Channels of US Monetary Policy Spillovers into International Bond Markets *

Elias Albagli   Luis Ceballos   Sebastian Claro   Damian Romero†

This version: May 11, 2017

Abstract

We document significant US monetary policy spillovers to domestic bond markets in a sample of 12 developed and 12 emerging market economies. We rely on an event study methodology where US monetary policy (MP) shocks are identified as the change in short-term US treasury yields within a narrow window around FOMC meetings, and trace its consequences on domestic bond yields using panel data regressions. We decompose yields in each country into a risk neutral and a term premium component using affine term-structure models. We emphasize three main results. First, US MP spillovers to international long-term rates have increased substantially after the global financial crisis. Second, these effects work through markedly different channels for different country groups. For developed economies, spillovers are concentrated in risk neutral rates (expectations of future rates). We find little evidence of an information channel –a comovement of rates due to correlated fundamentals with the US, potentially revealed in Fed minutes–, and that exchange rate considerations might explain the reaction of policy rates in these countries. For emerging countries, spillovers are concentrated predominantly on term premia. We provide evidence that portfolio flows into emerging fixed-income markets react significantly to US MP shocks, consistently with a "risk-taking channel". Third, we show that these spillovers are large compared to the effects of other events, and at least as large as the effects of domestic MP in long-term rates after 2008.

JEL classification: E43, G12, G15.

Keywords: monetary spillovers, affine models, risk neutral rates, term premia.

---

*The opinions and mistakes are of exclusive responsibility of the authors and do not necessarily represent the opinion of the Central Bank of Chile or its Board. We thank Jose Berrospide, Yan Carriere-Swallow, Diego Gianelli, Alberto Naudon, Horacio Sapriza, Larry Summers, and Rodrigo Vergara for valuable comments and discussions, and Tobias Adrian for sharing the code used in Adrian et al. (2013).

†All authors are from the Central Bank of Chile. Corresponding Author: Elias Albagli, ealbagli@bcentral.cl.

1 Introduction

The conduit of monetary policy (MP) in major advanced economies has changed in important ways since the global financial crisis. After reaching an effective zero lower bound, the focus has shifted towards influencing long term rates, with significant efforts made by central banks in communicating their intentions to keep rates at zero for an extended period (forward guidance), and/or through outright large scale asset purchase programs (LSAP). The increased presence of the Fed, the ECB, and other central banks in fixed income markets has been reinforced by large portfolio flows from private investors, further contributing to the fast expansion of the world bond market in the last decade.[1] This growth in size has also coincided with an increased presence of foreign investors in domestic bond markets, a change most noticeable for emerging market economies. [2]

While increased financial integration has multiple benefits, it also presents important challenges. In particular, it raises the question of whether the cost of funds in non-core economies can remain independent from developments in major financial centers, possibly undermining the ability of central banks in setting appropriate monetary conditions given each country's macroeconomic stance. This discussion is well captured by several recent studies which try to assess the international spillover effects from monetary policy in the US and other large developed economies, including Rey (2015), Bruno and Shin (2015), and Obstfeld (2015), among many others.

There are several open questions that remain to be settled in this literature. First, there is a non-trivial problem of identification that makes it hard to assess whether comovements in yield curves are driven by causal effects from MP in large financial centers, or merely reflect common underlying economic forces. Second, there are few studies that test spillover effects on emerging market economies, mostly due to the lack of reliable, long-dated yield curve information. Third, to the extent that spillover effects are identified, there is little evidence about the specific channels at work. In particular, do movements in domestic long term rates reflect the anticipation of future short-term rates that tend to follow MP changes in core economies, or do they result from changes in risk compensation due to portfolio rebalancing/risk-taking motives?

This paper contributes to the debate by presenting evidence of significant spillover effects of US MP into a group of 12 developed countries (henceforth, DEV) and 12 emerging market economies (henceforth, EME). In order to identify a US MP shock, we use the change in short-term treasuries (2-yr maturity in our baseline specification) in a narrow window centered around FOMC meetings. This identification strategy

[1] See IMF (2014), and BIS (2014).

[2] See Shek et al. (2015), and BIS (2015).

has been followed by several studies, most recently by Hanson and Stein (2015).[3] We then test how shocks to US MP affect international bond yields at different maturities using panel data regressions. Because we wish to highlight the difference between DEV and EME, we run panel regressions for each group of countries separately. Our sample runs from January 2003 to December 2016. We also split the time series in two, the first sub-sample up to and including the Oct. 2008 meeting, and the second starting form Dec. 2008. This date has been used in other studies, as Nov. 2008 marks the first Fed announcement about unconventional MP measures and serves as a natural break point in the MP regime change due to the global financial crisis (see Gilchrist et al. (2016)).

To further understand the economic mechanisms involved, we decompose bond yields for each country into a term premium and a risk neutral component, following the methodology proposed by Adrian et al. (2013), but correcting for small sample bias as suggested by Bauer et al. (2012). This allows us to determine whether US MP spillovers into other economies work by affecting market expectations of future domestic MP in those countries, or whether they reflect changes in risk compensation. Moreover, to compare the economic magnitude of such effects, we also study the impact of individual countries's own MP meetings, as well as other events such as US and individual countries releases on CPI, activity (industrial production), and unemployment.

We highlight three main results. First, we document significant spillovers of US MP on short and long term yields for both DEV and EME, in particular for the sub-sample starting in Nov. 2008. Throughout this period, we estimate that a 100 bp increase in US short-term rates during MP meetings increases long-term rates in DEV and EME countries in 43 and 56 bp, respectively. Prior to Nov. 2008 the elasticities are smaller in magnitude, particularly so for the EME sample.

Second, there are major differences in the transmission mechanisms involved. Based on the complete sample estimates, the contribution of the risk neutral component (expectations of future short-term ratres) account for almost all the variation in yields for DEV economies, with a non-significant contribution of TP component. For countries in the EME sample the effect is the opposite. Based on the complete sample estimates, almost all the variation in yields is driven by movements in the TP component, with a non-significant contribution of the RN component of yields. In the second half of the sample these stark differences tend to ameliorate somewhat, with the TP component explaining a statistically significant share of yield movements for DEV economies, while the RN component becomes marginally significant for EME. However, the relative dominance of the different channels for both groups of economies remain.

[3] A similar event study is also used in Gilchrist et al. (2016). Cochrane and Piazzesi (2002) and Bernanke and Kuttner (2005) use a related measure of US MP shocks, but focusing on shorter maturities –the 1-month Eurodollar future.

Digging deeper into the underlying mechanisms that could explain these patterns, we find little evidence of an *informational* channel –the notion that FOMC meetings could affect expected rates in other countries by communicating relevant information about US macroeconomic fundamentals, potentially correlated with fundamentals abroad. We argue that there are weak theoretical and empirical grounds for this view within our specific identification strategy. We instead argue that the dominance of risk-neutral rates in the case of DEV sample is consistent with an *exchange rate channel*: consistent with other studies, we document that negative US MP shocks depreciate the US dollar in a statistically and economically significant manner against DEV currencies. Together with ample evidence about the effects of exchange rates on trade balances, this suggests that markets may anticipate similar MP moves in these economies to avoid currency misalignment leading to loss in trade competitiveness and deflationary pressures, an argument akin to "currency wars" as mentioned by several commentators and academics. Regarding the dominance of the term premium component for the EME sample, we find evidence consistent with a *risk-taking channel*: we document a significant, negative effect of US MP shocks in fixed-income portfolio flows to EME countries, consistent with a "risk on" effect of softer US MP into riskier asset classes, namely emerging market debt.

Third, our results suggest that spillover effects are economically important compared to other events, and at least as large as the impact of domestic MP actions on long-term yields on those countries post Nov. 2008. In particular, the point estimates of the effects of US MP on domestic long-term bond yields of DEV economies is roughly equivalent to the effect of domestic MP, but significantly larger than the effect of domestic MP in the case of EME. In these domestic events, however, movements in the RN component dominate the action in yields, with playing a counteracting role of compressing yields when MP is perceived tighter.

There is a growing literature studying the effect of conventional and unconventional MP in the US post 2008. Hanson and Stein (2015) show that conventional Fed meetings have a significant impact on the long end of the US yield curve. Krishnamurthy and Vissing-Jorgensen (2011), Gagnon et al. (2011), and Christensen and Rudebusch (2012), show evidence of rather large effects of LSAP announcements on US long term yields. Several papers have also documented the international spillover effects of conventional US MP,[4] and more recently, the transmission of LSAP announcements.[5]

More closely related to our paper are the recent works by Gilchrist et al. (2016), Hoffman and Takáts (2015), and IMF (2015), who put special emphasis on spillover effects into emerging countries. The main

[4]See Craine and Martin (2008); Hausman and Wongswan (2011); Georgiadis (2015).

[5]Bauer and Neely (2014); Bauer and Rudebusch (2014); Rogers et al. (2014).

difference with these papers is our focus on studying the different transmission mechanisms behind US MP spillovers, which we do by applying the yield curve decomposition into risk neutral and term premium components for each individual country in the sample. Indeed, we see as the main result of the paper the important distinction that US MP spillovers into DEV work mostly by affecting expectations of future short-term rates, while the effect in EME is predominantly concentrated in movements on the term premium. The fact that the cost of credit at longer maturities could be partially disconnected from the expected path of MP decisions in this last group of countries poses important challenges for the conduit of MP in the emerging world, as highlighted among others by Rey (2015), and the BIS (2015). Furthermore, by presenting evidence about the impact of own MP and economic releases, our paper helps to put into perspective the economic importance of spillover channels relative to other domestic and foreign events in affecting yields. Another difference, particularly with Hoffman and Takáts (2015) and IMF (2015), is our identification strategy. While they use monthly VAR's with recursive (Cholesky) ordering to tease out the spillover effects of autonomous shocks on US long term yields, we use event-study analysis by focusing on narrow event windows around Fed meetings to identify MP shocks.

The remainder of the paper is structured as follows. Section 2 describes the data and main econometric specification, discussing in detail the construction of US MP events and the decomposition of yield curve movements into risk neutral and term premium components. In section 3, we present the effects of US MP spillovers into international bond markets, emphasizing their impact in each separate component of yields. We also provide complementary evidence on exchange rates and portfolio flows into fixed-income markets around FOMC meetings to guide the interpretation of our results. In section 4, we report the effect on yields of own MP meetings, as well as economic news both in the US and in individual countries. Section 5 discusses our results under alternative specifications, as a way of evaluating the robustness of our findings. Section 6 concludes.

2 Data description and identification strategy

2.1 Econometric specification: panel data event-study

To estimate the effect of US MP spillovers, we will test the following panel data specification:

$$\Delta y_{j,t}^{h} = \alpha_{year}^{h} + \alpha_{j,month}^{h} + \beta^{h} MPR_{t}^{US} + \gamma^{h} MPR_{j,t}^{Own} + \sum_{n=1}^{N} \delta_{n}^{h} S_{j,n,t}^{US} + \sum_{n=1}^{N} \theta_{n}^{h} S_{j,n,t}^{Own} + \varepsilon_{j,t}^{h} \quad (1)$$

In equation (1), the main explanatory variable of interest is MPR_{t}^{US} , which corresponds to the change in observed 2-yr US yield between the closing of the business day after each Fed meeting, and the closing of the business day before the announcement.[6] The rationale for this measure, proposed by Hanson and Stein (2015), is that actual MP rates display infrequent movements, and are often anticipated by the market.[7] Moreover, there could be significant information in each meeting about the future course of MP that could be relevant but missed if one uses only the actual Fed Fund Rate. For these reasons, they propose using a relatively short-maturity treasury yield for capturing changes in the stance of future MP that could arise form information released during each FOMC meeting.

The other variables in the right hand side of equation (1) include $MPR^{Own}_{j,t}$, defined as the change in country j's 2-yr yield around an analogously defined 2-day window centered at each of j's MP meetings; $S^{US}_{n,t}$, defined as the change in 2-yr US yield around a 2-day window centered at each US economic release n (with n=CPI, IP, and unemployment); and $S^{Own}_{j,n,t}$, the change in country j's 2-yr yield around a 2-day window centered at j's economic release n (also, n=CPI, IP, and unemployment).

To control for other common events that might be affecting yields, we try several specifications of fixed effects, and different ways of clustering standard errors. In our baseline specification, we include a year and a country-month fixed effect in each regression, denoted by α^h_{year} and $\alpha^h_{j,month}$ in equation (1). In section 5, we replicate the main regressions under different specifications to check the robustness of our results.

We now turn to the left hand side of equation (1). Because we are interested on the effect of US MP and other economic events on overall yields, as well as their decomposition, we use 3 different variables: the h-yr domestic bond yield (where the subscript h stands for maturity);[8] the portion of this yield identified as the risk-neutral component (that is, the expectations of future short-term interest rates); and the remaining term premium component. Hence, for each specification, we run 3 regressions using the yield and both of its components separately. While we run regressions for several maturities, we focus the discussion on 2-yr and 10-yr bonds, capturing the effects on short and long-term interest rates. In all specifications, $\Delta y^h_{j,t}$ is defined as the change in yields (or their components) the business day after the Fed meeting, relative to the yield close the day before the Fed meeting.[9]

[6] For example, for the meeting that ended on Oct. 29, 2014, the change in US yields is the difference between the 2-yr treasury at the close of Oct. 30, and the close of Oct. 28.

[7] See Cochrane and Piazzesi (2002).

[8] In the case of yields we use on the left-hand side the model-implied yield rather than the observed interest rates. These two need not coincide due to measurement error in the affine model estimation. An estimation using actual yields changes only the coefficients associated to yields, but not their decomposition into RN and TP components. The differences are marginal and not reported, but available upon request.

[9] Because of time zone differences, this means that for countries on time zones earlier than eastern standard time, the window is relatively longer before the Fed announcement than after, while the opposite is true for countries with later time zones. However, it is always the case that the FOMC meeting is contained within the window.

Because we place special emphasis on the effects of US MP on EME and DEV, we run separate regressions for each class of economies. That is, we estimate the set of US MP spillover coefficients β^h separately for DEV and EME. Analogously, we estimate a separate set of coefficients for own MP (γ^h) and economic releases (δ_n^h for US, and θ_n^h for domestic) for EME and DEV. Finally, we follow Gilchrist et al. (2016) in splitting the sample in two, with the first sub-sample including the period Jan. 2003-Oct. 2008.

2.2 Data sources

We consider 12 DEV economies, including Australia, Canada, Czech Republic, France, Germany, Italy, Japan, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. In the EME sample we include Chile, Colombia, Hungary, India, Indonesia, Israel, Korea, Mexico, Poland, South Africa, Taiwan, and Thailand. Some countries are excluded from the analysis due to lack of sufficient yield curve data, which is necessary for constructing the risk neutral and term premium components, as described momentarily.[10] Our panel data is balanced and built from January 2003 to December 2016.

We use different data sources. For DEV, we use yields mainly reported from Bloomberg and by central bank's websites. Fed and individual MP meetings dates, as well as dates on economic releases are taken from central banks and Bloomberg respectively. Table 1 lists the countries considered and the number of each class of events that enter the sample (Table 11 in Appendix A lists all data sources).

2.3 Identification issues

Our identification strategy relies on two main premises. First, implicit in the use of MP calendar days is the notion that such events are quantitatively relevant to the dynamics of interest rate movements in the US. Table 2 reports the moments of interest rate changes around different economic events. In the first sub-sample, the standard deviation of 2-yr US yields is larger around MP meetings than on non-meetings days, though the difference is marginally significant at 10% confidence levels. Post Nov. 2008 however, the volatility of rates around Fed meetings is significant larger than in non-event days (at 1% confidence). Similarly, macroeconomic releases are not associated with significantly higher volatility in the first sample. In the second sub-sample, unemployment releases, and to some extent CPI releases, do increase 2-yr rate volatility in a statistically significant manner compared to non-event days.

In the case of DEV economies, interest rates on MP meetings days, and during CPI and unemployment releases, display statistically larger volatility than non-event days in both samples, and so do activity

[10]This is the case, for example, of Brazil, for which reliable yield curve data exists only since 2007, and even then there is not enough cross-sectional information in bond yields at different maturities for applying the affine term-structure model decomposition according to the procedure described in Appendix C.

Table 1: Countries and Economic Releases

Code	Country	Classification	Number of Releases			
			MPM	CPI	Activity	Ump
US	United States	DEV	113	160	167	726
CAD	Canada	DEV	112	167	167	167
JPN	Japon	DEV	182	166	125	163
UK	United Kingdom	DEV	169	163	167	167
GER	Gemany	DEV	165	143	54	166
ITA	Italy	DEV	165	159	118	50
FR	France	DEV	165	167	167	33
AUD	Australia	DEV	107	54	55	167
NZ	New Zeland	DEV	111	44	55	56
CHK	Czeck Republic	DEV	131	167	167	0
NOR	Norway	DEV	108	167	132	164
SW	Sweden	DEV	91	167	147	108
SZ	Switzerland	DEV	48	167	50	167
KOR	Korea	EME	166	126	142	79
TW	Taiwan	EME	52	123	164	115
CL	Chile	EME	167	164	164	165
MX	Mexico	EME	108	217	167	134
HUN	Hungary	EME	160	144	145	110
SOA	SouthAfrica	EME	85	167	120	23
TH	Thailand	EME	80	95	43	0
ISR	Israel	EME	153	115	30	0
INDO	Indonesia	EME	133	150	49	0
IND	India	EME	62	47	39	0
POL	Poland	EME	148	167	167	166
COL	Colombia	EME	163	96	99	117

This table shows the number of economic releases considered for each country, based on Bloomberg's Surveys. The country classification into developed/emerging economy is based on the criteria followed by the International Monetary Fund, United Nations, MSCI and DJI. Columns 4 to 6 show the number of monetary policy meetings (MPM), inflation releases (CPI), economic activity releases (Activity), and unemployment (Ump). A value of zero is reported when coverage by Bloomberg is not systematic.

releases in the second part of the sample. For EME, during the pre Nov. 2008 volatility in 2-yr rates is in general larger, and actually larger during non-event days. This changes in the post Nov. 2008 sample, when MP, activity, and unemployment releases are all associated with statistically higher volatility.[11]

Table 2: Changes in Two-year rates around events

	Pre Nov. 2008						Post Nov. 2008					
	US		DEV		EME		US		DEV		EME	
	mean	std	mean	std	mean	std	mean	std	mean	std	mean	std
MPM	-0.22	9.50*	-0.86	9.73***	-1.72	18.47	-0.23	5.67***	-1.24	11.07***	-2.09	14.38***
No news	0.07	8.94	0.04	6.43	0.29	19.31	0.05	4.35	-0.25	7.35	-0.31	10.01
Inflation	-1.28	9.04	0.33	6.87**	0.42	19.24	-0.32	4.87*	-0.25	6.37	-0.97	11.53***
Activity	-1.86	9.04	-0.40	5.32	0.64	12.87	-0.19	4.51	-0.60	8.41***	-0.58	10.59**
Unemployment	0.10	9.33	0.27	7.52***	1.12	8.41	-0.24	4.95***	-0.27	7.93***	-0.29	8.44

This table shows the mean and standard deviation of changes in 2-yr yields around MP and other macroeconomic. Numbers are in basis points. *** p-value < 0.01, ** p-value < 0.05, and * p-value < 0.1, denote the probability that volatility is higher in the corresponding event that in non-event days.

Second, for the event to correctly measure US MP as a causal force affecting international yields, such events should not be contaminated by other economic releases that might obscure the transmission mechanism from US MP. Table 3 shows that, indeed, the overlap between US MP meetings and other events is rather small. For instance, there are 113 US MP meetings between January 2003 and December 2016 (first row of Table 1). In the panel regression of EME, this amounts to 12*113 = 1,356 country-days in the right hand side of the panel regression. We proceed to count the number of times in which domestic MP meetings overlap with FOMC meetings, leading to 36 occasions (for example, 4 overlaps with events in Chile, 7 in Thailand, 2 in Mexico, and so on). This means that of the 1,356 country-day events defined by US MP meetings, the overlap of events amounts to 36/1,428 = 2.65%. This is the overlap frequency reported in line 1, column 1, of Table 3 in panel B. Analogously, the table reports the overlap frequency between different US and individual countrys events. Column 5 in the table reports the cumulative overlap of any event vis-à-vis US key dates.[12] In short, although Fed meetings are not always the only event moving yields in a given day, this is the case much more often than not.[13]

[11]While the higher volatility of rates on event days is not a necessary condition for the identification strategy to be valid, it does provide support to the notion that Fed meetings are important events for movements in the yield curve, and thus suitable episodes to test MP spillovers.

[12]Because some economic events also coincide on the same day the total column does not correspond to the sum of each column.

[13]An overlap with other events does not introduce bias, only noise in the estimation of the corresponding coefficients.

Table 3: Economic releases overlap

	Monetary policy rate	Inflation	Activity	Unemployment	Total
Panel A: Developed economies					
US monetary policy	3.69	4.57	3.24	3.98	7.08
US inflation	2.74	5.38	1.42	2.69	6.75
US activity	2.30	4.59	1.65	3.04	5.99
US unemployment	0.78	3.59	4.05	3.51	5.74
Panel B: Emerging economies					
US monetary policy	2.65	2.88	2.36	2.73	7.30
US inflation	3.48	3.64	4.17	0.79	6.43
US activity	2.54	5.14	3.74	0.20	6.19
US unemployment	3.29	2.72	2.79	2.63	6.12

This table shows the overlap frequency (in percentage points) between the number of domestic releases of the variable in the column and the corresponding events in the US, in each row. For example, 3.69% in column 1, row 1, equals the number of own MPM summed across the 12 countries in the DEV sample which also occur during a US MPM window, divided by 113*12 country-episodes (where 113 is the number of US MPM, and 12 is the number of countries in group of panel regressions).

2.4 Decomposition of yields

To decompose interest rates into the risk neutral and term premium components, we rely on the affine model approach developed in Adrian et al. (2013). Here we briefly sketch the main elements of their decomposition, providing more details in Appendix C. The standard affine model is characterized by the existence of K risk factors, summarized in vector X_t which follow a first-order VAR under the probability measure $\mathbb{P}$:

$$X_{t+1} = \mu + \Phi X_t + v_{t+1}, \qquad v_{t+1} \sim N(0, \Sigma) \tag{2}$$

It is assumed that the short-term interest rate r_t is an affine linear function of the risk factors:

$$r_t = \delta_0 + \delta_1' X_t \tag{3}$$

Finally, it is assumed that there exists an unique stochastic discount factor (SDF) that prices all assets under no arbitrage, which is affine as in Duffee (2002):

$$-\log M_{t+1} = r_t + \frac{1}{2}\lambda_t'\lambda_t + \lambda_t' v_{t+1} \tag{4}$$

where the vector of risk prices (λ) are also affine to risk factors: $\lambda_t = \lambda_0 + \lambda_1 X_t$. Under the risk-neutral probability measure $\mathbb{Q}$, the price of an n-period zero coupon bond is determined by $P_t^n = E_t^{\mathbb{Q}}(\exp(-\sum_{h=0}^{n-1} r_{t+h}))$ and the risk factors under the risk neutral measure also follow a Gaussian VAR:

$$X_{t+1} = \mu^{\mathbb{Q}} + \Phi^{\mathbb{Q}} X_t + v_{t+1}^{\mathbb{Q}}$$

where $\mu^{\mathbb{Q}} = \mu - \Sigma\lambda_0$ and $\Phi^{\mathbb{Q}} = \Phi - \Sigma\lambda_1$. With this, the price of bonds at different maturities can be summarized into $P_t^n = \exp(\mathcal{A}_n + \mathcal{B}_n' X_t)$, where $\mathcal{A}_n$ and $\mathcal{B}_n$ are solved recursively. Using this methodology, one can compute model-implied yields at different maturities as $y_t^n = -\frac{\log(P_t^n)}{n} = A_n + B_n' X_t$, with $A_n = \frac{\mathcal{A}_n}{n}$ and $B_n = \frac{\mathcal{B}_n}{n}$.

By setting risk prices equal to zero, one can also calculate the yields $\tilde{y}_t^n$ that would obtain if investors priced bonds under risk neutrality, which gives a measure of pure expectations of future rates at different maturities –the so called risk-neutral component. The difference between model-implied yields and risk-neutral rates is then defined as the term premium component at different maturities, $tp_t^n \equiv y_t^n - \tilde{y}_t^n$, completing the term-structure decomposition.

To estimate the affine term structure model we follow the approach proposed by Adrian et al. (2013). This methodology exploits the log excess holding return predictability showed in empirical studies, such as Cochrane and Piazzesi (2005).[14] Based on that idea, Adrian et al. (2013) propose a simple methodology to construct market prices of risk into an affine model consistent with the predictability of excess bond returns. In Appendix C we detail the step-by-step procedure to compute the affine model using the Adrian et al. (2013) approach.

Bias correction. One issue faced by standard affine methodologies estimation is that the short-term interest rate follows a VAR(1) process. This assumption is key because it affects the statistical process of the stochastic discount factor, and therefore the capacity of the model to fit yields properly and the computation of risk-neutral yields and term premia. Given the well-known small sample bias present in this type of estimations, it is important to take into account procedures that could alleviate the bias, in order to properly estimate the parameters μ, Φ and Σ. If such bias is not corrected for, Bauer et al. (2012) shows that the OLS estimation generates artificially lower persistence than the true process, which is reflected in risk-neutral rates with too little volatility. In that case, most of the variability on interest rates is (incorrectly) attributed to term premium instead of risk-neutral rates.

[14] They show that a relevant fraction of excess returns on bonds can be captured with a small number of factors. In particular, a single factor helps to predict more than 44% of one-year returns. See Gürkaynak and Wright (2012) for a comprehensive revision of this literature.

To deal with this problem, we employ an indirect inference procedure to correct the bias in the VAR process of equation (2). The idea of this method is to choose parameter values which yield a distribution of the OLS estimator with a mean equal to the OLS estimate in the actual data.[15] In what follows, we estimate the affine model with the indirect inference bias correction procedure.[16]

3 International US MP Spillovers: developed vs emerging markets

3.1 Effect of regular Fed meetings

We now present the main results of the paper: the impact of US MP shocks on international bond yields. To build intuition about the regression design tested in equation (1), Figure 1 depicts three episodes of FOMC meetings. The plots include the change in US 2-yr yields (our measure of US MP shocks, depicted in white bars), as well as their impact on10-yr yields (gray bars) and their components (dashed line: RN component; solid line: TP component). For each sub-sample of countries (DEV and EME), the series plotted correspond to simple averages of yields across each group.

The upper panel shows the action in yields around the FOMC meeting of March 18, 2003. Our measure of US MP shock is a positive 8.2 bp move (the comparison of closing day 1, respect to the day before the meeting). It is followed by a change in average 10-yr yields of DEV of about 14 bp, 13 of which are explained by increases in the RN component. In contrast, the effect in 10-yr yields in EME, at about 5 bp that day, is explained by an increase in the TP component close to 9 bp, with a counteracting movement in the RN component. A similar pattern emerges for the FOMC meeting of August 9, 2011. Here, the minutes of the meeting lead to a market revision in 2-yr US yields of -8 bp. The 9.2 bp reaction in 10-yr yields in DEV is again dominated by movements in the RN component, although in this episode the TP component does contribute a significant fraction. The slightly larger reaction in EME yields at 10.7 bp, on the other hand, is clearly dominated by the TP component. The third episode plotted in Figure 1 corresponds to the FOMC meeting of June 19, 2013, an event that lead to an increase of 6.5 bp in the US 2-yr treasury. This shock had a comparably large effect of 16.7 bp in 10-yr yields for the DEV sample, of which more than 10 bp is again accounted by the RN component. Following a similar pattern as previous episodes, the 24 bp average effect on 10-yr yields in the EME sample is explained by an increase close to 19 bp in the TP component, and only 5 bp in RN rates. While these are hand-picked cases, they capture the general reaction of yields and their components to US MP shocks that we document more formally below: while rates in both groups of countries generally react to US MP shocks, in DEV countries the

[15] See the online Appendix of Bauer et al. (2012) for details.

[16] The Matlab code to apply bias correction are publicly available at `http://faculty.chicagobooth.edu/jing.wu/`.

action is frequently dominated by the RN channel, the opposite being true for the yield components in the EME sub-sample.

Table 4 now presents the impact of US MP shocks of our main econometric specification. The upper panel contains the estimated elasticity between movements in US 2-yr yields on FOMC days and yields on DEV economies, while the lower panel reports the coefficients for EME. The rows contain the coefficients associated with 2-yr yields, 10-yr yields, and the TP and RN components of 10-yr yields. The columns report the effects for three time samples: the complete sample running from Jan. 2003 through Dec. 2016, the sub-sample ending in Oct. 2008, and the sub-sample starting in Dec. 2008.

We begin the discussion of the effects of US MP on DEV economies (upper panel). For the complete sample (first column), we see that a 100 bp US MP shock increases 2-yr rates abroad in 26 bp. For 10-yr maturity, the effect is 34 bp. Comparing the pre and post Nov. 2008 periods, the effect of US MP shocks on 2-yr yields have decreased from 32 to 17 bp. Interestingly, the effect is the reverse for 10-yr rates, for which spillovers have increase from 30 to 43 bp shock in US MP. These differences are statistically significant at 5% confidence levels (not reported).

Focusing now on the composition of US MP spillovers on 10-yr yields, we see that the action is concentrated predominantly on the RN component. For the complete sample, a 100 bp shock in US MP is associated with 33 bp increase in RN (significant at the 1% confidence level), virtually the whole effect in yields, while the contribution of the TP component is not statistically different from zero. Comparing the first and second windows of estimation, we see that the TP component becomes statistically significant in the latter part of the sample, although the RN component still explains more than half of the overall transmission of US MP to foreign yields.

We now turn to EMEs. For the complete sample (first column), we see that a 100 bp US MP shock increases 2-yr rates abroad in about 16 bp, an effect that has increased between the first and second sub-samples from 10 to 29 bp (also statistically significant). For 10-yr maturity, the incremental effect is much more substantial, going from 19 bp to 56 bp per every 100 bp of US MP shocks (a difference also highly statistically significant).

Figure 1: US MP Shocks and International Bond Yields, Selected Episodes

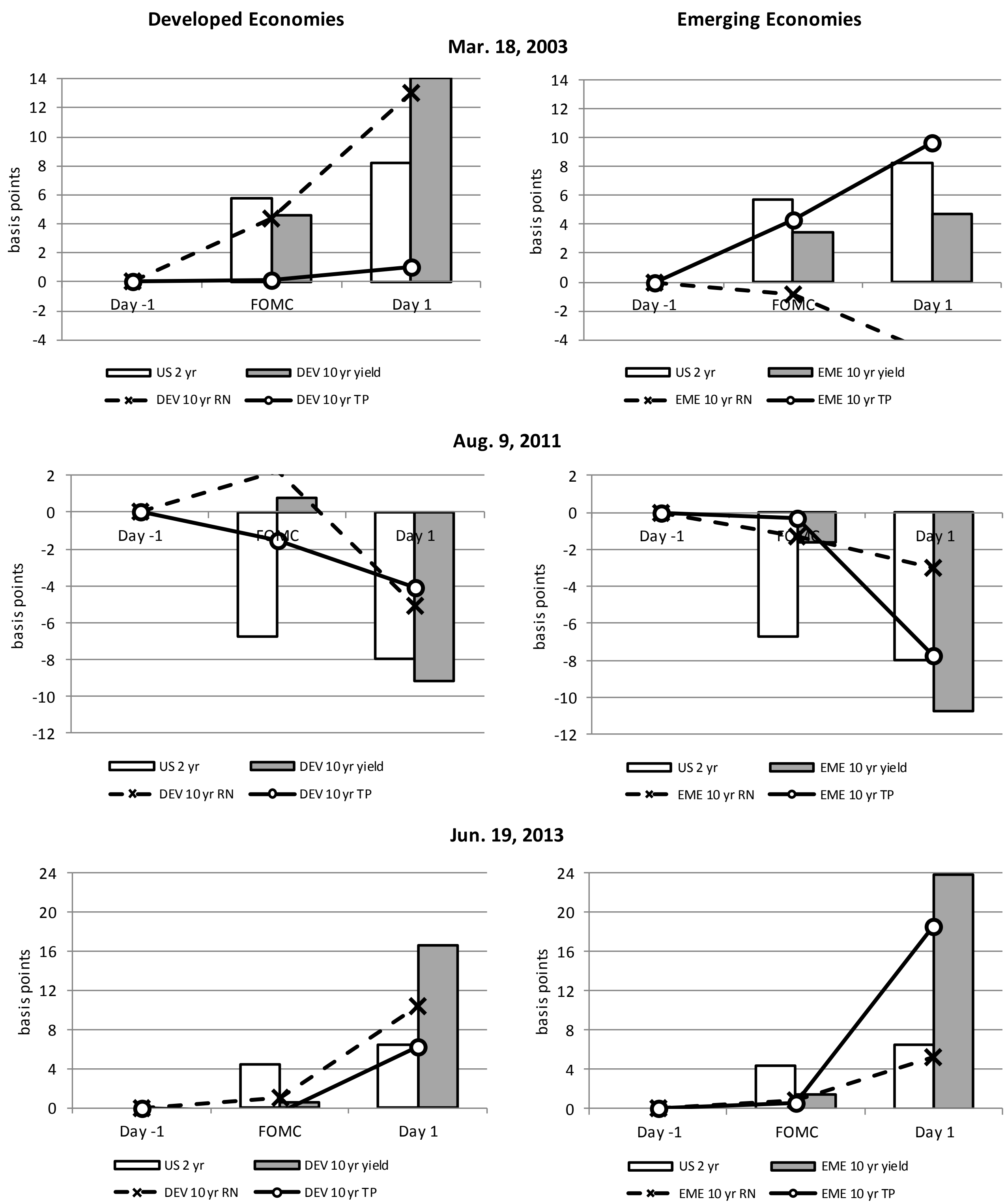

Table 4: Effects of US monetary policy

	Panel A: Developed economies		
	Full sample	Pre Nov. 2008	Post Nov. 2008
Two-year	0.263***	0.318***	0.173***
	(0.023)	(0.028)	(0.038)
Ten-year	0.335***	0.297***	0.429***
	(0.026)	(0.028)	(0.053)
risk neutral	0.331***	0.390***	0.234***
	(0.032)	(0.040)	(0.053)
term premia	0.005	-0.092***	0.196***
	(0.030)	(0.033)	(0.054)
	Panel B: Emerging economies		
	Full sample	Pre Nov. 2008	Post Nov. 2008
Two-year	0.160***	0.100*	0.287***
	(0.041)	(0.052)	(0.068)
Ten-year	0.293***	0.193***	0.557***
	(0.061)	(0.070)	(0.107)
risk neutral	0.054	0.019	0.136**
	(0.039)	(0.050)	(0.053)
term premia	0.239***	0.174**	0.421***
	(0.076)	(0.088)	(0.132)

This table shows the estimated coefficients of US monetary policy events, as described in equation (1). Standard errors in parentheses. *** p-value < 0.01. ** p-value < 0.05, and * p-value < 0.1

Regarding the composition of US MP spillovers, Table 4 shows that these are now heavily tilted towards transmission via term premia. Indeed, for the complete sample the contribution of the TP component is 24 bp of the 29 bp total spillover effect (significant at 1%), while the 5 bp estimation for the RN component is not statistically significant. This dominance of the TP channel is evident in both sub-samples, although in the latter part the contribution of RN rates increases somewhat and is now marginally significant (at 5% confidence levels).

3.2 Interpreting US MP Spillover Channels

The results presented in Table 4 show that while the magnitude of the transmission of US MP shocks into international long-term yields is comparable between DEV and EME countries, the nature of the transmission mechanisms appear to be different, as suggested by the contrasting decomposition of overall yield movements into RN and TP components across country groups. This section delves deeper into the possible underlying mechanisms that could be explaining these differences. We first discuss alternative hypotheses of why the RN component (expectations of future short-term rates) is the dominant channel for DEV economies, but relatively unimportant for EME. We then turn into why the TP channel may be dominant for EME, but of smaller importance for DEV countries.

3.2.1 Transmission of US MP shocks through RN rates: two competing hypotheses

There are two main hypothesis generally mentioned as possible explanations for the comovement between US MP and expected short-term rates (the RN component of yields) in other countries. We will refer to them as the *informational channel* and the *exchange rate channel*.[17]

The Informational Channel

This hypothesis argues that economic fundamentals such as inflation, activity and/or unemployment, may be correlated between the US other countries. If, in addition, FOMC meeting are times where relevant macroeconomic information about the US is revealed to the markets, then it would follow that expectations of fundamentals and MP rates in other countries should move in a similar fashion. If this is the dominant channel, then comovment between US and international rates during FOMC meetings should not be interpreted as actual spillovers from US MP actions, but merely as a correlation based on the natural reaction of expected policy rates to common economic fundamentals. For this channel to be potentially relevant therefore, one must document i) a statistically significant degree of comovement between US and other countries fundamentals, and ii) the revelation of new information about such fundamentals during FOMC meetings.

The first condition has some support in the evidence. For much of the post financial crisis period, the US and other advanced economies –in particular the Eurozone, Japan, and the UK– displayed similar patterns of persistently low inflation and activity, a comovement that has waned off in the last couple of years due to the faster recovery of the US. More formally, Jotikasthira et al. (2015) document that the observed comovement between yield curves in the US and other advanced countries (Germany and the UK) depend on common underlying factors. Specifically, interest rates depend on a set of macro variables, and those

[17] See, for example, Bowman et al. (2014). Bauer and Neely (2014) study the channels behind the international transmission of LSAPs in the US to a small sample of advanced economies, distinguishing between RN rates, which they dub the signaling channel, and the TP component of international yields. However, they do not investigate the underlying mechanisms behind the signaling channel of US MP into foreign yields.

variables in Germany and the UK load on both a global factor as well as a US factor, particularly so for inflation.

More problematic is to find support for the second condition –the revelation of fundamentals during FOMC meetings. Indeed, we have chosen the event study methodology around FOMC days precisely because these are days where the main economic event is the meeting itself, having zero overlap with US economic releases, and minimal overlap with other countries macro releases, as Table 3 shows. Hence, it is not obvious how the informational channel would play out in the context of our particular identification strategy. One possibility is that the market learns something about the state of the economy from the FOMC minutes that could not be anticipated with the accumulated economic releases up to that point. Such interpretation relies on some form of superior analysis or insight in the way the Fed processes commonly known information.

Several papers have formally studied whether Fed forecasts of macroeconomic variables can beat the market in a consistent fashion. While there is some evidence of forecasting superiority by the Fed in older studies, more recent papers document a significant deterioration of this advantage relative to private forecasts post 2000s.[18] One could argue, however, that while the FOMC minute may not a better forecast of future fundamentals than other market predictions, it could still be a relevant signal (in the Bayesian sense) and thus incorporated in market expectations. We now present two pieces of evidence that tend to downplay the role of this particular channel.

The first evidence is based on comparing the elasticity of international yields to US short-term rates in days of FOMC announcement, vis-à-vis other days. Hanson and Stein (2015) argue that non-FOMC days should have a comparably higher share of macro news, vis-a-vis Fed's reaction-function news (what the Fed will do about the accumulated macro news in terms of policy), compared to FOMC days. Therefore, if the elasticity of long-term rates to short-term rate movements around FOMC days is driven by macro news, this elasticity should be stronger during non-FOMC days. They find the exact opposite.

Based on a similar idea, we calculate the elasticity of long-term rates abroad to changes in US 2-yr yields around specific US macroeconomic release dates, which include CPI, IP, and unemployment announcements. Table 5 shows the main regression results. For DEV countries, we find that all US macroeconomic release

[18]Romer and Romer (2000) document superior forecasting power in Fed's projections of US inflation and activity pre 1991, while Gavin and Martin (2003), and Gamber and Smith (2009) find a deterioration in forecast superiority when extending the sample up to early 2000s. Similarly, D'Agostino and Whelan (2008) find that extending the sample leads to forecasting superiority by the Fed only on very short-term (within the quarter) projections of inflation, but not on other macroeconomic variables or forecast horizons.

dates show a significant comovement between US 2-yr yields and foreign 10-yr yields. However, the point estimates are all below the corresponding effects of US MP shocks reported in Table 4. Difference tests reveal that the transmission of US short-term rates to DEV long-term yields is in general significantly larger during FOMC meetings (our MP shock measure) than during macroeconomic releases. The only exceptions are unemployment releases in the first half of the sample, and activity in the second part of the sample, where the larger coefficient associated with US MP shocks is not statistically significant at 5% confidence levels.

Table 5: Response of 10-year interest rates during US economic releases

DEV	Full sample			Pre Nov. 2008			Post Nov. 2008		
	10y	rn	tp	10y	rn	tp	10y	rn	tp
Inflation	0.186***	0.129***	0.057	0.209***	0.173***	0.036	0.101**	0.031	0.069
	(0.028)	(0.035)	(0.036)	(0.033)	(0.044)	(0.044)	(0.049)	(0.050)	(0.054)
Activity	0.227***	0.257***	-0.030	0.179***	0.231***	-0.052	0.335***	0.313***	0.022
	(0.024)	(0.036)	(0.038)	(0.027)	(0.042)	(0.039)	(0.060)	(0.069)	(0.093)
Unemployment	0.305***	0.361***	-0.056***	0.307***	0.376***	-0.069***	0.307***	0.320***	-0.012
	(0.015)	(0.021)	(0.022)	(0.018)	(0.026)	(0.027)	(0.026)	(0.036)	(0.033)
EME	**Full sample**			**Pre Nov. 2008**			**Post Nov. 2008**		
	10y	rn	tp	10y	rn	tp	10y	rn	tp
Inflation	-0.055	-0.011	-0.044	-0.027	-0.036	0.009	-0.174*	0.055	-0.230*
	(0.063)	(0.037)	(0.073)	(0.075)	(0.047)	(0.086)	(0.105)	(0.056)	(0.132)
Activity	0.037	0.038	-0.001	0.006	0.056	-0.050	0.022	-0.045	0.067
	(0.054)	(0.049)	(0.064)	(0.064)	(0.062)	(0.078)	(0.100)	(0.063)	(0.104)
Unemployment	0.051*	0.036*	0.015	0.042	0.046*	-0.004	0.085**	0.023	0.062
	(0.031)	(0.021)	(0.038)	(0.040)	(0.027)	(0.049)	(0.040)	(0.029)	(0.050)

This table shows the estimated coefficients of US macroeconomic events for developed (DEV) and emerging economies (EME), as described in equation (1). In parentheses are reported standard errors. *** p-value < 0.01. ** p-value < 0.05, and * p-value < 0.1.

For EME countries the effect of changes in the US 2-yr treasury around macroeconomic releases is in general not significant, with a few exceptions where small effects are found, but in general not significant at 5% confidence. Not surprisingly then, we find that the impact of US MP on foreign bond yields is significantly higher than the corresponding effect of US macroeconomic releases.

All in all, and going back to the argument in Hanson and Stein (2015), we conclude that this evidence is not supportive of the informational channel. Indeed, while the exercise is not strictly comparable to Hanson and Stein's –as we study international bond yields, and they focus on US long-term rates–the results have similar implications for assessing the contributions of macro vs. reaction function news as transmission channels. If days with arguably larger share of US macro news (economic release days) display a weaker elasticity of international rates in DEV economies compared to days with lower share of macro news (FOMC days), it is reasonable to assume that during the latter events the main driving force must be unrelated to the revelation of US macroeconomic conditions. Notice also that this is an even starker comparison than the one presented by Hanson and Stein (2015), since we select specific US macroeconomic release dates for comparing the elasticities vis-à-vis FOMC days, whereas they use all non-FOMC days as control.

The second piece of evidence we present is based on testing directly whether yield changes during FOMC meetings affect macroeconomic variables in other countries.[19] Here it is important to recognize that, beyond a signaling channel of future macroeconomic conditions, US yield changes may also affect macroeconomic conditions in a causal manner through tighter policy –that being indeed the main feature of a countercyclical MP design. But notice that these channels are, a priori, associated with opposite signs: while the signaling channel suggests a positive correlation between US yield changes and expectations of future macro conditions (i.e., the Fed is tightening policy because it anticipates better macro performance in the US, in turn correlated with activity and inflation abroad), the causal effect predicts a negative relation –a tighter Fed policy, ceteris paribus, is contractionary for other economies, as has been widely documented.[20]

To test this hypothesis, we compute the monthly change in the 2-yr US yield and separate it into two components: the change around the FOMC meeting of that respective month (for those months with a FOMC meeting), and the difference between the total change in the rate and the FOMC component.[21] That is, at each month t where there is an FOMC meeting, we have

$$\Delta US\ 2YR_t = FOMC_t + Rest_t \qquad (5)$$

We then regress different leads of activity and inflation in the countries included in each of our DEV and EME samples using monthly panel regressions. Specifically, we estimate the following model:

$$y_{j,t+h} = \alpha + \beta_1 * FOMC_t + \beta_2 * Rest_t + \gamma * y_{j,t} + \varepsilon_{j,t+h} \qquad (6)$$

[19] We thank the referee for suggesting this test.

[20] See for example, Kim (2001), and Canova (2005), among others.

[21] A related approach is followed by Bernanke and Kuttner (2005), who study the dynamic effects of the surprise component of FFR changes on equity returns using a VAR approach at monthly frequency (see section II of their paper), although their measure of surprise refers to the unexpected change in actual FFR futures around FOMC meetings, while we focus on unexpected moves in 2-yr US yields.

Table 6: Response of macroeconomic data to US 2y shocks

Panel A: Developed economies								
	Inflation				**Activity**			
	Pre Nov. 2008		Post Nov. 2008		Pre Nov. 2008		Post Nov. 2008	
h	FOMC	rest	FOMC	rest	FOMC	rest	FOMC	rest
1	-0.003	0.002***	0.002	0.002	-0.030**	0.002	0.033	-0.021
2	-0.001	0.002**	-0.000	0.003**	-0.023	0.013***	-0.028	0.006
3	0.002	0.001	0.000	0.002	-0.052***	-0.005	-0.034	0.016
4	-0.001	-0.001	-0.005	0.004*	-0.037**	0.019***	-0.019	0.001
5	-0.002	-0.002	-0.003	0.002	-0.057***	0.003	-0.016	0.019
6	-0.004	-0.003**	-0.003	0.000	-0.047***	-0.007	0.033	0.033
7	-0.012***	-0.004***	-0.007	0.002	-0.050***	-0.002	-0.021	-0.012
8	-0.022***	-0.004***	-0.016***	0.002	-0.050**	-0.023***	-0.033	0.011
9	-0.018***	-0.003**	-0.021***	-0.000	-0.052***	-0.019***	-0.037	0.033
10	-0.007*	-0.001	-0.018***	0.002	-0.037**	-0.012	-0.042	0.016
11	0.001	-0.001	-0.011**	0.003	-0.014	-0.010	-0.084*	0.035*
12	-0.001	0.000	-0.014***	0.001	0.019	-0.000	-0.093**	-0.016

Panel B: Emerging economies								
	Inflation				**Activity**			
	Pre Nov. 2008		Post Nov. 2008		Pre Nov. 2008		Post Nov. 2008	
h	FOMC	rest	FOMC	rest	FOMC	rest	FOMC	rest
1	-0.001	0.003***	0.005	-0.001	-0.045**	0.002	-0.059**	-0.011
2	-0.000	0.004***	0.011	0.007***	-0.022	0.024***	-0.010	-0.034**
3	-0.002	0.004**	0.013	0.008***	-0.062***	-0.009	-0.053**	-0.004
4	-0.007	0.001	0.008	0.005*	-0.037**	0.021***	-0.086***	-0.026*
5	-0.013***	-0.001	0.001	0.005	-0.071***	0.005	-0.085**	-0.029***
6	-0.015***	-0.003	-0.001	0.006	-0.001	-0.011	-0.030	-0.009
7	-0.016***	-0.004*	-0.001	0.001	-0.047**	-0.006	0.006	-0.019**
8	-0.020***	-0.004*	-0.001	0.003	-0.030	-0.031***	-0.058	-0.006
9	-0.022***	-0.004	-0.014	0.004	-0.063***	-0.015**	-0.107**	-0.019*
10	-0.015**	-0.002	-0.031***	0.000	-0.019	-0.008	0.001	-0.021*
11	-0.004	-0.000	-0.018	-0.000	0.027	0.000	-0.030	0.025***
12	-0.004	-0.000	-0.014	-0.001	0.073***	0.013*	0.017	0.001

This table reports the impact of changes in the US 2-yr rate in effective inflation and activity data h-month ahead. Figures are in percentage points. In parentheses are reported standard errors. *** p-value < 0.01. ** p-value < 0.05 and * p-value < 0.1.

Table 6 summarizes the results. Consistent with the literature on the international spillovers of US MP to the real economy, we find that rate changes negatively predict expectations of activity and inflation. Moreover, the effect is generally similar for rate changes that occur around FOMC meetings from those that occur the rest of the days of a given month, suggesting that the impact of higher US interest rates on foreign activity and inflation work predominantly through the standard channel: that is, higher interest rates in the US, ceteris paribus, is contractionary for other countries, as documented by several authors.

Altogether, the evidence presented in this section suggests that, while impossible to completely rule out, the informational channel is unlikely to be the main driver behind the observed comovement between US 2-yr yields and international bond yields at long maturities. We remark again that the evidence presented here should not be interpreted as against commonality in economic fundamentals between the US and other economies documented in other studies, but merely against the interpretation that FOMC meetings are episodes where significant news about such fundamentals is revealed to markets.

The Exchange Rate Channel

A second hypothesis for why the RN component of long-term yields might dominate the international transmission of US MP shocks is that perceived changes in the pace of US MP affect exchange rates between the US dollar and other currencies, which in turn influence trade balances, economic activity, and inflation. For instance, an unexpected softening in the tone about the appropriate rhythm of FFR normalization in the Fed minutes (a negative US MP shock in our event study) could lead to a multilateral depreciation of the US dollar. This in turn could affect MP in other countries if central banks are worried about the adverse consequences in trade and activity, as well as lower inflation from a stronger domestic currency. These concerns are particularly relevant in an environment of low economic activity and deflationary pressures, as has been the case for most of the post-2008 sub-sample. At the margin then, it would be reasonable to expect a softer monetary policy in other countries as a response to the MP shock in the US in order to counteract the exchange rate appreciation. This narrative is indeed a common thread among many economists and practitioners who follow and fuel the debate on “currency wars”.[22]

Evaluating the merits of this explanation is complicated by the fact that, while it is common to hear central bankers and policymakers complain about the adverse exchange rate impacts of soft money in

[22]See for example Mohammed El-Erian (https://www.theguardian.com/business/economics-blog/2013/jan/24/currency-war-damage-to-world-economy), Niall Ferguson (https://www.ft.com/content/cdc80aa0-6638-11e2-b967-00144feab49a), and David Wessel (https://www.brookings.edu/opinions/the-return-of-the-currency-wars), among many others.

other countries,[23] it is hard to find explicit mention to currency goals when central bankers explain their own MP decisions.[24]

To evaluate this hypothesis, we therefore proceed to document evidence about two critical issues that would justify the concern of international policymakers from the exchange rate consequences of US MP shocks, which in turn could lead market participants to expect other countries to follow the Fed when setting their own MP. First, we review evidence regarding the impact of US MP on exchange rates, complementing this literature with new results using a methodology analogous to that of our baseline regressions. Second, we briefly review the evidence about the trade elasticity with respect to exchange rate fluctuations.

There is extensive evidence documenting the relation between US MP and the value of the US dollar in the pre-crisis period (Clarida and Gal 1994; Christiano et al., 1996; Faust and Rogers, 2003; Scholl and Uhlig, 2008; Bouakez and Normandin, 2010). All these papers focus on exchange rates between the US and developed economies, finding large and persistent effects (i.e., delayed overshooting). Moreover, several of these papers document that US MP shocks (identified in alternative ways through VAR models) are an important driver of the overall variance of exchange rate fluctuations against the US dollar in these countries. In the post-crisis period, Goodhart and Ashworth (2012), and Glick and Leduc (2013) focus on the impact of US QE, finding also significant US dollar depreciation around announcements dates.

For emerging markets, evidence of the exchange rate effects from US MP shocks is scant. Hausman and Wongsman (2011) is perhaps the most comprehensive study of the international effects of US MP shocks in terms of country coverage, albeit for the conventional MP period (sample ends in 2005). Using an event study methodology around FOMC meetings, they find significant effects on a variety of asset classes and countries. With respect to exchange rates, they find significant effects on developed countries, but in general non-significant impacts for emerging economies (see Table 5 in their paper). Bowman et al. (2014) study the impact of US unconventional MP on EMEs, finding significant effects on interest rates but in general no statistical significance for exchange rates (using both structural VARs and event study

[23] See for instance the criticism of prime minister Shinzo Abe about lax monetary policy in the US and Europe (WSJ article), as well as the criticism by the governor of the Bundesbank, Jens Weidmann, about the involvement of the Japanese government in the BoJ affairs with the objective of weakening the Yen (https://www.ft.com/content/d1d81962-63e7-11e2-b92c-00144feab49a).

[24] As The Economist observes: "When they loosen monetary policy, central banks don't declare that they are aiming for a weak currency; that would upset their neighbours"; http://www.economist.com/blogs/buttonwood/2016/04/currencies-and-economics. Some exceptions are statements about the effects of exchange rates on trade, activity and inflation, and thus indirectly on the appropriate stance of domestic MP. See speeches by Fed governor Yellen (https://www.federalreserve.gov/newsevents/speech/yellen20150924a.htm), and BoC governor Poloz (http://www.bankofcanada.ca/2016/01/expect-policy-divergence-economies-adjust-shocks).

methodologies).

As complementary evidence, we test whether the FOMC meetings in our sample affect nominal exchange rates. The regression we present in Table 7 essentially replaces the interest rate variables of the left-hand-side with the cumulative NER depreciation for each country (a depreciation of the Euro here means a fall of that currency with respect to the US dollar, for example) over the same interval around the FOMC meeting. The dependent variable is the same as before: the change in 2-yr US yields around the FOMC meeting.

We present results separated by period sub-sample (complete sample, as well as before and after Nov. 2008) and country-groups sub-samples. In line with the papers cited above, despite the difference in methodology, we find highly statistically significant effects on exchange rates for the DEV sample. Specifically, a 100 bp US MP shock would depreciate the exchange rate in the DEV sample by about 75 bp in the full sample, an effect that has increased from 55 bp in the first half to 109 bp in the period post Nov. 2008. For EME, we also find significant effects, although at smaller magnitudes. For instance, the full sample coefficient is just 33 bp, increasing from 16 to 66 bp when comparing both sub-periods.

Table 7: US MP shocks and nominal exchange rates

	Full sample	Pre Nov. 2008	Post Nov. 2008
Developing	7.50***	5.47***	10.92***
	(0.45)	(0.39)	(0.83)
Emerging	3.25***	1.60***	6.59***
	(0.44)	(0.50)	(0.73)

The table reports the impact of a 1 bp change in the US 2-yr rate in nominal exchanges rates, measured as the domestic currency price of the US dollar. The coefficients are in bp. For example, a 100 bp shock in the US 2-yr yield is associated with a 7.5% depreciation of DEV currencies against the US dollar, for the full sample estimation. Standard errors in parentheses. *** p-value < 0.01. ** p-value < 0.05, and * p-value < 0.1.

Regarding the impact of exchange rates on trade, there is a large empirical literature which focuses mostly on advanced economies. In general, it documents large trade elasticities with respect to exchange rate depreciation (see Prasad and Gable (1998), Fisher and Huh (2002), IMF (2015 b) and references therein). In the case of emerging market economies, some authors document that a second, counteracting channel might be present, namely the negative balance sheet effects of currency depreciations on unhedged firms. For example, Aguiar (2005) finds that this channel can make devaluations contractionary in the case of Mexico. More recently, a study by the BIS (Kearns and Patel, 2016) show that while depreciations boosts GDP through trade for developed economies, in the case of EMEs these benefits are counteracted by the negative effect on firm's valuation of external debt, consistent with the argument and evidence of Aguiar (2005).

In summary, while it is hard to document explicit exchange rate objectives behind MP decisions, the existing evidence regarding the impact of US MP shocks on the value of the US dollar vis-à-vis developed countries'currencies, as well as the evidence on trade elasticities to exchange rate fluctuations, are consistent with the exchange rate channel as a possible driver behind the impact of US MP shocks on expected rates in or DEV sample. Indeed, i) the existing evidence, including the regression results presented in Table 7 above, find a large and significant effects of US MP shocks on DEV exchange rates, but smaller effects in the case of EME; ii) the evidence also shows that an appreciation with respect to the USD tends to worsen the trade balance, particularly so for advanced countries. Taken together, we believe these arguments provide a reasonable justification for why markets could expect MP in advanced countries to follow the Fed.

It is important to note that we are not justifying nor documenting that CBs in developed economies indeed set policy rates to follow the Fed –beyond what their current fundamentals would advise– with an explicit trade balance objective in mind. We are merely documenting that the channels which justify the concern of market participants are present in the evidence. Indeed, the extensive talk about “currency wars” between economists, policymakers, investment banks and other financial market players cited above is suggestive that this channel is very present in the ongoing discussion.

3.2.2 Transmission of US MP shocks through TP: a risk-taking channel of US MP into emerging market debt

Several recent models highlight the balance sheet channel behind the transmission of MP. The idea is that when Fed changes policy (through either traditional or unconventional MP) it affects the willingness of investors to hold certain assets. For example, a signal of lower future rates and/or a direct intervention in bond markets that lowers yields may induce investors to seek higher yields in riskier securities. These include longer-term risk-free bonds, or riskier bonds such as mortgage-backed securities, corporate issues, and emerging market securities (see for example, Vayanos and Vila, 2009; Hanson and Stein, 2015; and Bruno and Shin, 2015, among others). Indeed, according to Ben Bernanke,[25] this is precisely the rationale

[25] See Jackson Hole speech, Aug. 31 (https://www.federalreserve.gov/newsevents/speech/bernanke20120831a.htm).

behind long-term bond purchases implemented in the various rounds of QE during his term as chairman of the Fed.

One direct testable prediction from this theory is that compression of premiums following expansive MP should be accompanied with positive net inflows into riskier asset classes. To test this, we run a similar event-study regression as the baseline exercise, but using as dependent variable the net fund inflows into fixed-income securities in each country, obtained from EPFR. Unfortunately, the data does not make the separation into flows that purchase domestic government bonds from corporate bonds. Also, the highest available frequency is weekly, so the identification is less clean in this exercise as in the baseline regressions since a wider window implies that more country-specific events can (and do) overlap with the US MP event being identified.

Nevertheless, we make some progress by constructing the following event study. We define the US MP surprise as the change in 2-yr treasury yields around the week of the FOMC meeting, and compute the net flows that occurs during the corresponding week. We use the flow in levels, as well as normalized by different controls for the size of the corresponding fixed-income market. These include nominal GPD and the amounts of bonds outstanding (using data from the BIS). Due to data limitations, we present results for the second sub-period only.

Table 8: US MP shocks and international fixed-income flows

Units	Deflator	DEV	EME
MM USD	None	-154.971**	-92.682**
percent	GDP	-0.016**	-0.019*
percent	Government Debt	-0.041*	-0.057**

This table reports the impact of changes in the US 2-yr yield in the week of each FOMC meeting, on net fixed income flows using weekly data from EPFR. Standard errors in parentheses. *** p-value < 0.01. ** p-value < 0.05, and * p-value < 0.1.

The main results of this exercise are shown in Table 8. The effect of US MP shocks on portfolio flow levels is significant for both groups of countries, and actually larger for DEV. However, flows normalized by either GDP or amount of bonds outstanding reveal that the relative effects on flows is larger for

EME, in particular when using bonds outstanding as deflator. Moreover, although consistent data for turnover in domestic bond markets is hard to compile for EME, it is well known that asset markets in emerging countries are generally more illiquid. Thus, a given order flow (say, an inflow equal to 1% of the outstanding securities) is likely to cause significantly more price pressure in these economies than in developed countries with more liquid financial markets.[26]

The evidence presented in Table 8 is reassuring, in the sense that the interpretation of yield changes through a term premium channel is not some artifact of the affine term-structure model decomposition. Rather, it seems to be the asset price consequence of genuine portfolio rebalancing activity towards/away from riskier, EME debt, as the Fed changes its tone during FOMC meetings signaling a more expansionary or contractionary stance of MP. This evidence complements the numerous studies mentioned above which document a "risk taking channel" of US MP, but in our case, materialized through flows into emerging market debt securities. The regression also shows that flows to DEV economies react significantly to US MP, although the relative effect is weaker than for EME, which is perfectly consistent with the fact documented in Table 4 above that the TP component explains some, though not the majority, of the transmission of US MP shocks to these countries in the post Nov. 2008 period.

4 Spillover effects in perspective: a comparison with other economic events

4.1 Effect of own MP

To gain perspective into the quantitative importance of US MP spillovers, we now study the impact of own MP meetings in domestic yields. The explanatory variable here is defined as the movement in 2-yr domestic rates on a 2-day window centered at the business day corresponding to each country's MP meetings. For this reason, we only present the elasticity of 10-yr domestic yields.

The estimated coefficients are reported in Table 9. In the case of DEV (panel a), we see that in the full sample, an increase of 100 bp of the local 2-yr rate is associated with a 37 bp increase in 10-yr yields. This corresponds to a highly significant increase of 78 bp in the risk neutral component, partly offset by a reduction in the term premium of 42 bp. These magnitudes are relatively similar across sub-periods, although the later sub-sample shows a somewhat larger effect in yields. Importantly, the point estimate of the effects of US MP shocks is almost identical to the effects of domestic MP shocks in both sub-periods

[26] For instance, the BIS reports turnover measures in equity markets for developed and emerging countries, consistently documenting less liquidity in the latter. See http://data.worldbank.org/data-catalog/global-financial-development

(a non-significant 1 bp difference in favor of domestic shocks in the earlier sample, and a non-significant 1 bp difference in favor of US MP shocks in the later period). That is, statistically speaking, US MP shocks are as important for long-term yields in DEV countries as their own MP throughout our whole sample.

In the post Nov. 2008 sample (2nd column), the magnitudes are larger, with an effect on overall yields of 47 bp corresponding to a larger increase in risk neutral rates, partly offset by a reduction in the term premium.

Table 9: Effects of Own monetary policy

	Panel A: Developed economies		
	Full sample	Pre Nov 2008	Post Nov. 2008
Ten-year	0.371***	0.304***	0.418***
	(0.060)	(0.098)	(0.070)
risk neutral	0.782***	0.723***	0.825***
	(0.070)	(0.093)	(0.092)
term premia	-0.412***	-0.419***	-0.407***
	(0.089)	(0.102)	(0.134)
	Panel B: Emerging economies		
	Full sample	Pre Nov 2008	Post Nov. 2008
Ten-year	0.416***	0.518***	0.325**
	(0.116)	(0.068)	(0.164)
risk neutral	0.614***	0.677***	0.560***
	(0.081)	(0.130)	(0.112)
term premia	-0.198	-0.159	-0.236
	(0.173)	(0.180)	(0.257)

This table shows the estimated coefficients of own monetary policy events, as described in equation (1). The regression is estimated separately for each block: Developed (DEV) and Emerging economies (EME). In parentheses are reported standard errors. *** p-value < 0.01. ** p-value < 0.05 and * p-value < 0.1.

For EME, the Table 9 shows that per every 100 bp shock in domestic MP (2-yr domestic rates), 10-yr rates increase by 42 bp in the complete sample, again explained by a larger increase in the RN component (61 bp), counteracted by a compression in the TP (20 bp). Interestingly, in the pre Nov. 2008 period the effect is more pronounced, at 52 bp, which is statistically larger than the effect of US MP shocks for EME in this sub-sample. In the second sub-sample however, the effect of domestic MP drops to 56 bp, which is now statistically smaller than the effect of US MP documented in Table 4.

It is also interesting to point out that both for DEV and EME countries, in all periods considered, the effect of domestic MP shocks follows a different pattern than US MP shocks. Namely, domestic policy consistently raises RN rates by a larger amount than 10-yr yields, with the TP component counteracting the effect. Interestingly, this evidence is consistent with a recent paper by Abrahams et al. (2017), who document a negative effect of US MP on term premia for long-term US treasuries. The argument is that an (unanticipated) increase in the fed fund rate reduces inflation risk, reducing the risk compensation demanded by investors for holding nominal bonds and lowering term premia. Table 9 suggest this result extends to a broader sample of countries, including both developed and emerging market economies.

4.2 Effect of economic releases

As a final exercise to put US MP spillovers in perspective, Table 10 shows the elasticities of 10-yr yields to changes in 2-yr yields around a 2-day window centered at domestic macroeconomic announcements, including inflation (CPI), activity (industrial production) and unemployment. Panel a) reports the results from the panel regression for economic releases for the DEV sample. Generally, 2-yr yield movements around most economic releases and time periods have significant effects on 10-yr yields. For DEV economies, in general the transmission is larger in the case of unemployment and activity releases, with inflation having a lesser effect. In contrast, in EME inflation episodes exhibit a larger comovement between short and long-term rates in the earlier episode, but is reversed in favor of activity and unemployment post Nov. 2008.

Table 10: Response of 10-year interest rates during Domestic economic releases

DEV	Full sample			Pre Nov. 2008			Pre Nov. 2008		
	10y	rn	tp	10y	rn	tp	10y	rn	tp
Inflation	0.361***	0.662***	-0.301***	0.351***	0.812***	-0.461***	0.362***	0.561**	-0.199
	(0.085)	(0.170)	(0.096)	(0.055)	(0.053)	(0.049)	(0.135)	(0.247)	(0.126)
Activity	0.509***	0.819***	-0.310***	0.444***	0.796***	-0.353***	0.520***	0.820***	-0.300**
	(0.050)	(0.111)	(0.109)	(0.048)	(0.063)	(0.059)	(0.066)	(0.144)	(0.143)
Unemployment	0.487***	0.819***	-0.332***	0.485***	0.811***	-0.325***	0.480***	0.827***	-0.346***
	(0.046)	(0.042)	(0.063)	(0.047)	(0.048)	(0.064)	(0.071)	(0.063)	(0.097)
EME	Full sample			Pre Nov. 2008			Pre Nov. 2008		
	10y	rn	tp	10y	rn	tp	10y	rn	tp
Inflation	0.394***	0.428***	-0.034	0.404***	0.424***	-0.020	0.369**	0.424***	-0.056
	(0.097)	(0.027)	(0.100)	(0.064)	(0.049)	(0.092)	(0.153)	(0.029)	(0.153)
Activity	0.341**	0.312***	0.030	0.135	0.253**	-0.118	0.640***	0.394***	0.246***
	(0.133)	(0.089)	(0.086)	(0.122)	(0.116)	(0.091)	(0.049)	(0.083)	(0.081)
Unemployment	0.400***	0.507***	-0.107	0.312*	0.530***	-0.218	0.422***	0.486***	-0.064
	(0.079)	(0.076)	(0.134)	(0.170)	(0.120)	(0.215)	(0.097)	(0.091)	(0.179)

This table shows the estimated coefficients of domestic macroeconomic events for developed (DEV) and emerging economies (EME), as described in equation (1). In parentheses are reported standard errors. *** p-value < 0.01. ** p-value < 0.05 and * p-value < 0.1.

All in all, the magnitudes of the effects are comparable to the impact of US MP on long-term yields, although its composition is different. As was the case for domestic MP events, we see a strong positive impact on risk neutral rates, partly offset by a negative movement in term premia.

5 Robustness

We now briefly describe different robustness checks that we perform on our main econometric specification. For space considerations, we report only the coefficients related to US MP spillovers for overall 10-yr yields, and each of their components, for the pre and post Nov. 2008. The main tables are included in Appendix B, and we limit our attention here to highlighting the main results.

A second set of robustness checks involve sample selection. We repeat all calculations excluding iteratively one country from each group (for example, we run all the regressions for DEV without Japan, then put Japan back in and exclude Sweden, and so forth). This is to ensure that our main results are not driven by specific outliers. These results are reported in Table 13. The main conclusions remain intact, namely, US MP spillover effects are larger in the post Nov. 2008 data, with similar point estimates for both DEV and EME samples, and these effect are much more tilted towards changes in the TP component in the case of EME.

6 Conclusions

We document the presence of significant US monetary policy spillovers to domestic bond markets in a sample of 24 countries, including 12 developed and 12 emerging market economies. We rely on an event study methodology where US monetary policy changes are identified as the response of short-term US treasury yields within a narrow window of Federal Reserve meetings, and trace its consequences on domestic bond yields using panel data regressions. Moreover, we decompose yields at each individual country level into a risk neutral component, which captures the expected evolution of short-term rates, and bond term premia.

We conclude that the spillover effect to developed countries work predominantly through changes in the risk neutral component. Further analysis of this mechanism suggest it could reflect market expectations that central banks on these countries are likely to follow Fed movements at the margin to avoid currency misalignment that could affect trade. We find little support for the alternative hypothesis that the positive comovement of interest rates around FOMC meetings could result from information provided by FOMC minutes about US macroeconomic conditions, in turn positively correlated with other DEV countries.

For our sample of emerging markets, the transmission seems to work through a different mechanism, more related to a risk-taking channel of US MP that has been highlighted in several recent theoretical and empirical contributions to the international finance literature. We provide evidence that fixed-income net portfolio flows into the developing economies we consider react significantly to US MP shocks. While the effects are also marginally significant for developed economies, the magnitudes of these flows are larger for emerging economies when controlling for the size of local bond markets.

Finally, our results suggest that US MP spillovers are economically large when compared to the effects of other events which move international yield curves. We find that they affect long-term yields as least as much as domestic MP shocks, and generally more so than macroeconomic releases, controlling for the impact of such releases on short-term rates.

References

Abrahams, M., Adrian, T., Crump, R., and E. Moench (2017). Decomposing Real and Nominal Yield Curves, *Journal of Monetary Economics*, 84, 182200.

Adrian, T., Crump, R. and E. Moench (2013). Pricing the Term Structure with Linear Regressions, *Journal of Financial Economics,* 110(1), 110-138.

Aguiar, M. (2005). Investment, Devaluation, and Foreign Currency Exposure: The Case of Mexico. *Journal of Development Economics*, 78(1), 95-113.

Bauer, M. and C. Neely (2014). International Channels of the FED Unconventional Monetary Policy, *Journal of International Money and Finance,* 44, 24-46.

Bauer, M. and G. Rudebusch (2014). The Signaling Channel for Federal Reserve Bond Purchases, *Journal of International Central Banking,* September, 3-43.

Bauer, M., Rudebusch, G. and J. Wu (2012). Correcting Estimation Bias in Dynamic Term Structure Models, *Journal of Business & Economic Statistics,* 30(3), 454-467.

Bernanke, B., and K. Kuttner (2005). What Explains the Stock Market's Reaction to Federal Reserve Policy? *Journal of Finance,* 60(3), 1221-1257.

BIS (2014). 84^{th} Annual Report.

BIS (2015). What do New Forms of Finance Mean for EM Central Banks? *BIS papers No 83.*

Bouakez, H., and M. Normandin (2010). Fluctuations in the Foreign Exchange Market: How Important are Monetary Policy Shocks? *Journal of International Economics*, 81(1), 139-153.

Bowman, D., Londono, J., and H. Sapriza (2014). U.S. Unconventional Monetary Policy and Transmission to Emerging Market Economies, *International Finance Discussion Papers No 1109, Board of Governors of the Federal Reserve System.*

Bruno, V. and H. Shin (2015). Cross-Border Banking and Global Liquidity, *Review of Economic Studies,* 82(2), 535-564.

Canova, F. (2005). The Transmission of US Shocks to Latin America, Journal of Applied Econometrics, 20(2), 229-251.

Christensen, J. and G. Rudebusch (2012). The Response of Interest Rates to US and UK Quantitative Easing, *The Economic Journal,* 122 (November), 385-414.

Christiano, L., Eichenbaum, M., and C. Evans (1996). Identification and the Effects of Monetary Policy Shocks. *Financial Factors in Economic Stabilization and Growth*, 36-74.

Clarida, R., and J. Gali (1994). Sources of Real Exchange-rate Fluctuations: How Important are Nominal Shocks? *Carnegie-Rochester conference series on public policy*, 41, 1-56.

Cochrane, J. and M. Piazzesi (2002). The FED and Interest Rates – A High-Frequency Identification, *American Economic Review,* 92(2), 90-95.

Cochrane, J. and Piazzesi, M. (2005). Bond Risk Premia, *American Economic Review,* 95(1), 138-160.

Craine, R. and V. Martin (2008). International Monetary Policy Surprises Spillovers, *Journal of International Economics,* 75(1), 180-196.

D'Agostino, A., and K. Whelan (2008). Federal Reserve Information During the Great Moderation, *Journal of the European Economic Association*, 6(23), 609620.

Duffee, G. (2002). Term Premia and Interest Rate Forecasts in Affine Models. *Journal of Finance*, 57(1), 405-443.

Faust, J., and J. Rogers (2003). Monetary Policy's Role in Exchange Rate Behavior, *Journal of Monetary Economics*, 50(7), 1403-1424.

Fisher, L., and H.Huh (2002). Real Exchange Rates, Trade Balances and Nominal Shocks: Evidence for the G-7. *Journal of International Money and Finance*, 21(4), 497-518.

Gagnon, J., Raskin, M., Remache, J. and B. Sack (2011). The Financial Market Effects of the Federal Reserve Large-Scale Asset Purchases, *Journal of International Central Banking,* March, 3-43.

Gamber, E. and J. Smith (2009). Are the Fed's Inflation Forecasts Still Superior to the Private Sector's?*Journal of Macroeconomics*, 31(2), 240251.

Gavin, W. and R. Mandal (2003). Evaluating FOMC Forecasts, *International Journal of Forecasting*, 19(4), 655667.

Georgiadis, G. (2015). Determinants of Global Spillovers from US Monetary Policy, *Journal of International Money and Finance,* 67, 2-21.

Gilchrist, S., Yue, V. and E. Zakrajsek (2016). US Monetary Policy and Foreign Bond Yields, in E. Albagli, D. Saravia and M. Woodford (eds), *Monetary Policy Through Asset Markets: Lessons from Unconventional Measures and Implications for an Integrated World, Vol. 24 of Central Banking, Analysis, and Economic Policies Book Series*, Central Bank of Chile, 257-283.

Glick, R., and S. Leduc (2013). The Effects of Unconventional and Conventional US Monetary Policy on the Dollar. *Federal Reserve Bank of San Francisco.*

Goodhart, C., and J. Ashworth (2012). QE: a Successful Start may be Running into Diminishing Returns, *Oxford Review of Economic Policy*, 28(4), 640-670.

Gürkaynak, R. and J. Wright (2012). Macroeconomics and the Term Structure, *Journal of Economic Literature,* 50(2), 331-367.

Hanson, S. and J. Stein (2015). Monetary Policy and Long-Term Real Rates, *Journal of Financial Economics,* 115(3), 429-448.

Hausman, J. and J. Wongswan (2011). Global Asset Prices and FOMC Announcements, *Journal of International Money and Finance,* 30(3), 547-571.

Hoffman, B. and E. Takats (2015). International Monetary Spillovers, *BIS Quarterly Review,* 105-118.

IMF (2014). Global Financial Stability Report, *International Monetary Fund*, April, chapter 2.

IMF (2015). Regional Economic Outlook: Western Hemisphere, *International Monetary Fund*, October, chapter 3.

IMF (2015 b). World Economic Outlook *International Monetary Fund*, October, chapter 3.

Jotikasthira, C., Le, A., and C. Lundblad (2015). Why do Term Structures in Different Currencies Co-move? *Journal of Financial Economics*, 115(1), 58-83.

Kearns, J., and N. Patel (2016). Does the Financial Channel of Exchange Rates Offset the Trade Channel?. *BIS Quarterly Review*, December.

Kim, S. (2001). International Transmission of US Monetary Policy Shocks: Evidence from VAR's. *Journal of Monetary Economics*, 48(2),339-372.

Krishnamurthy, A. and A. Vissing-Jorgensen (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy, *Brookings papers on Economic Activity,* Fall, 215-287.

Obstfeld, M. (2015). Trilemmas and Tradeoffs: Living with Financial Globalization, in C. Raddatz, D. Saravia and J. Ventura (eds), *Global Liquidity, Spillovers to Emerging Markets and Policy Responses, Vol. 20 of Central Banking, Analysis, and Economic Policies Book Series*, Central Bank of Chile, 13-78.

Prasad, E., and J. Gable (1998). International Evidence on the Determinants of Trade Dynamics. *Staff Papers (International Monetary Fund)*, 45(3), 401-439.

Rey, H. (2015). Dilemma Not Trilemma: The Global Financial Cycle and Monetary Policy Independence, *NBER Working Paper* 21162.

Rogers, J., Scotti, C. and J. Wright (2014). Evaluating Asset-Market Effects of Unconventional Monetary Policy: a Multi-Country Review, *Economic Policy,* 29(80), 749-799.

Romer, C., and D. Romer (2000). Federal Reserve Information and the Behavior of Interest Rates, *American Economic Review*, 90(3), 429457.

Scholl, A., and H. Uhlig (2008). New Evidence on the Puzzles: Results from Agnostic Identification on Monetary Policy and Exchange Rates, *Journal of International Economics*, 76(1), 1-13.

Shek, J., Ilhyok, S. and H. S. Shin (2015). Investor Redemptions and Fund Manager Sales of Emerging Market Bonds: How are they Related? *BIS Working Paper No 509*

Vayanos, D., and J. Vila (2009). A Preferred-Habitat Model of the Term Structure of Interest Rates, *NBER Working Paper No. 15487.*

Appendix A Economic indicators

Table 11 shows the economic indicators used to identify macroeconomic release days, as described in section 2.2. The three columns show the sources for CPI, Activity, and Unemployment, for all countries, with the corresponding release frequency in parenthesis: (Q): quarterly, (M): monthly, (B): bi-weekly and (W): weekly. N/A refers to data not available.

TABLE 11: Economic releases description

	CPI	Activity	Unemployment
US	CPI Urban Consumers (M)	Industrial Production YoY (M)	Initial Jobless Claims SA (W)
CAD	CPI YoY (M)	GDP All industries (M)	Unemployment rate SA (M)
JPN	CPI Nationwide YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
UK	CPI EU Harmonized YoY (M)	Industrial Production YoY (M)	Claimant Count Rate SA (M)
GER	CPI EU Harmonized YoY (M)	GDP YoY (Q)	Unemployment rate SA (M)
ITA	CPI EU Harmonized YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
FR	CPI EU Harmonized YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
AUD	CPI All Groups Goods (Q)	GDP YoY (Q)	Unemployment rate SA (M)
NZ	CPI All Groups (Q)	GDP YoY (Q)	Unemployment rate SA (Q)
CHK	CPI YoY (M)	Industrial Production YoY (M)	N/A (N/A)
KOR	CPI YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
TW	CPI YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
NOR	CPI YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
SW	CPI Headline YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
SZ	CPI YoY (M)	GDP YoY (Q)	Unemployment rate SA (M)
CL	CPI YoY (M)	Monthly Economic Index (M)	Unemployment rate SA (M)
MX	Biweekly CPI (B)	Industrial Production YoY (M)	Unemployment rate SA (M)
HUN	CPI YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)
SOA	CPI YoY (M)	Manufacturing Production (M)	Unemployment rate SA (Q)
TH	CPI YoY (M)	GDP YoY (Q)	N/A (N/A)
ISR	CPI YoY (M)	GDP YoY (Q)	N/A (N/A)
INDO	CPI YoY (M)	GDP YoY (Q)	N/A (N/A)
IND	CPI YoY (M)	GDP YoY (Q)	N/A (N/A)
POL	CPI YoY (M)	Industrial Goods & Services (M)	Unemployment rate SA (M)
COL	CPI YoY (M)	Industrial Production YoY (M)	Unemployment rate SA (M)

Appendix B Robustness estimation

Here we report the two robustness exercises described in section 5. Our first set of alternative specifications deal with including different fixed effects, as well as considering different clusters for constructing standard errors.

The first panel in Table 12 includes the results for US MP spillovers into DEV economies, while the second panel reports the results for EME. For ease of comparison, the third column of the table reproduces the spillovers effects on long term yields in the baseline regression from Table 4. Columns 4 to 11 replicate the estimation considering different combination of fixed effects in the panel regression, as well as alternative clusters, which have an effect only on the significance of point estimates. The different combinations consider for each specification are detailed in the bottom panel of the table. For example, the fourth column of the table considers a specification in which there are no fixed effects, and errors are clustered at annual frequency.

Table 12: Changes in Fixed effects and clusters

Sample	yields	Baseline	Panel A: Developed Economies							
Pre Nov. 2008	Ten-year	0.297***	0.291**	0.291***	0.294**	0.294***	0.294**	0.294***	0.297**	0.295***
Pre Nov. 2008	risk neutral	0.390***	0.387***	0.387***	0.388***	0.388***	0.388***	0.388***	0.390***	0.390***
Pre Nov. 2008	term premia	-0.092***	-0.097	-0.097**	-0.094	-0.094***	-0.094	-0.094***	-0.092	-0.090**
Post Nov. 2008	Ten-year	0.429***	0.424**	0.424***	0.438**	0.438***	0.438**	0.438***	0.429**	0.429***
Post Nov. 2008	risk neutral	0.234***	0.222**	0.222***	0.225***	0.225***	0.225***	0.225***	0.234***	0.231***
Post Nov. 2008	term premia	0.196***	0.203*	0.203**	0.213*	0.213**	0.213*	0.213**	0.196*	0.198**
Sample	yields	Baseline	Panel B: Emerging Economies							
Pre Nov. 2008	Ten-year	0.193***	0.182	0.182**	0.197	0.197***	0.197	0.197***	0.193	0.193**
Pre Nov. 2008	risk neutral	0.019	0.015	0.015	0.019	0.019	0.019	0.019	0.019	0.019
Pre Nov. 2008	term premia	0.174**	0.167	0.167*	0.178	0.178*	0.178	0.178*	0.174	0.174*
Post Nov. 2008	Ten-year	0.557***	0.524***	0.524***	0.544***	0.544***	0.544***	0.544***	0.557**	0.556***
Post Nov. 2008	risk neutral	0.136**	0.145***	0.145***	0.139***	0.139***	0.140***	0.140***	0.136***	0.135***
Post Nov. 2008	term premia	0.421***	0.379**	0.379**	0.405**	0.405**	0.404**	0.404**	0.421**	0.421**
Controls		Baseline	Fixed effects and clusters							
FE	Country	N	N	N	Y	Y	N	N	N	N
FE	Year	Y	N	N	Y	Y	N	N	Y	Y
FE	Month	Y	N	N	N	N	N	N	N	N
FE	Country-Year	N	N	N	N	N	Y	Y	N	N
FE	Country-Month	N	N	N	N	N	N	N	Y	Y
Cluster	Year		Y	N	Y	N	Y	N	Y	N
Cluster	Month		N	Y	N	Y	N	Y	N	Y

Source: author's calculations

The second robustness exercise studies the possibility that our results may be due to outliers in either samples of countries. To rule this out, we iteratively exclude a particular country (in each country group, DEV and EME), and estimate the baseline regression with the remainder 11 members. The first column of Table 13 identifies the country that is excluded in each iteration.

Table 13: Effects of removing each-country of the sample

Countries	Panel A: Developed economies					
	Pre Nov. 2008			Post Nov. 2008		
	Ten-year	risk neutral	term premium	Ten-year	risk neutral	term premium
AUD	0.283***	0.403***	-0.121***	0.426***	0.230***	0.196***
CAD	0.296***	0.376***	-0.080**	0.391***	0.218***	0.172***
CHK	0.303***	0.419***	-0.116***	0.457***	0.260***	0.197***
FR	0.291***	0.354***	-0.063*	0.428***	0.231***	0.197***
GER	0.294***	0.379***	-0.085**	0.414***	0.241***	0.174***
ITA	0.297***	0.381***	-0.084**	0.438***	0.259***	0.179***
JPN	0.319***	0.423***	-0.105***	0.456***	0.252***	0.204***
NOR	0.304***	0.419***	-0.115***	0.439***	0.251***	0.188***
NZ	0.276***	0.345***	-0.069**	0.432***	0.203***	0.229***
SW	0.298***	0.404***	-0.107***	0.424***	0.210***	0.215***
SZ	0.311***	0.401***	-0.090**	0.430***	0.252***	0.178***
UK	0.296***	0.372***	-0.076**	0.416***	0.194***	0.222***

Countries	Panel B: Emerging economies					
	Pre Nov. 2008			Post Nov. 2008		
	Ten-year	risk neutral	term premium	Ten-year	risk neutral	term premium
CL	0.189**	0.020	0.169*	0.591***	0.157***	0.434***
COL	0.141***	0.048	0.093	0.551***	0.148***	0.403***
HUN	0.217***	-0.007	0.223**	0.560***	0.114**	0.446***
IND	0.194**	0.013	0.181*	0.562***	0.123**	0.439***
INDO	0.203***	0.026	0.177*	0.484***	0.126**	0.358***
ISR	0.191***	0.021	0.170**	0.577***	0.147***	0.430***
KOR	0.193**	0.012	0.181*	0.573***	0.137**	0.437***
MX	0.200***	0.016	0.184*	0.520***	0.122**	0.398***
POL	0.195**	0.009	0.186*	0.568***	0.173***	0.395***
SOA	0.200***	0.049	0.152*	0.571***	0.120**	0.451***
THAI	0.199***	0.018	0.181*	0.517***	0.121**	0.396***
TW	0.193**	0.004	0.189**	0.604***	0.139**	0.465***

Source: author's calculations

Appendix C Affine Model estimation

Using equations (2) through (4), it can be shown that the coefficients in the term-structure recursion satisfy

$$\mathcal{A}_{n+1} = \mathcal{A}_n + \left(\mu^{\mathbb{Q}}\right)^{'} \mathcal{B}_n + \frac{1}{2}\mathcal{B}_n^{'}\Sigma\Sigma^{'}\mathcal{B}_n - \delta_0 \tag{7}$$

$$\mathcal{B}_{n+1} = \left(\phi^{\mathbb{Q}}\right)^{'} \mathcal{B}_n - \delta_1 \tag{8}$$

with initial values $\mathcal{A}_0 = \mathcal{B}_0 = 0$. Thus, the model-implied yields are $y_t^n = -\frac{\log(P_t^n)}{n} = A_n + B_n^{'}X_t$, with $A_n = \frac{\mathcal{A}_n}{n}$ and $B_n = \frac{\mathcal{B}_n}{n}$. On the other hand, the risk-neutral yield (the yields that would obtain if investors priced bonds under risk neutrality) corresponds to:

$$\tilde{y}_t^n = \tilde{A}_n + \tilde{B}_n^{'}X_t \tag{9}$$

$$\tilde{\mathcal{A}}_{n+1} = \tilde{\mathcal{A}}_n + \mu^{'}\tilde{\mathcal{B}}_n + \frac{1}{2}\tilde{\mathcal{B}}_n^{'}\Sigma\Sigma^{'}\tilde{\mathcal{B}}_n - \delta_0 \tag{10}$$

$$\tilde{\mathcal{B}}_{n+1} = \Phi^{'}\tilde{\mathcal{B}}_n - \delta_1 \tag{11}$$

The risk-neutral yield denoted in (9) essentially reflects the expected path of the future monetary policy rate, and the difference between model-implied yields and risk nutral rates gives the term premium component, at each corresponding maturity.

As we mentioned earlier, the main differences proposed by Adrian et al. (2013) regards the way in which market prices of risk are constructed. To obtain those prices, the authors propose the following three steps procedure:

1. Estimate the VAR(1) process for the observable state variables given by (2). With these estimates, collect residuals in vector $\hat{V}$ and compute its variance-covariance matrix ($\hat{\Sigma} = \hat{V}\hat{V}'/T$).

2. Construct the log excess holding return of a bond maturing in n periods as:

$$rx_{t+1}^{n-1} = \log P_{t+1}^{n-1} - \log P_t^n - r_t, \qquad n = 2, ..., N \tag{12}$$

   where P_t^n is the price of an n period bond and r_t is the risk free rate and N is the maximum maturity considered. In this regard, the main difference between Adrian et al. (2013) and Cochrane and Piazzesi (2005) is that the latter work with one-year excess return while the first uses one-month excess returns. Stacking the system across the N maturities and T time periods we can construct the vector rx and run a the following regression:

$$rx = \alpha\iota_T' + \beta'\hat{V} + cX_{-} + E \tag{13}$$

where ι_T is T vector of ones and X_- is the lagged value of factors. The idea of this regression is to recover the fundamental components of the data generating process of the log excess holding return. Adrian et al. (2013) shows that the fundamental decomposition of these returns could be written as:[27]

$$rx = \text{Expected return} + \text{Priced return innovation} + \text{Return pricing error}$$

After running (13), collect residuals in the $N \times T$ matrix $\hat{E}$ and estimate the return pricing error variance as $\hat{\sigma}^2 = \text{tr}(\hat{E}\hat{E}')/NT$.

3. Using the estimated parameters in (13), compute the market prices of risk as:

$$\hat{\lambda}_0 = (\hat{\beta}\hat{\beta}')^{-1}\hat{\beta}[\hat{a} + \frac{1}{2}(\hat{B}^* \text{vec}(\hat{\Sigma}) + \hat{\sigma}^2)] \tag{14}$$

$$\hat{\lambda}_1 = (\hat{\beta}\hat{\beta}')^{-1}\hat{\beta}\hat{c} \tag{15}$$

where $\hat{B}^* = [\text{vec}(\beta^1\beta^{1'}), ..., \text{vec}(\beta^N\beta^{N'})]'$ and β^i is the covariance between log excess holding return at maturity n and the VAR innovations.

With this procedure, we are able to compute equations (2)-(10). The difference between fitted yields and risk-neutral yields corresponds to the term premium component of yields.

[27] See that paper for details.