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Term premium in emerging market sovereign yields: Role of common and country specific factors

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This paper provides cross-country analysis of local bond market term premia in emerging countries. In order to investigate the role of domestic and global factors in the determination of compensation demanded by investors for their medium and long term fixed income investments, term premia is computed for emerging countries by using methodology adopted in Adrian et al. (2013). It is found that changes in market liquidity conditions is important for the variation in term premia. Moreover, movements in domestic and global factors are closely linked to term premia. In this regard, uncertainty related economic surprise indicator and exchange rate related expectations subsume some part of the expected excess returns in both medium and long term. Among other explanatory variables, inflation uncertainty is the only variable found to be insignificant in medium term, albeit it has an explaining power in the long term.

The views expressed in this working paper are those of the author(s) and do not necessarily represent the official views of the Central Bank of the Republic of Turkey.

1. Introduction

The term structure of interest rates presents the relationship between interest rates and the related maturities. From the monetary policy perspective, most of the central banks control short term interest rates in an attempt to affect interest rate at longer maturities so that the role of central banks in determination of long term interest rates is indirect in this regard. However, investment decisions and aggregate demand in the economy tend to depend on mid to long-term interest rates. In this context, from a perspective of a monetary authority understanding the behavior of medium to long term interest rates is important. According to the expectations hypothesis, today's longer-term interest rates are determined by agents' expectations about future short-term interest rates. As a result, policy makers can monitor market expectations about future monetary policy stance from the term structure and can use this valuable information to assess and possibly increase the effectiveness of their policy design and communication.

While the strong form expectation hypothesis claims that longer term yields are determined only by current and expected future short-term interest rates, it is commonly accepted that there exists an additional term premium component affecting the movements in long-term interest rates besides expectations. Term premium is assumed to reflect the compensation demanded by investors for bearing the duration risk by holding longer-term asset rather than rolling the investment with short-term instruments. Regarding this risk compensation, in its weak form the expectation hypothesis states that long-term yields are composed of market agents' expectations about future short-term interest rates and a constant risk premium. This constant premium is assumed to depend on the maturity and be stable throughout time.

Significant efforts in the literature have been devoted to the validation of the expectation hypothesis. Several studies have

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tested the validity of the hypothesis by using various market interest rates, through different periods and under different monetary policy regimes. However, most of these studies reject the strong and weak forms of the hypothesis. The common finding of these studies show that market interest rates provide biased estimates of future short-term rates and there is a high-degree of variability observed in the term premium component.[1] This line of research leads to framing of the widely accepted definition of term premium as the difference of long-term market rates and average of expected future short-term interest rates over the lifetime of the long-term investment. This definition assumes that the term premium is related to uncertainty of the future path of short-term interest rates. Uncertainty may stem from inflation risk and/or concerns related to future economic growth. Additionally, uncertainty related to carry trade returns, liquidity conditions of the interest bearing instruments and segmentation in the maturity preference of investors also affect the long-term excess yields over expected future short-term interest rates. Although the term premium is defined as the compensation demanded by investors for bearing duration risk, it may not be positive. If an investor prefers to secure a fixed return for a long-period of time, for instance an institutional investor like a pension fund, then the investor may be willing to accept a negative term premium rather than taking the roll-over risk.

From the viewpoint of a market participant, it is important to interpret the dynamics of term premium and the expected future short-term interest rates in terms of understanding the behavior of longer term interest rates. In this context, we aim to decompose the medium and long term interest rates into their components and then identify the possible macroeconomic and financial drivers of term premium. The term premium estimation literature relies heavily on affine term structure models. However, different specifications of these models may yield different estimates of the term premium. In this study, we employ the framework used in Adrian et al. (2013), ACM methodology. After extracting the term premium components for 5 and 10 year maturity yields of 16 emerging market economies, we estimate the effect of uncertainty related to inflation, economic growth, global risk aversion and related market liquidity conditions with a panel regression. Although there have been studies discussing the effect of uncertainty on term premium, to our best knowledge this is the first study measuring the effect of market liquidity conditions on the term premium in a panel data set. Since the affine term structure framework does not strip the liquidity premium from the term premium explicitly, it is insightful to investigate its effect in a panel regression framework. Our main contribution is to show that the deterioration in domestic market liquidity conditions leads to an increase in demanded premium. In addition to this, inflation and macroeconomic uncertainty indicators are found to boost term premium as well. Moreover, results indicate that exchange rate related uncertainties, increases the compensation demanded by investors over risk neutral yields also increase. Lastly, global market risk indicator has a significant positive effect on term premium component of medium-term market yields.

In this context, the models used in term premium estimation, corresponding results and possible drivers are discussed in the following section. Section 3 explores the theoretical framework for the term premium estimation procedure employed in this study. In this regard, the arbitrage-free asset pricing framework, connected affine term structure models and the ACM methodology are discussed in more detail. Section 4 explains the data used in the estimation and steps of term premium estimations. This sections ends with the presentation of the estimated term premium series for the selected group of countries. The framework used for cross-country analysis and the results of related panel regressions which aim to identify the determinants of the term premium are discussed in the fifth section and the last section concludes.

2. Literature review

Conceptually, measuring term premium is an easy task since it only requires the separation of future expected short-term rates from the observed longer term yields. However, it is not straightforward in practice since both of the components are not directly observable (Kopp and Williams, 2018). The most direct approach would be to incorporate a survey based measure of expected future short-term interest rates for a given investment horizon. However, it is usually not possible to find up-to-date survey data series covering long time horizons and sometimes survey participants may refrain from reflecting their objective expectations about the future short-term rates. Thus, studies employing survey based measures are quite limited. As an example of survey based research, Crump et al. (2016) use an extensive survey dataset covering market professionals' forecasts of real economic growth, inflation and short-term interest rates for the US economy for 1983–2016 period. They conclude that term premium is the main driver of bond yield variations and the effects of macroeconomic shocks on yield curve mostly materialize at the term premium component.

Since it is not easy to find such comprehensive survey data for a large set of countries, generally the information content of the yield curves is used to project the future path of short-term interest rates. The most commonly used parametric term structure models Nelson-Siegel (1987) and Svensson (1994), are very intuitive, easy to apply and provide high goodness-of-fit levels. However, these models do not allow for decomposition of long-term interest rates into expected short-rates and term premium (De Rezende, 2017). On the other hand, no-arbitrage term structure models provide the necessary framework by imposing consistent relationships for interest rates at different maturities and ensure that expected future path of yields coherently embedded in the estimated yield curves. Under the class of arbitrage-free interest rate models, affine term structure models dominate the related literature on extracting of the term premium from expected short-rates as workhorse models. The affine term structure models assume that observed market yields are linear combinations of observable or latent state variables/risk factors. This linearity assumption entails closed form solutions and high analytical and computational tractability of the term structure models. Duffie and Kan (1996) provide a complete characterization of affine term structure models.

Models classified under the third group also include macroeconomic, macro-financial variables in the state vectors in order to take into account the effect of macro risks on risk premiums. For instance, Joslin et al. (2014) employ the idea of unspanned macroeconomic factors which states that the selected macroeconomic variables have predictive ability for the term structure but not on the pricing of bonds. Their model includes the first principle component of two inflation and one economic activity indicator additional to the first three principle components of yield curve. Kopp and Williams (2018) state that in the case of US, a semi-structural dynamic term structure model augmented with macroeconomic factors results term premium estimates in line with previous studies and provides a more stable and realistic forecasts of risk-free rates. Abbritti et al. (2018) introduce global yield curve factors within FAVAR framework in the affine term structure model with domestic yield curve factors. In this framework, yields are assumed be governed not only by the traditional level-slope-

[1] For a detailed discussion please refer to Adrian et al. (2015) and Gürkaynak and Wright (2012).

curvature factors extracted from the observed interest rates but also affected by global level-global slope and global curvature-factors. They conclude that for a panel of advanced economies, global factors tend to explain long-term dynamics of yield curves where domestic factors are more relevant to short-term dynamics. Moreover, authors state that global curvature has a key role in shaping term premia dynamics. On the other hand, Adrian et al. (2013) also examine an extension of their specification with unspanned macro factors used in Joslin et al. (2014). The study emphasizes that extended specification with macro factors results with a poorer fit to the cross-section of US Treasury yield.

In terms of model estimation, most of the studies summarized above uses maximum likelihood methodology to estimate all parameters of the models at a single step. For the affine term structure models with large number of parameters, maximum likelihood estimation can be computationally challenging and some parameters can be weakly identified (Li et al., 2017). The ACM methodology on the other hand, offers a three step linear regressions system and it is computationally quite efficient. In this context, we employ ACM five factor model.[2]

Although, it has been argued that including survey data helps to overcome the small sample bias problem, if the surveys do not provide good measures of market participants' expectations, evidence supports that it would be better not to use them (Li et al., 2017). Since finding robust and comparable survey data for the 16 emerging market economies that we cover is not possible, we choose to leave survey based frameworks out of the scope of this study.

After extracting the term premium, we identify several macroeconomic and financial variables that can have explanatory power on the observed behavior of term premia. In terms of identification of the drivers of term premium, Wright (2011) and Bauer et al. (2014) point uncertainty related to inflation and economic growth as major drivers for a panel of 10 developed economies. Additionally, it is widely accepted that US monetary policy has significant effect on emerging market interest rates. In this context, Ceballos and Romero (2015) and Albagli et al. (2018) conduct studies with sample of 22–24 countries and conclude that US monetary spillover work through different channels. It is shown that for developed countries, transmission effect is dominant on risk neutral rates and for emerging market countries it is concentrated in term premium and exchange rate channel also plays a role for both country groups.

3. Term premium estimation methodology

This section summarizes the theoretical framework used in extraction of term premium. Term premia for the countries that are covered are estimated through a multi-step process. With the aim of elaborating the details of the employed methodology firstly the well-known parametric Nelson–Siegel yield curve model is briefly summarized. The estimated parameters of the Nelson–Siegel model enable us to calculate the monthly return data for the bonds with specific maturities which are necessary for implementation of the ACM model but do not actually exist in the market. Then affine term structure model which defines the internal consistency relationships for an arbitrage-free term structure framework, is described in detail since the arbitrage-free pricing framework and affine term structure models constitute natural starting point for term premium estimation. Then details of ACM model which is also based on this framework are discussed.

3.1. Nelson-Siegel model

Nelson and Siegel (1987) introduced a parametric yield curve model which is fitted to the cross-section of observed yields. The Nelson–Siegel (NS) model is one of the most widely used yield curve estimation technique due to its simplicity and success in capturing the main characteristics of the market rates. NS model given in Eq. (1) employs four main parameters in order to capture the level, slope and curvature of the yield curve.

$$r(m,\beta)=\beta_0+\beta_1\left[\frac{1-e^{\frac{-m}{\tau_1}}}{\frac{m}{\tau_1}}\right]+\beta_2\left[\frac{1-e^{\frac{-m}{\tau_1}}}{\frac{m}{\tau_1}}-e^{\frac{-m}{\tau_1}}\right] \tag{1}$$

In Eq. (1) m denotes the time to maturity and $\beta(\beta_0,\beta_1,\beta_2,\tau_1)$ are model parameters to be estimated where β_0 represents the level theoretical spot rates and discount factors are calculated by using the estimated NS parameters.

3.2. Arbitrage-free pricing framework and affine term structure models

The modelling framework for decomposition of expected short-term rates from term premium is based on the absence of arbitrage assumption. The most important implication of the absence of arbitrage is the existence of a positive stochastic process which gives the price of any traded asset at date t. This process is typically referred as a stochastic discount factor, M. The equation$P_t^{n+1}=E_t^P[P_{t+1}^n M_{t+1}]$, states that for a given stochastic discount factor the price of a zero coupon asset at time t is the expected value of discounted future price where P_t^n represents the price of an n-period zero coupon asset at time t, and its terminal value at its maturity, P_{t+n}^0 is normalized to 1. The existence of a stochastic discount factor also implies that there exists a risk-neutral measure$Q$, which is distinct from the physical measure,P The difference between expectations under the artificial risk neutral measure and historical, data generating measure is the market price of risk which captures the agents' attitude towards risk. The relation between risk-neutral and historical probability measure is $E_t^Q[P_{t+1}^n e^{-r_t}]=E_t^P[P_{t+1}^n M_{t+1}]$for the stochastic discount factor $M_{t+1}=\exp\left(-r_t-\frac{1}{2}\lambda_t{}'\lambda_t-\lambda_t\varepsilon_{t+1}\right)$ for a normally distributed variable ε and continuously compounded risk-free rate r_t. λ_t represents the market price of risk. When it is assumed that the market participants are risk-neutral $M_{t+1}=\exp(-r_t)$ and $P_t^n=E_t^P[e^{\Sigma_{i=0}^{n-1}-r_{t+i}}]$. However, when the investors are risk averse $P_t^n=E_t^Q[e^{\Sigma_{i=0}^{n-1}-r_{t+i}}]$. Given that zero coupon yield is equal to $y_t^n=\frac{\ln(P_t^n)}{n}$, the term premium is equal to

$$tp_t^n=\frac{\ln\left(E_t^Q\left[e^{\Sigma_{i=0}^{n-1}-r_{t+i}}\right]\right)}{n}-\frac{\ln\left(E_t^P\left[e^{\Sigma_{i=0}^{n-1}-r_{t+i}}\right]\right)}{n} \tag{2}$$

This formulization of term premium indicates that we have to specify dynamics of short-rate r and stochastic discount factor M and calculate the expected values.

The affine term structure (ATS) models consist the most popular arbitrage-free framework since they are highly tractable and impose a no-arbitrage condition that links yields at every maturity. They offer closed-form solutions for interest rates and such models are flexible enough to reproduce the moments of instrument yields and excess returns. The ATS assumes that

[2] We also estimate term premium using Abbritti et al. (2018) global financial factors model to confirm the robustness of our results. Results are not included but available upon request. Both estimated term premium series and panel regression yield similar results.

$$y^n = \mathrm{A}(n) + B(n)'X \tag{3}$$

for coefficients $\mathrm{A}(n), B(n)$ which depend on time to maturity n. Then the price process is also affine; $P_t^n = \exp(\mathcal{A}_n + \mathscr{B}_n X_t)$, where $\mathrm{A_n} = -\mathscr{A}_n/\mathrm{n}$ and $\mathrm{B_n} = -\mathscr{B}_n/\mathrm{n}$. The functions $\mathrm{A}(n), B(n)$ establish the necessary consistency relations between yields for different values of n.

The standard affine no-arbitrage term structure models is based on three main assumptions. The first assumption states that the risk-free short term interest rate is a linear function of a vector of state variables or factors i.e.

$$r_t = \delta_0 + \delta_1 X_t \tag{4}$$

The second assumption is that the dynamics of the state variables are described by a Vector Autoregression Process (VAR) under the objective probability measure;

$$X_{t+1} = \mu^P + \varphi^P \mathrm{X_t} + \Sigma\varepsilon_{t+1} \tag{5}$$

where $\varepsilon_{t+1} \sim$MVN(0,I). The final element of the model is the price of risk. The price of risk process is also assumed to be a linear function of the state variables;

$$\lambda_t = \Sigma^{-1}(\lambda_0 + \lambda_1 X_t) \tag{6}$$

The state variables follow a Gaussian VAR process under the risk neutral probability measure Q as well; $X_{t+1} = \mu^Q + \varphi^Q \mathrm{X_t} + \varepsilon_{t+1}^Q$, where $\mu^Q = \mu^P - \Sigma\lambda_0$ and $\varphi^Q = \varphi^P - \Sigma\lambda_1$. Putting it altogether, we get the following recursive relations;

$$\mathcal{A}_{n+1} = \mathcal{A}_n + \left(\mu^P - \Sigma\lambda_0\mathscr{B}_n + \frac{1}{2}\mathscr{B}_n\Sigma\Sigma\mathscr{B}_n - \delta_0\right. \tag{7}$$

$$\mathscr{B}_{n+1} = \left(\varphi^P - \Sigma\lambda_1\right)\mathscr{B}_n - \delta_1 \tag{8}$$

with initial values $\mathscr{A}_0 = 0$, $\mathscr{B}_0 = 0$. Yields estimated by using Eqs. (7) and (8) are constitutes the first term on the right hand side of Eq. (2) which is the market yields when investors are not risk neutral. And when it is assumed that the agents are risk neutral so the market price of risk, λ is equal to zero Eqs. (7) and (8) gives the second term on the right hand side of Eq. (2). By taking the difference we can find the term premium demanded by the investors for the respective maturity.

3.3. The ACM model

The ACM model (Adrian et al., 2013) introduces an excess holding period return equation to calculate the market price of risk coefficients. With the introduction of this additional equation, whole model parameters can be estimated through a series of linear regressions. Term premium calculation process starts with estimation of VAR(1) model to obtain parameters μ and ϕ in Eq. (5). The residuals form VAR equation are collected in matrix $\widehat{V}$ and compute $\widehat{\Sigma} = \widehat{V}\widehat{V}/T$. Then for n = 2, …, N one month log excess holding period returns are calculated as

$$rx_{t+1}^{n-1} = \log P_{t+1}^{n-1} - \log P_t^n - r_t^1 \tag{9}$$

For maturities up to N we get excess return series with length T as the summation of expected return, prices return innovations and price error and estimate the respective coefficients with OLS for Eq. (9).

$$rx_{t+1}^{n-1} = \alpha + cX_t + \beta\widehat{V} + e_{t+1}^{n-1} \tag{10}$$

After collecting residuals e, the variance of the error terms $\sigma = trace(\widehat{e}\widehat{e}')/NT$ is calculated. Using the estimated parameters, the price of risk parameters are estimated as

$$\lambda_0 = (\beta\beta')^{-1}\beta\left(a + \frac{1}{2}\left(B^* vec(\Sigma) + \sigma^2\right)\right)\lambda_1 = (\beta\beta')^{-1}\beta c \tag{11}$$

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

4. Data and results of the term premium estimation procedure

Using the methodology summarized in the previous section, term premium series of 16 emerging market economies are estimated. The set of these emerging markets consist of Brazil, Columbia, Czech Republic, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand and Turkey. Bloomberg data for 3 months, 6 months, and 1–10 years zero-coupon yields of these countries for the period January 2010 to October 2018 are used in estimation. The set of the countries is determined according to the data availability. Regarding the estimation period, although working with a longer data period would be more robust in terms of handling small sample bias problem, we had to take the maturity spectrum coverage into consideration as well. For instance, in Turkey issuance of sovereign bonds with 10 year maturity started in 2010. Therefore, extrapolating 10 year yields for the period before the first 10 year issuance with the yield curve parameters estimated using market yields up to 5 years could lead to misguiding conclusions. The daily series taken from Bloomberg are zero coupon yields derived by stripping the corresponding country's par coupon curve. We work with monthly data in order to test the possible effects of macroeconomic indicators on term premium. In this context monthly yield series used in the term premium estimation are the simple mean of respective months' daily observations. This section aims to elaborate the steps of our term premium estimation process, analyze the features of the decomposed expected future short-term interest rates and term premium series for the covered 16 countries.

Term premium estimation starts with identification and extraction of state variable series. In order to determine the number of factors to be used in application of the ACM framework, the cumulative portion of the sample variance of yields explained by the first six principle component are examined. As it is represented in Table 1, first five principle components explain almost all of the variation in the yield curves for the selected group of countries. The results for the yields with maturities from 3, 6, …, 117,120 months are presented in adhere to baseline specification of the model and use the first five principle components of each countries' yield curve as their state factors. Fitted NS yield curve parameters are used to generate time series of yields. The principle components are extracted from these fitted yield series. Then the VAR(1) dynamics of the state variables under the objective probability measure (Eq. (5)) are estimated by ordinary least squares (OLS) and error terms and their variance-covariance matrix are collected. Using generated asset prices and one month interest rate series implied by NS yield curves one month excess holding period returns are calculated as defined in Eq. (9). Estimation of Eq. (10) by OLS yields the error term series $\widehat{e}$ and after calculating variance of these errors we can compute the market price of risk parameters presented in Eq. (11) directly. Therefore, the ACM model employs only OLS estimations and reach recursive affine term structure parameters without using

Table 1
Principle component analysis of sovereign yields.

	Principle Components					
	1	**2**	**3**	**4**	**5**	**6**
Brazil						
Proportion of Total Variance Explained	97.0872	2.7251	0.1641	0.0224	0.0011	0.0000
Cumulative Proportions	97.087	99.812	99.976	99.999	100.000	100.000
Columbia						
Proportion of Total Variance Explained	95.6512	4.1176	0.2091	0.0207	0.0014	0.0001
Cumulative Proportions	95.651	99.769	99.978	99.999	100.000	100.000
Czech Rep.						
Proportion of Total Variance Explained	94.2075	5.5630	0.2028	0.0250	0.0016	0.0001
Cumulative Proportions	94.208	99.771	99.973	99.998	100.000	100.000
Hungary						
Proportion of Total Variance Explained	92.6822	7.0703	0.2285	0.0176	0.0013	0.0001
Cumulative Proportions	92.682	99.753	99.981	99.999	100.000	100.000
India						
Proportion of Total Variance Explained	96.0448	3.7652	0.1451	0.0424	0.0024	0.0001
Cumulative Proportions	96.045	99.810	99.955	99.998	100.000	100.000
Indonesia						
Proportion of Total Variance Explained	96.8282	2.9317	0.2238	0.0154	0.0009	0.0000
Cumulative Proportions	96.828	99.760	99.984	99.999	100.000	100.000
Malaysia						
Proportion of Total Variance Explained	96.6344	2.9558	0.3721	0.0349	0.0027	0.0002
Cumulative Proportions	96.634	99.590	99.962	99.997	100.000	100.000
Mexico						
Proportion of Total Variance Explained	96.6210	2.9049	0.4463	0.0268	0.0010	0.0001
Cumulative Proportions	96.621	99.526	99.972	99.999	100.000	100.000
Peru						
Proportion of Total Variance Explained	97.5303	2.2511	0.1889	0.0283	0.0013	0.0001
Cumulative Proportions	97.530	99.781	99.970	99.999	100.000	100.000
Phillipines						
Proportion of Total Variance Explained	98.7326	1.0937	0.1637	0.0093	0.0005	0.0000
Cumulative Proportions	98.733	99.826	99.990	99.999	100.000	100.000
Poland						
Proportion of Total Variance Explained	95.2188	4.6270	0.1273	0.0258	0.0011	0.0000
Cumulative Proportions	95.219	99.846	99.973	99.999	100.000	100.000
Russia						
Proportion of Total Variance Explained	85.0533	13.9758	0.9053	0.0611	0.0043	0.0002
Cumulative Proportions	85.053	99.029	99.934	99.996	100.000	100.000
South Africa						
Proportion of Total Variance Explained	93.0541	6.5738	0.3291	0.0416	0.0013	0.0001
Cumulative Proportions	93.054	99.628	99.957	99.999	100.000	100.000
Taiwan						
Proportion of Total Variance Explained	96.1388	3.7382	0.0987	0.0232	0.0011	0.0000
Cumulative Proportions	96.139	99.877	99.976	99.999	100.000	100.000
Thailand						
Proportion of Total Variance Explained	89.1005	10.0272	0.7938	0.0748	0.0033	0.0003
Cumulative Proportions	89.101	99.128	99.922	99.996	100.000	100.000
Turkey						
Proportion of Total Variance Explained	84.1752	15.1225	0.6657	0.0343	0.0021	0.0002
Cumulative Proportions	84.175	99.298	99.963	99.998	100.000	100.000

any optimization of likelihood functions.

Extracted term premiums of 5 and 10 year yields are presented in Fig. 1, Fig. 2 respectively and descriptive statistics for yields and their risk-neutral yield and term premium components are summarized in Table 2. For each country market observed mid and long-term yield, risk neutral yields estimated as the 5 and 10 years horizon average of projected one month yields and term premium series estimated as the difference of these two components are shown. There are several points to be noted in the figures. First of all, since our data set is a heterogonous sample which consist of emerging market economies with different characteristics, yields and their components do not follow a single pattern throughout the observation period. For instance, in Eastern European countries market yields trended downward staring with the European Debt Crises and have continued with declining policy rates and quantitative easing in the Eurozone. This trend seems to influence risk neutral yields as well, the most prominent example is Hungary where the estimated mid and long-term risk neutral rates are floating around zero lower bound. Meanwhile country's 5 and 10 year term premium have fluctuated in a narrow range (see Fig. 3).

For the countries other than Eastern European countries, the risk neutral rates have been stable around levels that are a few percentage points lower than market yields in general and variations observed in mid and long-term yields have been absorbed by the term premium component. This visual observation is supported by the descriptive statistics provided in Table 2. Country wise market yield, risk neutral rate and term premium variance figures reveal that contribution of term premia variance to market yields' variance are higher than variation stems from risk neutral rates in most of the cases. Another common feature of non-European countries is the non-negativity of 5 and 10 year risk neutral rates. And their term premium components have rarely broken the zero lower bound.

In the cases of Brazil and Russia a higher ratio of market yield variation is attributed to the variance of risk neutral yields. This also holds for Turkey. Additionally, Turkey's term premium is negative

Fig. 1. Decomposition of 5 year rates (% per annum).

for most of the observation period.[3] There are also other countries like Indonesia or Russia where the term premium have tested negative levels. The recent discussions generally concentrates on the decline of the term premium in advanced economies following the Global Financial Crisis. The stagnant compression observed in term premia in advanced market economies has generally been associated with the quantitative easing policies applied by Fed and ECB. While there are several studies referring to the negative term premium in developed countries, one of the rare studies referring to the negative term premium in emerging market economies is about Poland. Jablecki et al. (2018) show that term premium in Poland has been declined to negative levels and discuss possible reasons as the shortage in Treasury bonds with short maturities and declining uncertainty about the future path of the short-term interest rates. Aydin and Ozel (2019) estimate term premia for Turkey by using ACM and Joslin et al. (2011) methodologies. While ACM and JSZ term premium estimations yield similar results for Turkey, authors stated that while the Central Bank of the Republic of Turkey (CBRT) actively implemented the interest rate corridor, simultaneously term premia turns into negative territory after mid-2010. It is also emphasized that this policy had also aimed to encourage investors to portfolios with longer term and discouraging them in the short end of the curve which leads to negative term premia. They indicate that, the CBRT has referred to inverted yield curve as an indication of tight monetary policy stance.

While an inverted yield curve indicates a tight monetary stance, it also supports the expectation that in the medium to long-term as the inflation declines the rates would be declining as well. Obviously as the interest rates at the short-end of the curve gets lower the rest of the curve also retreats at varying degrees. Assets with medium and long term maturity would benefit more from such a move due to the duration effect. Therefore, invertedness of the yield curve may capture the potential duration gains associated to the possibility of a future bull-steepening in the yield curve.

Following the significant upward trend in the market yields in the third quarter of 2018, term premium turned to positive for 5 year yields and tested the zero upper bound for 10 year yields only. A common feature of Brazil, Russia and Turkey is the invertedness of their yield curves for more than a quarter of the observations. In this study, the slope indicator of the yield curve is calculated as the difference of 10 year and 3 month yields. Russia's yield curve became inverted at the end of 2014 and stayed this way for most of the 2016–2017 period. In the case of Brazil the yield curve was inverted from the end of 2014 till the second quarter of 2017. For Turkey 10 year–3 month yield difference was negative for most of the year 2015 and starting from February 2017 it has become inverted again. The inverted yield curve generally implies a tight monetary policy stance and assumed to affect growth and inflation projections as well as the future path of short-term interest rates. Today's tighter monetary policy is assumed to indicate looser

[3] On the other hand, as it is commonly emphasized in the literature related to the ACM methodology, only principal components of nominal yields are used as the pricing factors that drive bond yield movements. Cohen et al. (2018) points out that yield based factors are weighted sums of yields and using only yield depended data may lead to overreaction of the yields to changes in the general level of interest rates. It is also stated that "In particular, they may tend to interpret a change in interest rates as evidence that the steady-state (long-run) interest rate has changed correspondingly". In this regard it is possible that to some extent higher level of projected short-term interest rates may stem from this property of the applied methodology.

Fig. 2. Decomposition of 10 year rates (% per annum).

monetary conditions in the future. The following panel regression exercise investigates the influence of slope of yield curve on term premium. Another point to be noted is the relatively lower variance level of longer term risk neutral returns. While for almost half of the countries, variance of 10 year market yields are lower than 5 year yield variances and variation of 10 year risk neutral yields are lower than their 5 year counterparties for almost all of the countries. And the order is reverse for term premium components. So, risk neutral returns are assumed to be more stabilized for longer projection horizons while a higher share of variation in the yields are absorbed by term premium.

Level of bilateral relations between countries' 5 and 10 year yields, corresponding term premium and risk-neutral yield components are shown in Tables 3 and 4. While the risk-neutral yields do not show a clear pattern, country term premiums are positively correlated for most of the country pairs. This observation and the related literature help us to deduce that country specific factors like inflation or growth expectations might lead risk neutral yields. On the other hand, relatively higher level of interdependence between country term premiums might point a noteworthy role for global factors on term premium.

5. Cross-country analysis of term premia

Estimated term premium series are found to be positively correlated across countries in general and this observation raises interest in the effect of common global factors on term premium dynamics. Obviously, term premium has not only be governed by the common factors; country specific variables are also important in determining the course of the term premium. In this regard, uncertainty about the inflation and economic growth have been identified as the major determinants of term premium in literature. Additionally, financial market indicators like implied exchange rate volatility or liquidity premium which has not been separated from the market yields have potential to affect the level of term premium. In order to analyze the relation between term premium and country specific macroeconomic and financial market indicators and global financial indicators this section utilizes a panel data regression model. In this regard, in the following subsection we discuss the econometric model has been used and which variables are chosen for the model. Lastly, results of the employed panel data regression model are reviewed.

5.1. Panel data regression models

In order to examine the effects of country specific and global factors on the term premia of the selected countries, panel fixed effects regression method is used. Fixed effect models make it possible to capture time-invariant differences between countries which reduce the effects of possible biases that may stem from country specific factors. In order to explore the dynamics of term premia for the selected group of countries we run the following panel regression specification;

$$tp_t^i = c^i + \beta * D_t^i + \alpha * G_t + \varepsilon_t^i \tag{12}$$

where $tp_t^i, D_t^i and\ G_t$ present term premia, domestic and global factors respectively. The superscript is the country index, t denotes time, c^i is the fixed intercept for country$i$, β and α are domestic and global coefficient vectors and ε_t^i denotes the error term. The first set of independent variables are country specific financial and macroeconomic indicators and the second group gathers global factors that are expected to influence risk premium demanded by investors. A large set of domestic and global variables are tested in terms of their explanatory power on term premium. The most relevant variables are identified as the market liquidity conditions indicator, inflation surprise measure as a domestic indicator and volatility index and U.S. term premium as global variables. The global variables are included as a control for international behavior of risk taking and term premia that might affect local premium.

The arbitrage-free affine term structure framework does not allow the separation of liquidity premium from the term premium. However, when the market liquidity is tight and liquidating a position is more costly, investors demand an additional liquidity premium in order to compensate this risk. By introducing a liquidity indicator term, we aim to capture this embedded effect of market liquidity in the term premium. Other domestic variables are included to capture the impact of inflation and economic growth surprises on term premium. Although macroeconomic indicators are announced with a time lag, their deviation from market expectations have significant signaling effect in formation of market agents' future monetary stance projections and the level of uncertainty attached to these projections. When investors assess inflation as a major source of uncertainty for their future income, they are expected to demand an extra compensation.

5.2. Variables used in panel data regression model

As it is discussed in the previous section, one of our main contributions is to show precisely the reaction of term premium to changing market liquidity conditions. In order to measure market liquidity conditions, the liquidity indicator developed by Hu et al. (2013) is used. Hu, Pan and Wang (HPW) liquidity indicator is based on the pricing errors of a fitted parametric yield curve relative to market yields. By using the Bloomberg zero coupon yield database, we construct time series of zero coupon yield curves with NS model given in Eq. (1) for each country.

Following the HPW, to construct liquidity measure, the dispersion of yields around the fitted yield curve are measured as follows:

$$Noise_t = \sqrt{\frac{1}{N_t}\sum_{i=1}^{N_t}\left[y_t^i - y_t^i(\beta_t)\right]^2} \quad (13)$$

where y_t^i denotes the market yield and $y_t^i(\beta_t)$ denotes model-implied yields of each of N_t assets traded/quoted in the market on day t. The root mean squared distance between the market yields and the model-implied yields around the entire curve constitutes the liquidity measure. Driessen et al. (2016) construct two measures of noise similar to that of HPW and find some degree of liquidity segmentation between short and long term bonds. Taking possibility of segmentation of yield curve into consideration, we identify individual elements of the summation in Eq. (13) as the liquidity measure of corresponding segment. Therefore, we construct 5 and 10 year liquidity measures as square root of model implied and market observed yields squared difference.[4]

[4] The market observed yields are the zero coupon yields taken directly from the Bloomberg, which are basically calculated from the par coupon sovereign curve derived from the market observed sovereign yields for 5 and 10 year maturities. Although we do not directly work with individual bonds since the number of traded bonds in emerging market countries in each segment can be limited. In such a case bond specific features can also affect the liquidity indicator.

Table 2
Descriptive statistics for 5 and 10 year yield decomposition results.

	5 Year Yields				10 Year Yields			
	Mean	**Var.**	**Min.**	**Max.**	**Mean**	**Var.**	**Min.**	**Max.**
Brazil					**Brazil**			
Market Yield	11.76	3.63	8.65	16.91	12.06	3.10	9.31	17.07
Risk Neutral Yield	9.10	2.56	5.97	12.70	8.51	0.84	6.71	10.59
Term Premium	2.66	0.85	0.42	5.55	3.54	1.43	0.95	7.82
Columbia					**Columbia**			
Market Yield	6.50	0.78	4.43	8.57	7.29	0.89	5.02	9.62
Risk Neutral Yield	4.64	0.08	3.96	5.13	4.66	0.02	4.32	4.91
Term Premium	1.87	0.90	−0.03	4.32	2.63	0.91	0.43	5.17
Czech Rep.					**Czech Rep.**			
Market Yield	1.26	1.16	−0.09	3.38	2.05	1.69	0.14	4.66
Risk Neutral Yield	0.49	0.16	−0.17	1.26	0.52	0.07	0.11	1.02
Term Premium	0.75	0.52	−0.30	2.27	1.49	1.16	−0.18	3.69
Hungary					**Hungary**			
Market Yield	4.46	5.76	1.20	9.19	5.19	4.39	2.15	9.27
Risk Neutral Yield	1.80	3.94	−0.81	5.75	0.98	2.25	−1.00	3.96
Term Premium	2.64	0.26	1.55	3.63	4.09	0.57	2.26	5.62
India					**India**			
Market Yield	7.84	0.52	6.39	9.12	8.19	0.49	6.49	9.70
Risk Neutral Yield	7.56	0.12	6.88	8.28	7.53	0.03	7.16	7.92
Term Premium	0.28	0.15	−0.55	1.01	0.66	0.27	−0.66	1.78
Indonesia					**Indonesia**			
Market Yield	7.03	1.20	4.82	9.44	7.51	1.20	5.38	10.66
Risk Neutral Yield	5.99	0.04	5.60	6.45	5.98	0.01	5.79	6.21
Term Premium	0.45	0.81	−1.43	2.57	3.40	1.68	1.08	6.54
Malaysia					**Malaysia**			
Market Yield	3.58	0.05	3.09	4.04	3.95	0.07	3.12	4.63
Risk Neutral Yield	3.05	0.00	2.95	3.10	3.06	0.00	3.01	3.08
Term Premium	0.53	0.05	0.02	1.00	0.90	0.07	0.06	1.60
Mexico					**Mexico**			
Market Yield	7.73	0.58	5.50	9.58	8.50	0.46	6.25	9.91
Risk Neutral Yield	6.44	0.08	5.80	6.98	6.44	0.02	6.13	6.70
Term Premium	1.28	0.34	−0.70	2.59	2.05	0.36	−0.07	3.38
Peru					**Peru**			
Market Yield	4.77	0.60	3.04	6.71	5.93	0.69	4.14	8.02
Risk Neutral Yield	3.51	0.03	3.15	3.92	3.50	0.01	3.33	3.71
Term Premium	1.27	0.38	−0.12	2.78	2.44	0.57	0.81	4.35
Phillipines					**Phillipines**			
Market Yield	4.45	2.21	2.41	10.63	5.00	2.03	2.85	9.39
Risk Neutral Yield	2.97	0.12	2.48	4.19	2.93	0.03	2.69	3.53
Term Premium	1.49	1.33	−0.08	6.46	2.08	1.60	0.14	6.07
Poland					**Poland**			
Market Yield	3.54	1.68	1.89	5.89	4.16	1.57	2.23	6.44
Risk Neutral Yield	1.86	0.60	0.90	3.29	1.58	0.16	1.07	2.34
Term Premium	1.69	0.28	0.96	2.62	2.59	0.75	1.14	4.12
Russia					**Russia**			
Market Yield	8.26	3.12	6.26	15.60	8.49	2.23	6.66	13.98
Risk Neutral Yield	7.54	1.24	6.04	10.96	7.60	0.34	6.83	9.42
Term Premium	0.79	1.20	−0.53	5.22	0.92	1.46	−0.61	4.94
South Africa					**South Africa**			
Market Yield	7.73	0.60	5.50	9.58	8.59	0.45	6.35	10.02
Risk Neutral Yield	6.27	0.07	5.64	6.80	6.24	0.02	5.94	6.49
Term Premium	1.46	0.34	−0.53	2.80	2.35	0.36	0.23	3.70
Taiwan					**Taiwan**			
Market Yield	0.98	0.04	0.56	1.31	1.37	0.08	0.78	1.84
Risk Neutral Yield	0.52	0.00	0.45	0.59	0.52	0.00	0.49	0.56
Term Premium	0.46	0.03	0.09	0.77	0.85	0.08	0.28	1.35
Thailand					**Thailand**			
Market Yield	2.79	0.43	1.53	4.05	3.30	0.39	1.84	4.43
Risk Neutral Yield	1.99	0.12	1.50	2.81	1.95	0.04	1.67	2.41
Term Premium	0.80	0.13	−0.04	1.45	1.36	0.23	0.15	2.43
Turkey					**Turkey**			
Market Yield	10.25	4.13	5.89	24.39	10.18	3.43	8.16	22.83
Risk Neutral Yield	13.97	3.43	8.16	22.83	13.93	3.18	10.95	21.75
Term Premium	−1.98	0.98	−4.70	2.91	−3.80	0.64	−5.50	0.61

Piazzesi and Schneider (2006) suggest that term premia could be influenced by the compensation demanded for the risk of unexpected inflation or the uncertainty related to the future path of

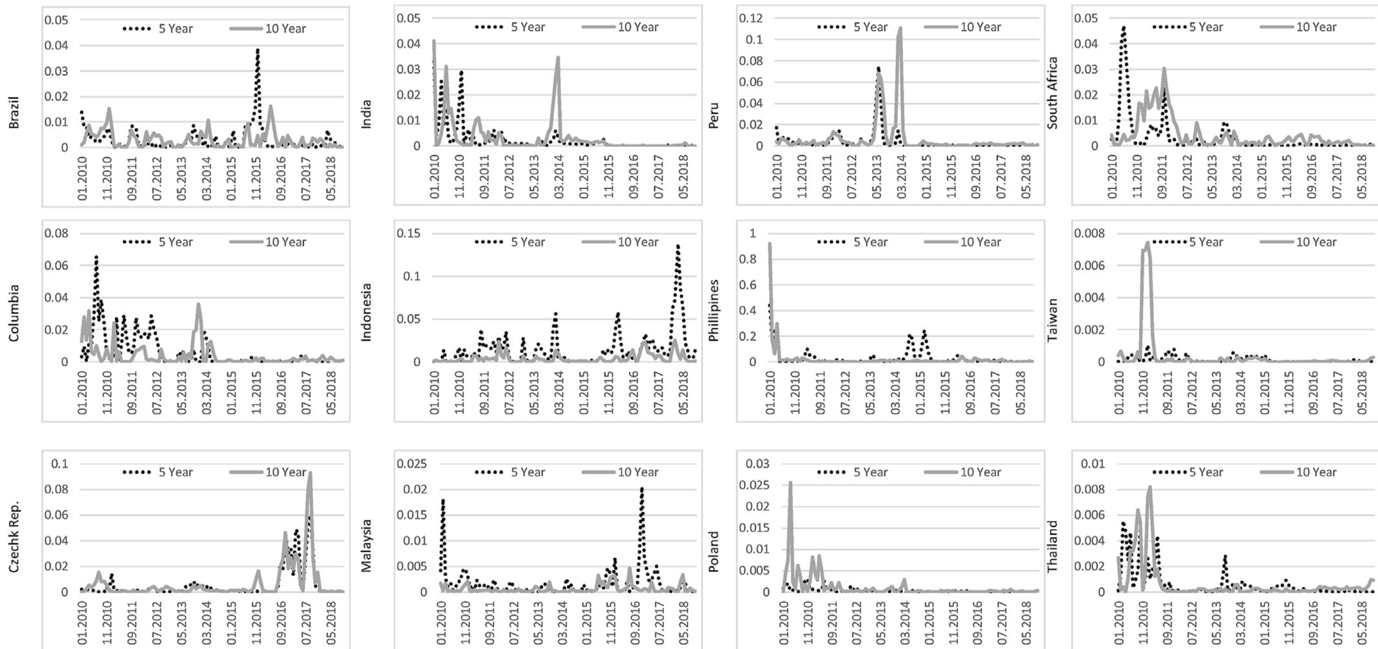

Fig. 3. Sovereign bond market liquidity indicator.

monetary policy[5]. Wright (2011) also finds a strong positive relation between term premium and inflation uncertainty. Taking these statements into consideration, we test the relationship between inflation uncertainty and term premia. This study uses the Citigroup country inflation surprise indices (ISI) in order to gauge the role of diversion between agents' expectations and realized values of inflation related indicators. Citigroup inflation surprise index is calculated as a weighted historical standard deviation of data surprises between actual inflation measures and Bloomberg survey median forecasts. According to the Citigroup's definition, weights of indicators are derived from the announcement effect of the respective inflation indicator on foreign exchange rates. Although this indicator is backward looking, it is used under the assumption that high deviations of inflation forecasts from the realized values would heighten agents' inflation related risk perception and might lead them to demand higher compensation for this unexpected variation. We also test the relevance of uncertainty related to macroeconomic conditions in driving term premia by using the Citigroup Economic Surprise Index (CESI), since it might influence expectations related to future stance of monetary policy. Similar to the inflation surprise index, CESI tracks how the economic data fare relative to the expectations. The index rises when the published data suppress the economist' consensus estimates. The country wise indexes can be seen in Fig. 4.

The implied volatility of 3 months at-the-money domestic currency versus USD options are included in the set of explanatory variables. The implied volatility is assumed to capture exchange rate related uncertainties. Especially for emerging market economies which attracted international fixed income portfolio inflows, expected returns in foreign exchange are important and an increase in implied volatilities might cause investors to demand higher term premium because of their increased perception of currency risk.

In order to analyze the relation between global financial factors and emerging market term premia, Chicago Board Options Exchange Volatility Index (VIX), a generally accepted indicator of global risk appetite, is used. Additionally, the Merrill Lynch Option Volatility Estimate Index (MOVE), which is the bond market equivalent of VIX and helps to gauge the degree of risk aversion in fixed income markets are included in the analysis. The monthly surprise indices, VIX, MOVE and implied volatility series are downloaded from the aforementioned data provider.

5.3. Estimation results of panel regressions

In order to examine the effects of country specific and global factors on the term premia of the selected countries, panel fixed effects regression method is used.[6] Fixed effect models make it possible to capture time-invariant differences between countries which reduce the effects of possible biases that may stem from country specific factors.

Table 5 presents the results of fixed effect panel regression model given in Eq. (12) for 5 year term premium (TP 5Y) and 10 year term premium (TP 10Y) series of 16 countries in our data sample.[7] In the order of Table 5, liquidity indicator and currency related uncertainty factors correspond to country specific financial market factors, inflation and economic environment uncertainty factors correspond to country specific macroeconomic factors and the VIX Index covers the global financial indicator in Eq. (12). The first and third specifications utilize these listed factors as independent variables.[8] As it is stated, all of our variables are stationary, so the regression results are for level variables. In case of 5 year term premium, results of Model 1 show that liquidity indicator for the

[5] Authors find that while on average the U.K. nominal yield curve is sloped upwards, the real yield curve is sloped downwards, since uncertainty related to future path of inflation makes long-term nominal bonds riskier.

[6] The output from Hausman tests imply that the null hypothesis is rejected at the 10% level and fixed effects specification is to be preferred.

[7] The panel unit root test results provide evidence that the variables are stationary, results are available upon request.

[8] MOVE Index was also tested as a global risk factor and the corresponding results do not have a higher explanatory power over the regressions that use VIX Index. Therefore, since VIX is more commonly used as a global risk indicator, we decided to continue with it.

Table 3
International correlation matrix for 5 year rates.

Correlation of 5 year zero coupon yields

	Brazil	Columbia	Czech R.	Hungary	India	Indonesia	Malaysia	Mexico	Peru	Phillippines	Poland	Russia	S. Africa	Taiwan	Thailand	Turkey
Brazil																
Columbia	0.66															
Czech R.	0.00	0.38														
Hungary	0.06	0.27	0.83													
India	0.29	-0.03	0.28	0.50												
Indonesia	0.72	0.52	-0.09	-0.24	0.07											
Malaysia	0.23	0.07	-0.26	-0.51	-0.12	0.61										
Mexico	0.54	0.60	-0.14	-0.42	-0.30	0.67	0.48									
Peru	0.78	0.65	-0.19	-0.16	0.06	0.59	0.27	0.64								
Phillippines	0.01	0.49	0.66	0.32	-0.28	0.18	0.13	0.26	-0.11							
Poland	0.07	0.43	0.91	0.91	0.29	-0.13	-0.39	-0.23	-0.06	0.50						
Russia	0.52	0.09	-0.43	-0.29	0.16	0.38	0.35	0.21	0.45	-0.22	-0.42					
S. Africa	0.52	0.66	-0.08	-0.36	-0.29	0.66	0.47	0.91	0.66	0.34	-0.16	0.22				
Taiwan	0.26	0.05	0.46	0.60	0.62	0.17	0.01	-0.33	0.01	0.02	0.53	-0.16	-0.31			
Thailand	0.08	0.11	0.72	0.86	0.66	-0.08	-0.29	-0.47	-0.19	0.16	0.78	-0.26	-0.42	0.81		
Turkey	-0.17	0.00	0.01	-0.37	-0.23	0.19	0.45	0.44	0.04	0.38	-0.28	-0.10	0.44	-0.45	-0.37	

Correlation of term premium related to 5 year zero coupon yields

	Brazil	Columbia	Czech R.	Hungary	India	Indonesia	Malaysia	Mexico	Peru	Phillippines	Poland	Russia	S. Africa	Taiwan	Thailand	Turkey
Brazil																
Columbia	0.28															
Czech R.	0.00	0.51														
Hungary	0.00	0.47	0.85													
India	0.30	0.06	0.33	0.43												
Indonesia	0.29	0.49	0.03	0.10	0.12											
Malaysia	0.22	0.10	-0.18	-0.15	-0.13	0.51										
Mexico	0.48	0.54	-0.05	-0.03	-0.18	0.60	0.46									
Peru	0.28	0.47	-0.24	-0.09	0.07	0.46	0.24	0.53								
Phillippines	0.10	0.55	0.57	0.44	-0.18	0.22	0.23	0.34	-0.13							
Poland	-0.08	0.57	0.91	0.84	0.35	-0.05	-0.31	-0.09	-0.03	0.45						
Russia	0.26	0.16	0.01	0.11	0.40	0.20	0.21	0.04	0.32	0.10	0.06					
S. Africa	0.45	0.61	0.01	0.05	-0.15	0.57	0.47	0.86	0.56	0.41	-0.01	0.08				
Taiwan	-0.06	0.21	0.49	0.53	0.57	0.25	0.09	-0.20	0.02	0.04	0.48	0.52	-0.16			
Thailand	0.04	0.24	0.73	0.73	0.60	0.12	-0.04	-0.24	-0.21	0.16	0.66	0.19	-0.19	0.82		
Turkey	0.24	0.07	0.10	0.10	-0.02	0.15	0.19	0.15	-0.18	0.43	-0.03	0.01	0.16	-0.16	-0.01	

Correlation of risk neutral 5 year zero coupon yields

	Brazil	Columbia	Czech R.	Hungary	India	Indonesia	Malaysia	Mexico	Peru	Phillippines	Poland	Russia	S. Africa	Taiwan	Thailand	Turkey
Brazil																
Columbia	0.08															
Czech R.	0.06	-0.37														
Hungary	0.09	-0.36	0.68													
India	0.12	-0.04	0.12	0.45												
Indonesia	0.63	-0.03	-0.15	-0.35	0.04											
Malaysia	0.03	0.47	-0.32	-0.35	0.30	0.09										
Mexico	0.53	0.32	-0.24	-0.55	-0.43	0.52	0.08									
Peru	0.78	0.34	-0.03	-0.08	0.07	0.61	0.17	0.60								
Phillippines	-0.01	-0.35	0.74	0.33	-0.34	0.07	-0.56	0.02	-0.02							
Poland	0.15	-0.53	0.76	0.89	0.21	-0.22	-0.59	-0.38	-0.01	0.57						
Russia	0.33	0.68	-0.55	-0.58	-0.03	0.39	0.60	0.48	0.38	-0.50	-0.74					
S. Africa	0.53	0.33	-0.18	-0.54	-0.45	0.50	0.08	0.94	0.62	0.06	-0.36	0.48				
Taiwan	-0.12	0.17	0.34	0.54	0.48	-0.46	0.24	-0.55	-0.13	-0.10	0.36	-0.17	-0.52			
Thailand	0.06	-0.36	0.60	0.90	0.60	-0.30	-0.21	-0.63	-0.12	0.19	0.79	-0.57	-0.61	0.68		
Turkey	-0.37	0.09	0.09	-0.49	-0.26	0.18	0.23	0.17	-0.01	0.27	-0.33	0.04	0.22	-0.17	-0.42	

Table 4
International correlation matrix for 10 year rates.

Correlation of 10 year zero coupon yields

	Brazil	Columbia	Czech R.	Hungary	India	Indonesia	Malaysia	Mexico	Peru	Phillippines	Poland	Russia	S. Africa	Taiwan	Thailand	Turkey
Brazil																
Columbia	0.74															
Czech R.	-0.01	0.33														
Hungary	0.04	0.26	0.87													
India	0.37	0.18	0.48	0.57												
Indonesia	0.67	0.67	0.15	0.01	0.26											
Malaysia	0.50	0.53	-0.03	-0.23	0.05	0.72										
Mexico	0.36	0.51	-0.09	-0.32	-0.30	0.49	0.56									
Peru	0.82	0.78	0.00	0.03	0.15	0.62	0.55	0.53								
Phillippines	-0.03	0.47	0.69	0.42	-0.01	0.23	0.26	0.35	0.12							
Poland	0.04	0.40	0.92	0.91	0.41	0.13	-0.07	-0.05	0.13	0.61						
Russia	0.56	0.31	-0.38	-0.23	0.15	0.30	0.31	0.02	0.45	-0.29	-0.37					
S. Africa	0.34	0.58	-0.02	-0.25	-0.27	0.48	0.58	0.87	0.55	0.41	0.03	0.02				
Taiwan	0.34	0.28	0.43	0.50	0.59	0.47	0.20	-0.28	0.24	0.10	0.42	0.30	-0.24			
Thailand	0.09	0.10	0.73	0.78	0.71	0.25	0.02	-0.39	-0.01	0.20	0.67	-0.13	-0.34	0.75		
Turkey	-0.10	0.05	-0.05	-0.36	-0.23	0.17	0.43	0.60	0.03	0.40	-0.19	-0.13	0.57	-0.44	-0.32	

Correlation of term premium related to 10 year zero coupon yields

	Brazil	Columbia	Czech R.	Hungary	India	Indonesia	Malaysia	Mexico	Peru	Phillippines	Poland	Russia	S. Africa	Taiwan	Thailand	Turkey
Brazil																
Columbia	0.56															
Czech R.	-0.01	0.37														
Hungary	-0.04	0.34	0.83													
India	0.43	0.30	0.57	0.50												
Indonesia	0.46	0.78	0.50	0.53	0.59											
Malaysia	0.42	0.54	-0.01	0.05	0.10	0.49										
Mexico	0.33	0.48	-0.04	-0.02	-0.19	0.20	0.52									
Peru	0.65	0.74	-0.02	0.12	0.18	0.63	0.55	0.47								
Phillippines	-0.05	0.51	0.62	0.47	0.09	0.31	0.27	0.39	0.13							
Poland	-0.02	0.46	0.91	0.85	0.46	0.52	-0.04	0.05	0.15	0.60						
Russia	0.50	0.34	-0.14	-0.06	0.31	0.41	0.30	-0.06	0.47	-0.14	-0.13					
S. Africa	0.32	0.56	0.03	0.08	-0.14	0.25	0.56	0.84	0.50	0.45	0.14	-0.04				
Taiwan	0.14	0.35	0.45	0.47	0.61	0.74	0.24	-0.25	0.26	0.09	0.37	0.47	-0.20			
Thailand	0.07	0.18	0.69	0.70	0.69	0.62	0.19	-0.25	0.04	0.15	0.55	0.13	-0.20	0.76		
Turkey	0.19	0.28	0.16	0.09	0.00	0.10	0.46	0.43	0.09	0.51	0.07	-0.08	0.46	-0.14	0.02	

Correlation of risk neutral 10 year zero coupon yields

	Brazil	Columbia	Czech R.	Hungary	India	Indonesia	Malaysia	Mexico	Peru	Phillippines	Poland	Russia	S. Africa	Taiwan	Thailand	Turkey
Brazil																
Columbia	0.05															
Czech R.	0.08	-0.36														
Hungary	0.10	-0.36	0.66													
India	0.12	-0.05	0.12	0.46												
Indonesia	0.63	-0.04	-0.14	-0.35	0.05											
Malaysia	0.02	0.47	-0.30	-0.35	0.29	0.09										
Mexico	0.52	0.31	-0.21	-0.55	-0.43	0.52	0.08									
Peru	0.77	0.33	-0.02	-0.08	0.08	0.61	0.17	0.60								
Phillippines	0.00	-0.35	0.73	0.33	-0.33	0.07	-0.56	0.02	-0.02							
Poland	0.17	-0.56	0.75	0.87	0.19	-0.19	-0.60	-0.36	0.00	0.59						
Russia	0.33	0.67	-0.52	-0.57	-0.04	0.39	0.60	0.48	0.38	-0.49	-0.74					
S. Africa	0.51	0.32	-0.16	-0.54	-0.46	0.50	0.08	0.94	0.62	0.06	-0.34	0.47				
Taiwan	-0.12	0.17	0.33	0.54	0.47	-0.46	0.24	-0.56	-0.13	-0.10	0.33	-0.17	-0.52			
Thailand	0.08	-0.38	0.58	0.90	0.60	-0.28	-0.22	-0.63	-0.12	0.20	0.78	-0.56	-0.61	0.67		
Turkey	-0.37	0.09	0.11	-0.49	-0.26	0.19	0.22	0.18	0.01	0.28	-0.31	0.03	0.22	-0.17	-0.42	

five year segment is highly significant and investors demand higher compensation as the pricing of the segment diverts more from the fitted market yield curve. Therefore, we can conclude that the liquidity effect is a significant determinant of term premium. With their positive coefficients, country specific macroeconomic uncertainty indicators boost term premium as well. While the inflation surprise is not significant, higher deviation of macroeconomic indicators from market agents' consensus translates into increasing term premium. As implied volatility of at-the-money currency options, which is assumed to reflect exchange rate

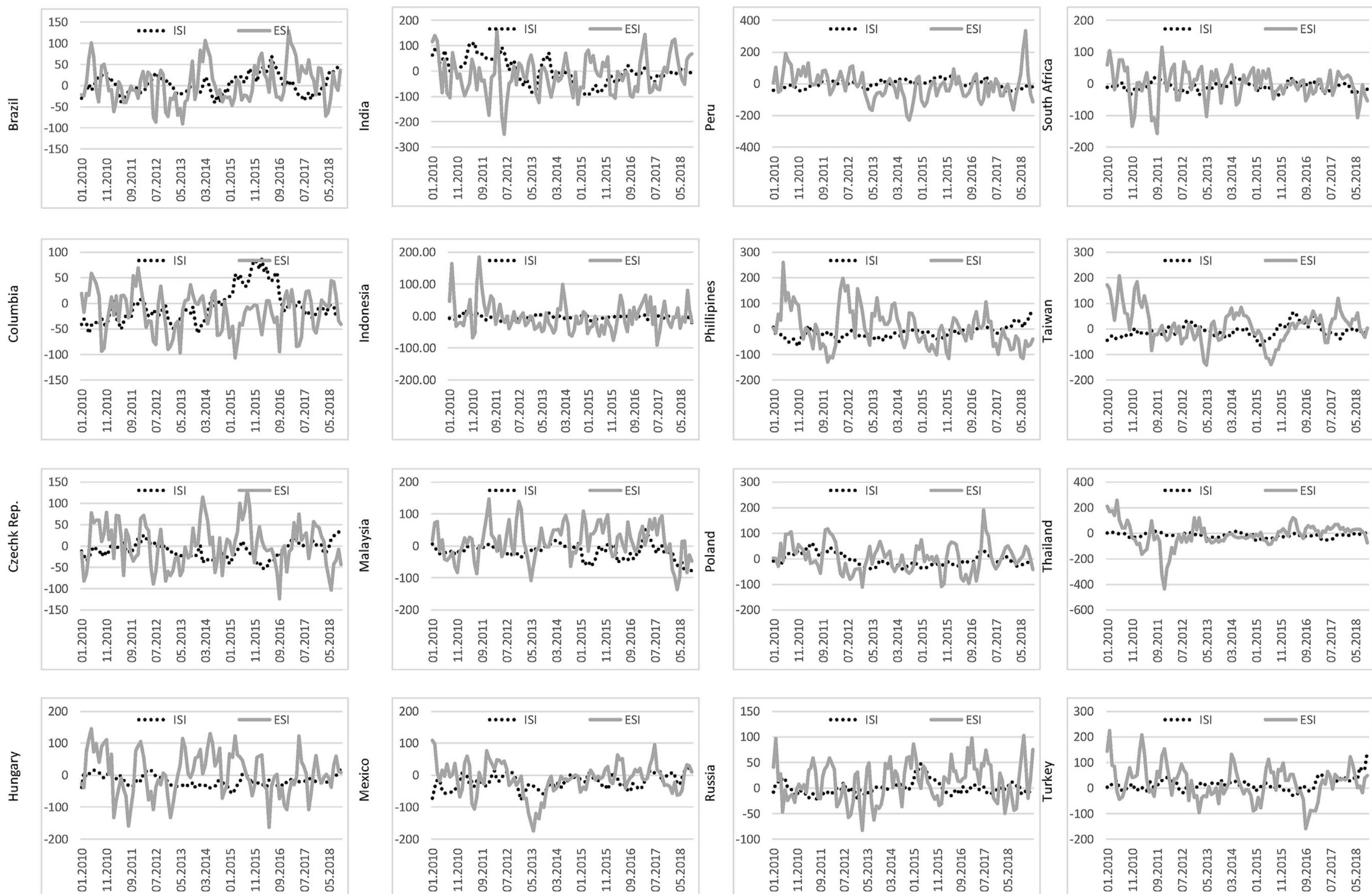

Fig. 4. Citibank inflation surprise index and economic surprise index.

Table 5
Estimation results.

VARIABLES	(1)	(2)	(3)	(4)
	TP 5Y	TP 5Y	TP 10Y	TP 10Y
Liquidity premium factor				
5 year liquidity	127.17***	139.29***		
indicator	[0.000]	[0.000]		
10 year liquidity			133.40***	158.12***
indicator			[0.004]	[0.003]
Inflation and Economic Environment Uncertainty Factors				
Inflation Surprise	0.003	0.003	0.003**	0.003**
Index	[0.122]	[0.148]	[0.024]	[0.040]
Economic Surprise	0.001*	0.001*	0.001**	0.001**
Index	[0.088]	[0.070]	[0.026]	[0.018]
Currency Related Uncertainty Factor				
Implied	0.045***	0.050***	0.050***	0.054***
Volatility	[0.000]	[0.001]	[0.000]	[0.000]
International Markets Uncertainty Factor				
VIX Index	0.016**	0.012*	0.023***	0.019**
	[0.014]	[0.089]	[0.008]	[0.028]
Yield Curve Factor				
Yield Curve		−0.581**		−0.690***
Slope Dummy[1]		[0.033]		[0.005]
Constant	0.111	0.144	0.372**	0.413**
	[0.428]	[0.301]	[0.037]	[0.022]
Observations	1696	1696	1696	1696
Number of countries	16	16	16	16

This table presents results of the fixed effect panel regression model given in Eq. 12 for 5 year term Premium (TP 5Y) and 10 year term premium (TP 10Y). Extended models are given in the Appendix. Robust standard errors in brackets.
***p < 0.01, **p < 0.05, *p < 0.1.
[1] Slope of the yield curve is calculated as the difference between 10 year and 3 month yields.

related uncertainties, increases the compensation demanded by investors over risk neutral yields also increase. Lastly, global market risk indicator has a significant positive effect on term premium component of medium-term market yields. Results are similar for 10 year term premium series. The only difference is the significant positive contribution of inflation surprise to long-term term premium. Models 2 and 4 includes slope dummy additional to other discussed independent variables. The dummy takes value 1 if the slope of the yield curve is negative and 0 otherwise. Panel regression results confirm an inverted yield curve results with a significant decline in medium and long-term term premium.

6. Conclusion

Understanding the behavior of medium and long-term interest rates is critical for both monetary authorities and other market participants. In this context, this study concentrates on the decomposition of medium and long-term zero coupon yields into their risk neutral rates and term premium components together with the analysis of term premium embedded in 5 and 10 year market yields. Using the ACM framework, term premium components for 5 and 10 year maturity yields of 16 emerging market economies are obtained. The risk neutral rates are modeled as the expectation of average future short-term yields over the next 5 and 10 years. Difference between the affine term-structure model implied medium and long-term yields and risk-neutral yields are collected as term premium series.

In line with the related literature, estimated series show that for most of the countries under coverage in this study, the risk neutral rates have been stable around levels that are a few percentage points lower than market yields and variations observed in mid and long-term yields have been absorbed by the term premium component in general. However, for some countries, exceptions of this observation exists and variation of risk neutral rates dominates the movements in market yields. Next step is the estimation of the effects of uncertainty pertaining to inflation, economic growth and exchange rate as well as global risk aversion and related market liquidity conditions within a panel regression framework. Regression results show that domestic market liquidity indicator is highly significant and deterioration in liquidity conditions leads to an increase in demanded premium. Inflation and macroeconomic uncertainty indicators are also found to boost term premium as well. Results indicate that exchange rate related uncertainties, increase the compensation demanded by investors over risk neutral yields. Lastly, global market risk indicator has a significant positive effect on term premium component of medium-term market yields. It is also found that in case of inverted yield curves significant declines in the term premium are observed.

Appendix

Model (1)

$$tp_t^i = c^i + \beta_1 * 5 Year\ Liquidity\ Indicator_t^i + \beta_2 * Inflation\ Surprise\ Index\ _t^i +$$

$$\ldots + \beta_3 * Economic\ Surprise\ Index_t^i + \beta_4 * Implied\ Volatility_t^i + \alpha_1 * VIX_t + \varepsilon_t^i$$

Model (2)

$$tp_t^i = c^i + \beta_1 * 5 Year\ Liquidity\ Indicator_t^i + \beta_2 * Inflation\ Surprise\ Index\ _t^i +$$

$$\ldots + \beta_3 * Economic\ Surprise\ Index_t^i + \beta_4 * Implied\ Volatility_t^i + \alpha_1 * VIX_t +$$

$$\ldots + \beta_5 * Yield\ Curve\ Slope\ Dummy_t^i + \varepsilon_t^i$$

Model (3)

$$tp_t^i = c^i + \beta_1 * 10 Year\ Liquidity\ Indicator_t^i + \beta_2 * Inflation\ Surprise\ Index\ _t^i +$$

$$\ldots + \beta_3 * Economic\ Surprise\ Index_t^i + \beta_4 * Implied\ Volatility_t^i + \alpha_1 * VIX_t + \varepsilon_t^i$$

Model (4)

$$tp_t^i = c^i + \beta_1 * 10\ Year\ Liquidity\ Indicator_t^i + \beta_2 * Inflation\ Surprise\ Index_t^i +$$

$$\ldots + \beta_3 * Economic\ Surprise\ Index_t^i + \beta_4 * Implied\ Volatility_t^i + \alpha_1 VIX_t + \ldots$$

$$\ldots + \beta_5 * Yield\ Curve\ Slope\ Dummy_t^i + \varepsilon_t^i$$

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