Comovement of the Sovereign Yields of Emerging Markets

M. Pavel Solís M. *

This draft: April 13, 2020

Abstract

This paper studies how interconnected are the sovereign yields of emerging markets. I use synthetic local currency yield curves to account for credit risk in order to estimate the term premia and the expected short rates of 15 emerging markets. This paper documents that a quarter of the 10-year yield of emerging economies is due to the term premium, more than double the size of the credit risk premium. In fact, the bond yields of emerging markets comove mainly driven by the term premia, which is more globally connected than the credit risk premia and the expected short rates. Further, the global component of term premia is highly linked to the U.S. term premia, whereas its idiosyncratic component is countercyclical.

Keywords: Synthetic yield curves, term premium, credit risk, emerging markets, affine term structure models, international spillovers.

JEL Classification: E43, F34, G12, G15, H63.

*Address: Wyman Park Building 544E, 3400 N. Charles Street, Baltimore, MD 21218, United States. Email: msolism1@jhu.edu.

1 Introduction

Financial conditions across countries are widely believed to be interconnected. Yet, the extent to which the local financial conditions in emerging markets are interrelated has barely been explored, in part due to data availability.

This paper asks whether and to what extent the local currency sovereign yields of emerging markets are interconnected. This is important for two reasons. First, emerging markets play an increasingly important role in the global economy. Second, bonds denominated in local currency have become an important source of funds for emerging markets over the last two decades (Du and Schreger, 2016b; Ottonello and Perez, 2019; Galli, 2020). As such, uncovering how their local financial conditions are interrelated will improve our understanding of the vulnerabilities of the global financial system.

Since sovereign yields compensate investors for different motives, decomposing them would provide further insights about the extent to which they are interconnected. Nevertheless, unlike for advanced countries that issue bonds denominated in their own currencies, international investors demand a credit risk premium to hold the bonds issued by emerging markets to compensate them for the risk of not receiving the promised payments.[1] Indeed, even though countries can, in theory, print their own currency to avoid defaulting on their debt, some emerging markets have actually defaulted (Reinhart and Rogoff, 2011).[2] Theoretical explainations for these episodes include Du and Schreger (2016b) and Galli (2020).

The no-credit-risk assumption is key to decompose the bond yields of advanced countries into a future expected short rate and a term premium which compensates investors for locking their money for the life of the bond. To account for credit risk, I use synthetic local currency yield curves; the idea is to swap the U.S. yield curve into local currency yields using currency derivatives. These synthetic yield curves are akin to the U.S. issu-

[1]Credit risk here is defined broadly including, for example, (selective) default risk, currency convertibility risk, regulation risk, capital controls, jurisdiction risk and, if any, liquidity risk. Therefore, when investors require compensation for any of these risks, it is considered that they demand a premium for credit risk even if the country does not default per se.

[2]Examples of actual defaults in local currency debt include El Salvador (2017), Ecuador (2008), Argentina (2001), Russia (1998); and in 1999 after an earthquake, Turkey retroactively taxed its debt.

ing bonds in the respective local currency and can thus be seen as free of credit risk.[3] Therefore, I use the synthetic rather than the actual curves of 15 emerging markets to estimate their future expected short rates and the term premia. The difference between the two curves is an indicator of the credit risk of each country (Du and Schreger, 2016a).

By correcting for credit risk, I can decompose the actual yield curves of emerging markets into three parts: the expected future short-term interest rate, a term premium and a credit risk premium. The evidence shows that a quarter of the 10-year yield of emerging economies (around 175 basis points on average) is due to the term premium, more than double the size of the credit risk premium. This decomposition is of interest to both practitioners and policymakers since it can be used for risk management, asset allocation and monetary policy transmission in emerging markets.[4]

This paper finds that the bond yields of emerging markets do indeed comove. The analysis of the yield curve components reveals that the comovement is mainly driven by the term premia. In fact, the term premia is more globally connected than the credit risk premia and the expected short rates. The strong factor structure of the term premia of emerging markets is consistent with the evidence for advance countries (Adrian, Crump, Durham, and Moench, 2019).

The analysis then focuses on the determinants of the term premia in emerging markets. The results show that both global and domestic factors are important drivers of the term premia. Specifically, the global component of the term premia is highly linked to the U.S. term premium, whereas its idiosyncratic component is countercyclical. In fact, an increase in the unemployment rate or domestic inflation is associated with an increase in the term premia. Meanwhile, the effect of the exchange rate is in line with the risk-taking channel of exchange rates (Hofmann, Shim, and Shin, 2017), according to which a currency appreciation is associated with easier financial conditions and compressed sovereign bond spreads.

This paper is related to different branches in the literature. Other papers have used

[3]Admittedly, this assumes that the U.S. yield curve and currency derivatives are free of credit risk.

[4]Some of these applications include simulations of the yield curve for scenario analysis, investments based on the term premium, and the effectiveness of monetary policy tools used by central banks.

synthetic yields to analyze deviations from covered interest parity (Du, Tepper, and Verdelhan, 2018c). Du and Schreger (2016a) define the difference between the actual and synthetic curves of emerging markets as the local currency credit spread, and show that it is a sensible measure of credit risk. Du et al. (2018b) focus on the difference between the actual and the synthetic curves of advanced economies to study the convenience yield of U.S. Treasuries relative to that of other countries. In this paper, rather than concentrating on the difference between the two curves, I focus on the synthetic yield curves themselves and rely on their no-credit-risk property to estimate the term premium and the future expected short rates of emerging markets. In this sense, the paper contributes to the large literature on term structure models by pioneering their application on synthetic yield curves. More importantly, the paper contributes to the literature that decomposes the bond yields of emerging markets (Blake et al., 2015; Adrian et al., 2019) by correcting for credit risk.

This paper also contributes to the literature on the international comparison of sovereign yields (Dahlquist and Hasseltoft, 2016; Adrian et al., 2019), which has mainly focused on advanced economies. In addition, it extends the work of Wright (2011) by considering emerging markets in the international comparison of term premia. On the effects of U.S. monetary policy shocks, the paper extends the results in Gilchrist, Yue, and Zakrajšek (2019) by studying not only the effects on the yield curve but on its components,[5] it also extends the results in Curcuru, Kamin, Li, and Rodriguez (2018) by analyzing the effects of the components of the U.S. yield curve on the components of the yields of emerging markets.

The rest of the paper is structured as follows. The next section explains how to construct both nominal and synthetic yield curves. Section 3 describes the affine term structure model, its estimation and data sources. Section 4 reports the evidence on comovement, the yield curve decompositions and some stylized facts. Section 5 studies the cyclical properties of the term premia. The last section concludes.

[5] Hofmann et al. (2017) already study the link between the U.S. monetary policy, the exchange rate and local currency credit spreads.

2 Local Currency Yield Curves

Although the focus of this paper is on the synthetic yield curve, the nominal yield curve is also of interest.[6] A byproduct of decomposing the synthetic yield curve into the expectation for the future short-term interest rate and a term premium, is to decompose the nominal yield curve into three parts, the third component being the deviation from covered interest rate parity (CIP) -which in the case of emerging markets is the LC credit spread-. In addition, the nominal yield curve is used to compare the estimated term premium obtained from it to the one obtained from the synthetic yield curve. This section explains how to construct both curves.

2.1 Construction of Synthetic Yield Curves

The key idea to construct the synthetic LC yield curves is to swap the U.S. yield curve into LC using the forward premium for the respective maturity (see Du, Im, and Schreger, 2018a).

For maturities of less than one year, the forward premium can be calculated as the difference between the forward and the spot exchange rates. Outright forwards, however, become illiquid for longer periods. Therefore, for maturities greater than one year, the forward premium can be calculated using cross-currency swaps (CCS).[7] Although, the fixed-for-fixed CCS rates are rarely observed in the market directly, they can be constructed using cross-currency basis swaps and interest rate swaps. The idea is to swap fixed payments in LC into floating rate USD-cash flows using cross-currency basis swaps (referenced to the USD London interbank offered rate), and then swapping those floating-rate cash flows into fixed USD-cash flows using interest rate swaps. CCS are usually collateralized instruments and so the bilateral counterparty risk in CCS is small.

Let $y_{t,n}^{US}$ denote the zero-coupon yield for the n-period U.S. Treasury bond at time t, and $\rho_{t,n}$ the n-period forward premium from the USD to the LC at time t. Then the

[6]Below the synthetic yield curve is denoted by $\widetilde{y}_{t,n}^{LC}$ and the nominal yield curve is denoted by $y_{t,n}^{LC}$.

[7]CCS are used instead of credit default swaps (CDS) for two reasons: the definition of default in CDS is not always straightforward and, more importantly, defaults on LC bonds are not considered trigger events of CDS contracts.

zero-coupon synthetic LC yield for the n-period bond at time t, $\widetilde{y}_{t,n}^{LC}$, is defined as

$$\widetilde{y}_{t,n}^{LC} = y_{t,n}^{US} + \rho_{t,n}. \tag{1}$$

Note that $\widetilde{y}_{t,n}^{LC}$ is the borrowing rate paid by a hypothetical risk-free issuer in LC, it is the n-period synthetic LC risk-free funding rate. Note that the resulting synthetic yield curve $\widetilde{y}_{t,n}^{LC}$ does not require knowledge of the nominal yield curve, $y_{t,n}^{LC}$.[8]

According to the CIP condition, the nominal (direct) and the synthetic (indirect) LC interest rates should be equalized. In particular, a sovereign issuer of an emerging market should be able to borrow directly or indirectly (synthetically) in LC at the same yield. However, Du, Tepper, and Verdelhan (2018c) show that there are persistent and systematic deviations from CIP. In fact, Du and Schreger (2016a) and Du et al. (2018b) study these deviations for emerging markets and advanced economies, respectively. In particular, the spread between the two yields ($y_{t,n}^{LC} - \widetilde{y}_{t,n}^{LC}$) is what Du and Schreger (2016a) define as the LC credit spread for emerging markets, and what Du et al. (2018b) called the convenience yield for advanced countries.

2.2 Construction of Nominal Yield Curves

I use Bloomberg Fair Value (BFV) curves to estimate the nominal yield curve, $y_{t,n}^{LC}$. BFV curves are par yield curves provided by Bloomberg on a daily basis for different maturities. To obtain the implied zero-coupon curves, the yields are converted into discount factors, which are then used to estimate the parameters of the Nelson-Siegel-Svensson model.[9]

Nelson and Siegel (1987) assume that the instantaneous forward rate n years ahead, $f_{t,n}$, is a continuous function that depends on four parameters:

$$f_{t,n} = \beta_0 + \beta_1 \exp\left(-n/\tau_1\right) + \beta_2 \left(n/\tau_1\right) \exp\left(-n/\tau_1\right). \tag{2}$$

[8] Note that $\rho_{t,n} = 0$ for the USD and, thus, $\widetilde{y}_{t,n}^{US} = y_{t,n}^{US}$.

[9] As a robustness check, I estimate the nominal yield curves from actual prices for some of the countries in the sample. These estimated yield curves follow those reported by Bloomberg closely.

The behavior at long and short maturities is determined by the parameters β_0 and β_1, respectively, while β_2 and τ_1 determine the magnitude, direction and position of the yield curve's "hump".

Svensson (1994) extends the Nelson-Siegel approach by considering a second hump to capture the convexity of bonds at longer maturities. This is achieved at the expense of introducing two more parameters in the functional form of the instantaneous forward rate:

$$f_{t,n} = \beta_0 + \beta_1 \exp\left(-n/\tau_1\right) + \beta_2 \left(n/\tau_1\right) \exp\left(-n/\tau_1\right) + \beta_3 \left(n/\tau_2\right) \exp\left(-n/\tau_2\right). \tag{3}$$

The continuously compounded zero-coupon yield curve implied by the Svensson model is obtained by integrating the instantaneous forward rate in equation (3), and is given as follows:[10]

$$\begin{aligned} y_{t,n} = \beta_0 + \beta_1 \left(\frac{1-\exp\left(-n/\tau_1\right)}{n/\tau_1}\right) &+ \beta_2 \left(\frac{1-\exp\left(-n/\tau_1\right)}{n/\tau_1} - \exp\left(-n/\tau_1\right)\right) \\ &+ \beta_3 \left(\frac{1-\exp\left(-n/\tau_2\right)}{n/\tau_2} - \exp\left(-n/\tau_2\right)\right). \end{aligned} \tag{4}$$

The parameters in the Svensson model are estimated by minimizing the sum of squared deviations between the log prices obtained from the reported BFV yields $y_{t,n}^{LC}$ and the log prices implied by equation (4) weighted by the inverse of the duration for each period. Using log price deviations weighted by duration is approximately equal to fitting yields but is faster because the latter requires numerically finding the root to a nonlinear equation (see Gürkaynak, Sack, and Wright, 2007).

3 Affine Term Structure Model

Discrete-time affine term structure models with an exponentially affine pricing kernel are commonly used in the literature to estimate the dynamics of the nominal yield curve

[10] The continuously compounded zero-coupon yield curve implied by the Nelson-Siegel model is obtained by setting β_3 equal to zero in equation (4).

mainly for advanced economies (see Wright, 2011). In this paper, however, I use an affine term structure model to estimate the dynamics of the synthetic yield curve. The advantage of this approach is that it allows to decompose the *nominal* yield curve into three parts: the expected future short-term interest rate, a term premium and the LC credit spread.

3.1 Model

Let $P_{t,n}$ be the price at time t of a zero-coupon risk-free bond with maturity n, then the continuously compounded yield on that bond is $y_{t,n} = -\ln P_{t,n}/n$. Thus, the one-period continuously compounded risk-free rate is $r_t = -\ln P_{t,1}$.

The no-arbitrage assumption implies that there exists a stochastic discount factor (SDF), M_{t+1}, such that today's price equals the expectation of tomorrow's discounted price:

$$P_{t,n} = \mathrm{E}_t \left[M_{t+1} P_{t+1,n-1} \right]. \tag{5}$$

Since the price at maturity of a zero-coupon bond is 1, recursive substitution of equation (5) implies that today's price equals the expectation of the product of SDFs over the life of the bond, $P_{t,n} = \mathrm{E}_t \left[\Pi_{j=1}^{n} M_{t+j} \right]$.

A $\mathrm{K} \times 1$ vector of state variables X_t is assumed to drive the dynamics of the one-period interest rate r_t, the $\mathrm{K} \times 1$ market price of risk λ_t and the logarithm of the SDF in an affine form as follows:

$$r_t = \delta_0 + \delta_1' X_t \tag{6}$$

$$\lambda_t = \lambda_0 + \lambda_1 X_t \tag{7}$$

$$M_{t+1} = \exp\left(-r_t - \frac{1}{2}\lambda_t' \lambda_t - \lambda_t' \nu_{t+1} \right) \tag{8}$$

where ν_{t+1} is $i.i.d.$ $\mathrm{N}(0, I_{\mathrm{K}})$.

Assume that the dynamics of the vector of state variables X_t evolve under the physical measure ($\mathbb{P}$) according to the following vector autoregression (VAR):

$$X_{t+1} = \mu + \Phi X_t + \Sigma \nu_{t+1}. \tag{9}$$

The SDF in equation (8) and the law of motion of the vector of state variables in equation (9) can be formalized separately or jointly; see Gürkaynak and Wright (2012) for a review of the literature.

The following parameters:

$$\mu^* = \mu - \Sigma \lambda_0$$

$$\Phi^* = \Phi - \Sigma \lambda_1$$

govern the dynamics of the vector of state variables under the risk-neutral or pricing measure ($\mathbb{Q}$):

$$X_{t+1} = \mu^* + \Phi^* X_t + \Sigma \nu_{t+1}. \tag{10}$$

The log price and the continuously compounded yield of a risk-free zero-coupon bond in this model are then affine functions of the state variables X_t:

$$P_{t,n} = \exp\left(A_n + B_n X_t\right)$$

$$y_{t,n} = -\frac{A_n}{n} - \frac{B_n}{n} X_t. \tag{11}$$

where the scalar $A_n = A(\delta_0, \delta_1, \mu^*, \Phi^*, \Sigma)$ and the $1 \times \mathrm{K}$ vector $B_n = B(\delta_1, \Phi^*)$. These coefficients can be computed recursively combining the no-arbitrage condition and the functional form for bond prices as follows:

$$A_{n+1} = -\delta_0 + A_n + B_n'\mu^* + \frac{1}{2}B_n'\Sigma\Sigma' B_n, \quad A_0 = 0$$

$$B_{n+1} = -\delta_1 + \Phi^{*\prime} B_n, \quad B_0 = 0$$

The term premium for maturity n at time t, $tp_{t,n}$, can then be estimated as the difference between the yields obtained under the $\mathbb{Q}$ measure and the yields obtained under the $\mathbb{P}$ measure:

$$tp_{t,n} = y_{t,n}^{\mathbb{Q}} - y_{t,n}^{\mathbb{P}}. \tag{12}$$

Note that a key assumption behind this model is that the yield $y_{t,n}$ is risk-free. Du and Schreger (2016a) find that the LC credit spread is statistically different from zero and, thus, that the nominal yield $y_{t,n}^{LC}$ for emerging markets is not risk-free. Therefore, I focus on the synthetic yield $\widetilde{y}_{t,n}^{LC}$ because it aligns better with the risk-free assumption.

3.2 Identification Problem

In principle, the only input needed to estimate the parameters of the affine term structure model are zero-coupon bond yields. This is enough to estimate (μ^*, Φ^*), the pricing coefficients under the $\mathbb{Q}$ measure in equation (10). However, they are not enough to identify (μ, Φ), the parameters under the $\mathbb{P}$ measure in equation (9), which are necessary to estimate the term premium as indicated in equation (12).

This identification problem is due to the high persistence of bond yields, which results in small sample bias as has been highlighted by Kim and Orphanides (2012) and Guimarães (2014). Accordingly, the dynamics of the state vector will tend to mean-revert too quickly, overestimating the stability of the expected path of the short-term interest rate. In that situation, much of the variability in yields will be attributed to fluctuations in the term premium.

Different solutions have been proposed to address this identification problem, including restrictions on parameters, bias-corrected estimators and using survey forecasts of professional forecasters. Guimarães (2014) compares the three approaches and concludes that the use of surveys is an effective solution to obtain a robust decompositions of the yield curve.

Therefore, there are two ways in which the information from surveys can be used in this context. First, to obtain a model-free estimate of the term premium as the difference between the long-term interest rate and the expected future short-term interest rate over the horizon of the survey; this estimate serves as a robustness check. Second, to supplement the information from bond yields in the estimation of affine term structure models.[11]

3.3 Estimation

This section describes both the estimation method and the data sources employed in the estimation of the model presented in section 3.1.

Affine term structure models can be estimated by maximum likelihood. Traditionally, the convergence to the global optimum of that method has been subject to computational challenges and multiple local optima. In light of this, Joslin, Singleton, and Zhu (2011) (hence JSZ) propose a normalization that improves the convergence to the global optimum of the likelihood function.

The model's likelihood function is the product of the $\mathbb{P}$ and $\mathbb{Q}$ likelihood functions. The JSZ normalization allows for the near separation of both likelihood functions and reduces the dimension of the parameter space from $(\delta_0, \delta_1, \mu^*, \Phi^*, \Sigma)$ to $(r_\infty^{\mathbb{Q}}, \lambda^{\mathbb{Q}}, \Sigma)$, where $r_\infty^{\mathbb{Q}}$ is the long-run short-term interest rate under $\mathbb{Q}$, $\lambda^{\mathbb{Q}}$ is a $\mathrm{K} \times 1$ vector of ordered eigenvalues of Φ^*, and Σ is a lower triangular matrix with positive diagonal elements.

The JSZ normalization allows a two-stage estimation of the model presented in section 3.1. First, the $\mathbb{P}$ parameters are estimated by OLS of the VAR in equation (9), using the estimated K principal components of the synthetic yield curve $\widetilde{y}_{t,n}^{LC}$. This provides initial

[11]In a future draft, I will therefore supplement the affine term structure model with survey data on the expected long-term policy rate for each country.

values for the maximum likelihood estimation of the matrix Σ. Then, taking $\hat{\mu}$ and $\hat{\Phi}$ as given, the $\mathbb{Q}$ parameters can be estimated by maximum likelihood.

3.4 Data

The macroeconomic and financial variables used in section 5 are downloaded from Bloomberg. Here I describe the data sources for the construction of the yield curves and for the surveys of professional forecasters.

3.4.1 Yield Curve Data

I use end-of-month data for the following 15 emerging markets (EMs):[12] Brazil (BRL), Colombia (COP), Hungary (HUF), Indonesia (IDR), Israel (ILS), Korea (KRW), Malaysia (MYR), Mexico (MXN), Peru (PEN), Philippines (PHP), Poland (PLN), Russia (RUB), South Africa (ZAR), Thailand (THB) and Turkey (TRY).

In order to establish a set of stylized facts for emerging markets, the results are compared against those obtained for 10 advanced countries (AEs): Australia (AUD), Canada (CAD), Denmark (DKK), Germany (EUR), Japan (JPY), Norway (NOK), New Zealand (NZD), Sweden (SEK), Switzerland (CHF) and the United Kingdom (GBP). These countries are sometimes split into two groups to assess whether the type of advanced country matters. The first group (G-3) is comprised by Germany, Japan and the United Kingdom. The second group (A-SOE) comprises the rest of the countries. Note that the latter is basically a group of advanced small open economies, which arguably are more directly comparable to emerging markets.

As explained in section 2.1, the U.S. yield curve and the forward premium for different maturities are needed to construct the LC synthetic yield curves. Data for the U.S. zero-coupon yield curve is obtained from the database developed by Gürkaynak, Sack, and Wright (2007) (hence GSW). Although the GSW dataset goes back to 1961, the main issue for the construction of the synthetic yield curves is the information needed to calculate the forward premium.

[12]The currency identifier for each country is shown in parenthesis.

As mentioned before, for periods less than one year, the forward premium is calculated using forward exchange rates, while for longer periods it is calculated from CCS rates. The maturities of less than one year considered in the analysis are 3, 6 and 9 months; that is, I use the forwards and the spot exchange rate to compute the forward premium for those maturities. To construct the CCS rates, I use each available maturity starting from year one. The maximum maturity available varies per country but there is data covering at least up to ten years for all but it can go as far as 30 years for some countries.[13]

The forwards used to construct the forward premiums (for less than one year) for Korea, Philippines and Thailand are obtained from Datastream. For all the other countries, the data to construct the forward premiums (using forwards and CCS curves) is obtained from Bloomberg.[14]

The model presented in section 3.1 is estimated for each country separately. Therefore, the starting dates vary (between January 2000 and November 2006) but the end date is the same for all countries (January 2019). Although data for advanced countries is available earlier, their initial dates are set at January 2000. Note that there are at least 10 years of data for all emerging markets, which is a reasonable time period for the estimation of affine term structure models.

3.4.2 Survey Data

As mentioned in section 3.2, long-horizon forecasts for the policy rate of emerging markets can be used to obtain model-free estimates of the term premium and to supplement bond yields in the estimation of affine term structure models.

Although Consensus Economics provides long-horizon forecasts for consumer inflation and real GDP growth, it does not provide those forecasts for policy rates. In order to approximate the policy rate expectations embedded in those survey responses, I use the

[13]After 10 years, the periodicity decreases to every five years. Then, when they are available, the maturities beyond 10 years are reported for 15, 20, 25 and up to 30 years.

[14]A spreadsheet with the Datastream and Bloomberg tickers used in the construction of the forward premiums and in the estimation of the nominal yield curves is available upon request. The file consolidates and expands (with tenors and tickers) equivalent files kindly posted online in Wenxin Du and Jesse Schreger's websites.

following model for the policy rate of each emerging market

$$r_t = \beta_0 + \beta_r r_{t-1} + \beta_\pi \pi_t + \beta_y g_t + \epsilon_t, \tag{13}$$

where r_t is the policy rate, π_t is the year-on-year consumer inflation and g_t is the year-on-year real GDP growth. β_r is a smoothing parameter that improves the fit of the model to the data. The information for r_t is obtained from the policy rate statistics of the Bank for International Settlements, while the data for consumer inflation and real GDP growth is downloaded from Bloomberg.

To obtain the implied expectations of the policy rate, I estimate the regression in equation (13) using quarterly data and assume that the parameter estimates apply to the long-horizon survey forecasts for inflation and real GDP growth from Consensus Economics. I do this for all emerging markets in the sample except for Israel and South Africa due to data availability.

The expectations of the policy rate obtained in this way can then be used for the two goals described in the first paragraph of this section. In particular, the term premium using surveys will be obtained as:[15]

$$tp_{t,n}^{survey} = y_{t,n} - \left(\frac{\hat{\beta}_0}{1-\hat{\beta}_r} + \frac{\hat{\beta}_\pi}{1-\hat{\beta}_r}\pi_t^{survey} + \frac{\hat{\beta}_y}{1-\hat{\beta}_r}y_t^{survey} \right). \tag{14}$$

Since the surveys used from Consensus Economics are long-term forecasts ten years ahead, $n = 10$ in equation (14).

4 Empirical Results

The aim of this paper is to decompose the synthetic yield curves of emerging markets, which in turn provides a decomposition of their nominal yield curves. I use two benchmarks to assess the relevance of the results. First, I compare the estimated term premia for emerging markets to those of advanced economies. Second, I compare the term premia

[15]Note that under stationarity, $\mathrm{E}(r_t) = \mathrm{E}(r_{t-1})$.

	Nominal	Synthetic
EM	0.15	0.48
AE	0.13	0.08

Table 1. Fit of Affine Term Structure Models.

obtained from both nominal and synthetic yield curves[16] to assess the benefit of using synthetic curves.

4.1 Estimated Synthetic Yield Curves

An affine term structure model is estimated for each country using the JSZ normalization and the two-stage procedure described in section 3.3. The VAR model in equation (9) is estimated using the first three principal components (PCs) of the synthetic yield curves. Consistent with the empirical evidence that uses nominal yield curves,[17] on average more than 99% of the variation in synthetic yields is explained by those three factors for all emerging markets.

Table 1 summarizes the fit of the models. The table shows the average root mean square fitting error in annualized percentage points of nominal and synthetic yields for emerging markets and advanced economies.[18] As can be seen, the fit of the model for the nominal curves of both groups of countries is similar. The fit for the synthetic curves of advanced countries slightly improves relative to the fit for their nominal curves, while that for emerging markets declines. It is worth mentioning that the latter is driven mainly by two countries, Brazil and Indonesia, whose root mean square fitting error is slightly above 2%.[19] This requires further inspection of the synthetic yield curves of these two countries.[20]

[16] In each case, assuming that the curve used is risk-free.

[17] Litterman and Scheinkman (1991) first report this and refer to those PCs as level, slope and curvature.

[18] For each country, the root mean square fitting error is calculated as the square root of the average (across months and maturities) squared difference between the observed yields and the fitted yields from the estimated affine term structure model.

[19] Although not as high, the root mean square fitting error for Peru and Philippines is also above average at around 0.64 and 0.54, respectively.

[20] In some special cases, outliers may need to be dropped in some periods to be able to fit the curve for the rest of the points.

	Nominal	Synthetic	Expected	Term Premium	CIP Dev
EM	7.10	6.11	4.29	1.74	0.85
A-SOE	3.48	3.52	1.54	1.97	-0.23
G-3	2.41	2.13	0.52	1.60	0.15

Table 2. 10-Year Yield Decomposition (%).

4.2 Nominal Yield Curve Decomposition

Once the affine term structure model is estimated for each country, I can compute the term premia for each maturity (as explained in section 3.1) and, in turn, decompose both the synthetic as well as the nominal yield curves.[21] In particular, the synthetic yield curve is decomposed into the expectation of the future short-term interest rate and a term premium. In addition to those two, the third element in the decomposition of the nominal yield curve is the deviation from CIP.

Table 2 shows the simple average across countries of the decomposition of the 10-year yields.[22] Several patterns emerge from the table. The values for the deviations from CIP (CIP Dev) are in line with the results reported by Du and Schreger (2016a) and Du et al. (2018b) referred to as the LC credit spread (LCCS) for emerging markets and the convenience yield for advanced countries, respectively. Note that the estimated term premium is higher on average than the CIP dev for the three groups of countries; it is almost 90 basis points higher for emerging markets, almost 150 basis points higher for Germany, Japan and the United Kingdom and more than 200 basis points for the advanced small open economies. Thus, the term premium plays a relatively bigger role than CIP deviations in the dynamics of sovereign bond yields.

While the main component of the nominal yield curve of emerging markets is the expectation of the future short-term interest rate, for advanced countries the main component is the term premium. That is, the term premium plays a relatively bigger role in the dynamics of the sovereign bond yields of advanced countries than those of emerging

[21] Although term premia estimates are calculated for all maturities, only the 10-year maturity is reported in what follows for the sake of brevity.

[22] The numbers in the table do not add up exactly for two reasons: (1) the term premium is obtained using equation (12), that is it uses the fitted synthetic yield curve, while the table reports the observed synthetic yield curve for the column 'Synthetic', and (2) the sample period for the yield curves might differ slightly to that of the CIP deviations.

markets.

Finally, note that for the subset of small open economies it is cheaper to borrow directly in their own currency (since CIP Dev is negative), unlike what is seen for emerging markets.

4.3 Term Premia: Nominal or Synthetic Yield Curve?

Affine term structure models are usually estimated using nominal yield curves on the assumption that they are free of default risk. Du et al. (2018c) show that deviations from covered interest parity are non-negligible. Therefore, there is a wedge between the nominal ($y_{t,n}^{LC}$) and synthetic ($\widetilde{y}_{t,n}^{LC}$) yield curves given by the LCCS in the case of emerging markets and by the convenience yield in the case of advanced economies. Does this wedge bias the estimation of term premia? Equivalently, does it matter which curve is used to estimate the term premia? We can answer these questions by fitting the model described in section 3.1 to both curves and compare the estimates.

Table 3 show the average term premia across groups of countries obtained by using the nominal and the synthetic yield curves. For advanced countries, the difference between the two is less than or equal to 10 basis points on average, while for emerging markets is more than 40 basis points. To assess whether the term premium estimates from the two curves are statistically different from each other, I perform a t-test for the equality of means (with unequal variances) between them for each country. The null of equal means is rejected at the 5% significance level for all emerging markets except Hungary and Malaysia. However, the null is only rejected for four advanced economies (Australia, Denmark, Japan and New Zealand). This shows that there are gains by using synthetic yield curves to account for credit risk when estimating the term premia, especially for emerging markets.

The evidence in tables 2 and 3 shows that, although sometimes used interchangeably, the terms ‘risk premium’ and ‘term premium’ are not the same thing, at least not for emerging markets, since *both* the term premium and the LC credit spread play an important role in the dynamics of the risk premium in the bond yields of emerging economies.

	Nominal	Synthetic
EM	2.17	1.74
A-SOE	2.03	1.97
G-3	1.70	1.60

Table 3. 10-Year Term Premium Comparison (%).

4.4 Stylized Facts of EM Term Premia

I use the U.S. term premium as a benchmark to compare the behavior of the term premia in emerging markets. Two frequently cited estimates of the U.S. term premium are Kim and Wright (2005) (hence KW) and Adrian, Crump, and Moench (2013). Analysis of the estimates of the U.S. term premium shows that: (1) it is time-varying; (2) it has declined over time; (3) its sign changed from positive to negative in recent years; and (4) increases during periods of uncertainty and vice versa. Common explanations for the decline in the U.S. term premium include an increased demand of U.S. assets by global investors, and the effects of the the large-scale asset purchases conducted by the the Federal Reserve in response to the Great Recession. Regarding the change in the sign of the term premium, Campbell, Sunderam, and Viceira (2017) argue that it is explained by a flip in the sign of the correlation between stocks and bonds; when investors changed their perception of bonds as hedges of stock investments, the correlation between the two assets turns negative which drives down the term premium. Finally, the U.S. term premium increased around the onset of the Great Recession (September 2008), the taper tantrum (June 2013), and the 2016 U.S. presidential election (November 2016), while it declined after the first unexpected announcement of the quantitative easing program by the Fed (March 2009) -which was seen as helping to reduce some of the uncertainty at the time-.

The 10-year term premia estimates for emerging markets are plotted in Figure 1. It is worth highlighting some regularities observed in the figure: (1) term premia in emerging markets are time-varying; (2) the estimates are sensible, i.e. they fluctuate between -1% and $+6\%$; (3) there appears to be co-movement in the term premia of some countries; (4) they behave similar to the U.S. term premium around key dates; (5) there is a slight downward trend in the term premia of some countries; (6) the term premia in emerging markets can be negative during some periods, but not to the level seen for the U.S.

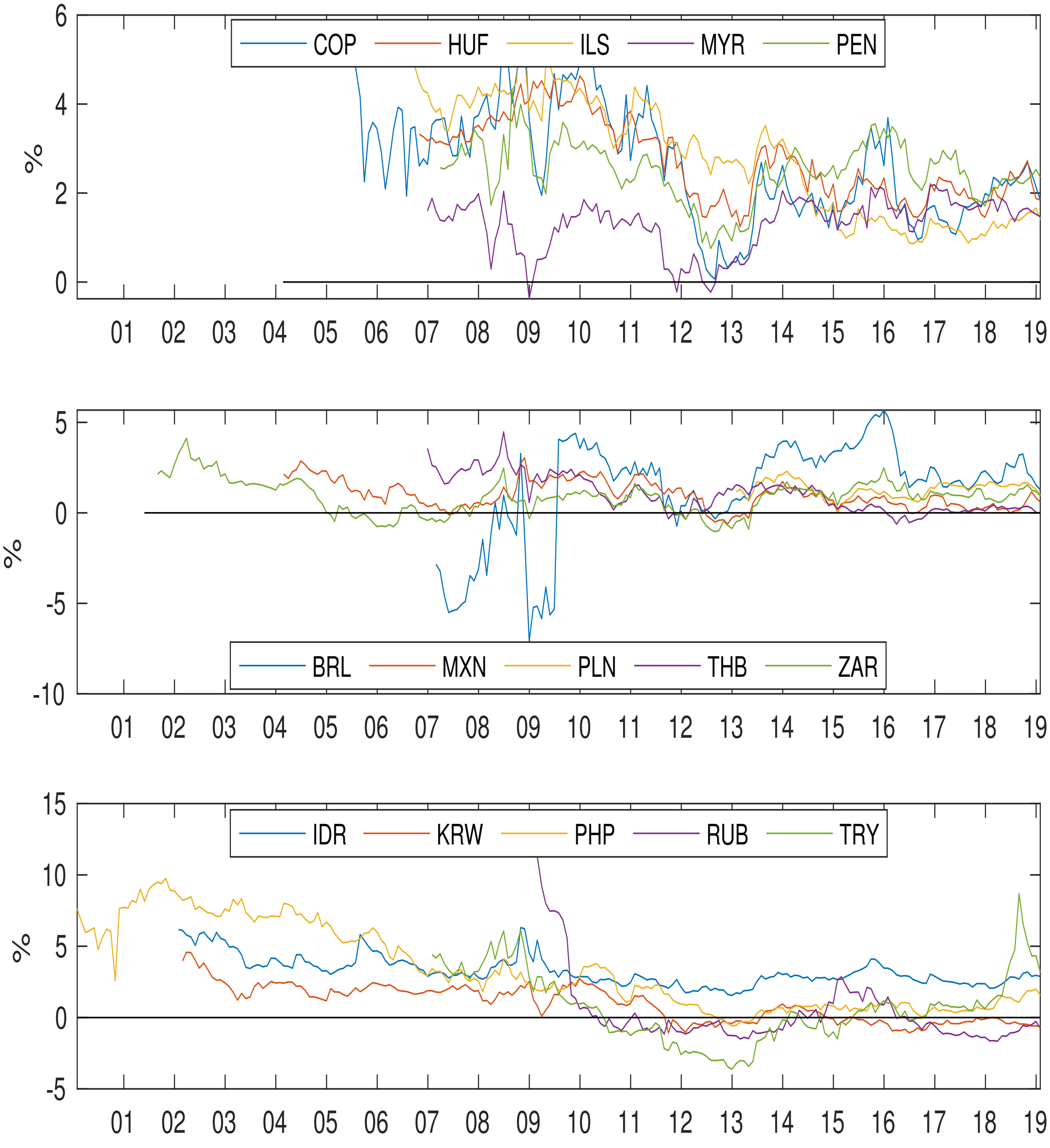

Figure 1. Estimated 10-Year Term Premia: Emerging Markets.

Special cases include that of Brazil whose term premium turn negative around the Great Recession and that of Russia whose term premium declined considerably. These cases might be reflecting local conditions and deserve further analysis. Consider, for example, the case of Turkey towards the end of the sample, where relevant events in

2018[23] translated into a higher term premium.

In addition to Brazil, Russia and Turkey, the term premia of most Asian countries has been in negative territory for some period of time. Moreover, with the exception of Brazil and South Africa, the term premia of emerging markets being negative is a phenomenon observed after the Great Recession.

For comparison purposes, Figure 2 shows the 10-year term premia estimates for advanced economies using synthetic yield curves. A clear downward trend is observed for all countries. This is consistent with the empirical evidence that uses nominal yield curves; Wright (2011) shows a declining trend in term premia for most of these countries going back to the 1990s and argues that it reflects a reduction in inflation uncertainty.

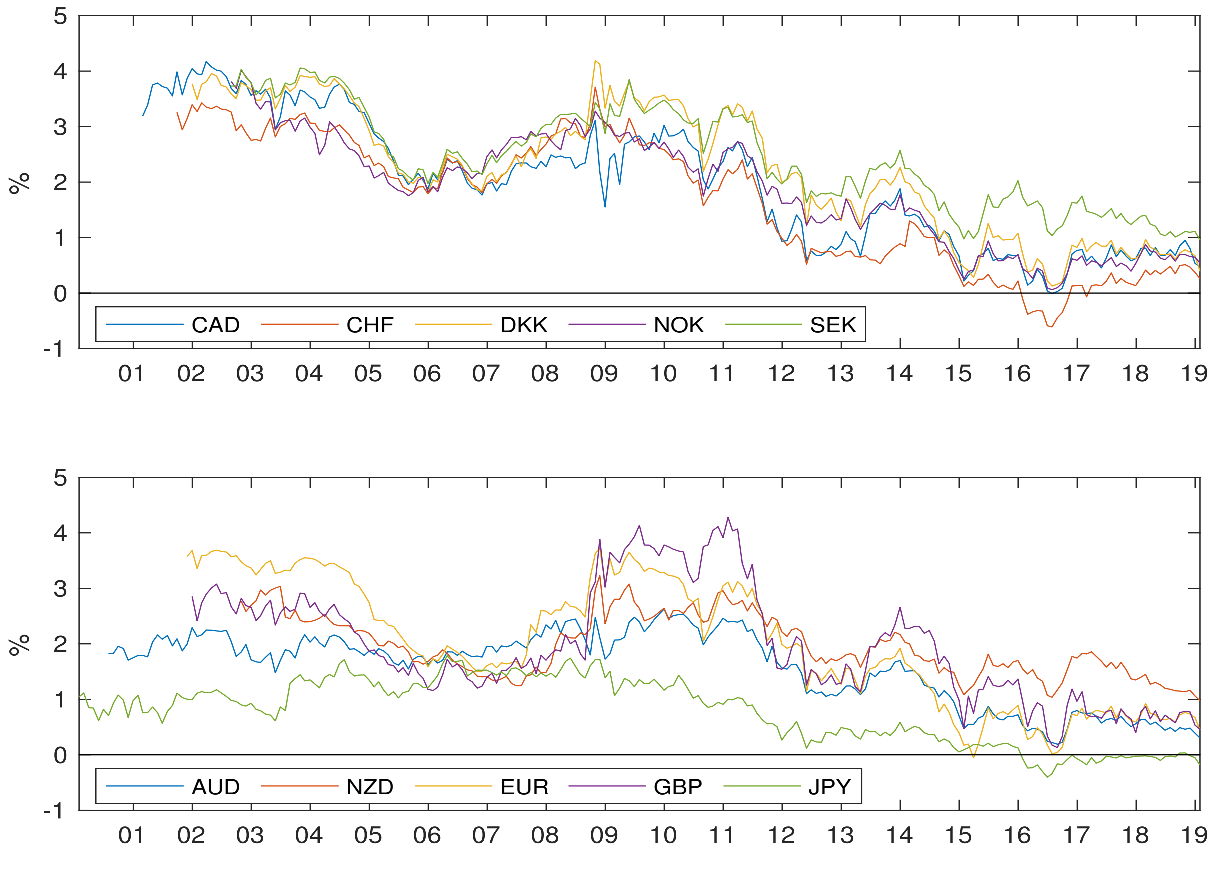

Figure 2. Estimated 10-Year Term Premia: Advanced Economies.

Note that although the term premia of most advanced countries seem to reflect a common factor, that of Japan behaves differently probably reflecting the fact that Japan was at the zero lower bound before the other countries.

[23] On June 24, 2018, Recep Tayyip Erdogan won the presidential election. On October 2, 2018, the journalist Jamal Khashoggi disappeared after he visited the consulate of Saudi Arabia in Istanbul.

According to KW, the 10-year term premium estimate for the U.S. has been negative for most of the time since mid-2011, fluctuating between -1% and 0. Of the advanced countries considered, only Switzerland and Japan have experienced more than one month with a negative term premium, compared to several emerging markets, mainly Korea, Russia and Turkey. In particular, before the taper tantrum there was a tendency of declining term premia for emerging markets, which for some countries actually turned out negative.

4.4.1 Term Structure of Term Premia

In addition to comparing the term premia across countries, one can also compare them across maturities per country. In general, the term premium increases with maturity. As one would expect, when long-term bonds are seen as riskier than short-term bonds, investors would require a higher compensation for holding long-term bonds. This pattern, however, is not universal as can be seen in Figure 4 in the Appendix, which shows two examples of this, namely Korea and Mexico. Therefore, the exceptions for the general pattern are observed in both emerging and advanced countries since the KW estimates also show that after the Great Recession, the 1-year U.S. term premium has been above the 5- and 10-year term premia at some points.

4.4.2 Common Factors in Term Premia

To see whether there are common factors influencing the term premia in emerging markets, Table 4 shows the proportion of the total variation in the 10-year term premia explained by their first three PCs. To consider all countries, the starting date is December 2006. The first three PCs explain more than 80% of the variation in the term premia of emerging markets and more than 98% for advanced countries. This evidence highlights the importance of considering global factors as drivers of the term premia. But at the same time, the evidence for emerging markets shows that both domestic and common factors seem to be at play as drivers of their term premia.

	Jun-2005
EM	65.32
AE	89.17

Table 4. Variation of 10-Year Term Premium Explained by First PC (%)

4.4.3 Survey-Based Term Premia

As already mentioned, one way to check the term premia estimates obtained from affine term structure models is to use survey data since long-term surveys of professional forecasters can be used to obtain a model-free estimate of the long-term term premium. Using this approach, the term premium is calculated as the difference between the long-term interest rate and the survey-expectation of the future short-term interest rate over the same horizon. Since the long-term expectations of the policy rate for emerging markets are not provided by Consensus Economics, they are approximated as explained in section 3.4.2. As it is also explained in that section, given the persistence of bond yields, surveys can also provide information to help in the identification of the term premium. It is important to acknowledge, however, that surveys might not represent the market expectations or the expectations of the marginal investor.

Figure 3 displays the 10-year (long-term) term premium estimated in this way for most of the emerging markets considered in Figure 1.

With the exception of Brazil during 2012-13, the term premia estimated using survey data are in line with the model-based term premia. In fact, the average correlation between the two is 80.4%.[24] This is reassuring and supports the idea of supplementing the term structure model with survey data to better pin down the term premia in emerging markets, which will in turn provide a more robust decomposition of the nominal yield curve. This will be done in future versions of this paper.

[24] Even for the term premia calculated using the nominal yield curve, the correlation with the survey-based term premia is equal to 85%.

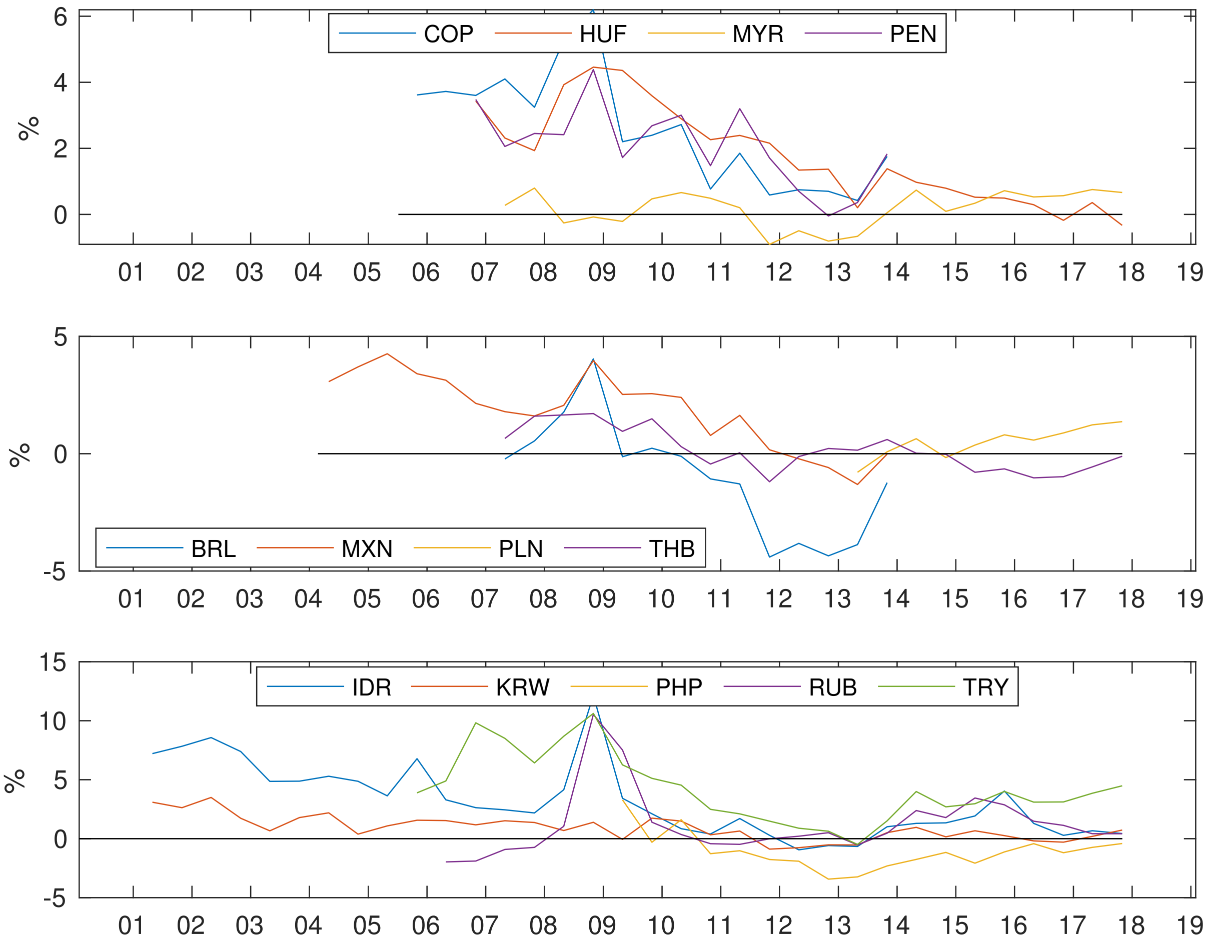

Figure 3. Survey-Based 10-Year Term Premium Estimates

	TP-USTP	TP-CIP Dev
EM	0.60	-0.28
A-SOE	0.80	-0.01
G-3	0.71	-0.29

Table 5. Correlations of 10-Year Term Premia: U.S TP and CIP deviations

	BRL	COP	KRW	MXN	RUB
TP-EPU	0.14	0.46	-0.32	0.40	-0.22

Table 6. Correlations of 10-Year Term Premia: Economic Policy Uncertainty Index

5 Cyclical Properties of the Term Premia

Since this is the first time that term premia is estimated using synthetic yield curves, I first present their correlation with variables commonly associated with risk and uncertainty before proceeding to a more formal analysis.

5.1 Relationship with Risk and Uncertainty Measures

To see how the term premia co-moves with variables associated with risk and uncertainty, they are compared against the 10-year U.S. term premium from KW, the LC credit spread from Du and Schreger (2016a) or the convenience yield from Du et al. (2018b), and the economic policy uncertainty (EPU) index proposed by Baker, Bloom, and Davis (2016). The first variable is an indicator of global financial conditions, while the second is an indicator of credit risk for emerging markets or the convenience yield for advanced economies. The EPU index is based on the frequency of articles in local newspapers containing key words such as 'economy', 'uncertainty' and 'central bank'; however, it is only available for 5 of the emerging markets in the sample. Tables 5 and 6 show these correlations.

The term premia in emerging markets is related to the U.S. term premium but not as tightly linked as those for advanced countries. To assess the relationship of the country-specific component of the term premia with the other two variables, I regress the term premium of each country on the U.S. term premium and use the residuals as the 'idiosyncratic' term premium (i.e. the part of a country's term premium orthogonal to the U.S. term premium).

The correlation of the term premia with the deviations from CIP is negative. Du and Schreger (2016a) show that the LC credit spread has a low reaction to global variables. This provides a possible explanation for the negative relationship between the term premia and the LC credit spread, since the former seems to react to global factors as is formally tested in the next section. The last column of table 5 shows that once the term premia in emerging markets is purged from the effect of the U.S. term premium, the relationship is still negative but the magnitude declines. The opposite is observed for advanced small open economies but remember that for them the deviations from CIP reflect a convenience yield.

The term premia for Latin American countries show a positive correlation with the EPU index; the correlation for Korea and Russia, however, is negative. The relationship might be related to the fact that after the Great Recession, the term premia for both countries has been negative during a considerable period as shown in figure 1. This can be verified if the EPU index for countries with a similar situation (like Turkey) becomes available. Although the magnitude declines, the sign of the relationship with the idiosyncratic component of the term premia holds suggesting a role for domestic drivers of the term premia.

5.2 Drivers of Term Premia

To study the cyclical properties of term premia in emerging markets formally, I run panel data regressions with a variety of macroeconomic and financial variables as explanatory variables. The macroeconomic variables considered have a monthly frequency; for the financial variables considered (which are available daily) end-of-month values are used.

The panel data regressions have the form

$$tp_{it} = \alpha_i + \beta' z_{it} + u_{it}. \tag{15}$$

where tp_{it} denotes the model-based 10-year term premium of country i in month t, z_{it} is a vector of regressors and α_i denotes country fixed effects. The regressors include global and domestic variables as suggested by the evidence presented in tables 4-6. This is a first step towards understanding the drivers of term premia and, therefore, it is important to acknowledge the potential econometric problems such as endogeneity as well as the effects of the persistence of the variables considered.

The global financial variables include the Cboe's volatility index (VIX), the federal funds rate, the S&P 500 index and the oil price. The VIX and the federal funds rate have been used in the global financial cycle literature (see Rey, 2013) to study the effects of common factors on capital flows. The VIX is usually used as a measure of risk aversion and economic uncertainty and the fed funds rate is a measure of the monetary policy stance in the U.S. Given the sudden spikes in the VIX, it is common to use the $\ln(VIX)$ instead of the VIX directly. For the U.S. monetary policy, the variable used is the effective federal funds rate calculated by the New York Fed.

The domestic variables include inflation, the unemployment rate and industrial production to capture macroeconomic effects. In addition, the exchange rate (LC per USD) and the local stock market index are used as measures of local financial conditions.

Monthly returns, calculated as the log difference of the series, are used for the stock market indexes, the oil price and the exchange rate.

Table 7 reports different specifications of the model in equation (15). The first model in the table focuses mainly on global variables, while the second one focuses on domestic variables. These two models already shed some light on the driving forces behind the term premia in emerging markets. However, the models with the most explanatory power include both global and domestic variables.

The main global factor is the U.S. term premium, and the two main domestic factors are inflation and unemployment. Holding the other factors constant, an increase in any of these three variables increases the term premia in emerging markets. Note that external conditions have a relevant impact on domestic bond markets since the greatest effect comes from the U.S. term premium. This is in line with the literature studying the

	(1)	(2)	(3)	(4)	(5)
log(Vix)	0.18		0.65***	0.14	
	(0.41)		(0.21)	(0.17)	
FFR	0.08		0.22**	0.12	
	(0.11)		(0.10)	(0.10)	
USTP10	1.55***			1.22***	
	(0.28)			(0.16)	
Return S\&P	-0.01		0.00		
	(0.01)		(0.01)		
Return Oil	-0.00		0.00		
	(0.00)		(0.00)		
INF		0.26***	0.22***	0.21***	0.222***
		(0.05)	(0.05)	(0.05)	(0.0400)
UNE		0.22***	0.21***	0.13**	0.137**
		(0.07)	(0.06)	(0.05)	(0.0583)
IP		-0.02	-0.02	-0.02*	-0.0193**
		(0.01)	(0.01)	(0.01)	(0.00792)
Return FX		0.02**	0.02*	0.02*	0.0199*
		(0.01)	(0.01)	(0.01)	(0.0103)
Return Stocks		0.00	0.00	0.00	0.000373
		(0.01)	(0.01)	(0.01)	(0.00751)
Constant	1.04	-1.40*	-3.18***	-0.84	1.235*
	(1.27)	(0.67)	(0.93)	(0.76)	(0.636)
Observations	2,406	1,969	1,969	1,969	1,969
R-squared	0.29	0.27	0.34	0.49	0.547
Number of Countries	15	15	15	15	15
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	Yes

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7. Panel Data Regressions. Dep. Variable: EM 10-Year Term Premium (%).

global financial cycle that focuses on capital flows. However, the channel does not seem to be through the VIX nor even through the monetary policy of the U.S. directly via the federal funds rate but through the U.S. term premia. Both the VIX and the federal funds rate appear to have a positive effect on the term premia in emerging markets but the effect disappears once the U.S. term premium is included in the regressions. An increase in the U.S. term premium translates into a more than proportional increase in the term premium of emerging markets.

The effect of the domestic variables is in line with what has been found for advanced countries using nominal yield curves. Investors demand a higher term premium during recessions, when the unemployment rate increases. This provides evidence of a counter-cyclical behavior of the term premia in emerging markets. Moreover, the positive effect of inflation on the term premia conforms with the idea that inflation erodes the value of nominal bonds and so in periods of rising inflation investors demand a higher term premium. The effect of both variables is broadly similar across models.

The exchange rate also seems to be playing a role; a depreciation of the local currency is associated with an increase in the term premium. This seems counterintuitive from the perspective of the standard trade-channel effect since emerging markets are usually commodity exporters. However, it is in line with the risk-taking channel of exchange rates found by Hofmann et al. (2017), according to which currency appreciation is associated with easier financial conditions and compressed sovereign bond spreads.

Finally, the effects of the domestic variables remain once one controls for time fixed effects. The effects of those variables remain broadly similar across the different specifications.

6 Concluding Remarks

The sovereign yields of emerging markets comove. I use synthetic yield curve to account for credit risk, which allows me to decompose the nominal yield curves of 15 emerging markets into three three parts: an expectation for the future short-term interest rate, a term premium and a credit risk premium. The comovement in sovereign yields is mainly driven by the term premia.

The term premia in emerging markets for the 10-year maturity is around 175 basis points on average, more than double the size of the credit risk premium. The results are compared to those obtained from surveys of professional forecasters and from advanced countries to establish a set of stylized facts. There are benefits of using synthetic yield curves. For instance, the phenomenon of a negative term premium is not limited to advanced countries. Furthermore, global and domestic factors are important drivers of the term premia in emerging markets. The U.S. term premium is a key common factor having a more than proportional effect on their term premia. The evidence also shows a countercyclical behavior of the term premia as well as a positive relationship with inflation, in line with the idea that it erodes the value of nominal bonds.

The work presented in this paper can be extended in several directions and I will continue working on them. First, as already indicated, the information from survey data can aid in mitigating the identification problem in affine term structure models, which translates into more robust estimates of the term premia. As a consequence, the decomposition of the nominal yield curve will also be more robust so that it can provide useful information for the analysis of monetary policy in emerging markets.

Different models can also be used to assess different characteristics of the data from the synthetic curves. A model that explicitly considers the joint behavior of nominal and real interest rates can allow to further decompose both nominal and synthetic yield curves into the expectation of the future real interest rate and the real term premium. The model can also be supplemented not only with survey data but also with macroeconomic information. Other extensions include models with jumps in yields, which might be applicable to a couple of emerging markets (those with a poor fit mentioned in section 4). Given the reaction to common factors, multi-country term structure models might be relevant. To further study the phenomenon of negative term premiums, quadratic term structure models with joint dynamics for stocks and bonds might be useful.

Finally, other improvements can also be included like extending the comparison with advanced economies for the analysis shown in section 5. In particular, analyzing the relationship between the EPU index for those advanced countries for which it is available (Australia, Canada, Germany, Japan, UK and Sweden) to compare it with what is reported for emerging markets, as well as contrasting the results from the panel regressions to advanced countries. More generally, the panel regression analysis can be applied to the other components of the nominal yield curve, namely the expectation part and the LC credit spread. This will provide a broader picture of the relative importance of global and domestic factors on local bond markets.

References

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

T. Adrian, R. K. Crump, J. B. Durham, and E. Moench. Sovereign Yield Comovement. *Working Paper*, 2019.

S. R. Baker, N. Bloom, and S. J. Davis. Measuring Economic Policy Uncertainty. *The Quarterly Journal of Economics*, 131(4):1593–1636, 2016.

A. P. Blake, G. R. Rule, and O. J. Rummel. Inflation Targeting and Term Premia Estimates for Latin America. *Latin American Economic Review*, 24(1), 2015.

J. Y. Campbell, A. Sunderam, and L. M. Viceira. Inflation Bets or Deflation Hedges? The Changing Risks of Nominal Bonds. *Critical Finance Review*, 6:263–301, 2017.

S. E. Curcuru, S. B. Kamin, C. Li, and M. Rodriguez. International Spillovers of Monetary Policy: Conventional Policy vs. Quantitative Easing. *International Finance Discussion Paper*, 2018(1234), 2018. ISSN 1073-2500.

M. Dahlquist and H. Hasseltoft. International Bond Risk Premia. In *Handbook of Fixed-Income Securities*, pages 169–190. 2016.

W. Du and J. Schreger. Local Currency Sovereign Risk. *Journal of Finance*, 71(3): 1027–1070, 2016a.

W. Du and J. Schreger. Sovereign Risk, Currency Risk, and Corporate Balance Sheets. *HBS Working Paper*, No. 17-024, 2016b.

W. Du, J. Im, and J. Schreger. A Dataset for Covered Interest Rate Parity Deviations Between Government Bond Yields. In *NBER IFM Data Sources Project*, 2018a.

W. Du, J. Im, and J. Schreger. The U.S. Treasury Premium. *Journal of International Economics*, 112:167–181, 2018b.

W. Du, A. Tepper, and A. Verdelhan. Deviations from Covered Interest Rate Parity. *Journal of Finance*, 73(3):915–957, 2018c.

C. Galli. *Inflation, Default Risk and Nominal Debt*. PhD thesis, University College London, 2020.

S. Gilchrist, V. Yue, and E. Zakrajšek. U.S. Monetary Policy and International Bond Markets. *Journal of Money, Credit and Banking*, 51(S1):127–161, 2019.

R. Guimarães. Expectations, Risk Premia and Information Spanning in Dynamic Term Structure Model Estimation. *Bank of England Working Paper*, 489, 2014.

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

R. S. Gürkaynak, B. P. Sack, and J. H. Wright. The U.S. Treasury Yield Curve: 1961 to the Present. *Journal of Monetary Economics*, 54(8):2291–2304, 2007.

B. Hofmann, I. Shim, and H. S. Shin. Sovereign Yields and the Risk-Taking Channel of Currency Appreciation. *BIS Working Paper*, 538, 2017.

S. Joslin, K. J. Singleton, and H. Zhu. A New Perspective on Gaussian Dynamic Term Structure Models. *Review of Financial Studies*, 24(3):926–970, 2011.

D. H. Kim and A. Orphanides. Term Structure Estimation with Survey Data on Interest Rate Forecasts. *Journal of Financial and Quantitative Analysis*, 47(1):241–272, 2012.

D. H. Kim and J. H. Wright. An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behavior of Long-Term Yields and Distant-Horizon Forward Rates. *Board of Governors of the Federal Reserve System Discussion Paper*, 33, 2005.

R. Litterman and J. Scheinkman. Common Factors Affecting Bond Returns. *Journal of Fixed Income*, 1(1):54–61, 1991.

C. R. Nelson and A. F. Siegel. Parsimonious Modeling of Yield Curves. *Journal of Business*, 60(4):473–489, 1987.

P. Ottonello and D. J. Perez. The Currency Composition of Sovereign Debt. *American Economic Journal: Macroeconomics*, 11(3):174–208, 2019.

C. M. Reinhart and K. S. Rogoff. The Forgotten History of Domestic Debt. *Economic Journal*, 121(552):319–350, 2011.

H. Rey. Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence. *Proceedings of the 2013 Federal Reserve Bank of Kansas City Economic Symposium at Jackson Hole*, pages 285–333, 2013.

L. E. O. Svensson. Estimating and Interpreting Forward Interest Rates: Sweden 1992-1994. *NBER Working Paper*, 4871, 1994.

J. H. Wright. Term Premia and Inflation Uncertainty: Empirical Evidence from an International Panel Dataset. *American Economic Review*, 101(4):1514–1534, 2011.

Appendix

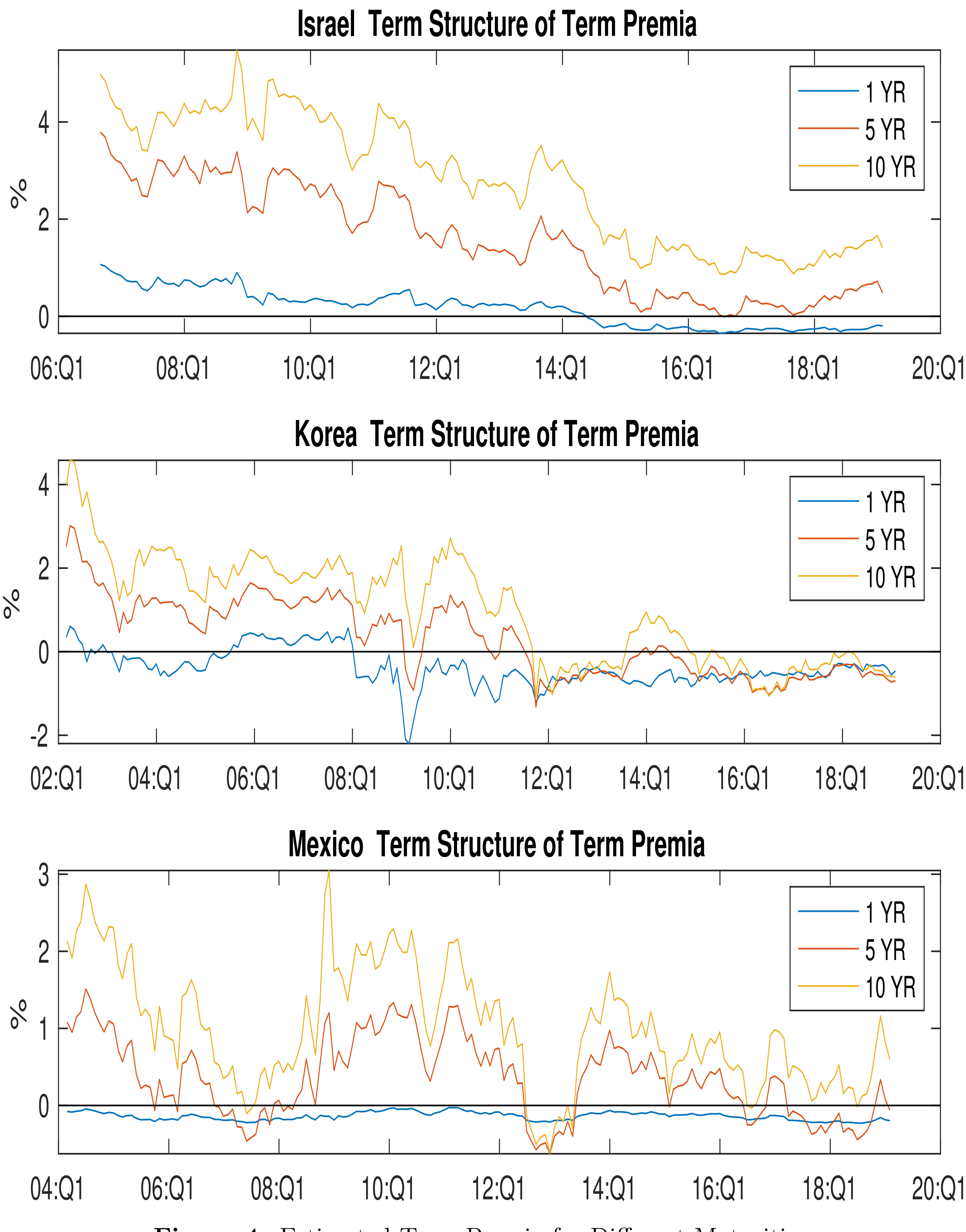

Figure 4. Estimated Term Premia for Different Maturities.