Bond Risk Premia in Emerging Markets: Evidence from Brazil, China, Mexico, and Russia

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Abstract

We employ an affine term structure model with no-arbitrage restrictions to analyse the global and domestic determinants of bond risk premia in major emerging markets. Our model captures (long-term) movements of realized risk premia and indicates that global economic and financial factors play a relevant role in explaining country-specific bond risk premia. We also provide evidence of heterogeneous responses of country-specific risk premia to global shocks.

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1 Introduction

Falling interest rates in developed economies have led global investors to shift their attention to high-yield instruments such as government bonds in emerging market (EM) economies, see IMF (2019). This trend, coupled with the increasing usage by EM countries of domestic government bonds to finance their activities, has amplified the size and importance of EM local currency debt[1]. Against this background, understanding the drivers of government bond risk compensation (risk premium) in EMs is of primary importance for investors (who want to have a clear view on the risk factors affecting returns) and policy makers (who are interested, for example, in assessing how national or international shocks affect the financing capacity of EM governments). This raises a number of questions. Are those risk premia driven by local factors, global factors, or both? And do risk compensation in EM economies react in a similar way to global shock? We tackle those questions for four of the largest EM economies, Brazil, China, Mexico, and Russia.[2]

The quest for understanding the drivers of international risk premia dates back to Ilmanen (1995), who finds that risk premia for long-maturity government bonds of six developed countries can be predicted by a small set of global instruments. In subsequent studies, scholars have explored the link between developed countries risk premia and (*i*) macroeconomic factors, in particular inflation uncertainty, see Wright (2011), (*ii*) latent factors, such as the Cochrane and Piazzesi (2005) factor[3], see Sekkel (2011) and Kessler and Scherer (2009), or a world interest rate level factor as in Driessen et al. (2003), and (*iii*) global and local factors, where the global factor is linked to international business cycles, as in Dahlquist and Hasseltoft (2013). Relative to developed economies, the literature on EM government bond risk

[1] In February 2020, S&P Global estimates that the top 20 EMs are expected to issue a combined \$1.62 trillion of government debt in 2020, up 4% from 2019 and a historical high, see `https://www.spglobal.com/en/`.

[2] The selected countries exhibit significant differences in terms of their degree of economic openness and dependence on commodity exports. According to the World Bank, in 2018,the trade-to-GDP ratios of Brazil, China, Mexico, and Russia were 29%,38%, 80%, and 51%, respectively. Furthermore, Brazil and Russia are considered as export-commodity-dependent countries while China and Mexico are not (UNCTAD, 2019). We exclude India and other countries because although there are interest rate databases for other emerging economies, their coverage in terms of time series length and maturity spectrum is rather limited.

[3] The Cochrane and Piazzesi (2005) factor is a linear combination of country-specific forward rates.

premia is scant.[4] Recently, Cepni et al. (2019) and Cepni and Güney (2019) make several contributions adopting a panel setting. Cepni et al. (2019) highlight the combined importance of global and local factors in explaining bond risk premia, while Cepni and Güney (2019), among other things, find that local factors influence on risk premia can vary with risk aversion.[5]

We contribute to this emerging literature in three ways. First, we show that arbitrage-free dynamic term structure models with local and global factors generate risk premia (model-implied expected excess return) that replicate the realized excess returns, with a correlation between the two series ranging from 0.83 (Brazil) to 0.65 (China). Second, through the lenses of our model, we assess the importance of local and global factors on risk premia dynamics. The results highlight the importance of global economic activity for Brazil and Russia, and of global commodity prices for China. Finally, we provide evidence of heterogeneous responses of country-specific risk premia to global shocks. For example, Chinese bond risk premia increase following global demand and commodity prices shocks, while Russian's counterparts decrease.

2 Model

Following Joslin et al. (2014), we assume the existence of K unobserved factors, X_t, which under the risk-neutral probability measure evolve according to a VAR(1) model:

$$X_t = \mu_X^Q + \Phi_X^Q X_{t-1} + \Sigma_X \epsilon_t^Q, \qquad \varepsilon_t^Q \sim N(0, I_K), \tag{1}$$

where Σ_X is lower-triangular and Φ_X^Q is diagonal with distinct entries. Assuming the short-term rate r_t is affine on X_t, $r_t = \delta_0 + \delta_1 X_t$, Dai and Singleton (2000) show that the n-maturity yield, $y_t(n)$, is affine on X_t:[6]

$$y_t^{(n)} = A^{(n)}(\Theta_n) + B^{(n)}(\Theta_n) X_t, \tag{2}$$

[4] Some scholars have focused their attention on the local and international drivers of EM government spreads. For example, Ciarlone et al. (2009) find that, in the pre-Lehman's period, large part of the co-variation in EM economies spreads is due to a single factor proxying for financial market volatility.

[5] The importance of global factors as drivers of EM bond risk premia is further stressed by the out-of-sample exercise proposed by Cepni et al. (2020).

[6] For econometric identification, we assume that $\mu_X^Q = 0$, allowing us to interpret δ_0 as the long-run mean of the short rate under the $\mathbb{Q}$-measure. We also choose δ_1 to be a K-dimensional row vector, all elements of which are one.

where $A^{(n)}(\Theta_n)$ and $B^{(n)}(\Theta_n)$ are derived from no-arbitrage conditions.[7] Assuming a total of N maturities, we can express eq. (2) as

$$Y_t = A(\Theta) + B(\Theta)X_t, \tag{3}$$

with $Y_t = [y_t(1), ..., y_t(N)]'$. Joslin et al. (2011) show that X_t can be rotated to be linked to a set of spanned yield curve factors, $P_t = WY_t$, with W being a full-rank matrix, leading to the following representation of the yield curve:

$$Y_t = A_P(\Theta) + B_P(\Theta)P_t, \tag{4}$$

with $A_P(\Theta) = I - B(\Theta)(WB(\Theta))^{-1}WA(\Theta)$ and $B_P(\Theta) = B(\Theta)(WB(\Theta))^{-1}$. Under the historical measure, spanned factors are related to U unspanned factors, M_t, via a VAR(1) model. Stacking P_t and M_t in a vector $Z_t = [M_t; P_t]$, we have that

$$Z_t = C^{\mathbb{P}} + \Phi^{\mathbb{P}} Z_{t-1} + \Sigma\varepsilon^{\mathbb{P}}_{Z,t}, \tag{5}$$

where $\varepsilon^{\mathbb{P}}_{Z,t} = (\varepsilon^{\mathbb{P}}_{M,t}, \varepsilon^{\mathbb{P}}_{P,t})' \sim N(0, I)$ and Σ is a lower-triangular matrix. Equation (5) implies that the h-period expected value of Z_t (and hence of P_t and Y_t), $\mathbb{E}_t Z_{t+h}$, is a function of both P_t and M_t.

The h-period risk premium of a zero-coupon bond with maturity n, $rx^{(n,h)}_t$, is

$$rx^{(n,h)}_t = (\mathbb{E}_t[p^{(n-h)}_{t+h}] - p^{(n)}_t) - y^{(h)}_t, \tag{6}$$

where $p^{(n)}_t = -ny^{(n)}_t$ is the log of the bond price. Iterating forward (5) and given (3), we can express (6) as:

$$rx^{(n,h)}_t = A^{(n)}_{rx} + B^{(n)}_{rx} Z_t, \tag{7}$$

with

$$A^{(n)}_{rx} = nA^{(n)}_Z - A^{(h)}_Z - (n-h)\sum_{j=0}^{h-1}(\Phi^{\mathbb{P}})^j C^{\mathbb{P}}, \tag{8}$$

$$B^{(n,h)}_{rx} = nB^{(n)}_Z - (n-h)B^{(n-h)}_Z(\Phi^{\mathbb{P}})^h - B^{(h)}_Z, \tag{9}$$

and $B^{(n)}_Z = [B^{(n)}_P \mathbf{0}]$, where the zero vector is of dimension U. Given that $\Phi^{\mathbb{P}}$ is a full matrix, (8) and (9) imply that risk premia are a function of spanned and unspanned factors.

We estimate the model in two steps. First, we obtain estimates of $C^{\mathbb{P}}$ and $\Phi^{\mathbb{P}}$ via OLS (eq. (5)). Subsequently, the remaining parameters, Φ^Q_X, δ_0, and Σ, are estimated using maximum likelihood.

[7] See Ang and Piazzesi (2003) for a detailed derivation.

3 Data

Our analysis covers the period from September 2005 to September 2017 and is composed of three sets of series: (*i*) the countries' term structures of interest rates; (*ii*) local macroeconomic factors; and (*iii*) global economic and financial factors. For each country's term structure, we use end-of-the-month zero-coupon yields with maturities of 1, 6, 12, 36, 60 and 120 months. For China, Mexico, and Russia the data are from Bloomberg[8]. For Brazil, due to longer data availability, we select the yields on swap fixed-DI contracts[9] retrieved from B^3, the Brazilian Stock Exchange and Over-the-Counter Market. All the yields refer to local currency-denominated contracts.

As local macroeconomic factors, we include proxies for inflation and local economic activity, which are closely monitored by central banks, and the nominal exchange rate, which is an important driver of local currency sovereign bond yields and risk premia in EM economies; see Gadanecz et al. (2018). Specifically, (*i*) a proxy for inflation (π_t^j) is computed as the yearly growth rate of the Consumer Price Index (CPI) of country j and obtained from the International Monetary Fund (IMF), (*ii*) a proxy for economic activity (g_t^j) is obtained as the normalized country-specific leading indicator for the Gross Domestic Product (GDP), which is developed by the Organization for Economic Cooperation and Development (OECD) and retrieved from the FRED, the Federal Reserve Bank of St. Louis, and (*iii*) the nominal exchange rate (s_t^j) is expressed as the price of one US dollar in terms of the local currency, also from the IMF.

We also include three global factors: (*i*) a proxy for real global economic activity (g_t^W), which accounts for the relationship between global risk premia and global economic activity as suggested by Dahlquist and Hasseltoft (2013). This factor is captured by Lutz Kilian's measure (Kilian (2009)), available at his webpage; (*ii*) a proxy for changes in global commodity prices (π_t^W), which might increase the risk of higher inflation in emerging countries, see Mallick (2013). This is given by the yearly growth of the global commodity price index;[10] and (*iii*) a proxy for global financial market tensions

[8] Since the Bloomberg data are for par yields, we bootstrap the original data to obtain zero-coupon yields.

[9] These are derivative instruments with the underlying values linked to Brazil's interbank lending rate.

[10] The choice of the latter two factors is also motivated by Ciarlone et al. (2009). Ciarlone et al. (2009) extract a common factor capturing the variability of emerging market sovereign spreads which is not directly linked to the specific macroeconomic characteristics of any given country. They find that this factor correlates strongly (0.9) with the VIX

(VIX_t), which is an important driver of market prices of risk in EM government bonds, see Borri and Verdelhan (2011) and Zinna (2013). This proxy is represented by the Chicago Board Options Exchange (CBOE) Market Volatility (VIX) Index. The last two factors are obtained from the FRED website.

For each country j, our model includes two spanned, P_t^j, and six unspanned factors, M_t^j. The spanned factors are the the first two principal components (PCs) of the country's bond yields. The unspanned factors are the country-specific and global factors listed above. We use a Cholesky identification scheme, whereby variables are ordered from the most exogenous (international factors) to the least exogenous (national factors):

$$M_t^j = [g_t^W, \pi_t^W, VIX_t, s_t^j, \pi_t^j, g_t^j]'; \quad P_t^j = [PC1_t^j, PC2_t^j]'. \tag{10}$$

Figure 1 shows the time series of all unspanned and spanned factors.

Insert Figure 1 here

4 Results

Figure 2 plots the one-year model-implied risk premium on a 10-year bond against the realized excess return.[11] Although realized excess returns are more volatile than risk premia, the model is able to capture the low frequency movements of such returns. The correlation between the realized excess return and the risk premium is equal to 0.83, 0.65, 0.74, and 0.77 for Brazil, China, Mexico, and Russia, respectively. We now assess how shocks to each of the unspanned factors influence our measures of bond risk premium.

Insert Figure 2 here

index and the growth of commodities prices

[11] The model delivers a very good fit of the yield curve in each of the four countries. The average of the Root Mean Squared Error (RMSE) of actual and forecasted yields for the six maturities used (1, 6, 12, 36, 60, and 120 months) is equal to 28.9, 7.0, 13.1, and 14.5 basis points for Brazil, China, Mexico, and Russia, respectively. As this is a standard result in the literature, we focus our attention on the fit of the risk premium.

4.1 Impulse response functions (IRFs)

Figure 3 shows the median of the risk premium IRF to shocks impacting the unspanned factors. In what follows, we discuss only statistically significant responses to standard deviation shocks.[12]

Insert Figure 3 here

In line with intuition, positive shocks to global economic activity (g^W) induces an instantaneous reduction in the risk premium in all countries but China.[13] Positive global commodity price (π^W) shocks decrease Russian risk premia. This is probably due to the country's heavy reliance on commodity exports. The reverse is true for China, where positive shocks on π^W trigger an increase in the risk premium of around 70 basis points. The response of China to shocks on π^W (and g^W) might be linked to possible fears of internal inflationary pressure following those global shocks[14]. Shocks to the VIX initially increases the Brazilian risk premium by 2%. The increase in the risk premium is also significant in the case of Russia with a peak after 6 months. These results point out to a higher sensitivity of those two bond markets to financial turbulence.

An exchange rate (s) devaluation shock drives risk premium up in Brazil and Russia, with a peak of above 2%. Intuitively, as part of a country's liabilities is denominated in foreign currency, a weakening of the domestic currency increases the total debt burden. This positive increment in the debt service harms the country's solvency, leading investors to require extra compensation for holding domestic assets. In line with the findings of Wright (2011), inflation (π) shocks increase bond risk premium for Brazil, Mexico and Russia, reaching a maximum of 150, 80, 120bp after 6, 18 and 9 months, respectively. This indicates that following inflationary pressures investors require a positive risk premium to hold nominal bonds of long maturities. Finally, a positive shock to the local economic activity factor (g) triggers,

[12]The confidence intervals are obtained from a bootstrap procedure and are constructed for a level of significance equal to 66%.

[13]In the case of Brazil, this response becomes positive and statistically significant after about three months. Long-term positive responses to economic growth are counter-intuitive but in line with the results of Abbritti et al. (2018) for a number of countries.

[14]As a matter of fact, a large body of literature documents that the international prices of commodities have nontrivial macroeconomic implications for developing economies, see Fernández et al. (2018) and Shousha (2016).

in general, a negative response of the risk premium. China is the exception presenting a positive and statistically significant response between 6 and 18 months.

4.2 Variance decomposition (VD)

Table 1 shows that, in all cases except Russia, the proportion of forecast variance accounted for by the six unspanned factors increases with the forecasting horizon. Overall, global economic activity is the most important factor driving movements in risk premia in the countries analyzed. This factor is especially important for Brazil, having a consistent impact across all horizons. Global commodity prices play a similar role for China. The exchange rate and the VIX index also have a significant influence in the forecast variance of bond risk premia for Brazil and Russia. Interestingly, domestic economic activity is unimportant for all the countries and inflation only plays a minor role for Brazil and Russia.

Insert Table 1 here

For Mexico, spanned factors account for most of the forecast variance for all forecasting horizons (89% for one-month to 51% for 10-year horizon). For longer horizons, we see the influence of global economic activity and domestic inflation. In the case of China, latent factors dominate the forecast variance for short horizons (1 and 12 months) but macro and financial factors slightly dominate medium to long horizons. Among those, global commodity prices stand out for having an important contribution (around 20%) at all horizons.

For Brazil and Russia, the unspanned factors are responsible for most of the forecast variance at all forecasting horizons, reaching 85% in the case of Brazil for a 10-year horizon. With respect to Brazil, global economic activity is the most important unspanned factor driving movements in the risk premium. The VIX index and the exchange rate also play a significant role in the short horizon, while domestic inflation appears relevant for longer horizons. For Russia, exchange rate and global commodity price shocks dominate at a short horizon, while global economic activity is predominant at long horizons.

4.3 Historical decomposition (HD)

In order to visualize the contribution over time of each factor, we perform a HD of the 10-year bond risk premium for each country over our sample period. This is shown in Figure 4. We focus our discussion on the main spikes of the risk premium in each country.

Insert Figure 4 here

For Brazil, we analyse two spikes. The first one occurred in October 2008, at the end of the global financial crisis. Not surprisingly, the sharp increase in the risk premium is mainly driven by variables external to the country. Global economic activity and the VIX index represent 37% and 27% of the absolute contribution to the total bond risk premium in that period. The second spike occurred at the beginning of 2016 (January). During this period, Brazil experienced a deep economic recession combined with high inflation and a depreciated domestic currency (see also Fig. 1). The exchange rate reached its weakest level against the dollar during that period. Global commodity prices were also still recovering from its bottom value in August 2015. As a consequence, we find that domestic inflation, global commodity prices, and the exchange rate are responsible for a substantial part of the bond risk premium (above 50% in absolute terms).

In the case of China, we focus on the main spike in the 10-year risk premium occurred in July 2008, also during the global financial crisis. Global commodity prices were almost at its peak, reached in June 2008 (see Fig. 1). The increase in the risk premium during this period, therefore, can be largely attributed (30%) to the high level of commodity prices in the world market. Global economic activity is also responsible for a substantial part (around 20%) of the risk premium.

With respect to Mexico, our HD shows the predominant contribution of latent factors. This can also be seen in the three spikes observed in the risk premium during our sample period. In the first spike (May 2006), we observe some contribution of global commodity prices and the VIX index (less than 10% each in absolute terms). Around the second spike (Oct 2009), at the end of the global financial crisis, global economic activity and global commodity prices play significant roles. In the third spike (Feb 2011), we observe a significant contribution (20% in absolute terms) from the global economic activity.

Finally, for Russia, we focus on the spike of July 2009. Local economic activity is responsible for a significant part of the 10-year bond risk premium (close to 30% in absolute terms) during this period. The VIX index and global commodity prices also have a significant impact on bond risk premium (almost 40% jointly in absolute terms).

5 Conclusions

The increasing importance of EM economies as source of economic growth calls for an understanding of the dynamics of local government debt market. This market is a major source of financing for local governments and offers to international investors financial instruments with relatively high returns. Understanding the dynamics of these markets is hence pivotal.

We examine the importance of global and local factors in the determination of bond risk premia in major EM economies, i.e. Brazil, China, Mexico, and Russia. Global economic and financial factors are key drivers of movements in risk premia. Global economic activity, financial tension and the exchange rate play a significant role for Brazil and Russia. Global commodity prices influence Russian bond risk premia and are a leading factor for Chinese ones. The Mexican bond market seems more resilient to global and financial shocks.

Policy makers and investors might benefit from our results. For investors, the diverse reaction of local risk premia to global shocks might create potential diversification opportunities. For policy-makers, our results show that, depending on the shock, some large countries might require closer monitoring than others.

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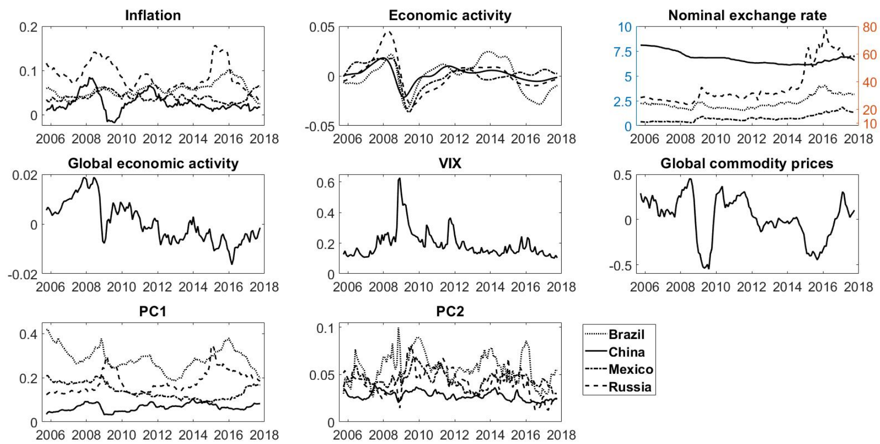
Figure 1: Unspanned and spanned factors



Note: The figure depicts all 8 factors used in the model. (*i*) Three country-specific unspanned factors. Inflation is the yearly growth rate of each country's CPI obtained from the IMF, economic activity is the normalized country-specific leading indicator for the GDP developed by the OECD and retrieved from the FRED, and the nominal exchange rate is expressed as the price of one US dollar in terms of the local currency (left-hand scale: Brazil and China; right-hand scale: Mexico and Russia), also from the IMF. (*ii*) Three global unspanned factors. Global economic activity is the Kilian's measure (Kilian, 2009), VIX is the CBOE Market Volatility Index, and global commodity prices is the yearly growth of the global commodity price index. The last two series are from the FRED website). (*iii*) The country-specific spanned factors ($PC1$ and $PC2$), which are the first two principal components of the country's bond yields. All series span from September 2005 to September 2017.

Table 1: Variance decomposition of the 10-year bond risk premium

Brazil

Horizon	g^W	π^W	VIX	s	π	g	$PC1$	$PC2$
1M	0.20	0.02	0.20	0.17	0.00	0.00	0.21	0.20
12M	0.29	0.06	0.09	0.13	0.14	0.00	0.15	0.14
60M	0.28	0.11	0.13	0.10	0.16	0.03	0.09	0.10
120M	0.29	0.10	0.15	0.09	0.18	0.04	0.07	0.08

China

Horizon	g^W	π^W	VIX	s	π	g	$PC1$	$PC2$
1M	0.05	0.23	0.05	0.01	0.06	0.00	0.16	0.44
12M	0.12	0.19	0.07	0.02	0.05	0.02	0.07	0.46
60M	0.10	0.20	0.08	0.02	0.07	0.06	0.06	0.41
120M	0.10	0.20	0.08	0.02	0.07	0.06	0.06	0.41

Mexico

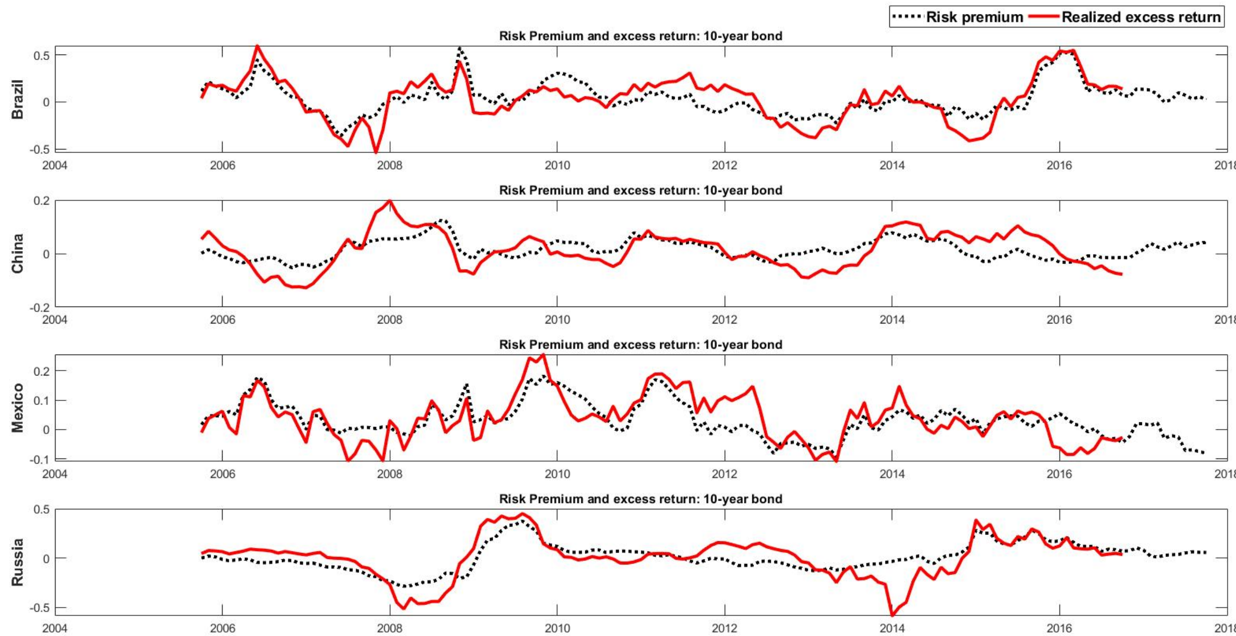
Horizon	g^W	π^W	VIX	s	π	g	$PC1$	$PC2$
1M	0.08	0.01	0.01	0.01	0.00	0.00	0.43	0.46
12M	0.04	0.02	0.01	0.01	0.01	0.02	0.45	0.44
60M	0.16	0.06	0.04	0.07	0.13	0.02	0.28	0.24
120M	0.16	0.06	0.05	0.07	0.13	0.02	0.27	0.24

Russia

Horizon	g^W	π^W	VIX	s	π	g	$PC1$	$PC2$
1M	0.04	0.19	0.05	0.32	0.00	0.06	0.05	0.29
12M	0.19	0.11	0.10	0.12	0.04	0.08	0.28	0.08
60M	0.21	0.06	0.11	0.11	0.06	0.05	0.33	0.07
120M	0.21	0.06	0.11	0.11	0.06	0.05	0.33	0.07

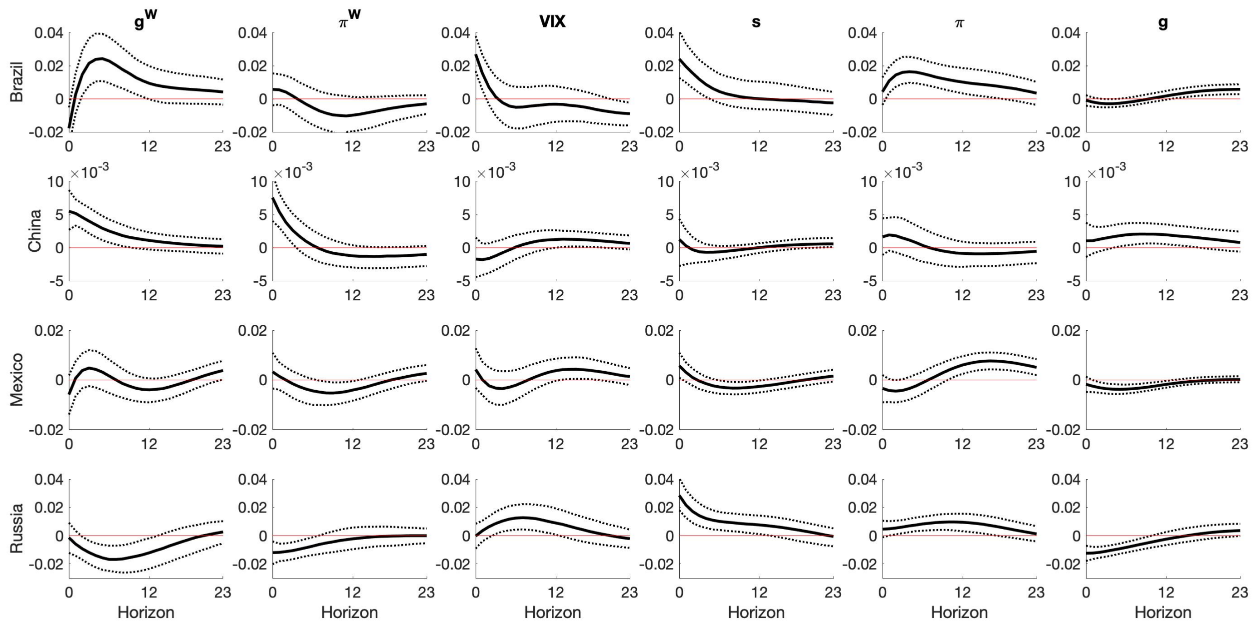
Note: The table reports the contribution of each factor to the forecast variance of the 10-yr bond risk premium for each country. Unspanned factors: g^W, global economic activity; π^W, global commodity price indicator; VIX, Market Volatility Index; s, nominal exchange rate; π, inflation; and g, economic activity. Spanned factors: $PC1$ and $PC2$, first and second principal components of the country's bond yields, respectively. The forecasting horizons considered are 1, 12, 60, and 120 months.

Figure 2: Fit of the 10-year bond risk premium



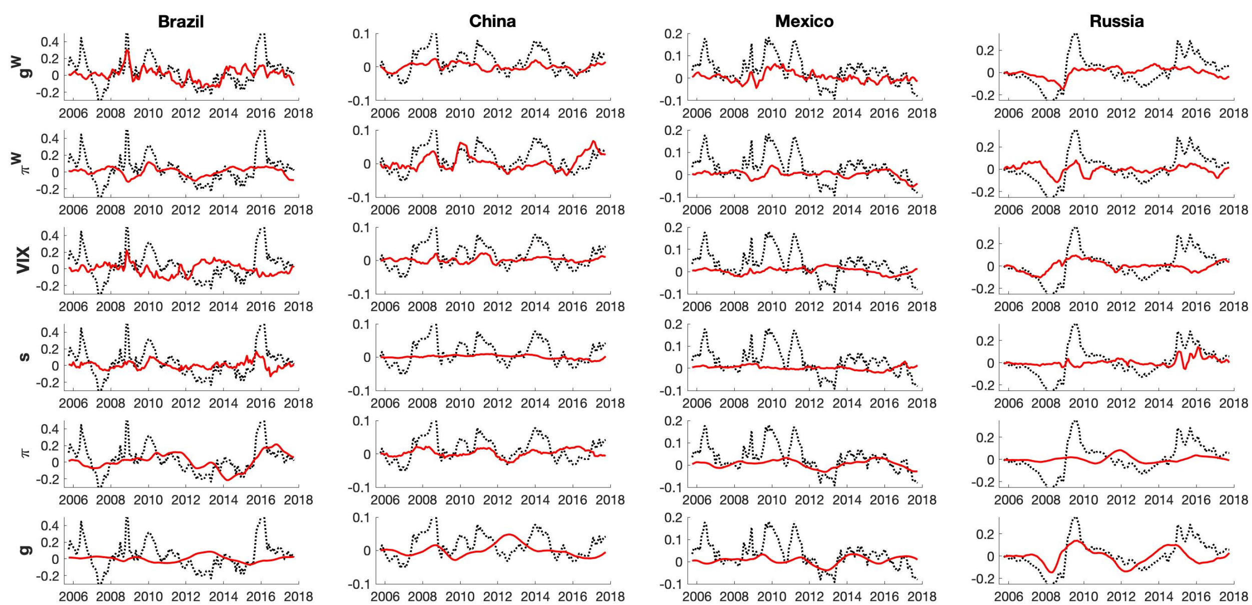
Note: The figure compares the model-implied risk premium on a 10-year bond with the realized excess return. The holding period is one year. All series span from September 2005 to September 2017.

Figure 3: Impulse response functions: response of the 10-year bond risk premium



Note: The figure shows the impulse responses of the 10-year risk premium for each country to a one standard deviation shock to each of the unspanned factors. Unspanned factors: g^W, global economic activity; π^W, global commodity price indicator; VIX, Market Volatility Index; s, nominal exchange rate; π, inflation; and g, economic activity. All series span from September 2005 to September 2017.

Figure 4: Historical decomposition of the 10-year bond risk premium



Note: The figure shows the historical contribution of each unspanned factor to the 10-year bond risk premium for each country. Unspanned factors: g^W, global economic activity; π^W, global commodity price indicator; VIX, Market Volatility Index; s, nominal exchange rate; π, inflation; and g, economic activity. All series span from September 2005 to September 2017.