzerland, the United Kingdom, and the United States cause significant spillovers into all or all but one of the other countries/zones in my panel for which data are available. Therefore, there are broad, significant spillovers from many source countries/zones into many recipient countries/zones, demonstrating

[15]Some countries/zones may change their monetary policy more often or by larger amounts and therefore are responsible for a larger share of spillovers in practice than might be suggested by the coefficients in the regressions. I capture a measure of this in appendix B.2 by estimating how much a country/zone's monetary policy statements/minutes during the 2010–2019 period caused spillovers to the average interest rate in (other) developed countries/zones. I find fairly similar results.

[16]These are the same as Panel C in table 2 and Panel C in table 3. Note these will not equal the mean of the individual countries/zones because, for example, some countries/zones have more observations than others.

the robustness of the spillovers.[17]

Table 5: Spillovers into Individual Developed Countries/Zones

Source\Recipient	→AUS	→CAN	→CHE	→ECB	→GBR	→JPN	→NOR	→NZL	→SWE	→USA	→Developed Ave.
AUS→	–	0.07	-0.07	0.07	0.05*	0.03		0.21**		0.10***	0.14***
		(0.09,51)	(0.21,14)	(0.04,89)	(0.02,68)	(0.03,256)		(0.06,220)		(0.02,330)	(0.02,386)
CAN→	0.33***	–	0.13***	0.21***	0.24***	0.03	0.06		0.12***	0.25***	0.19***
	(0.05,126)		(0.03,159)	(0.03,161)	(0.04,158)	(0.02,137)	(0.04,131)		(0.03,148)	(0.04,160)	(0.02,161)
CHE→	0.27***	0.02	–	0.28***	0.21**	0.09*	0.26***		0.28***	0.22***	0.23***
	(0.07,32)	(0.05,29)		(0.07,45)	(0.08,45)	(0.04,45)	(0.06,44)		(0.08,41)	(0.06,44)	(0.04,45)
CZE→	0.12	0.06	0.10*	0.14***	0.19***	0.07*	0.21***		0.14**	0.09*	0.12***
	(0.06,133)	(0.05,137)	(0.04,182)	(0.03,187)	(0.05,187)	(0.03,149)	(0.05,152)		(0.05,159)	(0.04,182)	(0.03,187)
ECB→	0.55***	0.52***	0.41***	–	0.50***	0.09***	0.63***		0.80***	0.74***	0.60***
	(0.08,116)	(0.08,143)	(0.06,130)		(0.06,150)	(0.02,86)	(0.05,117)		(0.05,131)	(0.10,149)	(0.04,150)
GBR→	0.18***	0.16***	0.14***	0.27***	–	0.02	0.15***		0.24***	0.19***	0.19***
	(0.03,217)	(0.03,190)	(0.02,259)	(0.03,278)		(0.02,194)	(0.03,224)		(0.03,242)	(0.02,274)	(0.02,279)
JPN→	0.26***	0.03	0.05	0.13	0.07	–		0.08	-0.05	0.10	0.18*
	(0.07,220)	(0.14,23)	(0.22,14)	(0.11,36)	(0.12,59)			(0.14,101)	(0.47,11)	(0.10,200)	(0.08,232)
KOR→	0.23**			-0.00	0.02	0.02		0.16		0.05	0.10*
	(0.08,118)			(0.03,41)	(0.03,32)	(0.04,115)		(0.10,82)		(0.03,114)	(0.04,118)
MEX→	0.07***	0.03	-0.01	0.03	-0.00	-0.00	0.01		0.01	0.03	0.03*
	(0.02,149)	(0.02,176)	(0.02,130)	(0.01,173)	(0.03,134)	(0.01,116)	(0.02,83)		(0.02,119)	(0.02,176)	(0.01,178)
NOR→	0.07	0.07	0.06	0.12**	0.11*	-0.07**	–		0.15***	0.08	0.09**
	(0.04,84)	(0.04,94)	(0.05,107)	(0.04,114)	(0.05,114)	(0.02,86)			(0.04,102)	(0.05,114)	(0.03,114)
NZL→	0.08	0.03		0.03				–		0.03	0.05*
	(0.05,100)	(0.02,97)		(0.03,39)						(0.03,115)	(0.02,130)
POL→	0.09	0.04	0.05	0.08**	0.04	0.03*	0.02		0.06*	0.08	0.05*
	(0.05,142)	(0.05,159)	(0.03,180)	(0.03,181)	(0.04,181)	(0.01,153)	(0.04,147)		(0.02,170)	(0.04,179)	(0.02,181)
ROU→	0.04*	0.01	0.02	0.05	0.04	0.01	0.04		0.03	0.03	0.03*
	(0.02,73)	(0.04,48)	(0.02,75)	(0.03,74)	(0.03,74)	(0.01,59)	(0.03,68)		(0.02,74)	(0.02,70)	(0.01,75)
SWE→	0.11*	0.09*	0.21***	0.19***	0.18***	0.04*	0.29***	-0.23	–	0.10***	0.17***
	(0.04,131)	(0.04,59)	(0.04,148)	(0.03,149)	(0.04,149)	(0.02,135)	(0.04,142)	(0.26,19)		(0.02,144)	(0.02,149)
USA→	0.63***	0.56***	0.20*	0.40***	0.04			0.49**	0.18**	–	0.50***
	(0.02,292)	(0.01,369)	(0.09,15)	(0.01,229)	(0.02,68)			(0.16,39)	(0.05,23)		(0.02,373)

This table presents results on the spillovers from the country/zone in the row index into the country/zone in the column index, so each cell represents a different regression. The spillovers are measured through a regression of the change in the 10-year interest rate in the recipient country/zone on the change in the 10-year interest rate in the source country/zone around monetary policy events in the source country/zone. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Regressions with fewer than 10 observations are dropped. The brackets show the standard error and the number of observations in the regression. Sources: Bloomberg, GovPX, Refinitiv.

There are strong spillovers into US and eurozone interest rates. The standard view in the literature is that the Federal Reserve—and to a lesser degree the European Central Bank—is the predominant source of spillovers. In this case, the main concern of the Federal Reserve with regard to spillovers is how its own policies may spill back to the United States through its impacts on the global financial cycle. My results instead show that there are large, significant spillovers from other countries to the United States and the eurozone. A 1 basis point rise in the 10-year interest rate in Australia, Canada, Switzerland, the eurozone, the United Kingdom, and Sweden around monetary policy events raises the 10-year US interest rate by 0.1, 0.25, 0.22, 0.74, 0.19, and 0.10 basis points, respectively. The eurozone also experiences substantial spillovers. A 1 basis point rise in the 10-year interest rate in Canada, Switzerland, Czechia, the United Kingdom, Sweden, and the United States raises 10-year eurozone interest rates by 0.21, 0.28, 0.14, 0.27, 0.19, and 0.40 basis points, respectively. All of these coefficients have a p-value of less than 0.001. Therefore, the Federal Reserve and the European Central Bank do face spillovers from other countries/zones into their monetary policy as well as spillbacks from their own policies.

There appear to be larger spillovers between countries/zones with closer relationships. The most noticeable examples of these relationships are the spillovers in both directions between Australia and New Zealand and

[17]The coefficient for the spillovers from the United States into the United Kingdom is surprisingly not significant. As demonstrated in figure B.1, there is a very large outlier in this regression. The 10-year US interest rate fell by over 40 basis points around the monetary policy event on March 18, 2009, but the 10-year UK interest rate rose slightly in the high-frequency window I consider before substantially in subsequent hours.

between Norway and Sweden.[18] Each of these countries causes by far the largest spillovers to its respective counterpart. This finding about close relationships appears to be true more broadly. Czechia, the United Kingdom, and Sweden cause larger spillovers into European countries/zones than non-European countries, for example. As I discuss further in section 5, the bond-pricing channel implies that if interest rates change in one country/zone, investors are most likely to switch their investments to/from similar bonds, and investors are likely to view these pairs of countries/zones as very similar. I examine the factors causing bilateral spillovers between countries/zones in section 4.3.

3.4 Impact Measured at Alternative Time Frames

The results are robust to using a narrower time frame. Table 6 considers the magnitude of spillovers from the main source countries/zones into the average rate in other developed countries/zones under a range of time frames. Panel A shows the standard time frame for the change in both the source and recipient rates measured from no earlier than one hour before to no later than one hour after a monetary policy event. Panel B shows results with the time frame for the change in both the source and recipient rates restricted to no earlier than 20 minutes before and no later than 20 minutes after an event. For the eight highlighted countries/zones with the strongest spillovers, those with a p-value of less than 0.001 in Panel A, the results continue to be significant and the coefficients look very similar. For the other countries/zones, the results become less significant but remain in a similar range.[19]

The spillovers have longer-term effects as well. Panels C through F show results with the time frame for the rates of the recipient developed countries/zones measured from 1 hour before to 24 hours, 48 hours, 72 hours, and 168 hours (1 week) after, respectively. I continue to measure the change in the interest rate in the source country/zone using the standard one-hour time frame. Panels C through F therefore show how the spillovers into the recipient country/zone's interest rate from the source country/zone evolve following the monetary policy announcement in the source country/zone. For the eight highlighted countries/zones that show the strongest spillovers, the spillovers at 24, 48, 72, and 168 hours are all stronger than at 1 hour.[20] This is somewhat surprising since, with more noise due to the wider time frame, it seems reasonable to expect some coefficients would rise and some coefficients would fall. The fact that the coefficients only increase could be because it takes time for interest rates decisions in other countries/zones to be priced in. Other countries/zones that cause weaker spillovers do not all show spillovers that systematically increase, but the results remain in a similar range. With wider time frames, the degree of significance diminishes; however, this is to be expected, as wider time frames introduce more noise into the dependent variable. Therefore, monetary policy spillovers from many central banks other than the Federal Reserve appear to have sustained effects after the monetary policy announcements, and it may take time for financial markets to process spillovers, leading to strengthening effects over time.

I show that spillovers are broadly similar across different time spans. In table 7, I consider spillovers across different subsets of years. Panels A through G consider all events, 1996 through 1999, 2000 through 2004,

[18]None of the spillovers from New Zealand to other individual countries/zones are significant, but the spillover to Australia shows the largest coefficient.

[19]With a shorter time frame, fewer data points are available, and financial markets may not have fully processed the impact of central bank announcements in other countries/zones. So, it is perhaps not surprising that the results become less significant for the countries/zones that do not demonstrate large spillovers.

[20]The only mild exceptions to this finding are for Switzerland at 72 hours, where the coefficient is 0.21 as opposed to 0.23 at 1 hour, and for the United States at 24 and 168 hours, where the coefficient is 0.47 and 0.48, respectively, as opposed to 0.50 at 1 hour.

Table 6: Varying the Time Frame

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: ΔI_{10y} Developed Average (excluding Source); 1 hour before - 1 hour after															
ΔI_{10y}	0.14***	0.19***	0.23***	0.12***	0.60***	0.19***	0.10*	0.18*	0.03*	0.09**	0.05*	0.05*	0.03*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	386	161	45	187	150	279	118	232	178	114	130	181	75	149	373
Panel B: Dependent: ΔI_{10y} Developed Average (excluding Source); 20 mins before - 20 mins after															
ΔI_{10y}	0.22***	0.13***	0.12**	0.06*	0.57***	0.15***	0.08	0.11	0.02	-0.00	0.02	0.03	-0.01	0.10***	0.47***
	(0.03)	(0.02)	(0.04)	(0.03)	(0.04)	(0.01)	(0.05)	(0.06)	(0.01)	(0.03)	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)
N	294	156	44	108	150	276	104	128	130	77	72	156	50	143	359
Panel C: Dependent: ΔI_{10y} Developed Average (excluding Source); 1 hour before - 24 hours after															
ΔI_{10y}	0.24**	0.23*	0.27	0.23*	1.12***	0.31***	0.14	0.35*	0.02	-0.10	0.20**	-0.09	-0.05	0.26**	0.47***
	(0.08)	(0.10)	(0.21)	(0.10)	(0.20)	(0.09)	(0.16)	(0.16)	(0.03)	(0.13)	(0.08)	(0.09)	(0.07)	(0.10)	(0.05)
N	401	161	45	187	150	279	118	233	178	114	134	181	75	149	375
Panel D: Dependent: ΔI_{10y} Developed Average (excluding Source); 1 hour before - 48 hours after															
ΔI_{10y}	0.30*	0.32*	0.26	0.31*	1.08***	0.34**	-0.18	0.50*	0.03	-0.10	0.28**	-0.14	0.04	0.24	0.56***
	(0.12)	(0.15)	(0.24)	(0.13)	(0.24)	(0.12)	(0.21)	(0.22)	(0.03)	(0.16)	(0.10)	(0.13)	(0.08)	(0.13)	(0.07)
N	401	160	45	186	150	278	115	228	175	114	134	181	75	147	371
Panel E: Dependent: ΔI_{10y} Developed Average (excluding Source); 1 hour before - 72 hours after															
ΔI_{10y}	0.35*	0.41*	0.21	0.46**	1.15***	0.29*	-0.11	0.44	0.05	-0.01	0.21	-0.08	0.10	0.30*	0.56***
	(0.16)	(0.17)	(0.32)	(0.15)	(0.28)	(0.14)	(0.23)	(0.26)	(0.04)	(0.17)	(0.11)	(0.14)	(0.08)	(0.15)	(0.08)
N	398	160	44	184	128	265	114	228	171	111	134	180	75	149	346
Panel F: Dependent: ΔI_{10y} Developed Average (excluding Source); 1 hour before - 1 week after															
ΔI_{10y}	0.20	0.38	0.60	0.25	1.57***	0.37*	-0.29	0.33	0.11	0.14	0.22	-0.09	-0.03	0.29	0.48***
	(0.20)	(0.22)	(0.42)	(0.21)	(0.43)	(0.18)	(0.32)	(0.37)	(0.09)	(0.22)	(0.17)	(0.19)	(0.13)	(0.24)	(0.11)
N	399	161	45	187	150	279	118	229	176	114	134	181	75	149	375

The table shows spillovers from the main countries/zones in my panel into the interest rates of developed countries. Each cell represents a single regression of the change in the average 10-year rate for (other) developed countries/zones on the change in the source country/zone 10-year rate where the source country/zone is given in the column. Panel A measures the changes using the standard time frame, that is, when measuring the interest rate before (after) a monetary policy event, I take the furthest interest rate measured at least 10 minutes before (after) the event and up to 1 hour before (after). For panel B, when measuring the interest rate before (after) an event, I take the furthest interest rate measured at least 10 minutes before (after) the event and up to 20 minutes before (after). For panels C through F, I use the standard one-hour time frame to measure the interest rate in the source country/zone. For panels C through F, I obtain the value for the interest rate in the recipient country/zone before the event in the usual way by taking the furthest interest rate measured at least 10 minutes before the event and up to 1 hour before. For panels C through F, I obtain the value for the interest rate of the recipient country/zone after the event by taking the furthest interest rate measured up to 24 hours, 48 hours, 72 hours, and 168 hours after, and measured at least 10 minutes, 24 hours, 48 hours, and 144 hours after, respectively. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

Table 7: Spillovers in Different Year Subsets

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: ΔI_{10y} Developed Average (excluding Source); All Events															
ΔI_{10y}	0.14***	0.19***	0.23***	0.12***	0.60***	0.19***	0.10*	0.18*	0.03*	0.09**	0.05*	0.05*	0.03*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	386	161	45	187	150	279	118	232	178	114	130	181	75	149	373
Panel B: Dependent: ΔI_{10y} Developed Average (excluding Source); 1996-1999															
ΔI_{10y}	0.07				1.03**	0.25**		0.71							0.55***
	(0.15)				(0.27)	(0.07)		(0.57)							(0.07)
N	19				15	29		21							37
Panel C: Dependent: ΔI_{10y} Developed Average (excluding Source); 2000-2004															
ΔI_{10y}	0.27***	0.25***		0.18**	0.97***	0.28***				0.11**	0.03	-0.02		0.36**	0.72***
	(0.07)	(0.07)		(0.06)	(0.10)	(0.06)				(0.04)	(0.04)	(0.03)		(0.10)	(0.05)
N	45	26		57	46	51				35	24	10		18	73
Panel D: Dependent: ΔI_{10y} Developed Average (excluding Source); 2005-2009															
ΔI_{10y}	-0.04	0.17**	0.23**	0.04	0.60***	0.22***		0.08	0.03	0.12	0.07	0.12*		0.22***	0.41***
	(0.06)	(0.05)	(0.07)	(0.03)	(0.09)	(0.04)		(0.11)	(0.03)	(0.07)	(0.05)	(0.06)		(0.03)	(0.02)
N	75	38	18	64	21	66		77	44	30	35	47		29	80
Panel E: Dependent: ΔI_{10y} Developed Average (excluding Source); 2010-2014															
ΔI_{10y}	0.10***	0.25***	0.27*	0.15	1.15***	0.15***	0.09	0.05	0.01	0.14	-0.02	0.04	0.02	0.15*	0.52***
	(0.02)	(0.07)	(0.11)	(0.10)	(0.20)	(0.04)	(0.05)	(0.10)	(0.03)	(0.10)	(0.03)	(0.05)	(0.02)	(0.06)	(0.02)
N	105	40	15	20	15	68	56	83	45	23	31	52	29	31	77
Panel F: Dependent: ΔI_{10y} Developed Average (excluding Source); 2015-2019															
ΔI_{10y}	0.25***	0.10*		0.51**	0.45***	0.18***	0.23*	0.15	-0.03	0.11*	0.09**	0.41***	0.05	0.11**	0.41***
	(0.03)	(0.04)		(0.16)	(0.05)	(0.03)	(0.11)	(0.08)	(0.02)	(0.05)	(0.03)	(0.08)	(0.04)	(0.04)	(0.02)
N	107	40		28	38	51	43	39	68	17	28	53	41	52	78
Panel G: Dependent: ΔI_{10y} Developed Average (excluding Source); 2020+															
ΔI_{10y}	0.28*	0.20***		0.04	0.34**	0.04	-0.01		0.06**		0.14	0.00		0.20*	0.61***
	(0.10)	(0.04)		(0.04)	(0.11)	(0.04)	(0.12)		(0.02)		(0.08)	(0.05)		(0.07)	(0.04)
N	35	17		18	15	14	15		21		12	19		19	28

The table shows spillovers from the main countries/zones in my panel into the interest rates of other developed-countries/zones. Each cell represents a single regression of the change in the average 10-year rate for (other) developed countries/zones on the change in the source country/zone 10-year rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panels A through G consider all events, 1996 through 1999, 2000 through 2004, 2005 through 2009, 2010 through 2014, 2015 through 2019, and 2020 onward, respectively. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Regressions with fewer than 10 observations are dropped. Sources: Bloomberg, GovPX, Refinitiv.

2005 through 2009, 2010 through 2014, 2015 through 2019, and 2020 onward, respectively. Each of the eight highlighted countries/zones with the strongest spillovers show positive, significant spillovers in at least two of the periods. Australia, Canada, Switzerland, the eurozone, the United Kingdom, Sweden, and the United States show positive, significant spillovers in all or all but one of the periods. The spillovers appear broadly similar for each country/zone across years. There is not an obvious trend across the different periods.

3.5 Impact on Other Asset Prices

There are significant spillovers into corporate interest rates. I have so far focused on spillovers into interest rates on government bonds. It is important to verify whether there are also spillovers into other areas of the economy. In table 8, I examine the degree of spillovers into corporate interest rates. I look at the change in different measures of corporate interest rates in response to a 1 basis point rise in interest rates in the source country/zone around its monetary policy events. The corporate interest rate data are available only on a daily basis, so I look at the response of corporate interest rates from one day before to one day after or to seven days after the monetary policy event. In Panel A, I look at how AAA-rated US corporate bonds respond one day after monetary policy events. I find positive effects for all of the eight highlighted countries/zones with the strongest spillovers (p-values of <0.001). The other countries/zones show more mixed effects, but the results remain in a reasonable range. I also look at other types of corporate bonds. Panels B and C

Table 8: Spillovers into Corporate Interest Rates

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: Corporate USA AAA; 1 day before - 1 day after															
ΔI_{10y}	0.90***	0.46	0.23	0.56*	1.40***	0.12	-0.42*	0.21	0.05	-0.16	0.13	-0.28	-0.02	0.40*	0.85***
	(0.25)	(0.45)	(0.65)	(0.21)	(0.36)	(0.18)	(0.20)	(0.29)	(0.06)	(0.21)	(0.18)	(0.18)	(0.10)	(0.16)	(0.08)
N	403	160	45	182	150	274	113	227	177	113	134	181	74	149	367
Panel B: Dependent: Corporate USA BBB; 1 day before - 1 day after															
ΔI_{10y}	0.42*	0.41*	0.26	0.43*	1.41***	-0.11	-0.36	0.13	-0.25***	-0.35	0.28	-0.33	0.07	0.31*	0.67***
	(0.17)	(0.19)	(0.55)	(0.22)	(0.37)	(0.18)	(0.20)	(0.29)	(0.07)	(0.21)	(0.14)	(0.23)	(0.08)	(0.16)	(0.09)
N	403	160	45	182	150	274	113	227	177	113	134	181	74	149	367
Panel C: Dependent: Corporate Asia All; 1 day before - 1 day after															
ΔI_{10y}	0.42**	0.45*	0.52	0.49**	1.45***	-0.03	-0.02	0.31	-0.17*	-0.26	0.43*	-0.22	0.18	0.20	0.68***
	(0.15)	(0.19)	(0.50)	(0.17)	(0.38)	(0.18)	(0.24)	(0.30)	(0.08)	(0.23)	(0.19)	(0.18)	(0.11)	(0.25)	(0.14)
N	392	160	45	182	150	255	113	214	177	113	134	181	74	149	350
Panel D: Dependent: Corporate USA AAA; 1 day before - 7 days after															
ΔI_{10y}	0.57	0.60	0.87	0.08	2.20***	0.45	-0.51	1.04*	0.68***	0.30	-0.12	-0.04	-0.13	0.68**	0.90***
	(0.31)	(0.55)	(1.31)	(0.39)	(0.60)	(0.27)	(0.36)	(0.49)	(0.12)	(0.57)	(0.38)	(0.48)	(0.15)	(0.26)	(0.14)
N	399	159	45	183	150	277	117	229	174	113	134	181	75	148	366

The table shows spillovers from the main countries/zones in my panel into measures of the corporate interest rate. Each cell represents a single regression of the change in a corporate interest rate on the change in the source country/zone 10-year rate from one hour before to one hour after the monetary policy event in the source country/zone where the source country/zone is given in the column. Panels A through D consider the following corporate interest rates, respectively: US AAA corporate bonds one day before to one day after, US BBB corporate bonds one day before to one day after, all Asian corporate bonds one day before to one day after, and US AAA corporate bonds one day before to seven days after. The corporate bond interest rates are from Intercontinental Exchange (ICE). *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, ICE, Refinitiv.

show the response of BBB-rated US corporate bonds and Asian corporate bonds one day later, respectively. In Panel D, I show that even after one week, AAA-rated US corporate bonds respond positively to interest rate increases in the highlighted countries/zones with the strongest spillovers. In each panel, seven of the eight highlighted countries/zones have coefficients of at least 0.2, implying that if they raise their rates by surprise around a monetary policy event by 1 basis point, it will raise corporate interest rates by 0.2 basis points. The coefficients are less significant than in my baseline regressions because with wider time frames there is more noise; however, many countries/zones still have a significant, positive effect on corporate interest rate measures, particularly the highlighted countries/zones with relatively strong spillovers. For example, there are significant, positive spillovers from Australia, Canada, Czechia, the eurozone, and Sweden into the interest rates of US BBB-rated corporate bonds one day later. Therefore, there is evidence that spillovers from source countries/zones affect corporate interest rates in other countries/zones and that these spillovers have lasting effects. This implies that spillovers increase the cost of borrowing for both governments and firms.

That being said, only the Federal Reserve appears to affect other asset prices systematically. In table 9, I look at the change in other asset prices in response to a 1 basis point rise in interest rates in the source country/zone around its monetary policy events. I have high-frequency intraday data for the asset prices, and they are measured in the same one-hour time frame as the change in the source country/zone interest rates. In Panels A through D, I look at the response of stock prices in (other) developed countries/zones, stock prices in (other) emerging countries/zones, the gold price, and the silver price, respectively. When looking at measures of stock prices in developed/emerging countries, I exclude the source country/zone. The Federal Reserve is the only central bank that causes significant spillovers across a range of asset prices. A rise in long-term US interest rates lowers the prices of all the assets I consider, and the p-value for each of the regressions is less than 0.001. There is some evidence that other central banks' monetary policy actions affect asset prices in other countries. When long-term interest rates rise in the eurozone, stock prices in other developed countries/zones fall significantly. And when Japan's long-term interest rate rises, gold and silver prices fall significantly. However, it is clear that the Federal Reserve has stronger and more systematic effects on general asset prices compared with other central banks. I discuss why central banks other than the Federal Reserve cause spillovers into corporate rates but not other assets further in section 5.

Table 9: Spillovers into Other Asset Prices

Source	AUS	CAN	CHE	CZE	ECB	GBR	KOR	JPN	MEX	NOR	NZL	POL	ROU	SWE	USA
Panel A: Dependent: $\Delta Stock$ Developed Average (excluding Source)															
ΔI_{10y}	-0.05	1.91**	-1.43	1.80	-4.37**	-0.41	0.44	-0.03	0.58	2.24*	0.11	-1.20	0.20	-1.21	-1.73***
	(0.44)	(0.71)	(1.46)	(1.12)	(1.67)	(0.57)	(0.78)	(1.10)	(0.38)	(0.89)	(0.62)	(0.63)	(0.37)	(0.84)	(0.46)
N	397	161	45	151	150	277	118	206	178	113	124	181	75	146	349
Panel B: Dependent: $\Delta Stock$ Emerging Average (excluding Source)															
ΔI_{10y}	1.78*	1.44*	-0.64	-0.38	-1.10	-1.18*	5.26	-2.37	0.14	1.20	0.99	-0.83	-0.17	-1.27	-3.25***
	(0.88)	(0.64)	(1.63)	(0.87)	(1.54)	(0.57)	(6.11)	(2.01)	(0.46)	(0.99)	(1.33)	(0.65)	(0.33)	(0.86)	(0.67)
N	289	161	45	173	150	278	33	165	176	113	68	181	75	148	369
Panel C: Dependent: $\Delta Gold$															
ΔI_{10y}	-0.42	-0.80	-2.79	-1.23	1.51	-0.44	0.61	-1.97**	-0.45	-1.24	1.25**	-1.53*	0.84**	0.18	-6.92***
	(0.33)	(0.87)	(1.76)	(0.67)	(1.60)	(0.44)	(0.81)	(0.68)	(0.36)	(0.86)	(0.37)	(0.68)	(0.31)	(0.54)	(0.57)
N	363	161	45	182	147	272	118	228	178	114	105	181	75	147	338
Panel D: Dependent: $\Delta Silver$															
ΔI_{10y}	0.48	-0.62	-2.24	-1.54	4.29	-1.23	-0.00	-2.93*	-0.27	0.04	1.69	-0.63	1.39	-1.44	-9.36***
	(0.67)	(1.61)	(2.96)	(1.55)	(2.53)	(1.13)	(1.59)	(1.23)	(0.62)	(1.88)	(0.91)	(1.34)	(0.75)	(1.08)	(0.97)
N	340	159	45	160	133	244	118	208	178	106	96	176	75	139	314

The table shows spillovers from the main countries/zones in my panel into other asset prices. Each cell represents a single regression of the change in an asset price on the change in the source country/zone 10-year rate where the source country/zone is given in the column. The changes both for the interest rates and the other asset prices are measured in the standard one-hour time frame around monetary policy events in the source country/zone. Panel A considers the average change in stock prices in developed countries/zones excluding the source country/zone. Panel B considers the average change in stock prices in emerging countries/zones excluding the source country/zone. Panel C considers the change in the gold price. Panel D considers the change in the silver price. The additional price data are obtained from Refinitiv. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

3.6 Additional Robustness Checks

I verify that measuring the interest rates with alternative specifications does not affect the results. The default method I use to measure the change in the 10-year interest rate in a country/zone is to look at the average change in the interest rates of any bonds for that country/zone with a maturity of 7 to 13 years. In table 10, I show that measuring the 10-year interest rate with alternative nonparametric windows or using the parametric Nelson-Siegel approach yields very similar results. In Panels B and C, I consider nonparametric windows of 6 through 14 years and 8 through 12 years, respectively. In Panel D, I consider what happens when I measure the interest rates using the Nelson-Siegel estimate of the 10-year interest rate. The results are broadly very similar.[21] I show in table B.6 and table B.7 that the results with alternative windows or a parametric estimation are similar for the six-month and two-year interest rates. In table B.8, I consider spillovers for additional maturities (one year, three years, five years, seven years, nine years, and fifteen years) and find that as the maturities increase, the magnitudes of the spillovers from central banks other than the Federal Reserve rise, matching my main results.

I demonstrate that spillovers are not explained by comovements in international interest rates. One concern with my empirical approach is that even within the high-frequency time frames I consider, there could be common movements in interests rates across countries for reasons other than monetary policy spillovers from a source country to a recipient country. This could lead to significant coefficients for spillovers even when there is no spillover. Therefore, I implement an alternative specification discussed in detail in appendix A

[21] The results for Nelson-Siegel are slightly less significant because I'm unable to construct Nelson-Siegel estimates for as many points, but the estimates are similar.

Table 10: Alternative Measures of 10-Year Interest Rate

Source	AUS	CAN	CHE	CZE	ECB	GBR	KOR	JPN	MEX	NOR	NZL	POL	ROU	SWE	USA
Panel A: Dependent: ΔI_{7y-13y} Developed Average (excluding Source)															
ΔI_{7y-13y}	0.14***	0.19***	0.23***	0.12***	0.60***	0.19***	0.10*	0.18*	0.03*	0.09**	0.05*	0.05*	0.03*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	386	161	45	187	150	279	118	232	178	114	130	181	75	149	373
Panel B: Dependent: ΔI_{6y-14y} Developed Average (excluding Source)															
ΔI_{6y-14y}	0.13***	0.18***	0.22***	0.11***	0.59***	0.19***	0.10*	0.19*	0.02	0.11***	0.04*	0.05*	0.01	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.07)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	391	161	45	194	150	279	119	244	190	115	133	182	86	151	373
Panel C: Dependent: ΔI_{8y-12y} Developed Average (excluding Source)															
ΔI_{8y-12y}	0.15***	0.21***	0.23***	0.13***	0.62***	0.20***	0.12**	0.18*	0.02	0.10**	0.05*	0.06*	0.03	0.18***	0.50***
	(0.02)	(0.02)	(0.05)	(0.03)	(0.04)	(0.02)	(0.04)	(0.07)	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	384	161	45	173	150	279	117	230	168	111	120	179	70	149	373
Panel D: Dependent: ΔI_{10y} Nelson-Siegel Developed Average (excluding Source)															
ΔI_{10y} (NS)	0.12***	0.20***	0.22***	0.13***	0.58***	0.19***	0.04	0.24***	0.08*	0.12**	0.06*	0.07**	0.02	0.21***	0.55***
	(0.03)	(0.03)	(0.05)	(0.04)	(0.05)	(0.02)	(0.08)	(0.06)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
N	271	143	45	104	149	274	43	147	20	81	83	131	44	74	334

The table shows spillovers from the main countries/zones in my panel into the interest rates in other developed countries/zones. Each cell represents a single regression of the change in the average 10-year rate in (other) developed countries/zones on the change in the source country/zone 10-year rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panel A measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of 7 to 13 years, which is the standard measure. Panel B measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of 6 to 14 years. Panel C measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of 8 to 12 years. Panel D measures the changes in the interest rates using the Nelson-Siegel estimate of the 10-year interest rate. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

to test for the existence of spillovers while controlling for comovement.[22] The basic idea of the alternative specification is that I remove the degree to which the source country/zone interest rate would change in response to this common comovement before conducting the spillover regressions. I present these results in table 11. Panels A, C, and E show the baseline results, while Panels B, D, and F show the coefficients when I test for comovement. The three pairs of panels (A/B, C/D, and E/F) look at six-month, two-year, and ten-year interest rate regressions, respectively. I find that removing the positive comovement between interest rates makes very little difference for my estimates or their significance, and therefore comovement does not explain why I find significant relationships. For the six-month and two-year rates (Panels A/B and Panels C/D), all countries that had a significant effect without controlling for comovement continue to have a significant effect once I control for comovement. For the 10-year rates, 12 of the 15 countries/zones that were significant without removing the comovement remain significant at the 5 percent level, and two of the other countries/zones are significant at the 10 percent level.[23] The coefficients also generally remain very similar. Therefore, I am confident that the high-frequency identification approach generally identifies spillovers as opposed to spurious comovement between interest rates.

Figure B.2 in the appendix displays scatter plots of the relationship between the change in the 10-year interest rate in the source country/zone and the average change in the 10-year interest rate in (other) developed countries/zones.[24] I show spillovers from the countries/zones where I find significant spillovers. The plots show the relationships hold broadly and are not driven by outliers.

[22]Note that the coefficients from the specification are not a consistent estimate of the spillover coefficient due to the presence of additional terms, which is why I do not use them as my primary specification.

[23]The one exception is the 10-year rate regression for Japan. This could be because Japan has quite small movements in its interest rates. The test is more likely to interpret these small movements as being due to comovement compared with larger movements in interest rates around monetary policy announcements.

[24]This corresponds to the regressions in Panel C in table 2 and table 3. I am particularly interested in this maturity and the impact on developed country interest rates because this is where I find the strongest spillovers.

Table 11: Controlling for Interest Rate Comovements

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: ΔI_{6m} Developed Average (excluding Source)															
ΔI_{6m}	0.05	0.03	0.06	-0.00	0.14**	0.05**			-0.02	0.01	-0.03	-0.01	-0.01	0.05	0.26***
	(0.04)	(0.02)	(0.03)	(0.01)	(0.05)	(0.02)			(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.03)	(0.04)
N	164	105	37	158	91	221			28	80	110	101	47	55	270
Panel B: Dependent: ΔI_{6m} Developed Average (excluding Source); Controlling for Comovement															
ΔI_{6m}	0.04	0.03	0.06	-0.00	0.13*	0.05**			-0.02	0.01	-0.03	-0.01	-0.01	0.05	0.24***
	(0.04)	(0.02)	(0.03)	(0.01)	(0.05)	(0.02)			(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.03)	(0.04)
N	164	105	37	158	91	212			29	79	110	101	47	56	270
Panel C: Dependent: ΔI_{2y} Developed Average (excluding Source)															
ΔI_{2y}	0.08***	0.06***	0.10***	0.01	0.28***	0.12***	-0.04	0.11	-0.00	0.05**	0.01	0.00	-0.01	0.06***	0.50***
	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)	(0.05)	(0.12)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)
N	359	160	45	182	149	279	134	236	71	97	140	160	76	135	368
Panel D: Dependent: ΔI_{2y} Developed Average (excluding Source); Controlling for Comovement															
ΔI_{2y}	0.06**	0.05***	0.10***	0.01	0.24***	0.11***	-0.04	-0.38***	-0.01	0.04**	0.01	0.00	-0.01	0.05***	0.52***
	(0.02)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.05)	(0.11)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
N	359	160	45	182	149	274	134	236	71	98	139	159	75	134	367
Panel E: Dependent: ΔI_{10y} Developed Average (excluding Source)															
ΔI_{10y}	0.14***	0.19***	0.23***	0.12***	0.60***	0.19***	0.10*	0.18*	0.03*	0.09**	0.05*	0.05*	0.03*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	386	161	45	187	150	279	118	232	178	114	130	181	75	149	373
Panel F: Dependent: ΔI_{10y} Developed Average (excluding Source); Controlling for Comovement															
ΔI_{10y}	0.09***	0.15***	0.22***	0.11***	0.42***	0.17***	0.07	-0.09	0.03*	0.06	0.04*	0.05*	0.04*	0.16***	0.58***
	(0.02)	(0.03)	(0.05)	(0.03)	(0.09)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
N	386	161	45	187	150	278	118	232	178	115	129	181	76	148	372

The table shows spillovers from the main countries/zones in my panel into the interest rates of other developed countries/zones. Each cell represents a single regression of the change in the average interest rate in (other) developed countries/zones on the change in the source country/zone interest rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panels A, C, and E use the standard specification, while Panels B, D, and F use the alternative specification explained in appendix A, where I control for comovements in interest rates for reasons other than monetary policy spillovers. Panels A and B, C and D, and E and F conduct regressions with the six-month, two-year, and ten-year interest rates, respectively. Panels *, **, and *** represent a significance of $< 0.05, 0.01$, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

4 Determinants of Spillovers

4.1 Which Part of the Yield Curve Drives Spillovers?

I investigate the degree to which changes in different parts of the yield curve cause spillovers. In table 12, I regress the change in the average interest rate in (other) developed countries/zones on different components of the 10-year source country/zone interest rate. Panel A shows the standard regression, while Panels B, C, and D include the change in the source country/zone's two-year and two- to ten-year forward rates.[25] Panel B shows that the United States and the eurozone are the only countries/zones where changes in short-term interest rates play a significant role in determining their spillovers into the 10-year rate in other countries/zones. The short-term rate explains a larger share for the United States than for the eurozone. Panel C reveals that the United States and Australia are the only countries/zones where the spillovers that their central banks cause are explained more by the change in the two-year rate than by the the change in the two- to ten-year forward rate. Panel D yields results similar to those in Panel B.

The results in table 12 demonstrate that only monetary policy surprises at non-Fed central banks to the long-term part of the yield curve, that is, changes in interest rates beyond the immediate two years, appear to cause spillovers. This implies that if a non-Fed central bank surprises markets by changing its policy rate,

[25] By two- to ten-year forward rate, I mean the two- to ten-year part of the yield curve; that is, $\text{TwotoTenYearForwardRate}_t = \frac{10 \times \text{TenYearRate}_t - 2 \times \text{TwoYearRate}_t}{10-2}$.

Table 12: Spillover Impacts across the Yield Curve

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: ΔI_{10y} Developed Average (excluding Source)															
ΔI_{10y}	0.14***	0.19***	0.23***	0.12***	0.60***	0.19***	0.10*	0.18*	0.03*	0.09**	0.05*	0.05*	0.03*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	386	161	45	187	150	279	118	232	178	114	130	181	75	149	373
Panel B: Dependent: ΔI_{10y} Developed Average (excluding Source)															
ΔI_{2y}	0.02	-0.01	0.03	0.02	0.12***	0.02	-0.06	0.20	-0.00	-0.01	-0.01	0.00	-0.04	0.01	0.25***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.05)	(0.15)	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
$\Delta I_{2-10yforward}$	0.11***	0.24***	0.21***	0.14***	0.49***	0.17***	0.13**	0.09	0.02	0.15*	0.06*	0.05*	0.04*	0.16***	0.30***
	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)	(0.02)	(0.05)	(0.09)	(0.02)	(0.06)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
N	364	160	45	136	149	277	113	193	65	95	127	157	60	122	369
Panel C: Dependent: ΔI_{2y} Developed Average (excluding Source)															
ΔI_{2y}	0.09***	0.02	0.05	0.01	0.22***	0.07***	-0.09	0.02	-0.00	-0.01	-0.00	-0.01	-0.01	0.01	0.47***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.06)	(0.15)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.03)
$\Delta I_{2-10yforward}$	-0.05	0.12***	0.17**	0.11**	0.25***	0.09***	0.11*	0.08	0.00	0.14**	0.03	0.05*	0.03	0.15***	0.03
	(0.04)	(0.04)	(0.05)	(0.03)	(0.04)	(0.02)	(0.06)	(0.09)	(0.02)	(0.05)	(0.04)	(0.02)	(0.02)	(0.03)	(0.03)
N	359	160	45	136	149	277	113	191	65	95	126	157	60	122	367
Panel D: Dependent: $\Delta I_{2-10yforward}$ Developed Average (excluding Source)															
ΔI_{2y}	0.00	-0.01	0.02	0.02	0.09**	0.00	-0.05	0.25	-0.00	-0.01	-0.01	0.01	-0.05*	0.01	0.19***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.05)	(0.17)	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
$\Delta I_{2-10yforward}$	0.15***	0.27***	0.22***	0.14***	0.55***	0.19***	0.13**	0.09	0.02	0.16*	0.07*	0.05	0.05*	0.16***	0.36***
	(0.03)	(0.04)	(0.06)	(0.03)	(0.05)	(0.02)	(0.05)	(0.11)	(0.02)	(0.06)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
N	349	160	45	136	149	277	113	191	65	95	124	157	60	122	367

The table shows spillovers from the main countries/zones in my panel to the interest rates in other developed countries. Each cell represents a single regression of the change in the average interest rate in developed countries/zones (excluding the source country/zone) on changes in the source country/zone interest rates where the source country/zone is given in the column. All regressions use the standard one-hour time frame. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively.

but markets believe this change will have temporary effects, it would cause few spillovers. This differs from the spillovers caused by the Federal Reserve, where movements in short-term interest rates, such as surprise policy rate changes, do cause large spillovers. As I discuss further in section 5, this implies that the Federal Reserve must spill over through channels that are in addition to those through which non-Fed central banks spill over.

4.2 Determinants of Which Central Banks Cause Spillovers

In this section, I investigate which factors determine the size of spillovers. I start by looking at why some central banks cause spillovers and others do not. I regress the change in the average interest rate in developed countries/zones (excluding the source country/zone) on the change in the interest rate in the source country/zone interacted with a variety of explanatory variables (see equation (2)). I limit the analysis to a few variables because there are only 20 countries/zones in my analysis across which I can consider differences. I present results for this analysis in table 13. I find that gross domestic product (GDP), GDP per capita, and population relative to the United States are all associated with larger monetary policy spillovers. When I include all three of these variables together, I find the most important factor determining whether a country/zone's monetary policy events causes spillovers is the size of that country/zone's GDP. These results are not surprising and match what I find in section 3.2. In that table, I found that the central banks that cause spillovers are in medium- to high-income countries/zones and that central banks in larger countries cause larger spillovers. In particular, the Federal Reserve and the European Central Bank cause the largest monetary policy spillovers and are in the countries/zones with the largest GDPs in my sample.

Table 13: Determinants of the Size of Spillovers from a Source Country/Zone

ΔI_{10y} Developed Average (excluding Source)	(1)	(2)	(3)	(4)	(5)
ΔI_{10y} Source	0.153***	0.046**	-0.017	0.055	0.011
	(0.006)	(0.016)	(0.033)	(0.042)	(0.011)
ΔI_{10y} Source * $\frac{GDP_{source}}{GDP_{USA}}$		0.466***			0.455***
		(0.021)			(0.031)
ΔI_{10y} Source * $\frac{GDPpercap_{source}}{GDPpercap_{USA}}$			0.297*		0.091***
			(0.123)		(0.017)
ΔI_{10y} Source * $\frac{Pop_{source}}{Pop_{USA}}$				0.298*	-0.044
				(0.149)	(0.024)
N	3189	3065	3065	3189	3065

In this table, I regress the change in the average 10-year interest rate in developed countries/zones (excluding the source country/zone) on the change in the source country/zone 10-year interest rate interacted with a variety of variables. The interaction variables are the total GDP of the country/zone divided by the total US GDP in the same year, the per capita GDP of the country/zone divided by the US per capita GDP in the same year, and the population of the source country/zone divided by the US population in the same year. The GDP and population data come from the IMF International Financial Statistics data set. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. I cluster standard errors by source country/zone. Sources: Bloomberg, GovPX, IMF, Refinitiv.

$$\Delta I_{10y,DevAve,t} = \beta \Delta I_{10y,s,t} + \gamma_1 \Delta I_{10y,s,t} * \frac{GDP_s}{GDP_{USA}} + \gamma_2 \Delta I_{10y,s,t} * \frac{GDPpercap_s}{GDPpercap_{USA}} + \gamma_3 \Delta I_{10y,s,t} * \frac{Pop_s}{Pop_{USA}} + u_{s,t} \quad (2)$$

4.3 Determinants of Bilateral Spillovers

I also investigate which factors determine the size of bilateral spillovers, that is, the degree to which a central bank impacts different recipient countries/zones. To do this, I regress the change in a recipient's 10-year interest rate on the change in a source's 10-year interest rate interacted with potential explanatory variables around monetary policy events in the source country/zone (see equation (3)). I consider a limited number of factors because I want to look at which factors determine how much recipients respond to spillovers from the Federal Reserve alone, and I have only a limited number of recipient countries/zones to consider. I consider factors relating to location (the difference in the time zone between the source and the recipient), economic links (the share of exports from the source that go to the recipient), and cultural factors (a measure of religious similarity).[26] I also include dummy variables for the source country/zone because I want to find which factors explain why a bilateral relationship may be stronger while taking into account that the central banks of some source countries/zones cause larger spillovers generally.

[26]These factors are taken from the CEPII Gravity data set, which relates to work in Head, Mayer, and Ries (2010) and Head and Mayer (2014).

Table 14: Determinants of the Size of Bilateral Spillovers

ΔI_{10y} Global	(1)	(2)
ΔI_{10y} * Timezone Difference	0.001	0.135***
	(0.007)	(0.027)
ΔI_{10y} * $\frac{Exports_{source \to dest.}}{TotalExports_{source}}$	0.214	3.980***
	(0.144)	(0.811)
ΔI_{10y} * Religious Similarity	0.243**	1.170*
	(0.094)	(0.456)
N	7784	953
ΔI_{10y} * Source Country/Zone Dummies	*	*
Source Zones	Dev. except USA	USA

In this table, I regress the change in the recipient 10-year interest rate (excluding the source country/zone) on the change in the source country/zone 10-year interest rate interacted with a variety of variables plus interactions with the dummy variables for each source country/zone. The interaction variables are the distance between the capital cities of the source and the recipient, the difference in hours of the time zones relative to GMT, the proportion of exports from the source that go to the recipient, the religious similarity between the source and the recipient, and whether the legal systems of the source and recipient countries/zones have a common origin. The interaction variables are taken from the CEPII Gravity data set. I conduct the regression for countries/zones in my panel that are classified as developed by MSCI. The first column conducts the regression for all developed countries/zones excluding the United States, and the second conducts it for the United States. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. I cluster standard errors by source/destination country/zone. Sources: Bloomberg, CEPII, GovPX, Refinitiv.

$$\Delta I_{10y,r,t} = \sum_s \beta_s \Delta I_{10y,s,t} * Zone_s + \gamma_1 \Delta I_{10y,s,t} * TimezoneDiff_{s,r} + \gamma_2 \Delta I_{10y,s,t} * \frac{Exports_{s \to r}}{TotalExports_s} + \gamma_3 \Delta I_{10y,s,r} * ReligiousSimilarity_{s,r} + u_{s,r} \quad (3)$$

Table 14 presents the results on the causes of bilateral spillovers for the United States and other developed countries/zones, separately. For the United States, all three factors are significant. A country/zone that is in a time zone farther from the United States, that receives a larger volume of exports from the United States, and that has greater religious similarity to the United States experiences larger spillovers. It is surprising that being in a more distant timezone magnifies spillovers, but the direction of this coefficient may result from its interaction with the trade control, because if a country/zone is in a more distant time zone but has the same volume of trade with the United States as other, less distant countries do, that country/zone is likely more economically linked to the United States. So being in a more distant time zone may be an additional proxy for economic links. For other developed countries/zones, the only factor that is significant is religious similarity. Therefore, it appears that cultural factors are relatively more important in explaining bilateral spillovers that do not originate from the Federal Reserve. I discuss this idea further in section 5.

5 Implications for the Channel of Monetary Policy Spillovers

Table 15 summarizes differences between spillovers caused by the Federal Reserve and those caused by other central banks. The Federal Reserve causes spillovers into developed- and emerging-market sovereign bonds, to corporate bonds, to global stock markets, and to gold and silver. In contrast, the policies of other central banks spill over to a more limited range of assets: developed-market sovereign bonds and corporate bonds. Similarly, the manner in which the Federal Reserve affects interest rates is broader. The Federal Reserve causes

Table 15: Summary of Differences between Spillovers Caused by the Federal Reserve and Other Central Banks

		Section	USA	Other Central Banks
Asset Type	Spillovers to developed sovereign bonds	3.1	✓	✓
	Spillovers to emerging sovereign bonds	3.1	✓	Mostly no
	Spillovers to corporate bonds	3.5	✓	✓
	Spillovers to global stockmarkets	3.5	✓	Mostly no
	Spillovers to gold/silver	3.5	✓	Mostly no
Int. Rates	Spillovers to short-term rates	3.2	✓	Mostly no
	Spillovers to medium/long-term rates	3.2	✓	✓
	Parts of yield curve causing spillovers	4.1	Short-Term, Long-Term	Long-Term
	Bilateral factors associated with spillovers	4.3	Economic links, Cultural links	Cultural links

spillovers through monetary policy surprises to its short-term and long-term interest rates, and these spill over into short-term, medium-term, and long-term interest rates. In contrast, non-Fed central banks cause spillovers through monetary policy surprises to their longer-term interest rates, and these spill over largely into medium-term and long-term interest rates. Cultural links between countries/zones play a smaller role in determining the size of spillovers from the Federal Reserve versus those from other central banks.

Central banks other than the Federal Reserve appear to cause spillovers through a bond-pricing channel. If a central bank lowers its interest rates, bonds in other countries/zones become more attractive, all else being equal. In this case, similar bonds in other countries/zones rise in price, and therefore their rates fall. Investors have specific preferences regarding the types of bonds they wish to hold, so this would primarily affect similar bonds in similar countries/zones. Therefore, if interest rates fall in a developed country/zone, the spillovers would affect similar developed countries/zones and particularly countries/zones with cultural links to the source country/zone. In the short-term, bond prices in other markets are pinned down by the expected path of interest rates and are unlikely to be affected substantially by this bond-pricing channel. However, for medium-term and long-term bonds for which term premia play a more important role in determining prices, these effects can have a stronger effect. Corporate borrowing rates are determined to a large degree by interest rates on domestic sovereign bonds, so spillovers that affect sovereign bond rates also affect corporate borrowing rates. A reasonable question to ask is, Why, if spillovers raise government and corporate borrowing costs, do they not also spill over into other asset prices? One simple answer is that the existence of significant spillovers from central banks other than the Federal Reserve is not well known as has been demonstrated by the literature review in this paper. Therefore, this narrow bond-pricing channel can explain why spillovers from other central banks are larger in developed countries/zones, why they affect corporate bonds but not other assets, why they affect medium-term and long-term rates through changes to the longer-term part of their yield curve, and why they are larger between countries with stronger cultural links.

Non-Fed central banks do not seem to cause spillovers through information effects. One other potential channel through which a central bank could cause spillovers is by conveying information about the likely path of interest rate movements at other central banks. This conveyance of information could result from central banks holding meetings at different times, enabling markets to gather information from one central bank meeting about another central bank's next meeting. Another specific example of these information effects would be an exchange rate peg compelling other central banks to change interest rates to match those in the source country/zone. However, these information effects would involve short-term interest rates mostly, and I generally do not observe non-Fed central banks causing sizeable spillovers into short-term interest rates as opposed to medium- and long-term interest rates. An alternative consideration is that the information effects involve broader economic indicators, such as economic growth. However, in this case, these information effects would have important implications for non-bond assets including stocks and commodity prices, and I find essentially no evidence of this. Therefore, information effects do not seem to be a channel through which non-Fed central banks cause spillovers.

The Federal Reserve seems to cause spillovers through additional channels. Unlike non-Fed central banks, the Federal Reserve causes pronounced spillovers to short-term interest rates including those in emerging markets. One explanation for this distinction is that when the Federal Reserve raises interest rates, markets expect that central banks in other developed countries/zones and emerging countries will do the same. Such expectation could be the result of many countries/zones having some form of exchange rate peg to the United States: If the Federal Reserve raises interest rates, those countries do the same to maintain the peg. Another channel for spillovers could involve the Federal Reserve's role as the bellwether for views about the global economy, such that if the Federal Reserve raises interest rates, it becomes more likely that other central banks will do so. As I show in Cotton (2022b), changes in short-term interest rates around monetary policy meetings are more important in driving asset prices compared with changes in long-term interest rates, so asset prices respond more to the short-term spillovers from the Federal Reserve than the long-term spillovers from other central banks. Thus, the additional channels help to explain why the Federal Reserve also impacts short-term rates, emerging markets, and other asset prices.

6 Conclusion

The literature focuses primarily on how monetary policy spillovers from the Federal Reserve affect other countries; only a limited amount of research studies the degree to which several other central banks cause interest rate spillovers. In this paper, I measure the degree to which 20 countries/zones cause spillovers. To do this, I use a high-frequency identification approach looking at the intraday movement of interest rates in source and recipient countries/zones around monetary policy announcements in source countries/zones. To my knowledge, this is the first paper to assess the existence and size of interest rate spillovers across a wide range of countries/zones. Contrary to the standard view that the Federal Reserve is the primary source of monetary policy spillovers, I demonstrate that 14 other central banks show evidence of causing monetary policy spillovers. I find that the United States explains only one-fifth of monetary policy spillovers into 10-year interest rates but explains a much larger share of spillovers into short-term rates. Also in contrast to the standard view that the Federal Reserve is primarily responsible for causing spillovers and may experience "spillbacks" of its own monetary policy but not substantial monetary policy spillovers from other central banks, I show that US interest rates are affected by large spillovers. These results hold over tight windows of no more than 20 minutes before and after monetary policy events to as long as a week afterward for sovereign and corporate bond interest rates, across different interest rate measures, and when controlling for potential comovement between bonds. That being said, spillovers from the Federal Reserve have broader effects—impacting emerging-market and short-term interest rates and other asset prices.

I look at the determinants of monetary policy spillovers across central banks and find that central banks other than the Federal Reserve cause spillovers primarily through monetary policy surprises to the long-term part of their country's/zone's yield curve. I also find that the degree to which a country/zone causes spillovers is related most strongly to the size of its gross domestic product. And I find that cultural factors are relatively important in determining the size of spillovers from central banks other than the Federal Reserve.

Overall, my results imply that central banks other than the Federal Reserve spill over primarily through the bond-pricing channel. When a central bank lowers its interest rates, this makes comparable bonds in developed countries/zones more appealing, which can raise their prices and lower their interest rates. This effect is stronger for long-term bonds because prices of long-term bonds are pinned down much less by the expected path of interest rates compared with short-term bonds. And corporate bond prices are determined to a large degree by long-term sovereign bond rates. The Federal Reserve policies appear to spill over through additional channels, which is why it affects emerging-market and short-term interest rates, and other asset prices.

This paper fits more broadly into the literature looking at the causes of the global financial cycle. Much of this literature focuses on the importance of Federal Reserve monetary policy. This paper's goal is to demonstrate that a much wider range of central banks is causing monetary policy spillovers and therefore playing a part in stimulating the global financial cycle, but through a narrower channel than the Federal Reserve. I hope this paper may inspire further work looking at the role that other countries have in driving the global financial cycle.

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Appendices

A Alternative Specification

To show more formally how the test works, I introduce some notation. As shown in equation (A.1), the change in the interest rate in the source country/zone, ΔI_s, is some combination of changes due to monetary policy announcements, ΔI_s^{MPS}, and changes for other reasons, ΔI_s^o. As shown in equation (A.2), the change in the recipient country/zone's interest rate can also be broken into the component due to changes in monetary policy in the source country, $\beta_r \Delta I_s^{MPS}$, and changes for other reasons, ΔI_r^o.[27] Outside of the monetary policy events I consider, $\Delta I_s^{MPS} = 0$ by definition.

$$\Delta I_s = \Delta I_s^{MPS} + \Delta I_s^o \tag{A.1}$$

$$\Delta I_r = \beta_r \Delta I_s^{MPS} + \Delta I_r^o \tag{A.2}$$

Next, the change in the non-monetary-policy-shock part of interest rates for both the source country/zone and the recipient can be rewritten as the part correlated with the other's interest rate and a residual in equation (A.3) and equation (A.4). I assume that there is some comovement so that $\nu_s, \nu_r > 0$:

$$\Delta I_s^o = \nu_s \Delta I_r^o + u_s \tag{A.3}$$

$$\Delta I_r^o = \nu_r \Delta I_s^o + u_r \tag{A.4}$$

Equation (A.5) expresses the primary specification in simplified notation (equation (1)). The identification assumption in the primary specification is that the movement of interest rates in the source country/zone in this window is basically just due to monetary policy changes ($\Delta I_s \approx \Delta I_s^{MPS}$) because a small enough time frame is used so that ΔI_s^o can be disregarded. However, if instead other factors drive interest rates in this period ($\Delta I_s^o, I_r^o \neq 0$), then the estimate for spillovers will be biased upward and potentially estimated to be positive ($\hat{\gamma} > 0$), even if there are no spillovers ($\beta_r = 0$), because the other factors that drive interest rates are correlated (ΔI_s^o is a function of ΔI_r^o, as shown in equation (A.3)). Therefore, monetary policy spillovers could

[27] I simplify this specification by ignoring maturity and time and by excluding intercept terms.

incorrectly be found to exist due to the general comovement of world interest rates.

$$\Delta I_r = \gamma \Delta I_s + v \tag{A.5}$$

To test for the existence of spillovers while controlling for comovement, I assume any spillovers are due to comovement and then remove them. If there are no spillovers, the expected comovement in the source interest rate that is associated with a change in the recipient interest rate is just $\hat{\nu}_s \hat{I}_r$. This comes from equation (A.3). I can then remove this from the change in the source interest rate before running the standard spillover regression. This is shown in equation (A.6). Inputting equations (A.1) to (A.3) demonstrates that this specification is equivalent to running equation (A.7). If there are no spillovers ($\beta_r = 0$), the two terms relating to ΔI_r^o cancel out in the limit so the coefficient estimate is zero ($\hat{\delta} = 0$). The only way to find a positive coefficient ($\delta > 0$) is if there are monetary policy spillovers; that is, $\beta_r > 0$. Therefore, I apply this specification to test for the existence of monetary policy spillovers while controlling for comovement. That being said, this is not a consistent estimate of the impact of ΔI_s^{MPS} on δI_r due to the presence of the additional terms in equation (A.7), which is why I do not use this as my primary specification.

$$\Delta I_r = \delta(\Delta I_s - \hat{\nu}_s \Delta I_r) + z_r \tag{A.6}$$

$$\Delta I_r = \delta((1 - \hat{\nu}_s \beta_r)\Delta I_s^{MPS} + \nu_s \Delta I_r^o + u_s - \hat{\nu}_s \Delta I_r^o) + z_r \tag{A.7}$$

B Measuring Spillovers: Additional Results

B.1 Impact on Global Rates: Additional Results

B.1.1 Alternative Measure of Developed and Emerging Rates

My results hold when I measure the interest rates in developed and emerging countries/zones differently. In my main analysis, I regress the average change in other developed/emerging countries on the source country/zone. I do this by taking the average of the change in the interest rate for whichever countries/zones have data available. An alternative approach is to conduct a regression of the change in interest rates in the panel of developed countries/zones (excluding the source) on the change in the interest rate in the source country/zone. This regression then takes individual countries/zones as the dependent rather than an average of them. Using this alternative approach, I repeat the analysis in table 2 and table 3 in table B.1 and table B.2, respectively. This regression includes more points because I consider the impact on each country/zone separately without averaging. Otherwise, the results are very similar.

Table B.1: Alternative Measure of the Impact of Spillovers from Developed Countries/Zones

Source	**AUS**	**CAN**	**CHE**	**ECB**	**GBR**	**JPN**	**NOR**	**NZL**	**SWE**	**USA**
Panel A: Dependent: ΔI_{6m} Developed (excluding Source)										
ΔI_{6m}	0.02	0.03*	0.07***	0.15*	0.06**		0.01	-0.02	0.05	0.23*
	(0.03)	(0.01)	(0.02)	(0.06)	(0.02)		(0.02)	(0.03)	(0.03)	(0.11)
N	323	411	142	357	681		334	231	222	534
Panel B: Dependent: ΔI_{2y} Developed (excluding Source)										
ΔI_{2y}	0.06*	0.06***	0.10***	0.28***	0.12***	0.13	0.05**	0.02	0.06*	0.44***
	(0.02)	(0.01)	(0.03)	(0.04)	(0.02)	(0.10)	(0.02)	(0.01)	(0.02)	(0.05)
N	823	928	265	848	1504	757	565	382	827	987
Panel C: Dependent: ΔI_{10y} Developed (excluding Source)										
ΔI_{10y}	0.12***	0.19***	0.23***	0.59***	0.19***	0.15*	0.09**	0.05*	0.17***	0.47***
	(0.03)	(0.03)	(0.05)	(0.08)	(0.02)	(0.07)	(0.03)	(0.02)	(0.03)	(0.04)
N	774	1046	282	942	1693	673	733	361	941	1040
Panel D: Dependent: ΔI_{6m} Emerging										
ΔI_{6m}	-0.03	0.02	-0.08	-0.12	-0.34*		0.17	-0.04	-0.08	0.19
	(0.15)	(0.05)	(0.13)	(0.19)	(0.15)		(0.17)	(0.04)	(0.04)	(0.12)
N	82	259	133	262	595		194	75	207	252
Panel E: Dependent: ΔI_{2y} Emerging										
ΔI_{2y}	0.04	0.04	-0.04	0.03	-0.02	-0.20	0.03	0.11	0.02	0.39***
	(0.09)	(0.02)	(0.07)	(0.07)	(0.05)	(0.33)	(0.06)	(0.09)	(0.04)	(0.08)
N	573	805	292	530	1227	312	433	149	917	431
Panel F: Dependent: ΔI_{10y} Emerging										
ΔI_{10y}	0.05	0.02	-0.07	0.29**	-0.03	0.31	0.02	0.17	0.16*	0.33**
	(0.04)	(0.03)	(0.06)	(0.11)	(0.05)	(0.19)	(0.05)	(0.14)	(0.07)	(0.11)
N	740	1005	314	631	1316	393	591	175	1086	591

This table repeats the analysis in Panels A through C and Panels G through I of table 2, except that I look at the impact on recipient countries/zones separately rather than looking at the average change in the interest rates in developed/emerging countries/zones. Therefore, the dependent variable is the change in the interest rate around the monetary policy event in individual developed countries/zones rather than the average change in developed countries/zones. I exclude Japan in regressions where the independent variable is measured at the six-month maturity because it was at the zero lower bound throughout the sample period. Standard errors are clustered by each monetary policy event in the source country/zone. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

Table B.2: Alternative Measure of Global Impact of Spillovers from Emerging Countries/Zones

Source	BRA	CHN	**CZE**	HUN	ISR	**KOR**	**MEX**	**POL**	**ROU**	ZAF
					Panel A: Dependent: ΔI_{6m} Developed					
ΔI_{6m}	-0.01	-0.01	-0.01	0.01	-0.02		-0.02	-0.01*	-0.01	-0.01
	(0.03)	(0.02)	(0.01)	(0.03)	(0.05)		(0.01)	(0.01)	(0.02)	(0.01)
N	24	30	674	55	155		141	437	189	113
					Panel B: Dependent: ΔI_{2y} Developed					
ΔI_{2y}	0.03	-0.03	0.01	-0.01	0.00	-0.06	-0.00	0.00	-0.01	0.01
	(0.06)	(0.02)	(0.01)	(0.01)	(0.00)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)
N	43	72	1124	1107	719	462	424	1074	520	694
					Panel C: Dependent: ΔI_{10y} Developed					
ΔI_{10y}	-0.05	-0.06	0.13**	-0.01	0.03	0.11*	0.02	0.06	0.03**	0.02
	(0.05)	(0.09)	(0.05)	(0.03)	(0.02)	(0.04)	(0.01)	(0.03)	(0.01)	(0.01)
N	50	126	1325	1285	805	397	1149	1346	559	806
					Panel D: Dependent: ΔI_{6m} Emerging (excluding Source)					
ΔI_{6m}		-0.08	-0.05	-0.08	-0.21		-0.03	0.08	-0.00	-0.14
		(0.26)	(0.06)	(0.13)	(0.20)		(0.08)	(0.04)	(0.04)	(0.16)
N		13	306	41	124		59	214	121	63
					Panel E: Dependent: ΔI_{2y} Emerging (excluding Source)					
ΔI_{2y}	-0.86*	0.39	0.02	-0.03	0.00	0.26	0.02	-0.00	-0.03	0.02
	(0.40)	(0.24)	(0.05)	(0.04)	(0.03)	(0.20)	(0.02)	(0.05)	(0.02)	(0.02)
N	12	37	570	718	500	254	265	654	381	442
					Panel F: Dependent: ΔI_{10y} Emerging (excluding Source)					
ΔI_{10y}	0.10***	0.08	0.04	0.02	-0.08	0.04	0.04	0.13**	-0.03	0.06
	(0.02)	(0.11)	(0.07)	(0.04)	(0.05)	(0.06)	(0.03)	(0.04)	(0.02)	(0.04)
N	11	99	696	952	666	313	737	887	448	593

This table repeats the analysis in table 3 except that I look at the impact on recipient countries/zones separately rather than looking at the average change in the interest rates in developed/emerging countries/zones. Therefore, the dependent variable is the change in the interest rate around the monetary policy event in individual emerging countries/zones rather than the average change in emerging countries/zones. Standard errors are clustered by each monetary policy event in the source country/zone. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

B.2 Alternative Measure of Spillover Share

In table 4, I provide a measure of the degree to which countries/zones cause spillovers. This is based on the coefficients in the baseline spillover regressions. One problem with this is that some countries/zones may move their interest rates more than others in practice and therefore cause more spillovers. I provide an alternative measure of spillover shares taking this into account. To do this, I estimate the total change in the interest rate around monetary policy events in my sample for each country/zone for the 2010–2019 period by multiplying the average absolute change in the interest rate during this period by the number of monetary policy meeting events in my sample for each country/zone.[28] I then multiply the total change in the interest rate around monetary policy events by the coefficient for the degree to which these domestic interest rate changes cause spillovers in table 2 and table 3. I show the results in table B.3. I prefer the method in table 4 to that in table B.3 because monetary policy may change outside of events in my sample (during other monetary policy guidance or because some countries/zones follow a more rule-based monetary policy), and because the main table is easier to understand conceptually. However, the results are fairly similar. One difference is that the eurozone explains a smaller share of 10-year spillovers in table B.3 because the movements in interest rates

[28]Note that I exclude meeting minutes when counting the number of events because these are available only for some countries/zones.

Table B.3: Share of Global Spillovers in 2010–2019

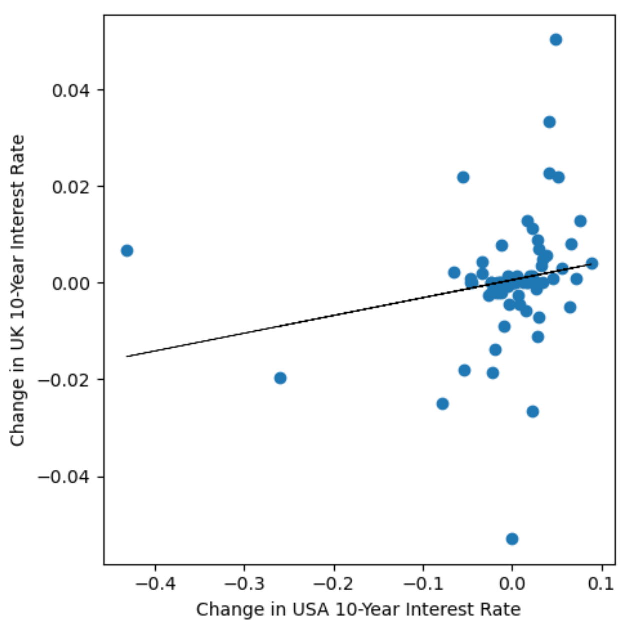
	AUS	CAN	CHE	CZE	ECB	GBR	KOR	JPN	MEX	NOR	NZL	POL	ROU	SWE	USA
A. ΔI_{6m} Developed					22.6	18.1									59.3
B. ΔI_{2y} Developed	8.0	6.9	5.1		16.8	11.1				5.6				4.0	42.5
C. ΔI_{10y} Developed	6.0	7.7	4.3	3.4	16.3	10.2	3.5	5.6	2.0	3.6	3.0	2.4	1.6	5.0	25.4

This table shows the share of global spillovers by maturity during the 2010–2019 period. To compute this, I start with the coefficient for a source country in table 2 and table 3. Non-significant coefficients are set to zero, and coefficients that can be explained by comovement are dropped. I then multiply these coefficients by the estimated total change in domestic interest rates around monetary policy events in the 2010–2019 period. I then divide the coefficients by the sum of all coefficients and multiply by 100. I do this for each maturity separately. Rows A, B, and C correspond to the share of spillovers of each source country/zone into the six-month, two-year, and ten-year interest rates. Sources: Bloomberg, GovPX, Refinitiv.

around monetary policy events were lower than for other countries/zones during the 2010–2019 period. Yet, the United States still explains only 25 percent of spillovers into the 10-year global rate.

B.3 Spillovers into Individual Countries/Zones: Additional Results

Figure B.1: Scatter Plot of Spillovers from the United States into the United Kingdom



The figure shows the change in US and UK 10-year interest rates around monetary policy events in the United States. Sources: Bloomberg, GovPX, Refinitiv.

B.4 Impact on Other Asset Prices

Table B.4: Spillovers into Other Asset Prices (6-Month Interest Rate)

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: $\Delta Stock$ Developed Average (excluding Source)														
ΔI_{6m}	-0.15	-0.48	-0.35	0.19	-6.74***	-0.10	-4.10	-0.08	0.18	0.13	-0.97***	0.24	0.62	-1.31*
	(0.32)	(0.45)	(0.62)	(0.63)	(1.70)	(0.44)	(3.08)	(0.83)	(0.55)	(0.35)	(0.24)	(0.41)	(0.73)	(0.62)
N	184	105	37	125	91	223	122	28	79	118	101	47	53	308
Panel B: Dependent: $\Delta Stock$ Emerging Average (excluding Source)														
ΔI_{6m}	-1.64*	-0.09	-0.77	-0.18	-3.76**	-1.09*	-0.39	1.51	-0.66	0.34	-1.17***	0.26	0.89	-3.23***
	(0.71)	(0.42)	(0.70)	(0.50)	(1.16)	(0.47)	(6.91)	(0.93)	(0.63)	(0.84)	(0.25)	(0.52)	(0.92)	(0.85)
N	119	105	37	146	91	223	86	28	80	64	101	47	54	324
Panel C: Dependent: $\Delta Gold$														
ΔI_{6m}	0.26	-0.19	-1.24	-0.09	1.64	-0.52	0.00	-0.05	-0.04	0.31	-0.24	-0.05	0.25	-3.29***
	(0.25)	(0.53)	(0.76)	(0.23)	(1.82)	(0.36)	(1.65)	(1.00)	(0.49)	(0.30)	(0.23)	(0.36)	(0.46)	(0.84)
N	168	105	37	151	91	219	134	28	80	99	101	47	51	292
Panel D: Dependent: $\Delta Silver$														
ΔI_{6m}	0.10	0.14	-0.13	-0.04	6.60*	-0.70	0.62	-0.22	0.80	0.88	0.86	0.49	1.05	-5.42***
	(0.51)	(0.96)	(1.26)	(0.49)	(2.75)	(1.05)	(3.54)	(2.00)	(1.21)	(0.67)	(0.47)	(0.80)	(0.77)	(1.36)
N	151	103	37	130	90	193	115	28	74	93	97	47	48	269

The table shows spillovers from the main countries/zones in my panel into other asset prices. Each cell represents a single regression of the change in an asset price on the change in the source country/zone's six-month rate where the source country/zone is given in the column. The changes are measured in the standard one-hour time frame around monetary policy events in the source country/zone. Panel A considers the average change in stock prices in developed countries/zones excluding the source country/zone. Panel B considers the average change in stock prices in emerging countries/zones excluding the source country/zone. Panel C considers the change in the price of gold. Panel D considers the change in the price of silver. The additional price data are from Refinitiv. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

Table B.5: Spillovers into Other Asset Prices (Two-Year Interest Rate)

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: $\Delta Stock$ Developed Average (excluding Source)															
ΔI_{2y}	0.21	0.01	-0.24	-0.05	-3.32**	-0.32	-0.37	-1.86	-0.25	0.67	0.18	-0.87	-0.45	-0.03	-1.77***
	(0.27)	(0.36)	(0.83)	(0.67)	(1.08)	(0.48)	(0.68)	(1.72)	(0.31)	(0.53)	(0.42)	(0.44)	(0.37)	(0.51)	(0.49)
N	373	160	45	141	149	276	134	211	71	95	135	160	76	134	347
Panel B: Dependent: $\Delta Stock$ Emerging Average (excluding Source)															
ΔI_{2y}	0.17	0.02	-0.59	-0.81	-1.64	-1.11*	-1.93	-2.07	-0.09	-0.23	0.92	-0.56	-0.45	-0.34	-3.72***
	(0.55)	(0.32)	(0.91)	(0.68)	(1.00)	(0.48)	(5.72)	(3.20)	(0.38)	(0.62)	(0.89)	(0.46)	(0.32)	(0.56)	(0.68)
N	272	160	45	165	149	277	32	172	71	96	73	160	76	134	367
Panel C: Dependent: $\Delta Gold$															
ΔI_{2y}	0.35	0.08	-1.06	-0.41	2.49*	-0.42	-0.64	-1.24	0.18	-0.31	0.56*	-0.66	0.16	0.53	-5.76***
	(0.20)	(0.43)	(1.01)	(0.32)	(1.03)	(0.38)	(0.65)	(1.00)	(0.33)	(0.51)	(0.27)	(0.49)	(0.32)	(0.31)	(0.65)
N	343	160	45	173	146	272	134	233	71	97	113	160	76	131	335
Panel D: Dependent: $\Delta Silver$															
ΔI_{2y}	0.40	-0.03	-0.17	0.40	5.31**	-1.57	-1.33	-2.77	-0.31	-0.09	0.86	-0.12	0.50	0.55	-8.54***
	(0.41)	(0.80)	(1.67)	(0.81)	(1.61)	(1.00)	(1.22)	(2.03)	(0.60)	(1.08)	(0.60)	(0.97)	(0.69)	(0.61)	(1.06)
N	320	158	45	151	132	244	134	199	71	90	104	155	76	128	311

The table shows spillovers from the main countries/zones in my panel into other asset prices. Each cell represents a single regression of the change in an asset price on the change in the source country/zone's two-year rate where the source country/zone is given in the column. The changes are measured in the standard one-hour time frame around monetary policy events in the source country/zone. Panel A considers the average change in stock prices in developed countries/zones excluding the source country/zone. Panel B considers the average change in stock prices in emerging countries/zones excluding the source country/zone. Panel C considers the change in the price of gold. Panel D considers the change in the price of silver. The additional price data are from Refinitiv. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

B.5 Other Robustness Checks

B.5.1 Alternative Interest Rate Measures

Table B.6: Alternative Measures of Six-Month Interest Rate

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: ΔI_{0y-1y} Developed Average (excluding Source)													
ΔI_{0y-1y}	0.05	0.03	0.06	-0.00	0.14**	0.05**	-0.02	0.01	-0.03	-0.01	-0.01	0.05	0.26***
	(0.04)	(0.02)	(0.03)	(0.01)	(0.05)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.03)	(0.04)
N	164	105	37	158	91	221	28	80	110	101	47	55	270
Panel B: Dependent: ΔI_{0m-3m} Developed Average (excluding Source)													
ΔI_{0m-3m}		0.11*	0.05	0.00	0.15		-0.04	-0.10*		-0.01		0.29	
		(0.05)	(0.09)	(0.04)	(0.12)		(0.04)	(0.04)		(0.02)		(0.22)	
N		39	23	65	43		17	31		63		24	
Panel C: Dependent: ΔI_{0m-6m} Developed Average (excluding Source)													
ΔI_{0m-6m}	0.32	0.10**	0.06	-0.03	0.25*	0.17	-0.02	-0.07		-0.01	-0.09**	0.02	0.22**
	(0.40)	(0.04)	(0.06)	(0.03)	(0.13)	(0.23)	(0.06)	(0.04)		(0.02)	(0.03)	(0.08)	(0.07)
N	11	67	29	111	66	11	25	38		75	27	41	40
Panel D: Dependent: ΔI_{1y} Nelson-Siegel Developed Average (excluding Source)													
ΔI_{1y} (NS)		0.11***	0.10*	-0.01	0.17		-0.00	-0.02		0.03	0.03	0.02	0.49**
		(0.03)	(0.04)	(0.04)	(0.09)		(0.03)	(0.04)		(0.02)	(0.07)	(0.08)	(0.12)
N		63	27	53	62		18	18		61	16	29	16

The table shows spillovers from the main countries/zones in my panel into the average interest rate in developed countries. Each cell represents a single regression of the average change in the six-month rate in (other) developed countries/zones on the change in the source country/zone six-month rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panel A measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of zero to one year, which is the standard measure. Panel B measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of zero to three months. Panel C measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of zero to six months. Panel D measures the changes in the interest rates using the Nelson-Siegel estimate of the one-year interest rate. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Regressions with fewer than 10 observations are dropped. Sources: Bloomberg, GovPX, Refinitiv.

Table B.7: Alternative Measures of Two-Year Interest Rate

Source	AUS	CAN	CHE	CZE	ECB	GBR	KOR	JPN	MEX	NOR	NZL	POL	ROU	SWE	USA
Panel A: Dependent: ΔI_{1y-3y} Developed Average (excluding Source)															
ΔI_{1y-3y}	0.08***	0.06***	0.10***	0.01	0.28***	0.12***	-0.04	0.11	-0.00	0.05**	0.01	0.00	-0.01	0.06***	0.50***
	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)	(0.05)	(0.12)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)
N	359	160	45	182	149	279	134	236	71	97	140	160	76	135	368
Panel B: Dependent: ΔI_{3m-2y} Developed Average (excluding Source)															
ΔI_{3m-2y}	0.07***	0.05***	0.06*	-0.01	0.27***	0.08***	-0.01	0.12	-0.02	0.04*	0.02	-0.01	-0.01	0.07***	0.44***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.04)	(0.02)	(0.09)	(0.12)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
N	357	140	44	185	149	276	49	202	26	90	132	131	70	89	348
Panel C: Dependent: ΔI_{6m-2y} Developed Average (excluding Source)															
ΔI_{6m-2y}	0.06**	0.05***	0.08***	0.00	0.25***	0.08***	-0.03	0.13	-0.03	0.03	0.02	-0.00	-0.01	0.07***	0.47***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)	(0.10)	(0.14)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
N	353	131	44	182	148	276	49	201	21	88	132	122	67	88	346
Panel D: Dependent: ΔI_{2y} Nelson-Siegel Developed Average (excluding Source)															
ΔI_{2y} (NS)	0.06***	0.06***	0.10***	-0.00	0.29***	0.10***	0.02	0.17	-0.01	0.04*	0.02	0.01	-0.02	0.07**	0.49***
	(0.02)	(0.01)	(0.03)	(0.01)	(0.04)	(0.02)	(0.09)	(0.11)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
N	271	143	45	104	149	274	43	147	20	81	83	131	44	74	334

The table shows spillovers from the main countries/zones in my panel into interest rates in developed countries. Each cell represents a single regression of the change in the average two-year rate in (other) developed countries/zones on the change in the source country/zone two-year rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panel A measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of one to three years, which is the standard measure. Panel B measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of three months to two years. Panel C measures the changes in the interest rates using the average change in interest rates of bonds with a maturity of six months to two years. Panel D measures the changes in the interest rates using the Nelson-Siegel estimate of the two-year interest rate. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

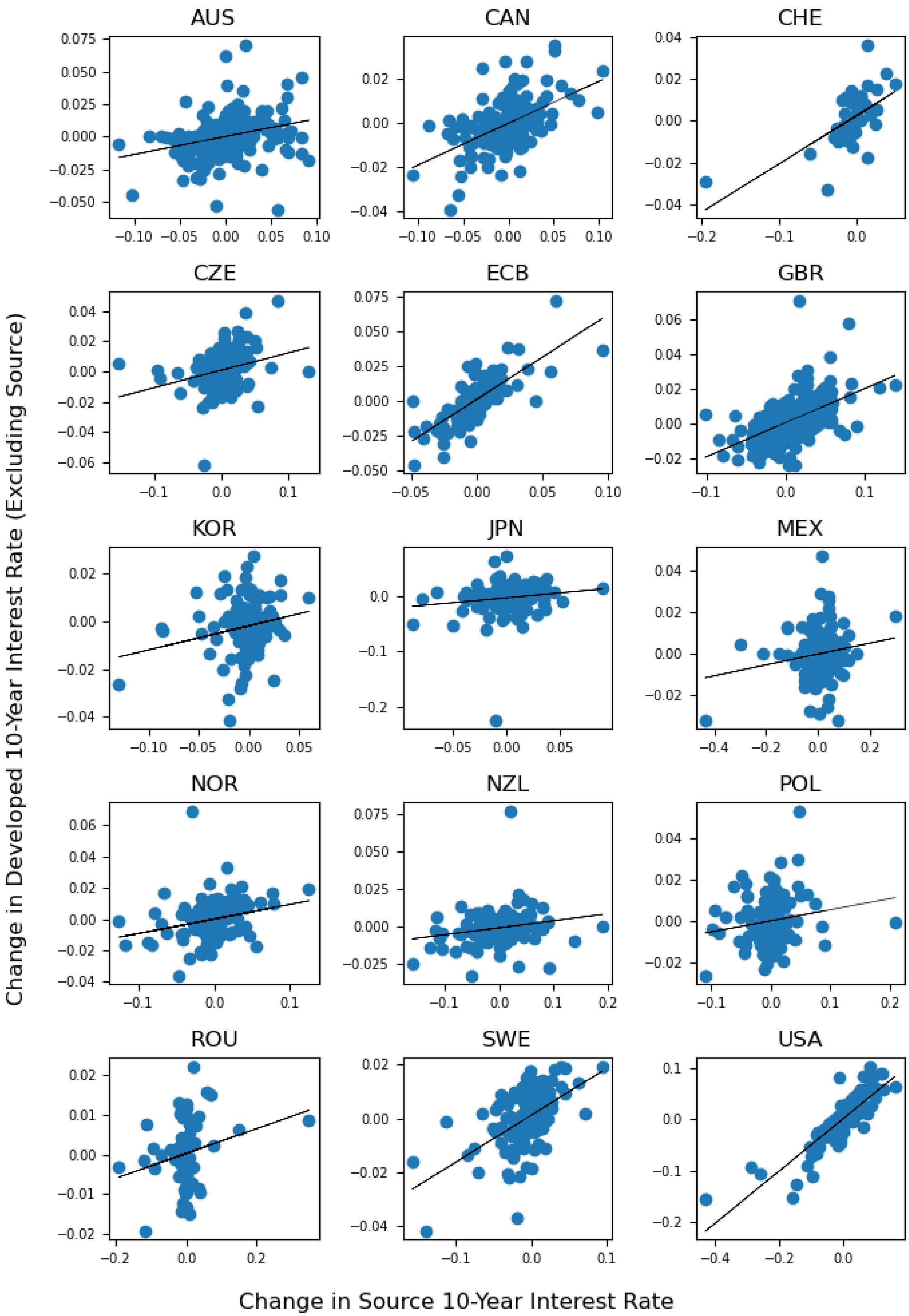
Table B.8: Alternative Maturity Ranges

Source	AUS	CAN	CHE	CZE	ECB	GBR	KOR	JPN	MEX	NOR	NZL	POL	ROU	SWE	USA
Panel A: Dependent: ΔI_{1y} Developed Average (excluding Source)															
ΔI_{1y}	0.06*	0.04***	0.06**	-0.00	0.23***	0.08***	0.09	0.33*	-0.03	0.03*	0.01	-0.01	-0.01	0.07**	0.38***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.04)	(0.02)	(0.11)	(0.14)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
N	359	144	45	185	149	276	49	204	28	115	134	149	70	95	351
Panel B: Dependent: ΔI_{3y} Developed Average (excluding Source)															
ΔI_{3y}	0.07***	0.08***	0.16***	-0.02	0.32***	0.14***	-0.06	0.17*	-0.00	0.05**	0.02	0.01	-0.01	0.09***	0.46***
	(0.01)	(0.01)	(0.04)	(0.02)	(0.03)	(0.02)	(0.05)	(0.07)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	346	161	44	137	150	276	137	224	105	102	115	171	83	108	368
Panel C: Dependent: ΔI_{5y} Developed Average (excluding Source)															
ΔI_{5y}	0.08***	0.11***	0.19***	0.01	0.40***	0.17***	0.01	0.19**	-0.00	0.09***	0.03	0.02	-0.02	0.12***	0.46***
	(0.01)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.06)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	371	161	45	147	150	278	139	212	125	108	124	167	70	124	373
Panel D: Dependent: ΔI_{7y} Developed Average (excluding Source)															
ΔI_{7y}	0.12***	0.13***	0.20***	0.11***	0.51***	0.19***	0.09*	0.19**	0.02	0.09**	0.04	0.04	0.00	0.14***	0.51***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.07)	(0.01)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)
N	370	147	45	137	150	275	112	220	126	107	117	146	64	121	362
Panel E: Dependent: ΔI_{9y} Developed Average (excluding Source)															
ΔI_{9y}	0.14***	0.21***	0.23***	0.13***	0.62***	0.21***	0.12*	0.18*	0.02	0.09**	0.04*	0.03	0.02	0.19***	0.46***
	(0.02)	(0.03)	(0.04)	(0.03)	(0.04)	(0.02)	(0.05)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	375	159	45	158	150	277	117	221	115	109	114	162	62	137	372
Panel F: Dependent: ΔI_{15y} Developed Average (excluding Source)															
ΔI_{15y}	0.14***	0.26***	0.22***	0.15***	0.47***	0.19***	0.10*	0.18***	0.02	0.10**	0.05*	0.08**	0.03	0.17***	0.53***
	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)	(0.02)	(0.05)	(0.05)	(0.02)	(0.04)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)
N	373	140	41	173	147	279	101	224	176	78	112	153	24	147	359

The table shows spillovers from the main countries/zones in my panel into the interest rates in developed countries. Each cell represents a single regression of the change in the average rate in (other) developed countries/zones on the change in the source country/zone rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panels A through F measure this using the one-year, three-year, five-year, seven-year, nine-year, and fifteen-year interest rates, respectively. These are measured using the average change in bonds with a maturity of zero to two years, two to four years, four to six years, six to eight years, eight to ten years, and ten to twenty years, respectively. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Sources: Bloomberg, GovPX, Refinitiv.

B.5.2 Scatter Plots

Figure B.2: Scatter Plots of 10-Year Spillovers to the Global Rate by Country/Zone



These plots show regressions of the change in the average 10-year rate in (other) developed countries/zones on the change in the 10-year source country/zone around monetary policy events in the source country/zone. They correspond to the regressions in Panel C in table 2 and table 3. Sources: Bloomberg, GovPX, Refinitiv.

B.5.3 Impact of Monetary Policy Announcement Types

Releases of both monetary policy meetings and meeting minutes appear to cause significant, fairly similar spillovers. In the analysis so far, I have considered spillovers from both releases of monetary policy meetings (that is, the release immediately after a meeting, typically a short statement) and releases of monetary policy minutes at a later date. The minutes provide additional information on how policymakers were thinking but are not released in conjunction with an interest rate decision, so they could have a different impact. Table B.9 presents the results separated into monetary policy statements and minutes. Panel A shows all events, Panel B shows only statements, and Panel C shows only minutes.[29] The coefficients for statements and meetings are similar for the United Kingdom, Japan, and the United States. The coefficients are stronger for meetings for Mexico and Romania. The coefficients are stronger for minutes for Australia, Czechia, Poland, and Sweden. The fact that one type of event does not yield systematically stronger effects suggests that spillovers are driven by how much a monetary policy event impacts the source country/zone's interest rates rather than by the nature of the event.

Table B.9: Spillovers by Monetary Policy Event Type

Source	**AUS**	**CAN**	**CHE**	**CZE**	**ECB**	**GBR**	KOR	JPN	MEX	NOR	NZL	POL	ROU	**SWE**	**USA**
Panel A: Dependent: ΔI_{10y} Developed Average (excluding Source); All Events															
ΔI_{10y}	0.14***	0.19***	0.23***	0.12***	0.60***	0.19***	0.10*	0.18*	0.03*	0.09**	0.05*	0.05*	0.03*	0.17***	0.50***
	(0.02)	(0.02)	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	386	161	45	187	150	279	118	232	178	114	130	181	75	149	373
Panel B: Dependent: ΔI_{10y} Developed Average (excluding Source); Meetings Only															
ΔI_{10y}	0.12***	0.19***	0.23***	0.07	0.60***	0.20***	0.10*	0.18**	0.03*	0.09**	0.05*	0.03	0.03*	0.17***	0.50***
	(0.03)	(0.02)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.07)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	237	161	45	106	149	139	118	159	135	114	130	167	64	98	197
Panel C: Dependent: ΔI_{10y} Developed Average (excluding Source); Minutes Only															
ΔI_{10y}	0.20***			0.21***		0.18***		0.21	-0.01			0.49*	-0.02	0.31***	0.55***
	(0.05)			(0.04)		(0.03)		(0.18)	(0.05)			(0.18)	(0.09)	(0.07)	(0.03)
N	149			81		140		73	43			14	11	51	176

The table shows spillovers from the main countries/zones in my panel into the interest rates in developed countries. Each cell represents a single regression of the change in the average 10-year rate in developed countries/zones (excluding the source country/zone) on the change in the source country/zone 10-year rate where the source country/zone is given in the column. All regressions use the standard one-hour time frame. Panel A uses all events. Panel B uses only monetary policy meetings, that is, the release immediately after a monetary policy meeting, typically a short statement. Panel C uses only monetary policy minutes, that is, more detailed information about monetary policy meetings released some time after the statement. *, **, and *** represent a significance of < 0.05, 0.01, and 0.001, respectively. Regressions with fewer than 10 observations are dropped. Sources: Bloomberg, GovPX, Refinitiv

[29] Note that the release times for minutes are available for only a limited number of countries, which is why Panel C shows results for only some countries/zones.