Term Premia Co-movement and Global Trade Network *

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Abstract

In this paper, we study how global trade network provides a channel through which term premia comove and transmit across a large group of countries consisting both developed and developing economies. We provide the theoretical derivations on why the term premia may decrease with the trade network centrality and conjuncture that the information contained in trade network can predict the trading partners' term premium change. We test our theoretical predictions with empirical analyses using both trade data and bond yields across different maturities from 37 countries. We show that the links of the global trade network contain useful information in explaining the variations in term premia through time and cross countries. Term premia co-movement and transmission are more pronounced among the developed countries than the developing countries. Both theoretical and empirical evidence of our paper indicate the propagation of global and local country shocks transferring in the global macro-economy through the global trade network.

JEL Classification: C32, C58, C52

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1 Introduction

Existing literature has demonstrated the importance of understanding the microeconomic underpinnings of aggregate fluctuations. An important line of research explores the role of firm and sectoral shocks in generating aggregate fluctuations (see, e.g., Foerster et al., 2011; Acemoglu et al., 2012). Acemoglu et al. (2012) demonstrate how the linkage in the inter-sectoral network forms a conduit through which sector-level shocks transmit across the economy of a single country. Recently, several papers have illustrated the importance of the trade network as a channel through which shock from single country propagates and aggregates in the global macro-economy. With a multi-country version of Acemoglu et al. (2012)'s sectoral trade network, Richmond (2019) show that the global trade network centrality is a significant determinant of a country's currency risk premia. Chang et al. (2021) studies how the risk embodied in the credit default swaps is transferred across countries through the international trade network.

The purpose of this paper is to investigate the role of the international trade linkages in transferring fluctuations of term premia implied in the bond yield curves across countries.[1] In particular, we study how trade network could provide a channel through which term premia comove and transmit among global trade partner countries. Previous literature reports that bond yields are driven by a few hidden factors, however, these factors and shocks work their way to the long end of the term structure largely through the term premia.[2] Some papers find that term premia are the main driver of cross-sectional variation in bond yields (see, e.g., Cochrane and Piazzesi, 2005; Crump et al., 2018).[3] Existing literature in the international setting of term structure also acknowledge that yield curve fluctuations across the most advanced economies are highly correlated (Dahlquist and Hasseltoft, 2013; Jotikasthira et al., 2015). Jotikasthira et al. (2015) argue that the co-movement at the short end of yield curve is likely to reflect co-movement in the economic fundamentals to which central banks are responding.[4] Given the established evidence showing that inflation transmits across countries and that inflation uncertainty is a main driver of term premia (Wright, 2011), it follows that the term premia may also be highly correlated. However, to the best of our knowledge, apart from Wright (2011) studying term premia in ten industrialized countries, no other empirical research examines whether and why term premia co-movement across countries, in particular

[1]The long term bond yields can be decomposed into two parts: the expected short rates and the term premia, see e.g Adrian et al. (2013), and Wright (2011). The term premium refers to that investors demand compensation for the risk associated with holding long term bonds over short term ones.

[2]See e.g., Ang and Piazzesi (2003); Dai and Philippon (2005); Evans and Marshall (1996).

[3]Wright (2011) find that inflation uncertainty is an important component of term premia.

[4]They investigate why term structure in the US, the UK, and Germany comove by exploring the channels through which macroeconomic shocks are transmitted across borders. Two channels have been identified, i.e., policy channel (arises when monetary authorities target short rate as a policy tool to manage domestic growth and inflationary pressures) and risk compensation channels (through the risk premia).

across both developed and developing countries.

In Figure 1, we plot the one year rolling window average pairwise correlation of daily changes in 10 year bond yields (blue color), term premia (red color), and the expected short rates (green color) for 37 global countries (the first plot), 24 developed (the second plot) and 13 developing countries (the third plot).[5] We can clearly observe that the term premia are correlated across countries, regardless if they are developed or developing countries. However, the term premia in developed countries are much more correlated than the developing countries. Figure 2 shows the scatter plot of the average changes in term premia of one country versus the changes in total trade weighted average of it's trading partner's term premia for 37 countries. The first subplot graphs the developing countries, and second plots the developed countries. It is obvious that the average changes in term premia of one country and the total trade weighted average of it's trading partner's term premia are positively correlated, indicating that trade relations may play a role in explaining the term premia co-movements across borders.

[*Insert Figures 1 and 2 about here*]

Given the information captured in these plots, we aim to study term premia comovements across 37 international countries consisting both developed and developing countries. We identify the international trade channel with a global trade network approach where countries are linked by the pairwise imports and exports, and through which global and local shocks are transmitted across countries. With the world economy exhibiting ever stronger international linkages, trade linkage (through the bilateral trade) is one important channel transferring risks.[6] Increased trade simply increases the magnitude of the transmission of shocks between two countries (Kose and Yi, 2006). If a country's major importing countries experience negative shocks due to, for example, new regulation policy, productivity shocks, or changes in raw material prices, the country's imports and exports will be affected, which tends to drive up its own risk, the trade linkage between countries, therefore, provides a channel through which the risks could spread between the importing and exporting countries. We study how the international trade can be a channel causing term premia co-move and transferring risks across the trading countries with a global network approach. We address why term premia comove by proposing a multi-country model with a network-based production environment as Richmond (2019) where countries share and are exposed to risk through trade links which form a global trade network. One example of the trade network can be visualized in Figure 3. Within the trade network, each circle corresponds to a country and each line represents a trade link. Each link is measured using pairwise total trade normalized by each country's total trade.

[5] The decomposition of the 10 year bond into the term premium and expected short rate is done with the method of Adrian et al. (2013). See later section of the paper for details on this method

[6] Glick and Rose (1999) is one of the earliest papers to make this argument. Forbes (2002) and Forbes (2004) provide evidence on the role of trade at the industry and firm level, respectively.

[*Insert Figure 3 about here*]

In our theoretical model, each country consumes a non-tradable and a tradable bundles of goods in a global production network. Because all countries consume a bundle of tradable goods, there is a common component in all country's consumption. We derive theoretically that both the common factor and country individual factors affect the term premia through the global trade network. Countries that are more central in the global trade network have higher exposures to global systematic shocks. The government bonds in these countries provide better hedge against these shocks, therefore investors demand lower premia for holding them. This intuition is confirmed in our model where we show that term premium decreases with the trade network centrality in simulations, implying that countries with larger (smaller) trade network centrality tend to have lower (higher) term premia. After separating term premia into several parts, we demonstrate that the negative correlation between trade network centrality and the risk premium is attributed to the parts dominated by the long-term yield, and that term premia are the main driver of cross-sectional variations in bond yields. We hypothesize that the trading intensity weighted term premia can predict next period's term premia.

In order to test our hypothesize, we construct an empirical analysis using both trade data and bond yields across different maturities and from different countries. The panel dataset of nominal bond yields covers a large spectrum of maturities from one month, three month, six months, nine months, 12 months, one year, three-year, five-year, 10-year, 12-year, 15-year. We collect all bond yield data from Global Yield database and Datastream. For trade data, we use the yearly country level imports and exports that are collected from UNComtrade. Yields data are from 1999 through 2019 whereas trade data are from 1998 to 2018 covering 37 countries, i.e., from 24 developed countries and 13 developing countries. Following Chang et al. (2021), for each country in our sample, we construct several trade-linkage based risk proxies to capture the variations in term premia in all the other countries which are connected to the country in question through the trade network. These trade linkage based risk proxies are then used to explain the variations in term premia and to predict the change in term premia of the country in question.

The global trade network is continuously changing. In Figure 4, we plot the share of the country's export to its total GDP in percentage against its share of the country's import to its total GDP in percentage. Four years have been randomly selected: 1998, 2002, 2012 and 2018. We can find that country (such as China) has gradually changed from the importing dominated country to be a exporting country. Therefore, our sample covers a large group of global countries including both developing (such as China) and developed countries and study the risk premia comovement across them separately.

[*Insert Figure 4 about here*]

According to Ready et al. (2017), the fundamental economic differences between countries could give rise to a heterogeneity of interest rate levels. For example, countries that specialize in exporting basic commodities (such as Australia or New Zealand) tend to have high interest rates, whereas countries that import most of the basic inputs and export finished consumption goods (such as Japan) have low interest rate on average. We establish trade sub-networks, based on categories of traded goods: commodity vs. final goods, and examine whether and how the term structure risks may be transmitted across countries through the trade sub-networks. Whether a country is commodities or final goods importing oriented is captured by the import ratio of the country.[7] We test if the import ratio contains any useful information in explaining the comovements and transmissions in term premia.

Our empirical analysis shows consisting results with the simulation study based on our theoretical model. The results from panel regression indicate that the trading intensity weighted change in term premia from the partner countries can predict next period's change in term premia of own country. As an additional test, we sort term premia into portfolios. When sorted on trade network centrality, we find that term premia are decreasing from the group of central countries to the group of peripheral countries. The peripheral countries minus central countries term premia provide a 0.16 and 0.32 basis points return on average for the whole sample and sub-sample from 2010-2019. Both findings are consistent with the model's predications.

This paper contributes to term structure of interest rates, network and international finance literature in several important ways. First, it is the first paper to examine the international covariations of the term premia across a large number of both developed and developing countries. The long-established literature studies the term structure, yet, most of the existing literature on the estimation of term premia is done for a single country. One exception is Wright (2011) who has studied the term premia in ten industrialized countries including the US, the UK, Canada, Japan, Germany, Norway, Sweden, Switzerland, Australia, and the New Zealand, however, this paper has not studied risk premia in developing countries. Brennan and Xia (2006), Diebold et al. (2008), Dungey et al. (2000) have studied zero yields for several countries and have fitted factors models to these countries' zero yields, but they have not examined term premia.

A few papers study the excess returns on long term bond yield comovements. Jotikasthira et al. (2015) study why term structure comove among three advanced economies, i.e., the US, the UK and Germany, yet, their focus is how macroeconomic variables affect bond yields through their correlation with the pricing factors. Dahlquist and Hasseltoft (2013) study the zero coupon interest rates for Germany, Switzerland, the UK and find that the cross country correlations of the excess return of the bonds are highly correlated.

[7] The import ratio is defined as the sum of net imports of final goods and net exports of basic goods scaled by the outputs of a country.

Second, this paper links fundamental quantities to trade network and term structure. In order to explain the carry trade abnormal returns, Richmond (2019) proposes a theoretical model in the global production economy consisting many countries which are affected by a common factor and shocks from individual countries. Using our term structure model, we show that the term premia is negatively correlated with the network centrality due to the long term interest rate's negative correlation with the network centrality. This results complement those of Richmond (2019).

Finally, our paper contributes to the understanding of the role of international trade network as a channel for risk transmission. The results from our paper help understand a well-established literature reporting that pairs of countries with stronger trade linkages tend to have more highly correlated business cycles (Frankel and Rose, 1998; Kose and Yi, 2006, see, e.g.,). This paper makes contribution by providing novel facts about the risk propagation in the global macroeconomy and showing the importance of the trade network for the propagation of macroeconomic shocks. Chang et al. (2021) has also studied how the shocks to global countries Sovereign CDS markets transmitted through the trade network, however, their focus is the CDS markets, while we study the term premia.

The reminder of the paper is organized as follows. In section 2, we develop a theoretical model that derives the links between the global trade network centrality and the term premia, and then formulate hypotheses accordingly. We present the data and methodology in section 3. Section 4 presents the empirical results confirming our hypotheses, and section 5 concludes. Appendices contain technical details and further robustness results.

2 Model and Hypotheses Development

Countries that are more central in the global trade network have higher exposures to global systematic shocks. The government bonds in these countries provide a better hedge against these shocks, therefore carry lower premia in equilibrium. We aim to verify this intuition within a Gaussian affine term structure model with a global factor structure incorporating the global trade network. Specifically, in this section, we theoretically derive the relationship between the trade network centrality and the term premia and construct the hypothesis we test in the empirical section. In our model, both the common factor and country individual factors affect the term premia through the global trade network where countries are central if they have many strong trade links to countries that are important to the global output tradable goods. Our model separates term premia into several parts, and we demonstrate that the negative correlation between trade network centrality and the risk premium is attributed to the parts dominated by the long-term yield, and that term premia are the main driver of cross-sectional variations in bond yields.

2.1 A trading network term structure model

Global factor structure

We follow the model of Richmond (2019), assuming an economy consisting of n countries. Each country has a unique tradable good production sector and a non-tradable good production sector. At time t, there is a pair of shocks to tradable and non-tradable goods in each country. We assume the same correlation structure of factor shocks of Richmond (2019), in which the cross countries idiosyncratic shocks to non-tradable outputs are uncorrelated, while the shocks to the tradable outputs are correlated due to heterogeneous business cycle correlations.

More specifically, we start by modeling the shocks to tradable outputs in different countries. For n countries, these shocks to tradable outputs that are captured by an $n \times 1$ state variable $\boldsymbol{X}_t$ and $\boldsymbol{X}_t$'s SDE under the $\mathbb{P}$ measure are given by:

$$d\boldsymbol{X}_t = -\boldsymbol{X}_t dt + \boldsymbol{\Sigma}_X dW^{\mathbb{P}}_{X,t}, \tag{2.1}$$

where $W^{\mathbb{P}}_{X,t}$ is an $n \times 1$ correlated Wiener process, $\boldsymbol{\Sigma}_X$ is an $n \times n$ diagonal matrix with ith diagonal element being $\sigma_{X,i}$, and the instantaneous covariance matrices of $\boldsymbol{X}_t$, $\boldsymbol{\Sigma}_X \rho_X \boldsymbol{\Sigma}_X^\top$ is an $n \times n$ matrix, where ρ_X is the correlation matrix between tradable outputs, which is a proxy of the business cycle correlation. Frankel and Rose (1998) show that these bilateral business correlations are increasing in bilateral trade intensity.

Similarly, we model the shocks to non-tradable output in different countries as an $n \times 1$ state variable $\boldsymbol{Y}_t$ and $\boldsymbol{Y}_t$'s SDE under the $\mathbb{P}$ measure are:

$$d\boldsymbol{Y}_t = -\boldsymbol{Y}_t dt + \boldsymbol{\Sigma}_Y dW^{\mathbb{P}}_{Y,t},$$

where $W^{\mathbb{P}}_{Y,t}$ is an $n \times 1$ independent Wiener process independent of $W^{\mathbb{P}}_{X,t}$ and $\boldsymbol{\Sigma}_Y$ is an $n \times n$ diagonal matrix with ith diagonal element being $\sigma_{Y,i}$. We denote the stacked $2n \times 1$ state variable $\left[\boldsymbol{X}_t^\top, \quad \boldsymbol{Y}_t^\top\right]^\top$ by $\boldsymbol{Z}_t$ which follows the SDE under the $\mathbb{P}$ measure as

$$d\boldsymbol{Z}_t = -\boldsymbol{Z}_t dt + \boldsymbol{\Sigma}_Z dW^{\mathbb{P}}_{Z,t}, \tag{2.2}$$

where $\boldsymbol{\Sigma}_Z = \begin{bmatrix} \underbrace{\boldsymbol{\Sigma}_X}_{n\times n} & \underbrace{\mathbb{0}}_{n\times n} \\ \underbrace{\mathbb{0}}_{n\times n} & \underbrace{\boldsymbol{\Sigma}_Y}_{n\times n} \end{bmatrix}$ and $W^{\mathbb{P}}_{Z,t} = \left[\left(W^{\mathbb{P}}_{X,t}\right)^\top, \quad \left(W^{\mathbb{P}}_{Y,t}\right)^\top\right]^\top$.

Country factor structure

Given $\boldsymbol{X}_t$, we define the following two state variables for country i:

$$z_{i,t} = e_i^\top \boldsymbol{X}_t \text{ and } x_t = \varsigma^\top \boldsymbol{X}_t,$$

where e_i is an $n \times 1$ vector with its ith element being one and all others being zero, ς is an $n \times 1$ vector with its ith element being $\frac{(1-\theta)\alpha}{n} s_i$. According to Richmond (2019, eq.25), θ is a constant, α is elasticity respect to labor, s_i is the share of output in tradable goods for country i. This is also known as the Katz centrality in the network literature (Katz, 1953) and the influence vector in Acemoglu et al. (2012). Therefore, x_t is the tradable output share weighted average of all countries' shocks to tradable outputs, representing a common global factor.

We also have another state variable $y_{i,t} = e_i^\top \boldsymbol{Y}_t$ that captures the shock to non-tradable output in country i. Therefore, for ith country we have a typical Gaussian three-factor setup for term structure modeling. Following the canonical Gaussian Dynamic Term Structure Model specification (see, e.g., Joslin et al., 2011; Li et al., 2020), we specify the $\mathbb{Q}$ measure dynamic of $Z_{i,t}$ as:

$$dZ_{i,t} = A_i Z_{i,t} dt + \Xi_i dw_{i,t}^{\mathbb{Q}}, \tag{2.3}$$

where $w_{i,t}^{\mathbb{Q}}$ is a 3×1 independent Wiener process under the $\mathbb{Q}$ measure,

$$\begin{aligned}
Z_{i,t} &= \begin{bmatrix} z_{i,t}, & x_t, & y_{i,t} \end{bmatrix}^\top = \zeta_i^\top \boldsymbol{Z}_t, \quad \zeta_i = \left[\begin{bmatrix} e_i \\ \underbrace{\mathbb{0}}_{n\times 1} \end{bmatrix}, \begin{bmatrix} \varsigma \\ \underbrace{\mathbb{0}}_{n\times 1} \end{bmatrix}, \begin{bmatrix} \underbrace{\mathbb{0}}_{n\times 1} \\ e_i \end{bmatrix} \right], \\
A_i &= \begin{bmatrix} -\lambda_{z,i} & 0 & 0 \\ 0 & -\lambda_{x,i} & 0 \\ 0 & 0 & -\lambda_{y,i} \end{bmatrix}, \lambda_{z,i} > 0, \lambda_{x,i} > 0, \lambda_{y,i} > 0 \\
\Xi_i &= \left(\zeta_i^\top \boldsymbol{\Sigma}_Z \rho_Z \boldsymbol{\Sigma}_Z^\top \zeta_i \right)^{\frac{1}{2}}, \\
\rho_Z &= \begin{bmatrix} \underbrace{\rho_X}_{n\times n} & \underbrace{\mathbb{0}}_{n\times n} \\ \underbrace{\mathbb{0}}_{n\times n} & \underbrace{\mathbb{I}}_{n\times n} \end{bmatrix}.
\end{aligned} \tag{2.4}$$

To start the term structure modeling, we assume the short rate is an affine function of the three fundamental factors. The short rate being an affine function of fundamental factors is a very typical and reasonable assumption in the term structure literature, supported in many theoretical studies (Cox et al., 1985). Also, Richmond (2019)'s equilibrium in a trading network economy confirms that the interest rate is an affine function of the three fundamental factors above, namely the two factors related to tradable and non-tradable outputs $z_{i,t}$ and $y_{i,t}$, and one global common factor, x_t. Therefore, we model the short rate as an affine function of the state variables:

$$r_{i,t} = \varphi_i + C_i^\intercal Z_{i,t}. \tag{2.5}$$

By the non-arbitrage condition, the time t price of a country i zero coupon bond with maturity at $t+\tau$ is the expectation of the discounted payoff under the $\mathbb{Q}$ measure. That is

$$zcb_{i,t}(\tau) = \mathbb{E}_t^{\mathbb{Q}}\left(e^{-\int_t^{t+\tau} r_{i,s}ds}\right),$$

and its zero yield is given by

$$zy_{i,t}(\tau) = -\frac{\log\left[\mathbb{E}_t^{\mathbb{Q}}\left(e^{-\int_t^{t+\tau} r_{i,s}ds}\right)\right]}{\tau}.$$

Since the state vector $Z_{i,t}$ is Gaussian, $zy_{i,t}(\tau)$ can be solved analytically using the well-known affine term structure model machinery (e.g., Duffie and Kan, 1996; Dai and Singleton, 2000):

$$zy_{i,t}(\tau) = -\frac{\mathbf{H}_i(\tau)}{\tau} + \frac{\mathbf{F}_i(\tau)^\intercal}{\tau} Z_{i,t},$$

where

$$\begin{aligned}
\mathbf{H}_i(\tau) &= -\int_0^\tau \mathbf{C}_i(s)^\intercal \left(A_i^{-1}\Xi_i\Xi_i^\intercal A_i^{-1}\right)\left(C_i - \frac{\mathbf{C}_i(s)}{2}\right) ds - \left(\varphi_i - \frac{1}{2}C_i^\intercal \left(A_i^{-1}\Xi_i\Xi_i^\intercal A_i^{-1}\right) C_i\right)\tau, \\
\mathbf{F}_i(\tau) &= A_i^{-1}\left(\mathbf{C}_i(\tau) - C_i\right), \\
\mathbf{C}_i(\tau) &= \exp(A_i\tau)\, C_i.
\end{aligned}$$

Using a constrained version of the "essentially affine" (Duffee, 2002) market price of risk setting, we can have a $\mathbb{P}$-measure dynamic of $Z_{i,t}$ consistent with (2.1). That is,

$$dZ_{i,t} = A_i^{\mathbb{P}} Z_{i,t}dt + \Xi_i dw_{i,t}^{\mathbb{P}}, \tag{2.6}$$

where $A_i^{\mathbb{P}} = A_i - \Xi_i R_{i,m} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$ (i.e., $R_{i,m} = -\Xi_i^{-1}\left(A_i^{\mathbb{P}} - A_i\right)$) and $w_{i,t}^{\mathbb{P}} = R_{i,m}Z_{i,t}t + w_{i,t}$.

2.2 Term premia and network centrality

For term premia, we define the instantaneous forward rate curve as follows:

$$f_{i,t}(\tau) = \frac{d\left[zy_{i,t}(\tau)\,\tau\right]}{d\tau} = \varphi_i - \Theta_i(0) + \Theta_i(\tau) + \mathbf{C}_i(\tau)^\intercal Z_{i,t},$$

where $\Theta_i(\tau) = \mathbf{C}_i(\tau)^\intercal \left(A_i^{-1}\Xi_i\Xi_i^\intercal A_i^{-1}\right)\left(C_i - \frac{\mathrm{C}_i(\tau)}{2}\right)$. Note that $f_{i,t}(0) = r_{i,t}$. Similarly, using the same affine techniques but applying to the $\mathbb{P}$ measure dynamic, we can define the expected short rate at future time $t+\tau$:

$$\mathbb{E}_t^{\mathbb{P}}\left(r_{i,t+\tau}\right) = \varphi_i + \boldsymbol{C}_i^{\mathbb{P}}(\tau)^\intercal Z_{i,t},$$

where $\boldsymbol{C}_i^{\mathbb{P}}(\tau) = \exp\left(A_i^{\mathbb{P}}\tau\right)C_i$. Following its typical definition (e.g., Wright, 2011; Adrian et al., 2013), the term premium from future time t_1 to t_2 can be written as:

$$\begin{aligned}
tp_{i,t}(t_1,t_2) &= \frac{\int_{t_1}^{t_2} f_{i,t}(s) - \mathbb{E}_t^{\mathbb{P}}\left(r_{i,s}\right) ds}{t_2 - t_1} \\
&= \left[\frac{\int_{t_1}^{t_2}\Theta_i(s)\,ds}{t_2-t_1} - \Theta_i(0)\right] + C_i^\intercal \frac{\int_{t_1}^{t_2}\exp\left(A_i s\right) - \exp\left(A_i^{\mathbb{P}} s\right) ds}{t_2-t_1} Z_{i,t} \\
&= \left[\frac{\int_{t_1}^{t_2}\Theta_i(s)\,ds}{t_2-t_1} - \Theta_i(0)\right] + C_i^\intercal \frac{\int_{t_1}^{t_2}\exp\left(A_i s\right) - \exp\left(A_i^{\mathbb{P}} s\right) ds}{t_2-t_1} \zeta_i^\intercal \mathbf{Z}_t.
\end{aligned} \tag{2.7}$$

We follow Richmond (2019) and define the trade network centrality of country i as

$$v_i = \sum_{j=1}^{n} \rho_X(i,j) s_j. \tag{2.8}$$

where $\rho_X(i,j)$ is the correlation between shocks to the tradeable outputs of country i and j. The trade network centrality affects the term premium unconditionally via the first two terms in Equation (2.7) and the trade network structure (e.g., the influence vector of the network Acemoglu et al., 2012) affects the term premium conditionally via the last term in Equation (2.7). There is no analytical relation can be derived for tp_i and v_i. To quantify the relation, we resort to simulations. In the simulations, the parameters are set to be consistent with the empirical observations in the later empirical study.

Specifically, we construct a 37-country network and conduct 1000 time simulations. In each simulation, we calculate the 37 countries' one-10 year term premia, $tp_i(1,10), i = 1,2,\ldots,37$, and their trade network centrality v_i, and record the OLS slope coefficient in regressing $tp_i(1, 10)$ to $v_i / \max_{i=1,\dots,37}(s_i)$.[8] In the end, we compute the average value of the recorded slope coefficients and the t-statistic. The numerical values of parameters are set as following: $\lambda_{x,i} = \lambda_{y,i} = \lambda_{z,i} = 5$; s_i's are drawn from the uniform distribution and normalized to have sum of one; $\rho_{i,j}$'s in ρ_X (σ_i's in Σ_X and Σ_Y) are drawn from an even distribution on [-0.05, 0.2] ([0.4, 0.6]). $C_i(1) = C_i(3) = 1$ and $C_i(2)$'s are drawn from an even distribution on [0.4, 4] to ensure there are heterogeneity in exposures to x_t among the 37 countries. The elements in Z_t are drawn from an even distribution on [-0.3, 0.3]. The result is presented in the second column of Table 2. We can see the slope coefficient is significantly negative. This indicates that countries with larger (smaller) trade network centrality tend to have lower (higher) term premia.

[*Insert Table 2 about here*]

To further understand which component in the term premium contributes to this result, we decompose the term premium into three parts:

$$tp_{i,t}(t_1, t_2) = \underbrace{\frac{\int_{t_1}^{t_2} \Theta_i(s)\, ds}{t_2 - t_1}}_{\text{Part 1}} + \underbrace{[-\Theta_i(0)]}_{\text{Part 2}} + \underbrace{C_i^\top \frac{\int_{t_1}^{t_2} \exp(A_i s) - \exp\left(A_i^{\mathbb{P}} s\right) ds}{t_2 - t_1} \zeta_i^\top \mathbf{Z}_t}_{\text{Part 3}}. \tag{2.9}$$

The average slope coefficients of regressing simulated Parts 1 to 3 to $v_i / \max_{i=1,\dots,37}(s_i)$ are presented in Table 2 as well. We can clearly see that the negative relation between the term premium and the trade network centrality is driven by the negative relation between Part 2 $[-\Theta_i(0)]$ and the trade network centrality. Part 2 is an important part in the long term interest rate. To see this, let us set $\tau \to \infty$ in $f_{i,t}(\tau)$:

$$f_{i,t}(\infty) = \varphi_i - \Theta_i(0) + \Theta_i(\infty) + \mathbf{C}_i(\infty)^\top Z_{i,t} = \varphi_i - \Theta_i(0). \tag{2.10}$$

$\Theta_i(\infty)$ and $\mathbf{C}_i(\infty)$ being zero is by the definition of $\Theta_i(\tau)$ and $\lambda_{z,i} > 0, \lambda_{x,i} > 0, \lambda_{y,i} > 0$. Setting aside φ_i, the negative relation between Part 2 and the trade network centrality indicates that the long term interest rates tend to decrease with the centrality. This is consistent with Richmond (2019)'s equilibrium result. Our model shows that this relation between the long term interest rate and the centrality has resulted in a similar relation between the term premium and the centrality. Our model also confirms the intuition that more central countries have higher exposures to global systematic shocks, government bonds in these countries provide better hedge against these shocks, therefore investors demand lower premia for holding them. This leads us to Hypothesis 1.

[8]Dividing by $\max_{i=1,\dots,37}(s_i)$ is to make the LHS and RHS in the regression more comparable in magnitude.

Hypothesis 1 *Term premia decreases with the trade network centrality.*

Our model also allows us to identify the trade network's role in the term premia' cross-country correlations. To see this, we stack $tp_{i,t}$'s into an $n \times 1$ column vector, $\boldsymbol{tp}_t$ and rewrite Equation (2.7) in matrix form as:

$$\underbrace{\boldsymbol{tp}_t}_{n\times 1} = \underbrace{\boldsymbol{L}}_{n\times 1} + \underbrace{\boldsymbol{J}}_{n\times 2n} \boldsymbol{Z}_t, \tag{2.11}$$

where

$$\begin{aligned} \boldsymbol{L}_i &= \frac{\int_{t_1}^{t_2} \Theta_i(s)\, ds}{t_2 - t_1} - \Theta_i(0) \\ \boldsymbol{J}_{(i,:)} &= C_i^\top \frac{\int_{t_1}^{t_2} \exp(A_i s) - \exp\left(A_i^{\mathbb{P}} s\right) ds}{t_2 - t_1} \zeta_i^\top. \end{aligned}$$

Therefore we have the variance-covariance matrix of $\boldsymbol{tp}$ as

$$\mathbb{C}ov\left(\boldsymbol{tp}\right) = \frac{\boldsymbol{J}\left(\boldsymbol{\Sigma}_Z \rho_Z \boldsymbol{\Sigma}_Z^\top\right)\boldsymbol{J}^\top}{2}. \tag{2.12}$$

Then the correlation matrix of $\boldsymbol{tp}$ is given by

$$\mathbb{C}orr\left(\boldsymbol{tp}\right) = \mathbb{C}ov\left(\boldsymbol{tp}\right) \oslash \left(\sqrt{\mathbb{V}ar\left(\boldsymbol{tp}\right)}\sqrt{\mathbb{V}ar\left(\boldsymbol{tp}\right)}^\top\right), \tag{2.13}$$

where $\oslash$ is the element-by-element division, and $\mathbb{V}ar\left(\boldsymbol{tp}\right)$ is the diagonal elements of $\mathbb{C}ov\left(\boldsymbol{tp}\right)$. Given Equation (2.4), it is easy to see that $\mathbb{C}orr\left(\boldsymbol{tp}\right)$ is positively related to ρ_X in the matrix sense. Based on the same numerical setting, we show in Figure 5 this positive relation between $\mathbb{C}orr\left(\boldsymbol{tp}\right)$ and ρ_X using pair-wise correlations from one simulated sample of 37 countries.

[*Insert Figure 5 and Table 3 about here*]

To further understand the trade network's role in the term premia' cross-country correlations, we conduct a similar simulation exercise based on the same numerical setting as above, in which three rank correlations (Spearman's rho) are calculated for each country by pairing its partner countries' normalized Richmond centralities, influence vector, and trading intensities with their term premium correlations with this country. The results are presented in Table 3. We find that all three rank correlations are positive and highly significant. One implication for these results is that the trading intensity weighted term premium can provide incremental predictive power over the simple cross-country average in forecasting term premia. We summarize this implication in Hypothesis 2.

Hypothesis 2 *The trading intensity weighted term premia can predict next period's term premia and the predictive power is robust to using other centralities, e.g., Richmond centrality, as the weights.*

3 Data and Empirical design

In this section, we first present the trade and bond yield data and the way we process these data, the detailed procedures for estimating the term premium. Second, we present the methodology we employ in this paper to investigate the co-movement and transmission in term premia across countries.

3.1 Global trade and financial linkage data

We use the yearly country level trade data that are collected from the UN ComTrade with their online Application Programming Interface (API) program. The trade Data are annual from 1998 to 2018 covering 37 reporting countries.

We construct the trade network based on the annual import and export from UN ComTrade and calculate various measures of centrality and trading intensity. Each year, all countries report their imports and exports values as well as to which countries they import from and to which they export in the UN ComTrade database and this allows us to construct the trade network according to their bilateral trades. In Table 1 we show one portion of the sample data from UN ComTrade for Germany in 2018 (see Appendix A for details of data processing). Figure 6 shows the top 25 imports and exports values of the trading partners for four randomly selected countries (Germany, Japan, USA and New Zealand) in 2018. It is obvious from this figure that the import and export values of each country vary. Therefore, we carry out our empirical analysis by constructing the total trade, import and export trade network and calculate the centrality for total trade, import and export network, respectively.

For controlling the possible impact of the financial linkage on transferring the shocks, we also use the IMF Coordinated Direct investment Survey (CDIS) database to collect bilateral FDI data and the IMF Coordinated Portfolio Investment Survey (CPIS) database to collect bilateral portfolio investment data. The FDI data is available from 2009-2018 and the portfolio investment data covers a period from 2001 to 2018. Other macroeconomic data, including GDP growth, CPI inflation, and the export-to-GDP ratio, import-to GDP ratio, total-trade-to GDP ratio in a yearly basis are all collected from the International Monetary Fund World Economic Outlook (WEO) database.

For the basic and finished goods based sub-network, we collect the classifications of trade data at the STIC 2-digit (Rev 2) level on the UN ComTrade with the online API. The classifications of the Basic and Complex goods are from Ready et al. (2017), kindly provided and updated from Robert Ready.

[*Insert Table 1 and Figure 6 about here*]

3.2 Bond yields and term premia

Interest rates and term premia

We access data on daily bond yields at all maturities from Bloomberg and Global Yield Database. Our sample include 37 countries consisting of 24 developed countries and 13 emerging markets. The final sample period starts from 2002 to 2019. These 37 countries are chosen because these countries are liquid markets with a broad range of maturities, i.e., have at least five maturities. We start the sample from 2002 as a trade-off between maximizing the sample size and minimizing the likelihood of a large structural break.

Decomposition of expected short rate and term premia

This section discusses decomposition of the sovereign yield curves of 37 developed and emerging market economies into expected short rate and term premium components.

Long term bond yields are made up of two parts: the expected short rate and the term premia. The latter part represents the compensation that risk adverse investors demand for holding long-term bonds. In order to study the term premia, we need to first decompose the long-term bond yields and get the term premia.

One simple way of estimating the term premium is to subtract a survey measure of the average expected short rate from the observed yield. However, Survey data are not updated frequently and include only a limited set of forecast horizons. Survey may not always represent the actual expectations of market participants due to that larger players have a disproportioned impact on the market.

The term structure literature disentangles term premia and interest rate expectations (see e.g., Duffie and Kan (1996), Dai and Singleton (2000) and Joslin et al. (2011)). Typically, the models are affine and represent the time-series dynamics of bond yields with simple vector autoregressions. Restrictions are imposed to reflect the no arbitrage assumption. Much of the term structure has relied on models where a small set of pricing factors is assumed to be affine in some state variables. Therefore, the choice of factors used typically represent or determine the size and the dynamic of term premia (see e.g., H*ö*rdahl and Tristani (2014); Dai and Singleton (2000); Kim and Wright (2005)). Other factors include e.g., macroeconomic factors (see Jotikasthira et al. (2015)). Wright (2011) estimate term premia with two methods, e.g, decomposing forward rates into future expected three-month interest rates and the term premium by fitting an affine term structure, and using the survey data on future three-month interest rates.

Another stream of papers relies on models where a small set of yield-based factors that are assumed to drive bond yields. For example, the model from Adrian et al. (2013), uses principle components of bond yields as pricing factors. What makes the model appealing is its simplicity and yet provides better in and out of sample estimates of term premia than the four-factor specification of Cochrane and Piazzesi (2005) as demonstrated by the authors. We estimate the term premia using the decomposition method of Adrian et al. (2013), and as a robustness control, we have also estimated term premia with the affine model of Wright (2011). (Decomposing details see Appendix B)

We calibrate the model of Adrian et al. (2013) based on the daily interest rates and use the monthly frequency by taking the last observations in each month to perform the regression. When estimating the term premia at time t, we ensure to use all available information by t.

3.3 Empirical design

Portfolio sorting

We first test our Hypothesis 1, that Term premia decrease with the trade network centrality, with a portfolio sorting strategy. We sort all countries term premia at time t into four portfolios based on the centrality estimates based on the trade data from the previous year, $t-12$. In particular, Portfolios are re-balanced monthly although trade network centralities are observed yearly. The portfolio with the highest (lowest) centrality estimates are the central (peripheral) portfolio. We also create a peripheral minus central portfolio to reflecting a mimicking portfolio by buying the peripheral countries term premia and selling central countries term premia.

Dynamic panel regression model

In order to test our Hypothesis 2, we examine whether and how term premia co-move across countries through the international trade network, we employ the following dynamic panel regression model:

$$\Delta TP_{i,t} = \alpha + \beta \Delta TP^{*}(Trade)_{j,t} + \rho \Delta TP_{i,t-1} + Control'_{i,y-1}\gamma + \mu_i + \lambda_y + \epsilon_{i,t} \tag{3.1}$$

where ΔTP_{it} denotes the change in country i's term premium from time $t-1$ to time t. $\Delta TP^{*}(Trade)_{j,t}$ is the risk proxy to capture the variations in term premia among the countries js from time $t-1$ to time t. More specifically, $TP^{*}(Trade)_{j,t}$ is calculated as the weighted change in term premia of the other countries js which are connected to country i through the trade network from time $t-1$ to time t. The weights are determined according to several different network weighting schemes based on the trade network (details see the next subsection). $Control_{i,y-1}$ include: export-to-GDP ratio, import to GDP ratio, total trade to GDP ratio, inflation, and lagged GDP growth rate in the previous calendar year $y-1$ of month t. μ_i, λ_y are the country and year fixed effects, respectively.

We investigate further whether and how term premium can be transmitted from one country to another through international trade network, according to:

$$\Delta TP_{i,t} = \alpha + \beta \Delta TP^*(Trade)_{j,t-1} + \rho \Delta TP_{i,t-1} + Control'_{i,y-1}\gamma + \mu_i + \lambda_y + \epsilon_{i,t} \tag{3.2}$$

Here, we replace $\Delta TP(Trade)_{j,t}$ with $\Delta TP(Trade)_{j,t-1}$ in equation 3.1 in order to examine whether $\Delta TP^*(Trade)_{j,t-1}$ is useful to predict the change in term premium of country i in month t, the $\Delta TP_{i,t}$.

Richmond (2019) proposes a trade centrality as state-variable to uncover the risk premia of the currency carry trade. In this trade network central (peripheral) countries have low (high) average interest rates and currency risk premia. Richmond (2019) shows that two components decide the centrality of a county in the total trade network. The first is the bilateral trade.[9] The second component is the share of the exports of the countries trading partners in the global total exports. In equilibrium, the cenrtal countries have strong trade linkages with countries that are important for the global total output of tradable goods. We follow Richmond (2019) to calculate the empirical centrality of the country as follows:

$$C_{it} = \sum_{j=1}^{N} \left(\frac{X_{ijt} + X_{jit}}{G_{it} + G_{jt}} \right) s_{jt} \tag{3.3}$$

where C_{it} is the trade network centrality of country i at time t, $\frac{X_{ijt}+X_{jit}}{G_{it}+G_{jt}}$ is the bilateral trade intensity bewtween country i and j at time t[10]. X_{ijt} is the total trade between countries i and j, and G_{it} is the GDP of country i. The s_{jt} is the fraction of the exports of country j to the global exports at time t. Thus, we use C_{jt} is one measure of the trade Linkage. Similarly, we use page rank centrality for the import network and export network to capture the trade linkage of country i with all the other countries.

$TradeLinkage_{j,y-1}$ can also be the import value, export value or total trade value between country i and country j in the previous calendar year $y-1$.

$\Delta TP^*(Trade)_{j,t}$ measures the overall change in the term premia among a country's trade-linked countries. Thus, a positive β in equation (3.1) indicates term premia co-move in the same direction through the

[9] Many papers have also reported the positive relation between business cycle and bilateral trades. Frankel and Rose (1998) show that bilateral business cycle correlations are increasing in bilateral intensity, Baxter and Houparitsas (2012) show that the relation between bilateral trade intensity and business cycle correlations is robust across developed and developing countries. Many other studies that reported the positive relations between business cycle correlations and bilateral trades, see e.g., in Kose and Yi (2006).

[10] This is the proxy for ρ_X in (2.8)

trade linkages. Similarly, a positive β in equation (3.2) implies changes in term premia among one countries' trade-linked partners in month $t-1$ will induce a change in term premia in month t of this particular country. In other words, changes in term premia in one country can be spilled over or transmitted to other countries through the trade network.

Trade linkage measurement

Following Chang et al. (2021), for each country i at month t in our sample, we construct several trade-linkage based risk proxies to capture the variations in term premia in all the other countries js which are connected to country i through the trade network. we define $\Delta TP^*(Trade)_{j,t}$ as the trade linkage variable weighted changes in term premium of all trading partners of country i, as follows,

$$\Delta TP^*(Trade)_{j,t} = \frac{\sum_{j\neq i} TradeLinkage_{j,y-1}\Delta TP_{j,t}}{\sum_{j\neq i} TradeLinkage_{j,y-1}} \tag{3.4}$$

where $\Delta TP_{j,t}$ is calculated as the change in country j's term premium from time $t-1$ to time t. $TradeLinkage_{j,y-1}$ is trade linkage measure from country i to country j through the trade network in the prior calendar year $y-1$ before month t. We use the prior calendar year's trade linkage information as the weight to make sure that the trade data is accessible to investors at the time they need to calculate our proxy and adjust their portfolio accordingly.

Here, we consider several measures to capture the trade linkage among the countries, e.g. trade intensity and centrality in the trade network. Thus, $\Delta TP^*(Trade)_{j,t}$ can be trade centrality (or import centrality, export centrality) weighted change in term premia of all the other countries (all $j\neq i$) in the trade (or import and export) network excluding country i. Alternatively it can be the trade value (or import value, export value) weighted change in term premia of all the countries (all $j\neq i$) which are the trading partners of country i. The key difference between the centrality weighting scheme and the trade value weighted scheme is that centrality weighting considers the fact that all countries are connected through either direct trade between two countries or indirect linked by trading partner's partner whereas the trade value weighting scheme considers only the countries which import from or export to country i.

The commodities and final goods channel: the composition of the trade

Ready et al. (2017) find that the countries are different in interest rates due to the composition of their trades. In aprticualr, countries that specialize in exporting basic commodities tend to have high interest rates. While countries that import most of the basic inputs and export finished consumption goods have low interest rates. They show that final good producing countries are substantially more exposed to global output shocks,which makes the commodity countries less risky. The countries are categorized as commodity or final goods producer according to the import ratio:

$$\frac{Net\ Imports\ of\ Finished\ Goods\ + Net\ Exports\ of\ Basic\ Goods}{Manufacturing\ Output}. \tag{3.5}$$

where manufacturing output is the total output in the sector that produces complex goods. The non-negative import ratio indicates that the country is a commodity country. We will test if the import ratio contains useful information in transferring the term premia fluctuations across countries.

System GMM estimation for dynamic panel regression model

Our fixed effects panel regression model has a dynamic feature in that we include the lagged dependent variables in the model. Therefore, the usual Least Square Dummy Variable (LSDV) estimation method may not be the best choice since the estimation may be subjected to Nickell's bias. Hence, we estimate the dynamic panel regression models in equations (3.1) and (3.2) by system GMM proposed by Blundell and Bond (1998, 2000) to alleviate this problem.

4 Empirical results

4.1 Time variation and cross-country heterogeneity in term premia

In Figure 7 and Figure 8, we show the 10 year bond yield (blue), fitted bond yield (black), and the decomposed two parts of term premia (red) and expected short rate (green) for the five randomly chosen developed (US, Japan, UK, Germany, Sweden) and developing countries (China, India, Mexico, Thailand, Philippine) from 2002 to 2019. In all countries, the model implied is effectively indifferent from the observed bond yields. All the term premia and short term expectation demonstrate plausible time series variations. In developed countries, the estimates of the term premia show an overall downward trend both in the US and in the euro area since the 2007-09 Great Financial Crisis. Term Premia have increased recently but still well below pre financial crisis period. These term premia are higher than interest rate expectations, and especially in recent years, higher than the bond yields, reflecting the negative interest rate in most of the developed countries. However, we observe a different trend for term premia in developing countries. The short rate expectations are more correlated than the term premia in general. The bond yields and the term premia remain on the same level pre and post Great Financial Crisis. The term premia are much flatter in developing countries than the developed countries.

[*Insert Figure 7 and Figure 8 about here*]

4.2 Summary statistics

Table 4 reports the summary statistics for the term premia, changes in term premia and other macroeconomic variables based on 37 countries during 2002-2019. On average, the term premia is 1.38%, indicating investors requiring a positive compensation to hold long term bonds instead of short term interest rates. The second row indicates that although changes in term premia are on average very small, i.e., only -0.67 basis points, there is considerable variations in term premia. The mean inflation and GDP growth rate for the sample is 2.64% and 2.94%, respectively. The fourth to seventh row shows that the average countries' total trade-to-GDP ratio is 95.64%, with even shares from import and export. As a consequence, understanding trade activity is critical to understanding GDP.

[*Insert Table 4 about here*]

4.3 Portfolio sorting results

Table 5 presents the results on portfolio sorting based on the centrality of Richmond (2019). We sort the 37 countries term premia into four portfolios according to their centrality scores in the total trade network. The central (P4) and Peripheral (P1) portfolios contains the countries with the highest and lowest centrality scores, respectively. The Central minus Peripheral portfolio refers to a strategy by selling the term premia of central countries and buying term premia of peripheral countries.[11] Panel A reports the summary statistics for the term premia in each of the four centrality groups for the whole sample whereas Panel B is based on more recent sample period from 2010 to 2019. We can see from both Panel A and Panel B, the average term premia increases almost monotonically with the decreases in the trade network centrality (i.e., from the central (high centralit to peripheral (low centrality) portfolios) of Richmond (2019). Furthermore, the average difference in term premia between P4 (peripheral) and central (P1) potfolio is 16 basis points, significant at 5% significance level in Panle A and 32 basis points, significant at 1% level in Panel B, respectively. The results in Table 5 is consistent with the simulation results reported in Table 2 . This is also an affirmation on our Hypothesis 1, that Term premiums decreases with the trade network centrality.

[*Insert Table 5 about here*]

[11]This is not a tradable strategy, however, we have it here as an experiment for demonstrative purpose.

4.4 Term premium co-movement through trade network

In this subsection, we report the results from the dynamic panel regression to verify our Hypothesis 2 that the trading intensity weighted term premiums can predict next period's term premiums and the predictive power is robust to using other centralities. We consider the total trade network centrality of Richmond (2019) and the total import and export trade network centrality based on the page ranking. We also report the results from the different types of subnetwork constructed based on, e.g., developed vs developing, and the basic and complex goods of Ready et al. (2017).

In Table 6, we present the Blundell-Bond system GMM estimation results for the dynamic panel regression model in equation (3.1) based on 37 countries and from 2002 to 2019. Here we constructed six measures of trade-linkage weighted risk proxy of change in term premia, based on i.e., the centrality of Richmond (2019), two pagerank centralities of the export and import trade network, total trade, total export, total import values. We include country fixed effect and year fixed effects in all regression specifications. As can be seen in the second to seventh column, the β coefficient is always positive and highly significant for each of the six measures based on different trade linkages. E.g., the coefficient for the centrality of Richmond (2019), centrality of export trade network, and import trade network are 0.846, 0.819, and 0.856, respectively, and all coefficients are significant at 1% level, while the coefficients for total trade, export and import values are slightly lower but still significant at 1% level.

As documented in previous literature (see e.g. Asgharian et al. (2018)), the financial linkage among the countries can also be a risk transfer channel. Trade linkage between two countries are often accompanied by financial linkages. Therefore, in our empirical analysis, we control for the bilateral financial linkage. More specifically, we examine the bilateral capital flow that is composed of both the long term equity investment (FDI) and the portfolio investment including both debt and speculative equity investment from CPIS. We measure the FDI and portfolio investment following Chang et al. (2021) by replacing the $TradeLinkage_{j,y-1}$ with $FinancialLinkage_{j,y-1}$ in equation 3.4. Then we include $\Delta TP^*(Financial)_{j,t}$ in equation 3.1 as additional control in our panel regression.

The coefficients of the additional control of the financial linkage between country i and it's financial linked partners, through FDI (CDIS) or portfolio investment (CPIS) from country i are reprted in column 8 to 15. The results indicate that the trade linkage is most of the time robustly significant after controlling the financial linkage.

[*Insert Table 6 about here*]

As can be shown in appendix Figure A1, the estimated term premia data covers 24 to 31 countries from 2002 to 2009 whereas the data includes 34-37 countries for the period 2010 to 2019, Thus, by focusing on the more recent period, we suffer less problems brought by unbalanced panel. Further, The period 2010-2019 simply excludes the 2007-2009 global financial crisis which might drive up or down the possible relationship between the dependent and independent variables. Lastly, the bilateral CDIS data is only available from 2009.

Therefore, we repeat the same panel regression of specification 3.1 with the more recent sample period from 2010 to 2019, and the results from this sub-sample regression can be found in Table A3. Comparing the results in Table 6 and Table A3, we find the co-movement in term premia is much stronger in the more recent period with more counties included in the trade network. Hence, we conclude that the trade network is one channel that significantly transfers the contemporaneous term premia risk across international boarders.

4.5 Term premium transmission through trade network

In this session, we test if the lagged information contained in the trade network can be used to predict the global term premia cross countries. In particular, we study if the trade network weighted term premia of one country's trading partners at time $t-1$ can be used to predict the term premia of the country in question with the trade network as a transmission channel.

We perform the panel regression based on the specification of 3.2. The regression results with the Blundell-Bond system GMM estimation for the dynamic panel in equation (3.2) based on 37 countries and from 2002 to 2019 are present in Table 7. As in the previous regression, we constructed six measures of trade-linkage weighted risk proxy of change in term premia, based on i.e., the centrality of Richmond (2019), two pagerank centralities of the export and import trade network, total trade, total export, total import values, from previous year. We include country fixed effect and year fixed effects in all regression specifications. As can be seen in the second to seventh column, the β coefficient is always positive and highly significant for each of the six measures based on different trade linkage, such as trade centrality and trade intensity. The coefficient of the trading network weighted average term premia of all trading partners significantly and positively predict the term premis of this country in question. We also control for the financial linkeage as in the previous seciton, use $\Delta TP^*(Financial)_{j,t-1}$ in equation 3.2 as additional control in our panel regression.

In column 8 to 15, we report the results of adding additional control of the financial linkage between country i and it's financial linked partners, through FDI (CDIS) or portfolio investment (CPIS) from country i. The results indicate that the trade linkage is most of the time robust after controlling the financial linkage.

[*Insert Table 7 about here*]

We again repeat the same exercise based on the more recent sample period from 2010 to 2019. The results are presented in Table A4. Comparing the results in Table 7 and Table A4, we find the spillover or transmission in term premia is stronger with higher β in the more recent period with more counties included in the network.

Therefore, we conclude that our hypothesis 2 is verified. The term premia of the trading network weighted avergae of the country's trading partener can significantly predict this country's own term premia, the trading network is a channel transfer the contemptuous and previous term premia risk.

4.6 Developed countries vs developing countries

In this section, we study if the trade network based on only developed or developing country can be a channel so that the term premia risk transfers globally.

We re-estimate the dynamic fixed effects panel regression model in equations (3.1) and (3.2) based on the sub-network which includes developed or developing countries only. The motivation for conducting such an analysis is that we find the correlation is higher in term premia among developed countries, which is consistent with the frequently reported results that countries have higher trading intensity tend to have more correlated business cycle (see,e.g., Frankel and Rose (1998)). We thus investigate further whether the comovement through the trade network is stronger in developed countries compared to developing.

[*Insert Table 8 and Table 9 about here*]

In Table 8, we report the regression results based on the trade network consisting only the developed countries. As can be seen in Table 8, the βs are all significant and positive in these six trade-linkage based risk proxies. Furthermore, βs are higher in the developed countries' trade network compared to that reported in Table A3 including all 37 countries.[12] We also see significant co-movement through the financial linkages and the β is lower than using the trade linkages.

Table 9 presents the predictive regression results in equation (3.2). All the six trade-linkage based risk proxies are positive and significant at 1% significance level. Thus, our trade-linkage based term premia risk proxy is useful to predict the term premia change for the typical country. Further, an increase in term premia of all the other countries j, which are connected to country i through the trade network from month $t-1$ to month t would induce an increase in country i's term premia from month t to month $t+1$. However, the β is lower compared to the case that we include all 37 countries.

[12]Here we do not control the financial linkage variables in the panel regression since these financial linkage variables are highly correlated to the trade linked measure. The correlation is much higher than the sample with 37 countries.

For developing countries, Table A5 presents the panel regression results according to equation (3.1). The co-movement in term premia is much less compared to developed countries and only significant at 10% level. In addition, We find β for the financial linkages is much lower and less significant than using the trade linkages.

Similarly, we examine whether trade-linkage based term premia risk proxy is useful to predict the term premia change for the typical country for the developing countries only according to equation (3.2). However, neither the trade-linkages nor the financial linkages show any predictability in the change in term premia for the typical country.

To sum up, comovement in term premia is stronger in developed countries than developing countries. However, when it comes to the investigation of whether the trade linkage based risk proxy is useful for prediction in term premium change for a certain country, we find that β coefficients are smaller and less significant in a network of either developed countries only or developing countries only than a network of all 37 countries. This shows that a more complete network based risk proxy is more influential in predicting the term premium changes.

4.7 Sub-trade network: Basic goods vs Final goods

As illustrated in Ready et al. (2017), countries differ a lot in their endowments and technologies. In their model, Ready et al. (2017) show that the production of the basic goods is relatively insulated from global productivity shocks whereas final goods producing are substantially more exposed to global output shocks. Therefore, if a country is more of an exporter of basic goods relative to final goods, it may play a larger role in transmitting the shocks to its partner countries. Thus, we apply the import ratio defined in Ready et al. (2017) and as specified in 3.5 to capture the linkage in sub-trade networks. Movement in term premia in partner country of a given country i with higher import ratio receives higher weight in affecting the change in term premium in country i than other partner countries of country i.[13]

Table 10 presents the term premia co-movement and transmission results according to equation (3.1) and equation (3.2) for the sub-trade network of basic goods trade and the import ratio based network. Column 2 and 3 in Panel A present the results for the whole sample from 2002 to 2019 while Column 4 and 5 show the results for the sub sample from 2010 to 2019. We can see that column 2 and column 4 imply that β coefficient in equation (3.1) is always positive and highly significant for the whole sample and the more recent sample, which indicate that the sub network information based on both basic goods and final goods, as captured by import ratio in Ready et al. (2017) is useful in explaining the comovement

[13]Here we re-scale the original import ratio as defined in 3.5 into an adjusted import ratio which lies in [0,1], in order to calculate the import ratio weighted change in term premium.

in term premia.

[*Insert Table 10 about here*]

Column 3 and 5 present the term premia transmission results according to equation (3.2) for the sub network of basic and final goods trade (import ratio). We find that both of the β coefficients of import ratio trade-linkage based risk proxies are positive and significant. An increase in the term premia of all the other countries j which are connected to country i through the sub-trade networks from month $t-1$ to month t would induce an increase in country i's term premia from month t to month $t+1$. To sum up, the import ratio constructed based on the sub-trade networks contains useful information in explaining the comovements and transmissions in term premia.

4.8 Other additional tests

So far, we have presented evidence for the trade network as a channel to drive comovement and transmission in term premia. A natural question arise, what about the other part from the yield decomposition: expected short rate. Therefore, we repeat the empirical investigation according to equation (3.1) and equation (3.2), but replacing term premium with expected short rate. The results are reported in Table A6 and Table A7. We can see from Table A6 that Expected short rate seems also comove through the international trade linkage, however, Table A7 shows that the information of expected short rates of all the other countries j which are connected to country i through the trade network can not be used to predict country i's expected short rate .

5 Conclusions

This paper investigates the impact of the international trade linkages on global term premia. In particular, we study how trade network could provide a channel through which term premia comove between the importing and exporting countries.

We study term premia comove across 37 international countries consisting both developed and developing countries, and identify the international trade channel with a global trade network approach where countries are linked by the pairwise imports and exports, and through which global and local shocks are transmitted across countries. We address why term premia comove by proposing a multi-country model with a network-based production environment from Richmond (2019) where countries share and are exposed to risk through trade links, and hypothesize that Term premiums decreases with the trade network centrality and the trading intensity weighted term premiums can predict next period's term premiums and the predictive power is robust to using other centralities.

We test the hypothesis by an empirical analysis using both trade data and bond yields across different maturities and from different countries. We create a total trade network based on the trad links and use the centrality proxied by the trading intensity to investigate if the trade centrality weighted term premia of the countries trading partners help to explain and predict the term premia of this country. Both the simulation and the empirical results have confirmed our hypothesis and show that the trade network is a channel to transmit the term premia risk.

References

Acemoglu, D., Carvalho, V., Ozdaglar, A., and Tahbaz-Salehi, A. (2012). The network origins of aggregate fluctuations. *Econometrica*, 80(5):1977–2016.

Adrian, T., Crump, R., and Moench, E. (2013). Pricing the term structure with linear regressions. *Journal of Financial Economics*, 110:110–318.

Ang, A. and Piazzesi, M. (2003). A no-arbitrage vectorautoregressive regression of term structure dynamics with macroeconomic and latent variables. *Journal of monetary economics*, 50:745–787.

Asgharian, H., Liu, L., and Larsson, M. (2018). Cross-border asset holdings and comovements in sovereign bond markets. *Journal of International Money and Finance*, 86:189–206.

Baxter, M. and Houparitsas (2012). Determinants of business cycle comovement: a robust analysis. *Journal of Monetary Economics*, 52(1):113–157.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, 87(1):115–143.

Blundell, R. and Bond, S. (2000). Gmm estimation with persistent panel data: an application to production functions. *Econometric reviews*, 19(3):321–340.

Brennan, M. and Xia, Y. (2006). International capital markets and foreign exchange risk. *Review of Financial Studies*, 19(3):793–95.

Chang, J., Du, H., Lou, D., and Polk, C. (2021). Ripples into waves: Trade networks, economic activity, and asset prices. *Journal of Financial Economics, forthcoming*.

Cochrane, J. and Piazzesi, M. (2005). Bond risk premia. *American Economiccan Review*, 95:138–160.

Cox, J. C., Ingersoll Jr, J. E., and Ross, S. A. (1985). A theory of the term structure of interest rates. *Econometrica*, 53(2):385–408.

Crump, R. K., Eusepi, S., and Moench, E. (2018). The term structure of expectations and bond yields. *Federal Reserve Bank of New York Staff Reports*, (775).

Dahlquist, M. and Hasseltoft, H. (2013). International bond risk premia. *Journal of International Economics*, 90:17–32.

Dai, Q. and Philippon, T. (2005). Fiscal policy and the term structure of interest rates. *NBER Working paper*.

Dai, Q. and Singleton, K. J. (2000). Specification analysis of affine term structure models. *The Journal of Finance*, 55(5):1943–1978.

Diebold, F. X., Li, C., and Yue, V. Z. (2008). Global yield curve dynamics and interactions: a dynamic nelson–siegel approach. *Journal of Econometrics*, 146(2):351–363.

Duffee, G. R. (2002). Term premia and interest rate forecasts in affine models. *The Journal of Finance*, 57(1):405–443.

Duffie, D. and Kan, R. (1996). A yield-factor model of interest rates. *Mathematical finance*, 6(4):379–406.

Dungey, M., Vance, L. M., and Pgan, A. R. (2000). A multivariate latent factor decomposition of international bond yield spreads. *Journal of Applied Econometrics*, 15(6):697–715.

Evans, C. and Marshall, D. (1996). Economic determinants of the nominal treasury yield curve. *Journal of monetary economics*, 54:1896–2003.

Foerster, A., Sarte, P., and Watson, M. (2011). Sectoral versus aggregate shocks: A structural factor analysis of industrial production. *Journal of Political Economy*, 119(1):1–38.

Forbes, K. (2002). Are trade linkages important determinants of country vulnerability to crises? *NBER working paper*, in S. Edwards and J. A. Frankel (Eds.), Preventing Currency Crises in Emerging Markets:77–124.

Forbes, K. (2004). The asian flu and russian virus: Firm-level evidence on how crises are transmitted internationally. *Journal of International Economics*, 63:59–92.

Frankel, J. and Rose, A. (1998). The endogenity of the optimium currency area criteria. *The Economic Journal*, 108(449):1009–025.

Glick, R. and Rose, A. (1999). Tcontagion and trade why are currency crises regional? *Journal of International Money and Finance*, 18:603–617.

Hördahl, P. and Tristani, O. (2014). Inflation risk premia in the euro area and the united states. *International Journal of Central Banking*, 10(3):1–47.

Joslin, S., Singleton, K. J., and Zhu, H. (2011). A new perspective on gaussian dynamic term structure models. *The Review of Financial Studies*, 24(3):926–970.

Jotikasthira, C., Le, A., and Lundblad, C. (2015). Why do term structures in different currencies co-move? *Journal of Financial Economics*, 115(1):58–83.

Katz, l. (1953). A new status index derived from sociometric analysis. *Psychometrika*, 18(1):39–43.

Kim, D. and Wright, J. (2005). An arbitrage-free three factor term structure model and the recent behavior of long term yields and distant-horizon forward rates. *Finance and Discussion Series, Board of Governors of the Federal Reserve System*, 33(August).

Kose, M. and Yi, K.-M. (2006). Can the standard international business cycle model explain the relation between trade and comovement? *Journal of international economics*, 68(2):197–225.

Li, H., Ye, X., and Yu, F. (2020). Unifying gaussian dynamic term structure models from a Heath–Jarrow–Morton perspective. *European Journal of Operational Research*, 286(3):1153–1167.

Ready, R., Roussanov, N., and Ward, C. (2017). Commodity trade and the carry trade: A tale of two countries. *The Journal of Finance*, 72(6):2629–2684.

Richmond, R. J. (2019). Trade network centrality and currency risk premia. *The Journal of Finance*, 74(3):1315–1361.

Wright, J. H. (2011). Term premia and inflation uncertainty: Empirical evidence from an international panel dataset. *American Economic Review*, 101(4):1514–34.

Table 1: Sample of raw trade data

Year	Flow Code	Flow	RCode	RISO	PCode	PISO	Value
2018	1	import	276	DEU	0	WLD	1.292726e+12
2018	2	export	276	DEU	0	WLD	1.562419E+12
2018	1	import	276	DEU	4	AFG	1.324338E+07
2018	2	export	276	DEU	4	AFG	9.551145E+07
2018	1	import	276	DEU	8	ALB	1.443794E+08
2018	2	export	276	DEU	8	ALB	2.954648E+08
2018	1	import	276	DEU	12	DZA	7.6387735E+08
2018	2	export	276	DEU	12	DZA	2.595952E+09
2018	1	import	276	DEU	156	CHN	1.267509E+11
2018	2	export	276	DEU	156	CHN	1.1045293E+11
2018	1	import	276	DEU	20	CHL	1.5989E+09
2018	2	export	276	DEU	20	CHL	3.16504408E+09
2018	1	import	276	DEU	484	MEX	9.448827E+09
2018	2	export	276	DEU	484	MEX	1.6479936E+10
2018	1	import	276	DEU	31	NOR	8.70115e+09
2018	2	export	276	DEU	31	NOR	1.102543e+10

Notes: This table shows the sample data of the raw trading for Germany(DEU) in 2018. RISO (PISO) is the ISO code for the reporting (partner country). The first two rows with PISO of WLD are the total exports and the imports for Germany. Randomly selected trading partners reported in this table including: AFG (Asgharian), ALB (Albania), DZA (Algeria), CHN(China), CHL(Chile), MEX(Mexico), Nor(Norway). Trade data are collected from the UN Comtrade Database.

Table 2: Simulation results

The table shows the average slope coefficients and t-statistics in regressing the simulated $tp_i(1, 10)$ (Term premium), $\frac{1}{9}\int_1^{10}\Theta_i(s)\,ds$ (Part 1), $-\Theta_i(0)$ (Part 2), and $C_i^\top \frac{1}{9}\int_1^{10}\exp(A_i s) - \exp\left(A_i^{\mathbb{P}} s\right) ds \zeta_i^\top \boldsymbol{Z}_t$ (Part 3) to $v_i/\max_{i=1,\ldots,50}(s_i)$. The sample contains 1000 simulation results. The numerical values of parameters in the simulations are set as following: $\lambda_{x,i} = \lambda_{y,i} = \lambda_{z,i} = 5$; s_i's are drawn from the uniform distribution and normalized to have sum of one; $\rho_{i,j}$'s in ρ_X (σ_i's in Σ_X and Σ_Y) are drawn from an even distribution on [-0.05, 0.2] ([0.4, 0.6]). $C_i(1) = C_i(3) = 1$ and $C_i(2)$'s are drawn from an even distribution on [0.4, 4]. The elements in Z_t are drawn from an even distribution on [-0.3, 0.3].

	Term premium	Part 1	Part 2	Part 3
average	-0.10***	0.00	-0.09***	-0.00
t statistic	[-7.54]	[23.08]	[-23.08]	[-0.05]

Table 3: Simulation results: cross-country term premium correlations

This table shows the average rank correlation (Spearman's rho) coefficients and their t-statistics. The rank correlations are calculated for each country by pairing its partner countries' normalized Richmond centralities, influence vector, and trading intensity with their term premium correlations. The sample contains 1000 simulation results. The numerical values of parameters in the simulations are set as following: $\lambda_{x,i} = \lambda_{y,i} = \lambda_{z,i} = 5$; s_i's are drawn from the uniform distribution and normalized to have sum of one; $\rho_{i,j}$'s in ρ_X (σ_i's in Σ_X and Σ_Y) are drawn from an even distribution on [-0.05, 0.2] ([0.4, 0.6]). $C_i(1) = C_i(3) = 1$ and $Ci(2)$'s are drawn from an even distribution on [0.4, 4].

	Richmond Centrality	Influence Vector	Trading Intensity
average	0.11***	0.06***	0.32***
t statistic	[162.63]	[85.38]	[435.02]

Table 4: Summary statistics for the term premia and other macro variables

This table reports the summary statistics for the monthly term premia, change in term premia and the yearly macro variables, such as inflation, GDP growth and trade to GDP ratio for the sample period from 2002 to 2019.

variables	N	mean	std	p05	median	p95	min	max
Term premium (%)	6825	1.38	1.69	-0.60	1.15	4.03	-10.39	15.28
Change in Term Premium (bps)	6825	-0.67	44.55	-48.28	-1.42	50.12	-742.32	679.18
Inflation (%)	6825	2.64	2.94	-0.27	2.08	7.96	-2.98	29.50
GDP growth rate (%)	6825	2.94	2.76	-1.09	2.70	7.66	-6.70	14.53
Import to GDP ratio (%)	6825	47.18	38.45	16.46	34.29	165.24	9.67	221.01
Export to GDP ratio (%)	6825	49.33	42.63	13.18	35.95	178.14	8.26	228.99
Total trade to GDP ratio (%)	6825	95.64	79.77	30.01	69.86	329.47	19.80	442.62

Table 5: Portfolio sorting based on Richmond Centrality

This table reports the results of the term premia sorting based on the centrality of Richmond (2019) for the 37 countries. The term premia are sorted into four portfolios. The reported are the number of observations, mean, median, standard deviations of the portfolio returns. The t ratio is for testing if the mean is significantly different from zero, respectively. The central (peripheral) portfolio contains countries with the highest (lowest) centrality scores.

Centrality Bins	N	mean	median	std	t ratio
Central (P1)	191	1.28%	1.25%	0.55%	31.96
P2	191	1.30%	1.17%	0.59%	30.22
P3	191	1.34%	1.34%	0.76%	24.23
Peripheral (P4)	191	1.44%	1.51%	0.95%	20.92
Peripheral - Central (P4-P1)	191	0.16%	0.23%	0.86%	2.52
Centrality Bins (2010-2019)	N	mean	median	std	t ratio
Central (P1)	119	1.26%	1.32%	0.52%	26.52
P2	119	1.36%	1.21%	0.54%	27.48
P3	119	1.68%	1.64%	0.57%	32.32
Peripheral (P4)	119	1.58%	1.73%	0.81%	21.32
Peripheral - Central (P4-P1)	119	0.32%	0.38%	0.88%	3.94

Table 6: Term premium comovement through the trade network

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample period from 2002 to 2019, according to equation 3.1. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t. The main independent variable of interest is presented are the centrality measures. $RM\_centrality(j,t)$ denotes the Richmond centrality weighted average change in term premia in month t among all trading partner countries, and it is calculated based on 3.3. $EX\_centrality$ and $IM\_centrality$ are the page bank centrality of the export and import network weighted average of all trading partners term premia at month t. Trade Value, Export Value and Import Value are the total trade, export and import values weighted average of all trading partner countries term premia. CDIS and CPIS values are the long term equity investment (FDI) and the portfolio investment including both debt and speculative equity investment, respectively. In all specifications, country i' own change in term premium in month $t-1$ and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i													
RM_centrality (j,t)	0.783***						0.731**	0.482*						
	(0.113)						(0.326)	(0.251)						
EX_centrality (j,t)		0.795***												
		(0.111)												
IM_centrality (j,t)			0.870***						0.712**	0.505*				
			(0.121)						’(0.320)	’(0.030)				
Trade Value (j,t)				0.698***							0.772***	0.466*		
				(0.115)							(0.245)	(0.268)		
Export Value (j,t)					0.625***									
					(0.117)									
Import Value (j,t)						0.776***							0.772***	0.521*
						(0.126)							(0.225)	(0.271)
CDIS Value (j,t)							0.111		0.136		0.012		0.032	
							(0.223)		’(0.218)		(0.158)		(0.142)	
CPIS Value (j,t)								0.435**		0.444**		0.387*		0.365*
								(0.193)		’(0.212)		(0.215)		(0.211)
$\Delta TP_{i,t-1}$	-0.186***	-0.186***	-0.186***	-0.186***	-0.186***	-0.187***	-0.168***	-0.154***	-0.169***	-0.153***	-0.167***	-0.153***	-0.168***	-0.154***
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.052)	(0.034)	(0.043)	’(0.033)	’(0.044)	(0.032)	(0.043)	(0.033)	(0.043)
Control variables														
Inflation	1.200	1.179	1.225	1.297	1.217	1.312	4.015**	0.663	4.332**	0.690	4.434**	0.725	4.469**	0.672
	(1.202)	(1.189)	(1.210)	(1.219)	(1.212)	(1.229)	(1.573)	(0.676)	’(1.837)	’(0.951)	(1.839)	(0.672)	(1.843)	(0866)
GDP growth	-0.345	-0.235	-0.384	-0.395	-0.325	-0.429	-1.132	-1.107	-0.435	-0.884	-0.555	-1.198	-0.577	-1.303
	(0.877)	(0.839)	(0.923)	(0.883)	(0.830)	(0.943)	(1.231)	(0.778)	’(1.736)	’(0.903)	(1.722)	(0.783)	(1.746)	(0.951)
Trade to GDP	-0.048			-0.046			-0.074	0.032	0.038	0.046	0.041	0.033	0.038	0.029
	(0.052)			(0.052)			(0.070)	(0.033)	’(0.101)	’(0.036)	(0.103)	(0.032)	(0.104)	(0.036)
export to GDP		-0.105			-0.102									
		(0.097)			(0.096)									
import to GDP			-0.086			-0.075								
			(0.116)			(0.113)								
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6777	6777	6777	6777	6765	6765	4275	5656	4275	5656	4275	5656	4275	5656

Table 7: Term premium spillover/transmission through the trade network

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample period from 2002 to 2019, according to equation 3.2. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t. The main independent variable of interest is presented are the centrality measures. RM_centrality(j,t-1) denotes the Richmond centrality weighted average change in term premia in month t among all trading partner countries, and it is calculated based on equation 3.3. $EX\_centrality(j,t-1)$ and $IM\_centrality(j,t-1)$ are the page bank centrality of the export and import network weighted average change in term premia in month $t-1$ among all countries. Trade Value, Export Value and Import Value are the total trade, export and import values weighted average changes in term premia in month $t-1$. CDIS and CPIS values are the long term equity investment (FDI) and the portfolio investment including both debt and speculative equity at t-1. For example, RM_centrality(j,t-1) denotes the Richmond centrality weighted average change in term premia in month $t-1$ among all countries, and it is calcualted based on the specification 3.3. In all specifications, country i' own change in term premium in month $t-1$ and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	change in term premium (t) for country i													
RM_centrality (j,t-1)	0.269***						0.329***	0.134						
	(0.100)						(0.326)	(0.121)						
EX_centrality (j,t-1)		0.253**												
		(0.108)												
IM_centrality (j,t-1)			0.282**						0.272***	0.203*				
			(0.113)						(0.085)	(0.120)				
Trade Value (j,t-1)				0.204***							0.190	0.079		
				(0.074)							(0.154)	(0.097)		
Export Value (j,t-1)					0.188***									
					(0.068)									
Import Value (j,t-1)						0.204**							0.172*	0.024
						(0.080)							(0.104)	(0.077)
CDIS Value (j,t-1)							0.059		0.097		0.116		0.132	
							(0.151)		(0.143)		(0.215)		(0.175)	
CPIS Value (j,t-1)								0.172*		0.164*		0.193		0.230*
								(0.101)		-0.095		(0.143)		(0.121)
$\Delta TP_{i,t-1}$	-0.193***	-0.192***	-0.192***	-0.191***	-0.191***	-0.191***	-0.178***	-0.176***	-0.177***	-0.176***	-0.175***	-0.176***	-0.176***	-0.175***
	(0.051)	(0.050)	(0.051)	(0.050)	(0.049)	(0.051)	(0.036)	(0.046)	(0.036)	(0.046)	(0.045)	(0.045)	(0.035)	(0.045)
Control variables														
Inflation	1.259	1.229	1.280	1.272	1.235	1.299	4.550**	0.849	4.535**	1.424	4.538**	0.862	4.536**	0.862
	(1.224)	(1.221)	(1.231)	(1.227)	(1.220)	(1.233)	(1.798)	(0.778)	(1.786)	’(1.182)	(1.800)	(0.768)	(1.788)	(0.763)
GDP growth	-0.396	-0.358	-0.460	-0.486	-0.427	-0.549	-0.633	-1.387	-0.672	-1.292	-0.793	-1.427	-0.794	-1.422*
	(0.885)	(0.846)	(0.928)	(0.890)	(0.850)	(0.934)	(1.693)	(0.851)	(1.693)	’(1.041)	(1.692)	(0.858)	(1.695)	(0.856)
Trade to GDP	-0.046			-0.043			0.036	0.032	0.035	0.031	0.033	0.033	0.033	0.034
	(0.049)			(0.049)			(0.105)	(0.031)	(0.105)	’(0.044)	(0.107)	(0.032)	(0.107)	(0.032)
export to GDP		-0.100			-0.099									
		(0.090)			(0.090)									
import to GDP			-0.076			-0.071								
			(0.108)			(0.109)								
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6777	6777	6777	6777	6765	6765	4275	5656	4275	5656	4275	5656	4275	5656

Table 8: Term premium comovement through the trade network in developed countries

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample from 2010 to 2019 for the 24 developed countries, according to equation 3.1. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t, The main independent variable of interest is presented in the first column for each regression model specification. For example, RM_centrality (j,t) denotes the Richmond centrality weighted average change in term premia in month t among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t-1 and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i							
RM_centrality (j,t)	0.981***							
	(0.105)							
EX_centrality (j,t)		0.880***						
		(0.098)						
IM_centrality (j,t)			0.944***					
			(0.107)					
Trade Value (j,t)				0.946***				
				(0.157)				
Export Value (j,t)					0.901***			
					(0.143)			
Import Value (j,t)						0.975***		
						(0.165)		
CDIS Value (j,t)							0.805***	
							(0.095)	
CPIS Value (j,t)								0.819***
								(0.139)
$\Delta TP_{i,t-1}$	-0.125***	-0.128***	-0.127***	-0.130***	-0.127***	-0.132***	-0.130***	-0.134***
	(0.024)	(0.023)	(0.024)	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)
Control variables								
Inflation	-1.940	-1.813	-1.729	-2.008	-1.908	-2.043	-1.420	-1.990
	(1.881)	(1.800)	(1.807)	(2.000)	(1.895)	(2.099)	(1.433)	(1.866)
GDP growth	-1.729***	-1.587**	-1.621**	-1.807***	-1.651**	-1.953**	-1.767**	-1.667**
	(0.640)	(0.646)	(0.638)	(0.846)	(0.814)	(0.862)	(0.840)	(0.783)
Trade to GDP	0.087			0.078			0.081	0.072
	(0.100)			(0.098)			(0.110)	(0.097)
export to GDP		0.144			0.134			
		(0.181)			(0.180)			
import to GDP			0.148			0.179		
			(0.182)			(0.214)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2755	2755	2755	2755	2755	2755	2755	2755

Table 9: Term premium transmission through the trade network in developed countries

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample from 2010 to 2019 for the 24 developed countries, according to equation 3.2. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t. The main independent variable of interest is presented in the first column for each regression model specification. For example, RM_centrality (j,t-1) denotes the Richmond centrality weighted average change in term premia in month t among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t-1 and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

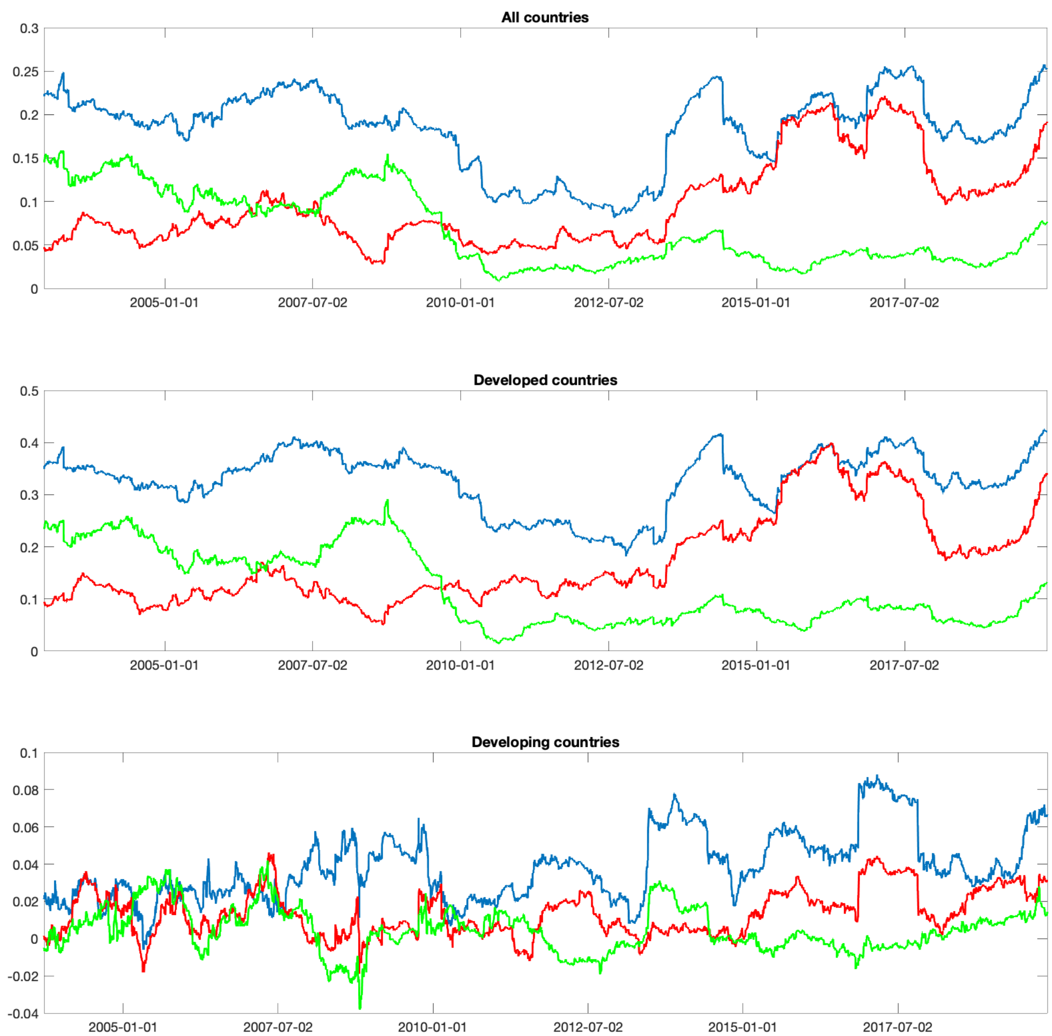
	$\Delta TP_{i,t}$, change in term premium (t) for country i							
RM_centrality (j,t-1)	0.211***							
	(0.047)							
EX_centrality (j,t-1)		0.200***						
		(0.042)						
IM_centrality (j,t-1)			0.203***					
			(0.042)					
Trade Value (j,t-1)				0.190***				
				(0.042)				
Export Value (j,t-1)					0.207***			
					(0.047)			
Import Value (j,t-1)						0.176***		
						(0.042)		
CDIS Value (j,t-1)							0.220***	
							(0.051)	
CPIS Value (j,t-1)								0.144***
								(0.036)
$\Delta TP_{i,t-1}$	-0.145***	-0.146***	-0.145***	-0.147***	-0.150***	-0.145***	-0.154***	-0.146***
	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.025)	(0.027)
Control variables								
Inflation	0.406	0.615	0.214	0.423	0.627	0.207	-1.234	0.382
	(2.005)	(1.925)	(2.098)	(2.038)	(1.937)	(2.134)	(1.5662)	(2.049)
GDP growth	-1.922***	-1.889***	-1.988***	-2.061***	-2.037***	-2.083***	-2.035***	-2.020***
	(0.706)	(0.695)	(0.708)	(0.710)	(0.718)	(0.704)	(0.729)	(0.679)
Trade to GDP	0.104			0.106			0.082	0.104
	(0.107)			(0.108)			(0.113)	(0.107)
export to GDP		0.184			0.186			
		(0.194)			(0.196)			
import to GDP			0.238			0.239		
			(0.236)			(0.237)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2755	2755	2755	2755	2755	2755	2755	2755

Table 10: Term premium co-movement and transmission through the trade sub-network (import ratio)

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample from 2002 to 2019 and the sub sample from 2010 to 2019 for the 37 countries, according to equation 3.1 and equation 3.2. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t. The main independent variable of interest is presented in the first column for each regression model specification. For example, Import Ratio (j,t) (Import Ratio $(j,t-1)$) denotes the Import ratio weighted average change in term premia in month $t(t-1)$ among all countries, where Import ratio is calculated based on the prior year's bilateral total trade sub networks. In all specifications, country i' own change in term premium in month $t-1$ and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

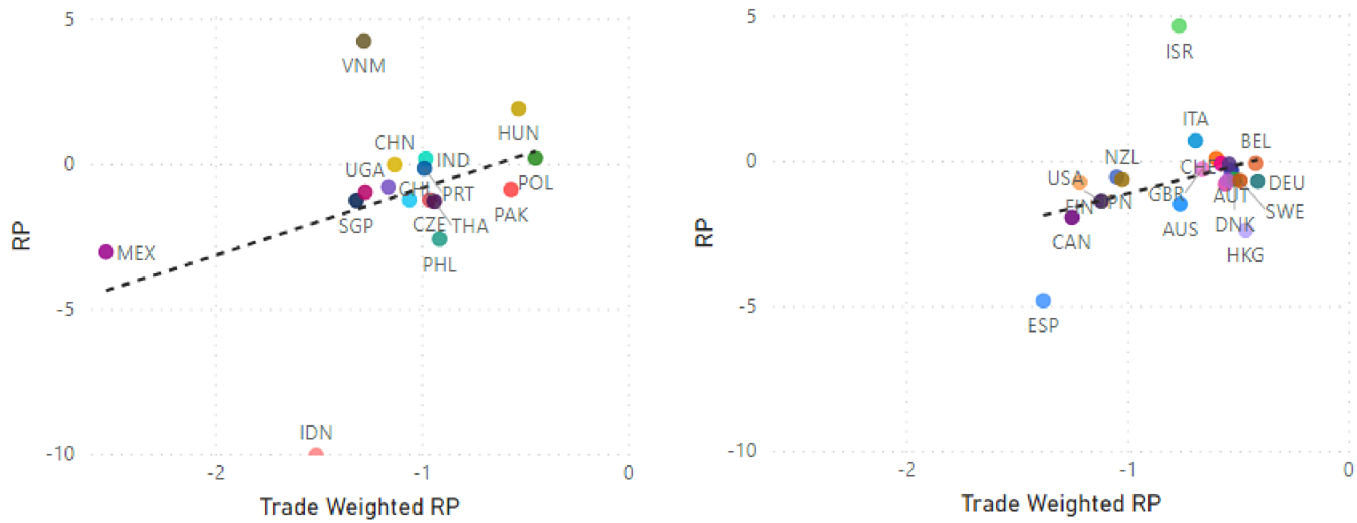
	$\Delta TP_{i,t}$, change in term premium (t) for country i			
	Panel A: Sample period: 2002-2019		Panel B:Sample period: 2010-2019	
Import Ratio (j,t)	0.658***		0.631***	
	(0.089)		(0.108)	
Import Ratio (j,t-1)		0.270***		0.328**
		(0.103)		(0.146)
$\Delta TP_{i,t-1}$	-0.191***	-0.194***	-0.169***	-0.176***
	(0.051)	(0.051)	(0.034)	(0.037)
Control variables				
Inflation	1.279	1.401	3.885***	4.423***
	(1.146)	(1.149)	(1.400)	(1.386)
GDP growth	-0.267	-0.335	-0.886	-1.221
	(0.883)	(0.896)	(1.156)	(1.157)
Trade to GDP	-0.030	-0.232	-0.061	-0.054
	(0.051)	(0.049)	(0.063)	(0.061)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	6777	6777	4275	4275

Figure 1: Rolling correlations of 37 global bond yields



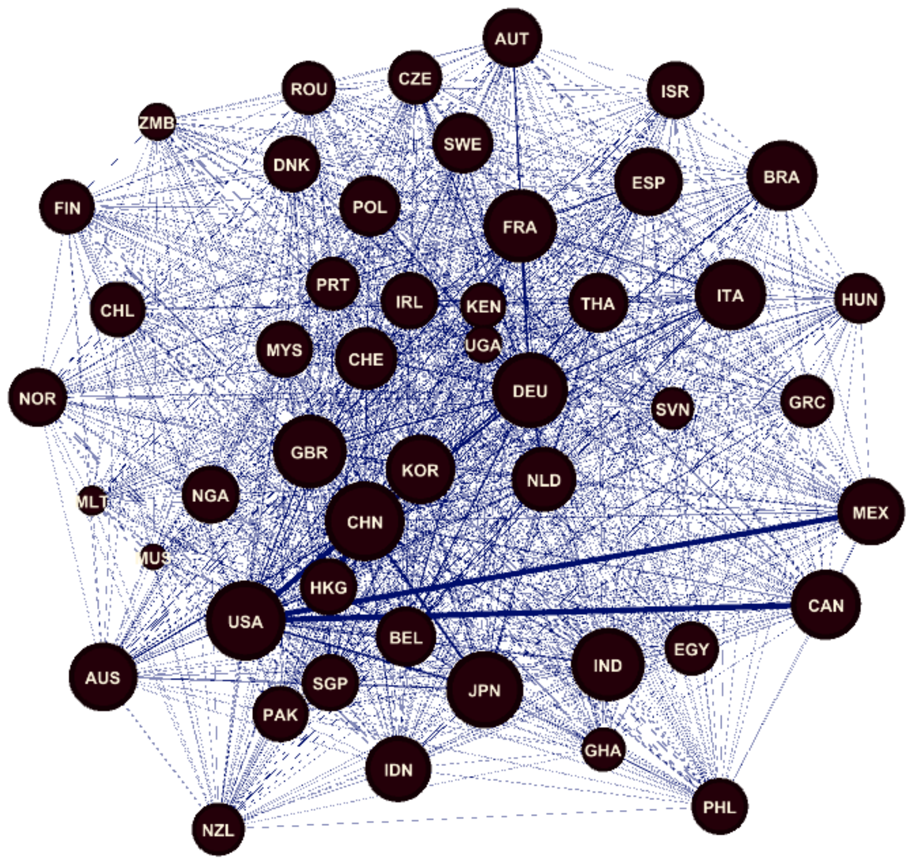
Notes: This figure plots the one year rolling window of the average pairwise correlation of daily yield changes (blue), daily changes of risk premium (red) as well as the daily changes in short rates (green) from 37 global countries from 1999 to 2018. The first panel are for all 37 countries, the second one plots correlations for 24 developed countries and the last one plots correlations for 13 developing countries. The decomposition of the 10 year bond filed into the risk premium and expected short rate is done with the method of Adrian et al. (2013).

Figure 2: Bond risk premium versus trading weighted bond risk premium



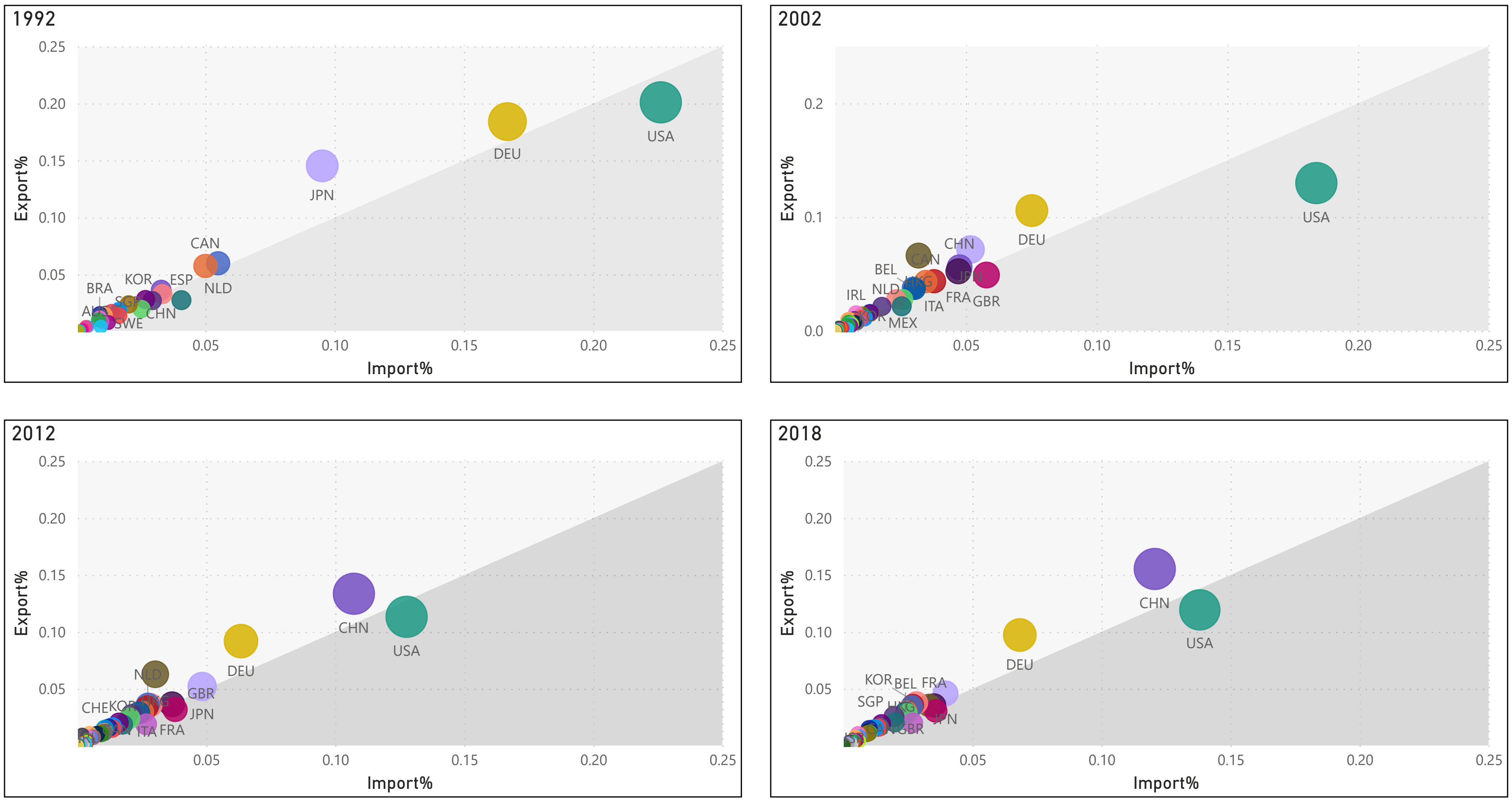
Notes: This figure graphs the scatter of the average changes in term premia versus the changes in total trade weighted average of trading partner's term premia changes in a randomly chosen year 2002. The first subplot graphs is for the developing countries, and second is for the group of developed countries.

Figure 3: Centrality of total trade network



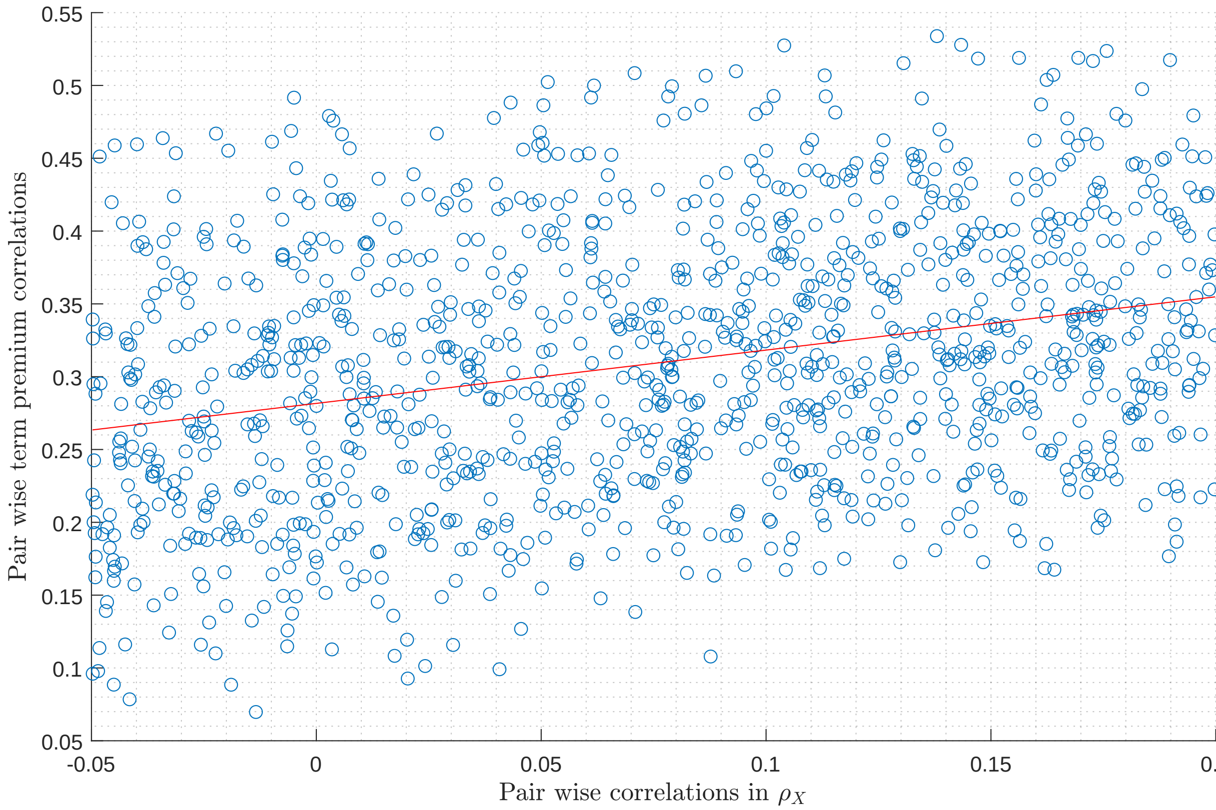
Notes: The figure plots the centrality of the total trade network based on *Richmond* (2019). The countries are linked by the pair wise trade intensity and the share of the trading partners exports to the global exports, specified in equation 3.3. The circle size represents the GDP of the country. The position of the circle indicates the country's centrality in the total trade network. The thickness of the link shows the size of bilateral trades of the paired countries.

Figure 4: Global exports and imports



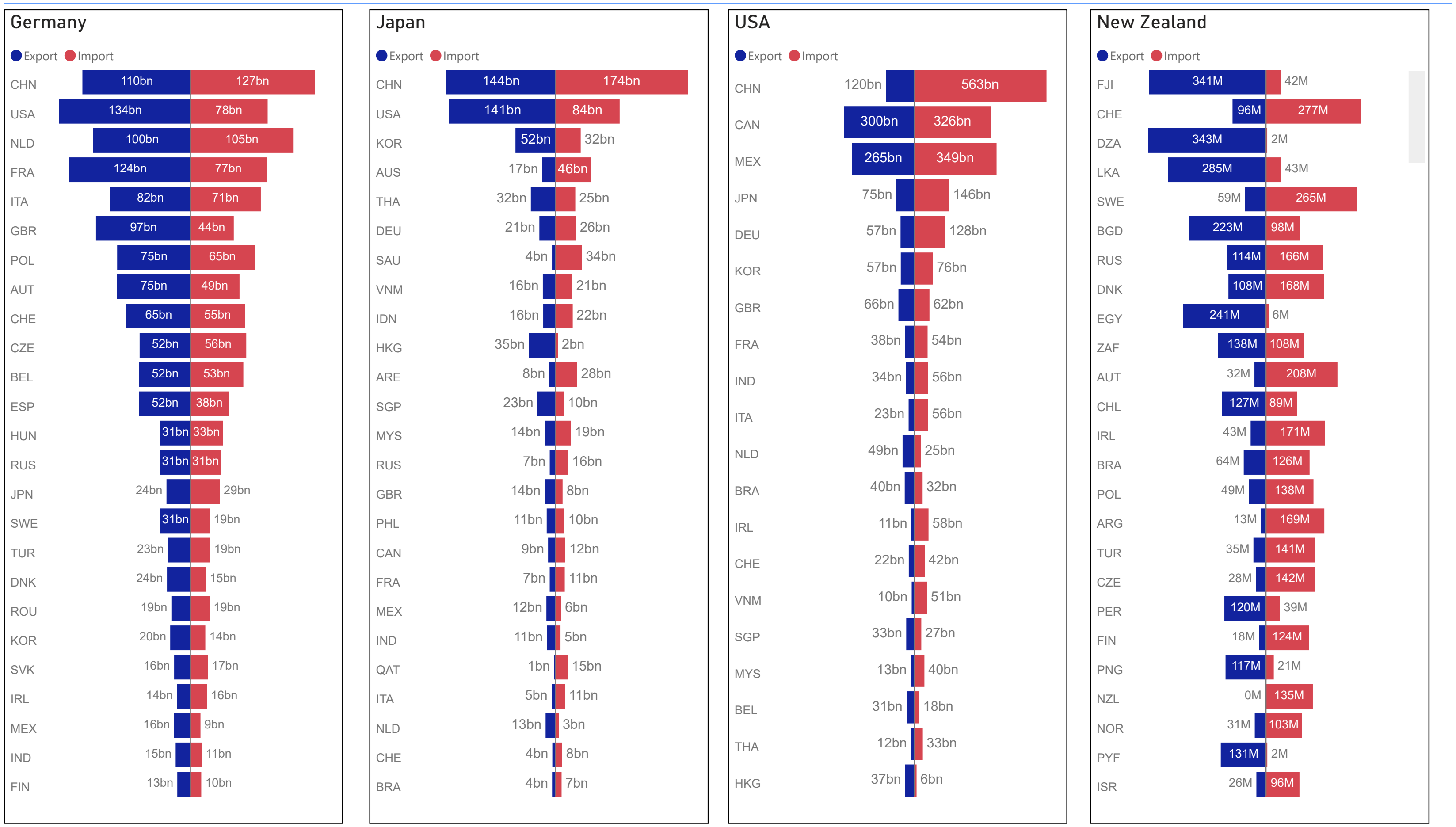
This figure plots the share of the country's export to its total GDP in percentage against its share of the country's import to its total GDP in percentage. Fours years have been randomly selected: 1992, 2002, 2012 and 2018.

Figure 5: Pair-wise correlations simulations



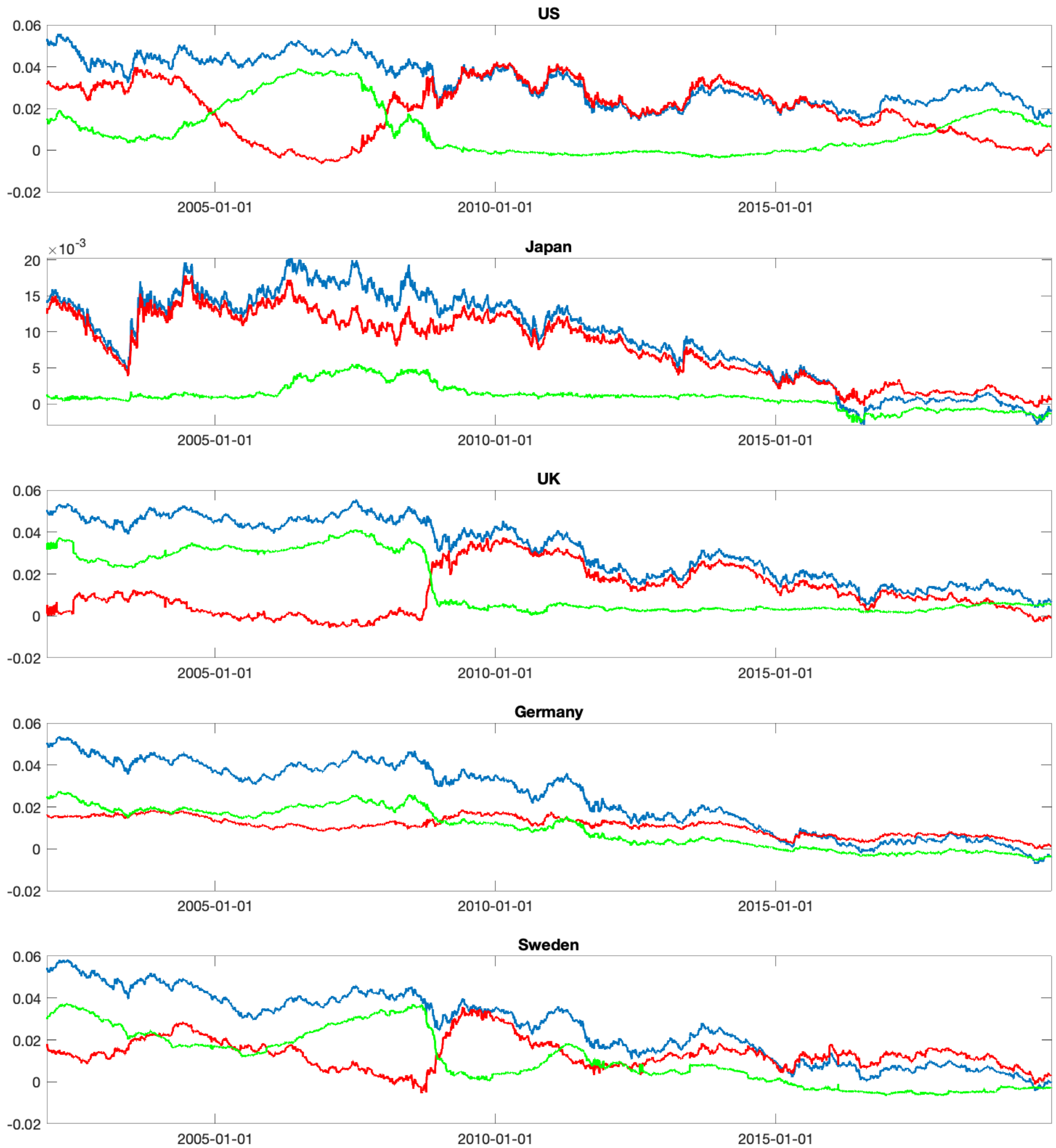
In this plot, the pair-wise term premium correlations are scatter plotted against the pair-wise correlations in ρ_X based on one simulated sample with 37 countries. The numerical values of parameters in the simulations are set as following: $\lambda_{x,i} = \lambda_{y,i} = \lambda_{z,i} = 5$; s_i's are drawn from the uniform distribution and normalized to have sum of one; $\rho_{i,j}$'s in ρ_X (σ_i's in Σ_X and Σ_Y) are drawn from an even distribution on [-0.05, 0.2] ([0.4, 0.6]). $C_i(1) = C_i(3) = 1$ and $Ci(2)$'s are drawn from an even distribution on [0.4, 4].

Figure 6: Trading partners of countries: imports and exports



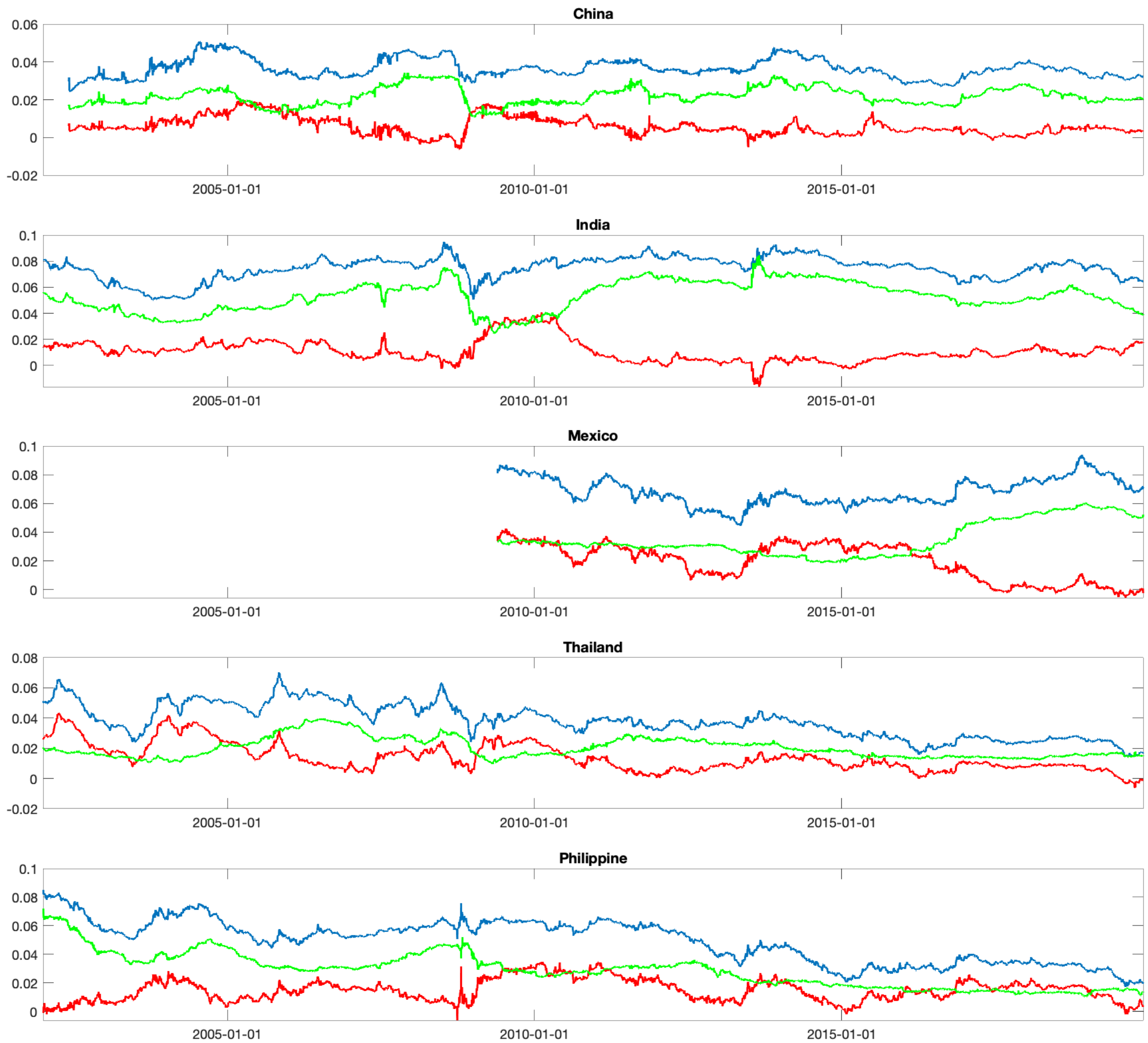
Notes: The figure plots the top 25 imports and exports values of the trading partners for four randomly selected countries in 2018. The four countries are: Germany, Japan, USA and New Zealand. The blue (red) bars plot the exports (imports) values for each country.

Figure 7: 10-year bond yield decomposition: five developed countries



Notes: This figure plots the decomposed risk premia (blue) and expected short rate (green) together with the 10 year bond zero yields (red) and the fitted bond yield from the model estimation (black) for the largest five developed countries. The decomposition method used is Adrian et al. (2013).

Figure 8: 10-year bond yield decomposition: five developing countries



Notes: This figure plots the decomposed risk premia (blue) and extected short rate (green) together with the 10 year bond zero yields (red) and the fitted bond yield from the model estimation (black) for the largest five developing countries. The decomposition method used is Adrian et al. (2013).

Appendices

A Trade data processing procedure

Inter-Country Trading values are collected from UN Comtrade database. We base on each country's reported total trade values, select the 37 countries (due to the availability of the term premium) to construct the trade network. In the originate trade data of UN Comtrade, each country reports both "import" and "export" to each "partner country". It is very common that there is large difference between two countries for reporting the trading values among them. For example, Base on the report of USA, the import from China is 357 Billion, but base on the report of China, the export to US is only 250 Billion. Therefore, we decided to use only the exported values of countries to conjecture the imports values so that the reported export and import from the paired countries are identical. Then we construct the export and import as well as the total trade networks. Then, we calculate the centrality of the export and import network, and also the centrality of the total trade according to Rich (2019). As both the export and import trade networks are directed network, we use "page ranking" R package, which is often used to calculate the importance of each webpage.

B Detailed procedure of decomposing bond yields

The details steps of applying the Adria, Crump, Moench (2013) are as follows:

1. In the first step, we estimate a vector autoregression of order one via an ordinary least square, and collect all the autoregressive coefficients and estimated factor innovations.

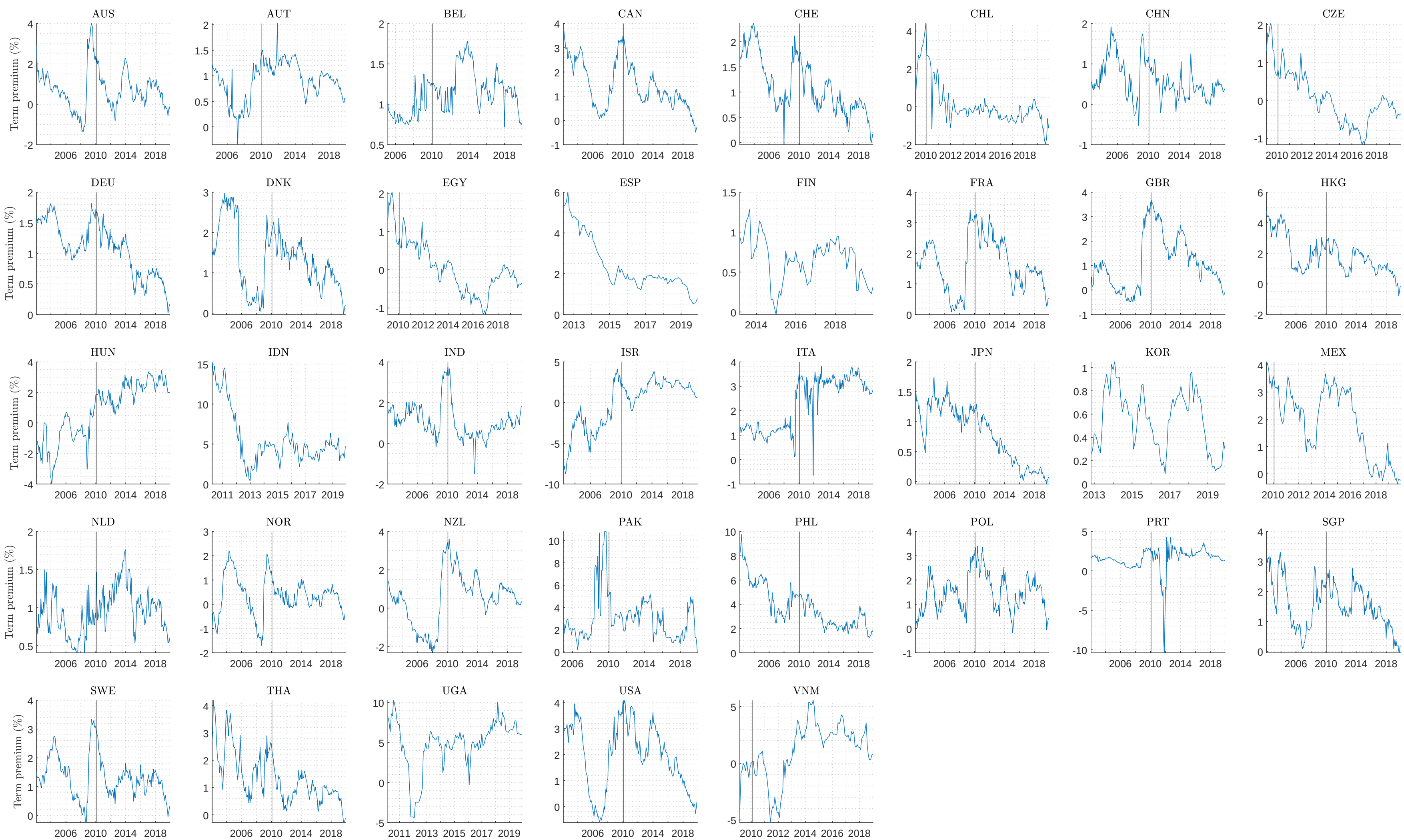
2. In the second step, we regress monthly excess bond returns, i.e., 10 year zero bond yileds on a constant, lagged yield curve factors and the contemporaneous factor innovation in the first regression. This procedure will provide us with a vector of predictive coefficients and a vector of risk factors.

3. In the third step, we estimate the price of risk parameters via a third cross-sectional regression.

4. Finally, the term premia is estimated by deducted the expected short rate from the fitted values of the zero yield based on the pricing of risk parameters.

C Tables and Figures

Figure A1: Term premia for 37 countries



Notes: This figure plots the term premia (in percent) for all 37 countries from 2002 to 2019. The vertical line indicates Jan. 2010.

Table A1: Sample of countries with term premium and Trade data

Country	Start Date
Australia	March1999
Austria	March2004
Belgium	February2005
Canada	March1999
Chile	February2009
China	July2002
China, Hong Kong	February2002
Czechia	February2010
Denmark	March1999
Egypt	February2009
Finland	February2013
France	March1999
Germany	March1999
Hungary	March1999
India	October2001
Indonesia	March2010
Israel	June2006
Italy	January2000
Japan	March1999
Korea, Republic of	October2012
Mexico	June2009
Netherlands	March1999
New Zealand	March1999
Norway	March1999
Pakistan	December2004
Philippines	April2001
Poland	December1999
Portugal	December2001
Singapore	September2001
Spain	March1999
Sweden	March1999
Switzerland	March1999
Thailand	October1999
Uganda	February2010
United Kingdom	March1999
United States of America	March1999
Viet Nam	February2009

Notes: This table reports the sample length of countries that have both estimated term premium data and trade date available. Trade data are collected from the UN Comtrade Database. Interest rate data used to calculate the term premium are collected from the Global Yield Curve Database and Bloomberg.

Table A2: Cross correlation in Term premia among selected countries

The diagonal part of this table reports the % of the variance of the 10 year yields that can be explained by the term premia. The off diagonal shows the % of the covariance of cross sectional 10 yeras yiled can can be explained by the covariance of the cross sectional risk premia of 11 global countries. We choose the most developed 8 countries and 3 developing ocuntries due to their GDP level.

	US	Japan	UK	Germany	Canada	France	Swiss	Sweden	China	India	Thiland
US	0.74										
Japan	0.68	0.85									
UK	0.59	0.46	0.65								
Germany	0.37	0.26	0.27	0.33							
Canada	0.70	0.27	0.54	0.25	0.63						
France	0.67	0.70	0.52	0.39	0.57	0.74					
Swiss	0.53	0.58	0.51	0.24	0.56	0.18	0.87				
Sweden	0.64	0.69	0.62	0.30	0.62	0.58	0.69	0.79			
China	0.34	0.23	0.35	0.22	0.37	0.07	0.20	0.18	0.64		
India	0.61	0.11	0.18	0.15	0.62	0.86	0.08	0.61	0.70	0.46	
Thiland	0.49	0.39	0.61	0.33	0.58	0.10	0.53	0.52	0.91	0.39	0.64

Table A3: Term premium comovement through the trade network for 2010-2019

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample period from 2010 to 2019, according to equation 3.1. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t, The main independent variable of interest is presented in the first column for each regression model specification. For example, RM_centrality (j,t) denotes the Richmond centrality weighted average change in term premia in month t among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t-1 and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i													
RM_centrality (j,t)	0.846***						0.737**	0.457						
	(0.151)						(0.324)	(0.368)						
EX_centrality (j,t)		0.819***												
		(0.147)												
IM_centrality (j,t)			0.856***						0.712**	0.380				
			(0.149)						’(0.320)	’(0.384)				
Trade Value (j,t)				0.773***							0.772***	0.417*		
				(0.146)							(0.245)	(0.237)		
Export Value (j,t)					0.706***									
					-0.144									
Import Value (j,t)						0.796***							0.772***	0.464**
						(0.144)							(0.225)	(0.234)
CDIS Value (j,t)							0.108		0.136		0.012		0.032	
							(0.223)		’(0.218)		(0.158)		(0.142)	
CPIS Value (j,t)								0.510*		0.566**		0.487**		0.461**
								(0.276)		’(0.281)		(0.183)		(0.174)
$\Delta TP_{i,t-1}$	-0.165***	-0.166***	-0.165***	-0.165***	-0.165***	-0.165***	-0.169***	-0.202***	-0.169***	-0.206***	-0.167***	-0.202***	-0.168***	-0.202***
	(0.035)	(0.034)	(0.035)	(0.034)	(0.034)	(0.034)	(0.033)	(0.047)	’(0.033)	(0.047)	(0.032)	(0.047)	(0.033)	(0.047)
Control variables														
Inflation	3.766***	3.744***	3.792***	3.918***	3.876***	3.964***	4.328**	-0.481	4.332**	-0.433	4.434**	-0.333	4.468**	-0.299
	(1.424)	(1.434)	(1.426)	(1.412)	(1.396)	(1.414)	(1.833)	(0.856)	’(1.837)	’(1.113)	(1.839)	(0.833)	(1.843)	(0.804)
GDP growth	-0.371	-0.349	-0.376	-0.515	-0.542	-0.513	-0.398	-0.710	-0.435	-1.339	-0.555	-0.870	-0.577	-0.901
	(1.569)	(1.593)	(1.562)	(1.593)	(1.590)	(1.601)	(1.724)	(1.257)	’(1.736)	’(1.710)	(1.722)	(1.265)	(1.746)	(1.283)
Trade to GDP	-0.030			-0.024			0.037	0.009	0.038	0.019	0.041	0.013	0.038	0.014
	(0.076)			(0.075)			(0.102)	(0.105)	’(0.101)	’(0.124)	(0.103)	(0.105)	(0.104)	(0.105)
export to GDP		-0.069			-0.052									
		(0.150)			(0.150)									
import to GDP			-0.034			-0.034								
			(0.161)			(0.155)								
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4275	4275	4275	4275	4275	4275	4275	3513	4275	3513	4275	3513	4275	3513

Table A4: Term premium spillover/transmission through the trade network for 2010-2019

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the more recent sample period from 2010 to 2019, according to equation 3.2. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t, The main independent variable of interest is presented in the first column for each regression model specification. For example, Richmond centrality (j,t-1) denotes the Richmond centrality weighted average change in term premia in month t-1 among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t-1 and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i													
RM_centrality (j,t-1)	0.397***						0.329***	0.380**						
	(0.155)						(0.326)	(0.158)						
EX_centrality (j,t-1)		0.369**												
		(0.155)												
IM_centrality (j,t-1)			0.384**						0.272***	0.336***				
			(0.159)						(0.085)	(0.120)				
Trade Value (j,t-1)				0.312***							0.190	0.101		
				(0.114)							(0.154)	(0.127)		
Export Value (j,t-1)					0.297***									
					(0.097)									
Import Value (j,t-1)						0.301**							0.142*	0.084
						(0.125)							'(0.086)	-0.109
CDIS Value (j,t-1)							0.059		0.097		0.116		0.156	
							(0.151)		(0.143)		(0.215)		'(0.163)	
CPIS Value (j,t-1)								0.064		0.095		0.191		0.227
								(0.163)		(0.155)		(0.231)		-0.208
$\Delta TP_{i,t-1}$	-0.177***	-0.176***	-0.175***	-0.175***	-0.174***	-0.175***	-0.178***	-0.218***	-0.177***	-0.217***	-0.175***	-0.218***	-0.175***	-0.216***
	(0.037)	(0.037)	(0.037)	(0.036)	(0.035)	(0.036)	(0.036)	(0.055)	(0.036)	(0.055)	(0.045)	(0.055)	-0.035	-0.054
Control variables														
Inflation	4.465***	4.497***	4.420***	4.486***	4.498***	4.441***	4.550**	1.331	4.535**	1.336	4.538**	1.901*	4.531**	1.424
	(1.434)	(1.442)	(1.416)	(1.427)	(1.437)	(1.407)	(1.798)	(0.984)	(1.786)	(0.987)	(1.800)	(1.119)	'(1.774)	'(0.967)
GDP growth	-0.409	-0.428	-0.437	-0.613	-0.599	-0.595	-0.633	-0.785	-0.672	-0.819	-0.793	-1.858	-0.783	-1.000
	(1.534)	(1.562)	(1.517)	(1.566)	(1.587)	(1.553)	(1.693)	(1.378)	(1.693)	(1.386)	(1.692)	(1.934)	'(1.706)	'(1.392)
Trade to GDP	0.039			0.038			0.036	0.103	0.035	0.102	0.033	0.097	0.033	0.100
	(0.075)			(0.076)			(0.105)	(0.106)	(0.105)	(0.106)	(0.107)	(0.118)	-0.107	(0.106)
export to GDP		0.059			0.052									
		(0.142)			(0.145)									
import to GDP			0.107			0.103								
			(0.164)			(0.16)								
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4275	4275	4275	4275	4275	4275	4275	3513	4275	3513	4275	3513	4275	3513

Table A5: Term premium co-movement through the trade network in developing countries

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample from 2010 to 2019 for the 13 developing countries, according to equation 3.1. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t, The main independent variable of interest is presented in the first column for each regression model specification. For example, RM_centrality (j,t) denotes the Richmond centrality weighted average change in term premia in month t among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i							
RM_centrality (j,t)	0.370							
	(0.262)							
EX_centrality (j,t)		0.351*						
		(0.213)						
IM_centrality (j,t)			0.301*					
			(0.164)					
Trade Value (j,t)				0.336*				
				(0.173)				
Export Value (j,t)					0.348**			
					(0.158)			
Import Value (j,t)						0.311*		
						(0.164)		
CDIS Value (j,t)							0.164*	
							(0.088)	
CPIS Value (j,t)								0.156
								(0.097)
$\Delta TP_{i,t-1}$	-0.169***	-0.171***	-0.170***	-0.169***	-0.170***	-0.169***	-0.175***	-0.284***
	(0.047)	(0.049)	(0.048)	(0.049)	(0.051)	(0.049)	(0.053)	(0.048)
Control variables								
Inflation	3.278***	3.213***	3.329***	3.303***	3.219***	3.357***	3.824***	-0.235
	(0.900)	(0.908)	(0.923)	(0.907)	(0.857)	(0.929)	(1.175)	(1.179)
GDP growth	0.324	0.365	0.430	0.327	0.308	0.355	0.764	-2.194
	(0.755)	(0.759)	(0.784)	(0.749)	(0.750)	(0.782)	(1.108)	(2.431)
Trade to GDP	-0.083			-0.081			0.001	0.245
	(0.069)			(0.067)			(0.124)	(0.160)
export to GDP		-0.12			-0.135			
		(0.133)			(0.120)			
import to GDP			-0.16			-0.180		
			(0.189)			(0.178)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes		Yes
N	1520	1520	1520	1520	1520	1520	1510	758

Table A6: Expected short rate co-movement through the trade network

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample from 2010 to 2019 for the 37 countries, according to equation 3.1. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t, The main independent variable of interest is presented in the first column for each regression model specification. For example, RM_centrality (j,t) denotes the Richmond centrality weighted average change in term premia in month t among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i							
RM_centrality (j,t)	0.669***							
	(0.117)							
EX_centrality (j,t)		0.646***						
		(0.122)						
IM_centrality (j,t)			0.636***					
			(0.117)					
Trade Value (j,t)				0.659***				
				(0.158)				
Export Value (j,t)					0.600***			
					(0.149)			
Import Value (j,t)						0.658***		
						(0.159)		
CDIS Value (j,t)							0.332***	
							(0.113)	
CPIS Value (j,t)								0.764***
								(0.283)
$\Delta TP_{i,t-1}$	-0.134**	-0.134**	-0.134**	-0.137**	-0.135**	-0.137**	-0.142***	-0.225***
	(0.065)	(0.066)	(0.066)	(0.066)	(0.066)	(0.067)	(0.064)	(0.048)
Control variables								
Inflation	-3.688***	-3.711***	-3.692***	-3.744***	-3.748***	-3.758***	-4.240***	-3.598**
	(1.121)	(1.134)	(1.112)	(1.134)	(1.110)	(1.136)	(1.130)	(1.589)
GDP growth	2.174	2.170	2.180	2.104	2.207	2.061	2.588	4.113*
	(1.559)	(1.576)	(1.523)	(1.530)	(1.553)	(1.502)	(1.658)	(2.375)
Trade to GDP	0.036			0.033			-0.025	0.062
	(0.144)			(0.143)			(0.228)	(0.070)
export to GDP		0.092			0.095			
		(0.292)			(0.284)			
import to GDP			0.034			0.034		
			(0.288)			(0.282)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4275	4275	4275	4275	4275	4275	4275	3513

Table A7: Expected short rate transmission through the trade network

This table reports the dynamic panel regression results based on the system GMM method proposed in Blundell and Bond (1998) for the sample from 2010 to 2019 for the 37 countries, according to equation 3.2. The dependent variable is $\Delta TP_{i,t}$ is the change in term premium for country i in month t, The main independent variable of interest is presented in the first column for each regression model specification. For example, RM_centrality (j,t-1) denotes the Richmond centrality weighted average change in term premia in month t among all countries, where Richmond centrality is calculated based on the prior year's bilateral total trade network. In all specifications, country i' own change in term premium in month t-1 and country fixed effects and year fixed effects are always included. Other macroeconomic control variables include: lagged one-year trade-to-GDP ratio, lagged one-year inflation, and lagged one-year GDP growth rate. The standard errors are clustered in country and reported in brackets. *, **, and *** indicate statistical significance at the 10%, and 1% levels, respectively.

	$\Delta TP_{i,t}$, change in term premium (t) for country i							
RM_centrality (j,t-1)	-0.172							
	(0.106)							
EX_centrality (j,t-1)		-0.166						
		(0.104)						
IM_centrality (j,t-1)			-0.169					
			(0.107)					
Trade Value (j,t-1)				-0.123				
				(0.110)				
Export Value (j,t-1)					-0.103			
					(0.103)			
Import Value (j,t-1)						-0.111		
						(0.106)		
CDIS Value (j,t-1)							0.053	
							(0.102)	
CPIS Value (j,t-1)								-0.090
								(0.124)
$\Delta TP_{i,t}$	-0.131**	-0.131**	-0.131**	-0.130**	-0.130**	-0.130**	-0.136***	-0.216***
	(0.065)	(0.065)	(0.065)	(0.064)	(0.064)	(0.064)	(0.065)	(0.049)
Control variables								
Inflation	-3.724***	-3.661***	-3.750***	-3.697***	-3.652***	-3.732***	-4.201***	-2.526**
	(1.226)	(1.235)	(1.211)	(1.230)	(1.254)	(1.211)	(1.139)	(1.155)
GDP growth	1.910	1.934	1.907	1.918	1.935	1.918	20494.000	4.151*
	(1.694)	(1.730)	(1.651)	(1.692)	(1.721)	(1.649)	(1.785)	(2.484)
Trade to GDP	0.011			0.011			0.020	0.143
	(0.226)			(0.228)			(0.234)	(0.128)
export to GDP		0.07			0.067			
		(0.432)			(0.438)			
import to GDP			-0.038			-0.038		
			(0.457)			(0.461)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4275	4275	4275	4275	4275	4275	4275	3513