The term structures of global yields

By Emanuel Mönch[1]

Abstract

Sovereign bond yields in more than 20 developed and emerging market economies are decomposed into expected short rates and term premia using the Adrian, Crump and Moench (2013) approach. I document that (i) term premia account for large fractions of global bond yield variation; (ii) the co-movement of sovereign bond yields is, to a large extent, driven by the term premium components of sovereign yields, especially in recent years; (iii) connectedness and tail dependence between international bond markets are primarily driven by the term premium components of global yields; and (iv) global bond yields strongly respond to US target rate shocks, albeit with considerable delay. This response is primarily driven by a reassessment of global policy rate expectations.

JEL classification: G12, G15

Keywords: term structure decomposition, sovereign bond yields

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This is an expanded version of the keynote speech given at the Bank of Korea–BIS conference on "Asia-Pacific Fixed Income Markets" held in Seoul on 19–20 November 2018. The keynote is based on ongoing work with Tobias Adrian (International Monetary Fund), Richard Crump (Federal Reserve Bank of New York), and Benson Durham (Blackrock). I thank conference participants for very helpful comments. Nora Lamersdorf provided excellent research assistance. A special thanks goes to Andreas Schrimpf for sharing the monetary policy shock measures and to Kamil Yilmaz for sharing replication codes. The views expressed in this paper are those of the author and do not necessarily represent those of Blackrock, the IMF, Deutsche Bundesbank, the Eurosystem, the Federal Reserve Bank of New York or the Federal Reserve System.

1. Introduction

Effective monetary policy making relies on central banks' ability to steer longer-term interest rates. This can be achieved indirectly through changes in the short-term policy rate and communication about the intended rate path, or through direct intervention in secondary bond markets. Given its importance for the monetary policy transmission mechanism, surprisingly little is known about central banks' effectiveness at affecting longer-term rates.

Without the risk of default, the yield on longer-term bonds can be decomposed into two components: the average short-term rate expected to prevail over the life of the bond, and a term premium. The latter compensates investors in longer-term bonds for the risk that interest rates may not evolve as expected. While central banks can affect both components through actions and communication, other factors can also influence the evolution of interest rates. Due to limited or slow-moving arbitrage capital, changes in the supply and demand for bonds likely drive their evolution. With bond markets becoming more integrated globally, events in foreign economies may also affect the dynamics of national sovereign debt markets. In particular, monetary policy decisions by major central banks may spill over into other national bond markets.

Against this background, this paper seeks to provide tentative answers to the following questions. How much of the variation of global longer-term interest rates is due to term premia? How much of the co-movement of global sovereign yields is due to short rate expectations versus term premia? Does national monetary policy spill over into global yield curves and, if so, through which component of bond yields?

Of course, I am not the first one to ask these questions. There is a growing literature studying these topics. Given the limited space available here, however, I will only reference a few selected related papers. I refer the interested reader to the reviews in these papers for a more comprehensive account of the relevant literature.

This paper is structured as follows. Section 2 shows how to decompose global sovereign bond yields into expected short rate and term premium components using the methodology of Adrian, Crump and Moench (2013). In Section 3, I characterise the co-movement among sovereign yield curves and their components. Section 4 documents that global yield curves show a delayed and persistent response to US monetary policy shocks. Section 5 concludes.

2. Decomposing global yield curves

This section discusses decompositions of the sovereign yield curves of 21 developed and emerging market economies into expected short rate and term premium components. I start by describing the yield data and estimation approach. I then briefly document the properties of the estimated term structure decompositions.

We use zero coupon yield curves obtained from Bloomberg as input for our term structure decompositions. To minimise the influence of default risk, we rely exclusively on local currency bond yields. Depending on the country, the yield curve data becomes available between 1991 and 1997. The sample ends in September 2018.

We decompose these local currency yield curves into expected rate and term premium components using the estimation approach of Adrian, Crump and Moench (2013), ACM henceforth)). Given a set of yield curve factors summarising the cross-section and time series of bond yields, this method consists in running three sets of consecutive regressions. First, a vector autoregression (VAR) of order one is estimated on the yield curve factors via ordinary least squares. This provides autoregressive coefficients and estimated factor innovations. Second, monthly excess bond returns are regressed on a constant, lagged yield curve factors, and the factor innovations estimated in the first step. This delivers a vector of predictive coefficients and a vector of factor risk exposures akin to "betas" in empirical asset pricing models. ACM show that no-arbitrage implies that the two sets of coefficients are directly related to one another when market prices of risk are affine in the pricing factors, as is commonly assumed in many term structure models. The relevant market price of risk coefficients are then easily estimated via a third cross-sectional regression of the predictive coefficients on the factor risk exposures, both obtained in the second step. ACM prove the consistency of this estimator and provide the asymptotic variance, taking into account the estimation uncertainty in the first two stages of the regression.

Following the common practice in the term structure literature (see eg Joslin, Singleton and Zhu (2011) and Wright (2011)), we choose principal components of yields as pricing factors. To span both the cross-sectional as well as the time series dynamics of yields, we use the first four principal components for each country as pricing factors.[2] The model fits the sovereign yield curves very precisely, with absolute mean fitting errors below 10 basis points in all countries. Figure 1 exemplarily shows the model fit for the 10-year maturity for the United States, Japan, Germany, and the United Kingdom. In all four countries, the model implied is effectively indistinguishable from the observed yield. The figures also provide the decomposition of 10-year yields into average expected future short rates over the next 10 years and the 10-year term premium. These show plausible time series variation. While still being elevated in the early 1990s, term premia saw a secular decline in all four countries over the past 20 years, consistent with a reduction of inflation uncertainty (Wright (2011)). In the case of the United Kingdom, the timing of this decline is clearly associated with the announcement of the independence of the Bank of England in May 1997. In Japan, the bulk of variation in 10-year yields is driven by term premia, consistent with investors expecting short rates to stay close to the zero lower bound through most of the sample.

3. Global term structure co-movement

An inspection of term structure decompositions for all other countries shows that the decline of term premia is not restricted to the largest economies, but is also prevalent for the remaining developed and emerging market economies in our panel. But the

2 ACM show that for the United States, five principal components are needed to fully span the monthly excess returns, while Joslin, Singleton, Zhou (2011), Wright (2011) and others rely on three principal components as these fully span the cross-section of contemporaneous yields. Our results are robust to using four or five principal components. Note that due to the different number of pricing factors and the different sample period used in the estimation, the term structure decomposition for the United States differs slightly from the one based on ACM, which is updated on the Federal Reserve Bank of New York website (https://www.newyorkfed.org/research/data_indicators/term_premia.html)

prominent role of term premia in explaining yield variation is not merely due to a common trend in interest rate risk compensation.

Table 1 documents the importance of term premia in explaining the (co)-variance in monthly changes of 10-year sovereign bond yields. For ease of presentation, I focus on the G7 countries here, but the general pattern extends to the remaining countries as well. On the diagonal, I report the share of variance explained by the term premium component. With the exception of Germany, these shares exceed 50% of the variance in all G7 countries, and are particularly elevated in Italy and Japan. The off-diagonal elements show the share of covariance of monthly yield changes explained by the term premium. These shares are also sizable and indicate that a large fraction of the month-to-month co-variation of sovereign yield curves is due to global term premium co-movement.

The unconditional variance and covariance shares summarised in Table 1 may mask interesting time variation in sovereign yield co-movement. The top panel of Figure 2 shows one-year rolling window correlation coefficients of daily yield changes (black), term premium changes (red), and expected rate path changes (blue) averaged across all country pairs in our panel of 21 countries. The chart shows that global yield curves have co-moved strongly since the late 1990s, but this co-movement declined sharply during the Great Financial Crisis (GFC) and only picked up again around 2013. Interestingly, while average expected short rates were correlated more strongly over the earlier episode, since 2013, the pick-up in cross-country yield correlation is almost exclusively driven by a strong increase in term premium correlation. Moreover, as the bottom panel of Figure 2 also documents, much of the increased correlation may be explained by the fact that global term premia have co-moved particularly strongly with US term premia in recent years.

These preliminary findings suggest that global yield curves and especially their term premium components have become more closely interrelated in recent years. Does this imply that shocks to one sovereign bond market transmit to other sovereign bond markets more strongly? Diebold and Yilmaz (2014) propose a measure of connectedness that enables me to directly assess this question. More precisely, their approach quantifies how much of the forecast error variance in a country's bond market is driven by shocks arising in other countries' bond markets.

Figure 3 shows the time series of global sovereign bond market connectedness measures according to Diebold and Yilmaz (2014). This index is obtained using a VAR of order one on daily changes of 10-year sovereign yields and their expected short rate and term premium components, respectively, for all 21 countries in our panel. The figure documents that global yield curve connectedness has been elevated throughout the last two decades, with a dip around the GFC. Strikingly, however, while the expected rates and term premium components were connected across countries to similar extents until around 2007, the term premium connectedness declined sharply during the GFC and only picked up again around 2010. At the same time, the connectedness of expected short rates declined and has since remained at lower levels than before the GFC. In contrast, the connectedness of global term premia has continued to increase and reached levels not seen before the crisis at the end of the sample. This suggests that in recent years, innovations to term premia in other countries have become substantially more important for the variation in sovereign bonds yields than in the early 2000s.

In light of this finding, policy makers might be particularly concerned with a strong tail dependence of global sovereign yields in the sense that sharp movements in one bond market spill over into other bond markets. A simple heuristic to measure such tail dependence is the number of days over the past year on which the sovereign yields of two countries both experienced sharp increases.[3] This measure, averaged across all country pairs, is plotted in Figure 4. It shows that tail dependence had seen a secular decline since 2001 but moved up sharply starting around 2013. More importantly, this increase was almost entirely driven by the term premium component of global yields, suggesting that risk attitudes of global bond investors might be an important source of co-movement in tail events.

The increased average tail dependence shown above may be a reflection of changes in the network structure of global yield dependencies. Figure 5 shows the tail dependence between pairs of countries in August 2010 and in August 2017. To highlight the changing network structure, I exclude edges between countries whose bilateral tail dependence estimates are lower than the average of all country pairs across the two different dates. The charts give rise to two main observations. First, tail dependence in yields is generally higher among countries in the same economic region. This is most obvious in the August 2017 network chart, which shows a clear association among countries in Europe or the Asia-Pacific region, respectively. Second, the estimated tail dependence for the term premium components of global yields has increased sharply between the two dates. In 2017, the network of term premium tail dependence was considerably denser than in 2010. This highlights that sudden jumps in term premia have become much more synchronised across countries in recent years.

In sum, the results documented in this section show that global sovereign yield curves co-move strongly, more so since around 2013. Spillovers between national bond markets have become more important and large movements in sovereign yields and especially in term premia tend to occur on the same dates. As all major central banks have intervened in bond markets via quantitative easing policies during this period, this raises the question whether monetary policy has important international spillovers. This question is addressed in the next section, focusing on US monetary policy as a case in point.

4. US monetary policy and global yield curves

In this section, I estimate the effects of US monetary policy shocks on global yield curves and their components via panel local projections, following the approach in Jordà (2005). Specifically, for a given measure of a monetary policy shock ε, I run the following regression:

$$Y_{i,t+h} - Y_{i,t} = \alpha_h + \alpha_i + \alpha t + \beta_h \epsilon_t + \sum_{1}^{P} \gamma_{p,h} Y_{i,t-p} + \sum_{0}^{P} \phi_{q,h}\, x_{i,t-q} + \sum_{R_1}^{-R_2} \delta_{r,h}\, \epsilon_{i,t-r} + u_{t+h}.$$

The coefficients of interest β_h measure the average response of yields Y_i across countries i in period $t+h$ to an impulse ϵ_t, controlling for country-specific fixed

[3] Here, sharp increases are defined as those in the top decile of daily changes of 10-year yields over the past year. Considering the top 5% of daily yield changes gives very similar results.

effects, a linear time trend, past and future shocks, lagged dependent and additional (country-specific) controls $x_{i,t-q}$.[4] To study the differential response of the expected short rate and term premium components of global yields, I run identical regressions for the two components of yields.

I obtain monetary policy shock measures from Kearns, Schrimpf and Xia (2018). These are identified as interest rate changes in a 40-minute window around salient monetary policy events, including central bank announcements and the release of minutes and speeches. Kearns et al (2018) distinguish between "target", "path", and "term premium" shocks. Target shocks are identified as the 40-minute change of the one-month overnight indexed swap (OIS) rate around the policy event. Path and term premium shocks are identified as the 40-minute change of the two-year Treasury and 10-year Treasury yields, orthogonalised with respect to the 40-minute change of the one-month OIS rate as well as the 40-minute change of the two-year Treasury in the case of term premium shocks. Their sample period is from 2004 through 2015. For the sake of brevity, I focus here on the effects of US target rate shocks on global yield curves and their components.

Figure 6 shows the impulse responses of global sovereign bond yields as well as their expected short rate and term premium components to US target shocks for the two- and 10-year maturity, respectively. As controls, I include five lags of the dependent variables, past and future target shocks, past and contemporaneous path and term premium shocks, and past and contemporaneous observations of country i's exchange rate vis-à-vis the US dollar. The response of global yields to US monetary policy shocks, shown in the left column, is significant but small on impact. This is in line with earlier work. For example, Kearns et al (2018) document an average pass-through below 0.3 from US target rate shocks to international two-year bond yields on the same day. Similarly, Gilchrist, Yue, and Zakrajsek (2014) find that the pass-through of the conventional Federal Reserve interest rate policy to global sovereign yields is substantially lower than one to one after two days, with Canada being an exception. Their sample period runs from 1992 to 2008 and is thus considerably longer than the one studied in Kearns et al (2018). The on-impact spillovers of US target rate changes documented here are thus comparable to those reported in previous studies.

That said, the response of global bond yields to target rate shocks strongly increases with the horizon. Specifically, while there are only small spillovers on impact, the estimated β_h coefficients rise sharply over the following days and weeks. After 50 and 100 days, global two-year bond yields increase by a coefficient of about 3.5 and 5, respectively, relative to a target rate shock. This implies that a 10 basis points surprise in the US one-month OIS rate in tight windows around salient Federal Reserve announcements leads to an increase of global two-year bond yields by 50 basis points after about four to five months.[5] While also statistically significant, the increase in global 10-year bond yields is somewhat smaller in magnitude, peaking

4 Controlling for future shocks is important here since longer response windows may contain additional policy decisions or communication events that likely have an effect on bond yields and their components (see also the discussion in Brooks et al (2018)).

5 These effects are even larger when excluding the three largest target rate shocks observed in the sample, and thus are not driven by outliers. The timing of the responses is very similar with and without the largest shocks included.

around 15 basis points for a 10 basis point shock after 50 days and flattening out at 10 basis points after 100 business days.

These results are striking and in sharp contrast to the typical estimates of less than one to one for on-impact spillovers of US monetary policy shocks to international bond markets documented in the prior literature. To the best of my knowledge, a six-day window after the monetary shock in the paper by Gilchrist et al (2014) is the longest horizon studied thus far in the literature. However, my finding of a delayed and protracted response of global yields to US target rate shocks is consistent with recent evidence of a similar response of US Treasury yields documented in Brooks, Katz and Lustig (2018). These authors show that longer term US Treasury yields also respond more than one to one, albeit only with a substantial delay, to US target rate shocks.

There are a number of differences between their analysis and the one conducted here. First, Brooks et al (2018) only consider US Treasury yields instead of global bond yields. Second, their measure of a policy shock follows Kuttner (2001), who uses changes in federal funds futures on announcement dates from the Federal Open Market Committee to measure the surprise component of the target rate decision. Instead, the Kearns et al (2018) shocks considered here are based on tighter windows around the policy events, which also include the release of minutes and speeches. Third, Brooks et al (2018) study a different sample covering the period 1989–2008. Despite these differences, the delayed response of longer-term US Treasury yields to US target rate shocks, which they document, is qualitatively and quantitatively similar to the response of global sovereign yields documented here.

Brooks et al (2018) provide evidence that this pattern is driven by downward (upward) price pressures arising via investors withdrawing from or shifting money into bond mutual funds following the federal funds target increases (decreases). In a similar vein, the results documented here could be consistent with investors withdrawing from or moving into international bond funds following policy actions by the Federal Reserve. Such investment behaviour, in turn, could be consistent both with investor expectations about further federal policy tightening (easing) or with a repricing of interest rate risk leading to higher term premia.

Which of the two components of sovereign bond yields explain the observed responses of global yields? The decomposition into expected short rates and term premia allows me to answer this question. The middle column of Figure 7 shows the response of the expected short rate component of global yields to US target rate shocks. Both at the two-year and the 10-year horizon, short rate expectations increase strongly and persistently in response to a surprise monetary tightening. This suggests that investors expect global central banks to follow the Federal Reserve's policy decision or communication. Importantly, the estimated responses control for current and lagged levels of each country's foreign exchange rate with respect to the US dollar. A simple reaction of short rate expectations in response to exchange rate movements is therefore ruled out as an explanation for this finding.

The responses of global term premia to US target rate shocks are shown in the right column of Figure 7. They are positive but insignificant at the two-year maturity and slightly negatively significant at the 10-year maturity after around 20 days. Combined, these results suggest that the sharp reaction of global bond yields to US target rate shocks is primarily driven by a reassessment of global policy rate expectations, and not by a repricing of global interest rate risk. Note, however, that this latter finding is specific to the target rate shocks studied here. In unreported results I find that US path and term premium shocks as identified by Kearns et al (2018) lead to substantial adjustments of global yields through their term premium components. A more detailed analysis of these spillovers is left for future work.

5. Conclusion

Based on term structure decompositions of local currency sovereign yield curves for 21 developed and emerging market economies, I have documented substantial co-movement of sovereign debt markets since the 1990s. The extent of co-movement and spillovers has become more pronounced since the GFC, and this is primarily due to the term premium components of global yields. Panel regressions show that global bond markets react strongly to identified US Federal Reserve target rate shocks, but only with a substantial lag of several weeks. This is consistent with similar recent finding of a delayed response of US Treasury yields to US target rate shocks by Brooks et al (2018). Term structure decompositions suggest that the Federal Reserve's short rate decisions and communication primarily drive global bond markets via a reassessment of global policy rate expectations and, to a lesser extent, via a repricing of risk. More research is needed to better understand the dynamic effects of monetary policies on global sovereign bond yields.

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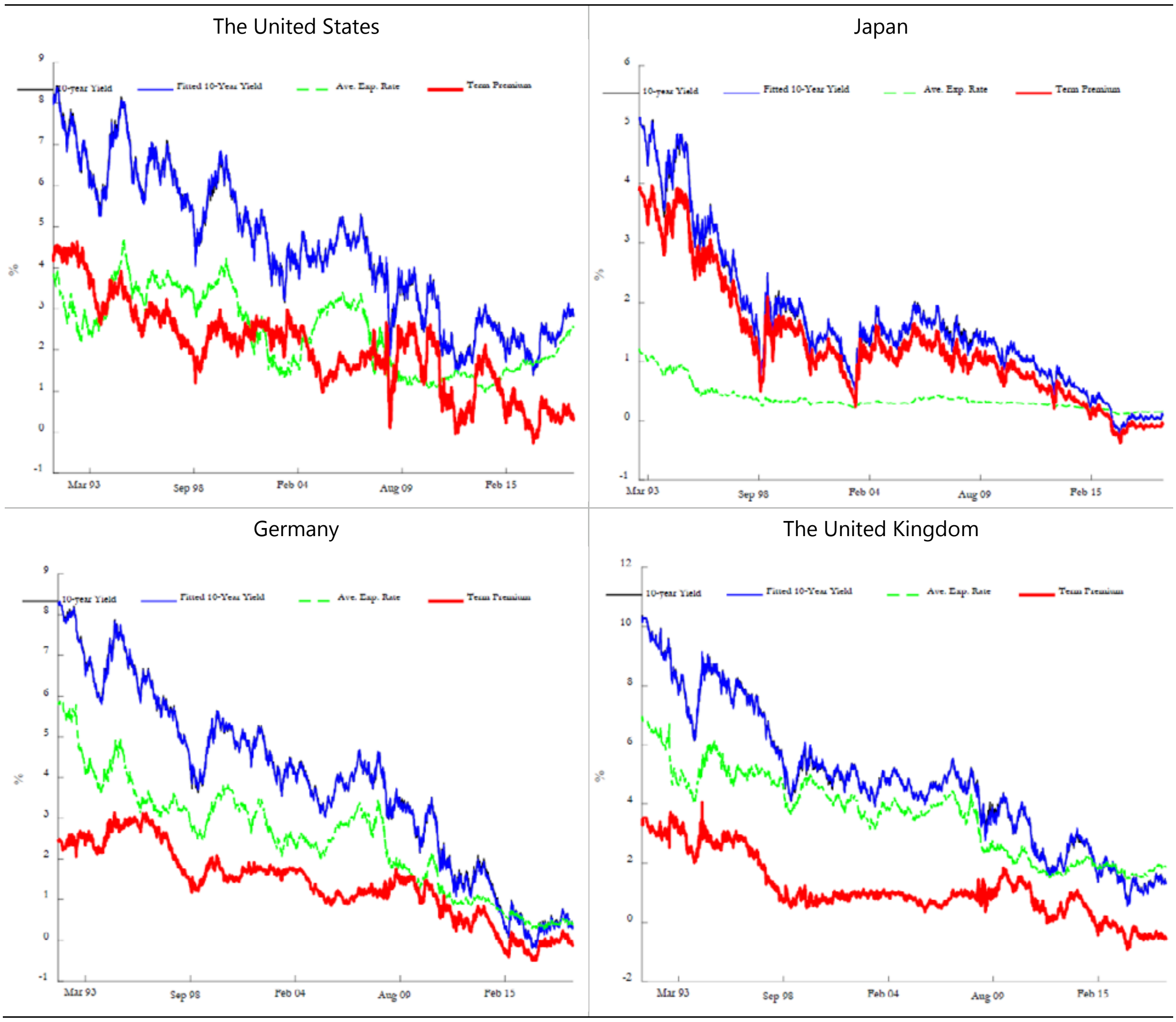
Tables and figures

G4 yield curve decompositions Figure 1



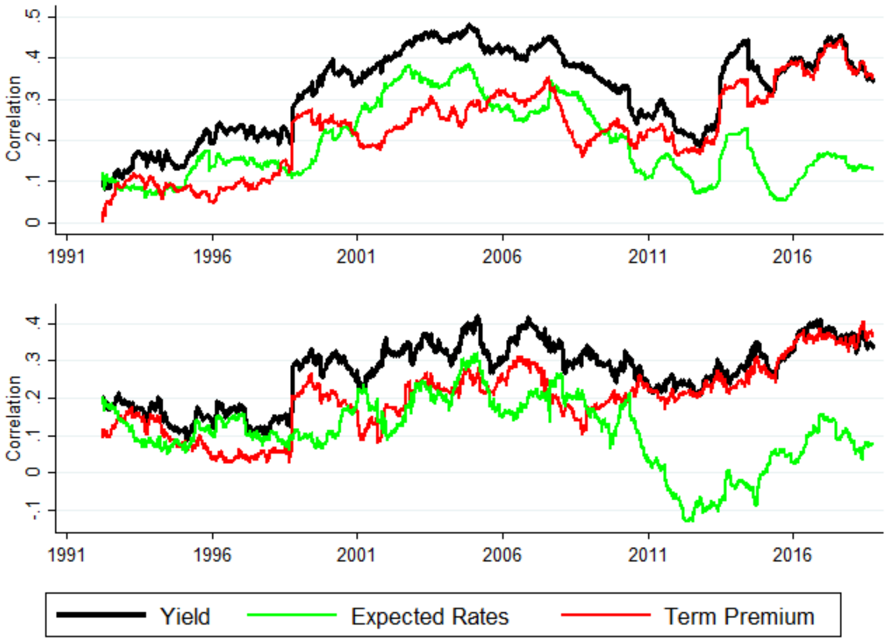
G7 variance and covariance shares due to term premia
Table 1

Table 1: G7 Variance and covariance shares due to term premia

	dUSA	dJPN	dDEU	dGBR	dFRA	dITA	dCAN
dUSA	.73						
dJPN	.82	.92					
dDEU	.43	.42	.49				
dGBR	.48	.45	.33	.61			
dFRA	.47	.34	.38	.39	.56		
dITA	.73	.78	.54	.61	.60	.89	
dCAN	.53	.47	.33	.40	.38	.72	.65

Note: Diagonal elements report the share of variance of 10-year yields explained by the term premium component for each G7 country: $\frac{Cov(\Delta Y^{10}_{i,t}, \Delta TP^{10}_{i,t})}{Var(\Delta Y^{10}_{i,t})}$, off-diagonal elements the share of covariance explained by the 10-year term premium comovement between the two countries: $\frac{Cov(\Delta TP^{10}_{i,t}, \Delta TP^{10}_{j,t})}{Cov(\Delta Y^{10}_{i,t}, \Delta Y^{10}_{j,t})}$

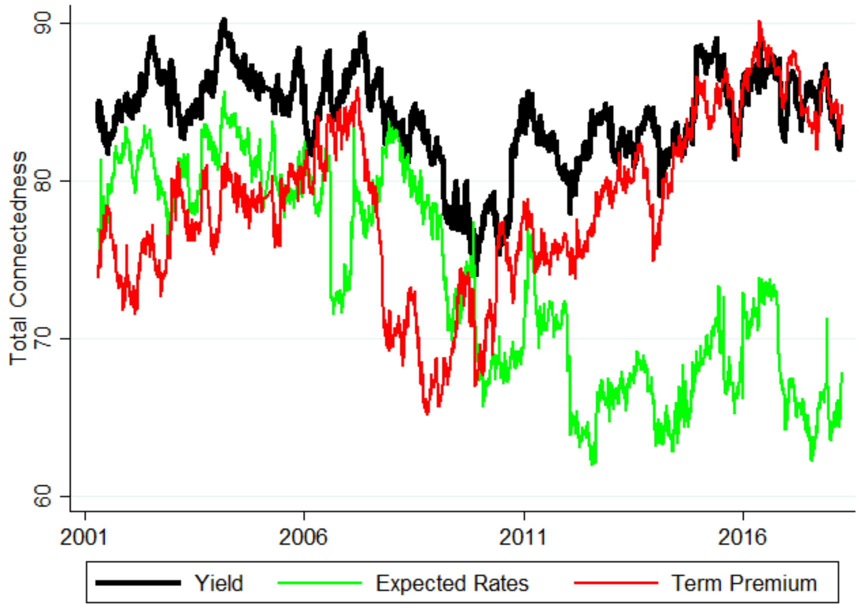
Rolling correlations of global sovereign yields
Figure 2



[1] One-year rolling window correlation coefficients of daily yield changes (black), term premium changes (red), and expected rate path changes (green) averaged across all country pairs (top panel) and averaged across all countries with the United States (bottom panel).

Global yield curve connectedness

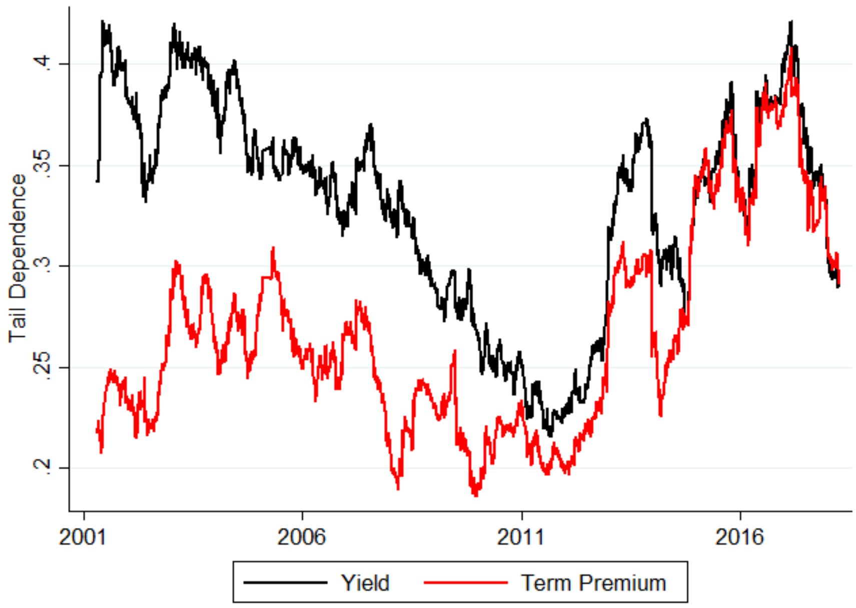
Figure 3



[1] Diebold and Yilmaz (2014) connectedness index based on one-year rolling VAR(1) estimation of daily yield changes (black), term premium (red) and expected short rate (green) components.

Global yield curve tail dependence

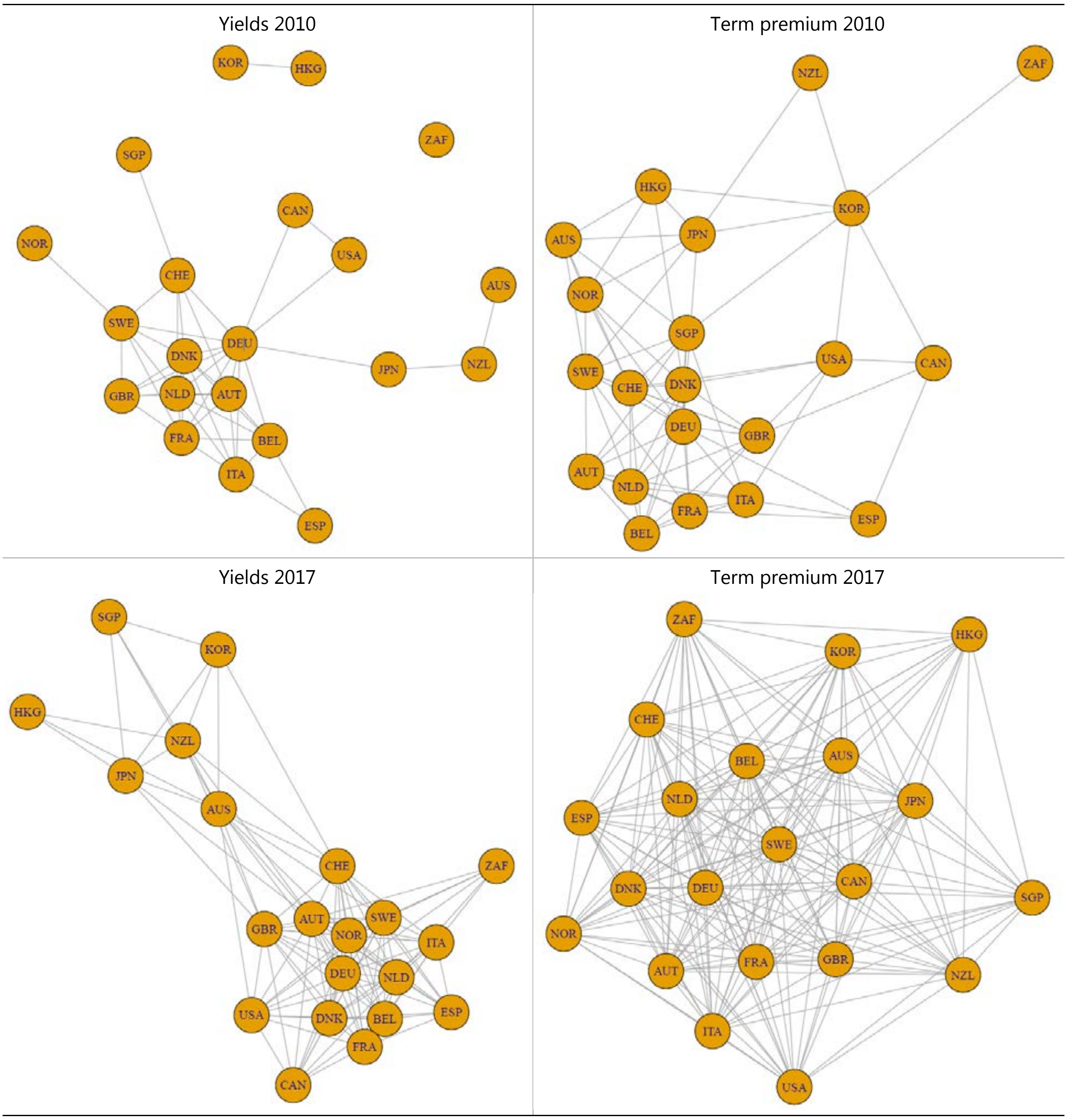
Figure 4



[1] Tail dependence between two countries is measured as the probability that both experienced large (in top 10% of all days over previous year) 10-year yield (black) or term premium (red) increases on the same days. Probabilities averaged across all country pairs.

Tail dependence between two countries

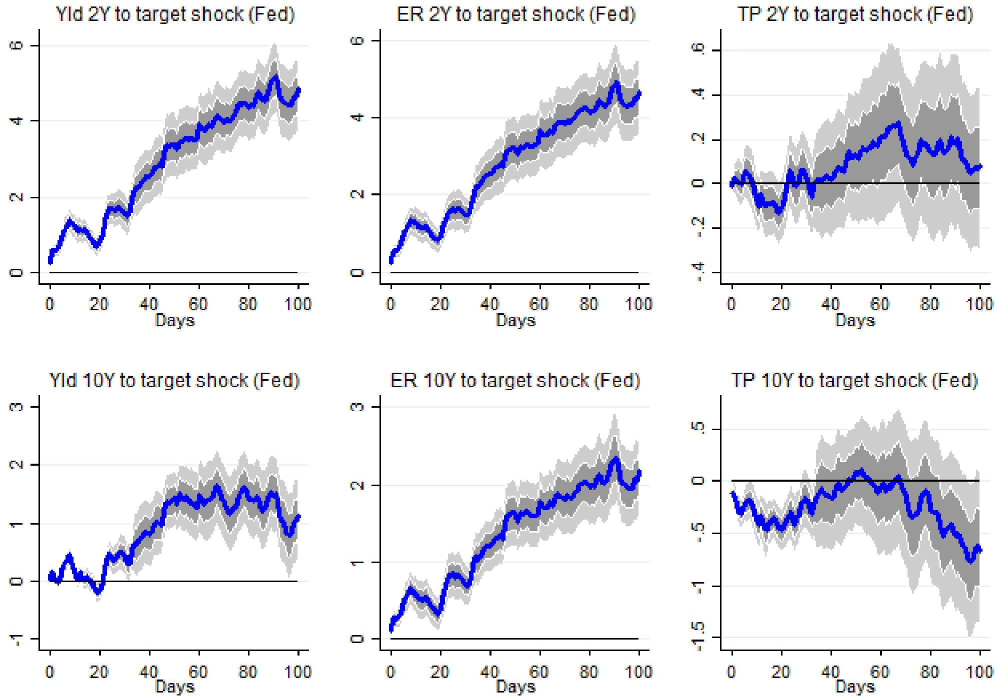
Figure 5



[1] Tail dependence between two countries is measured as the probability that both experienced large (in top 10% of all days over previous year) 10-year yield or term premium increases on the same days. Edges between pairs with lower than average tail dependence (across all pairs across August 2010 and August 2017) are not shown.

Response of global yields to US target rate shocks

Figure 6



[1] Responses of two- and 10-year zero coupon yields and their components to Federal Reserve target shocks based on panel of 21 countries. Sample: Jul 2004 - Oct 2015.