An Emerging Market Term Structure View of the Global Financial Cycle

M. Pavel Solís M. [*]

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Abstract

This paper studies the dynamics of the sovereign yields of emerging markets and how they respond to U.S. monetary policy. Decomposing sovereign yields provides valuable information but relies on a default-free assumption. Traditional decompositions are thus not suitable for emerging markets. I show that their yields can be decomposed into an expected future short-term interest rate, a term premium and a compensation for credit risk using a new dataset of nominal and synthetic local currency yields along with survey forecasts for 15 emerging markets from 2000 to 2019. I document a strong, yet delayed, response of the yields to U.S. monetary policy changes. The decomposition reveals that those changes lead to a reassessment of policy rate expectations and a repricing of interest and credit risks in emerging markets.

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

1 Introduction

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It is well-known that U.S. monetary policy has effects beyond its borders, but the extent to which it influences financial conditions in emerging markets is not yet well understood. Given the increasingly important role these countries play in the global economy, it is pressing to understand how their domestic interest rates respond to changes in the monetary policy of the U.S.

The analysis of U.S. monetary policy spillovers on sovereign bond yields has so far mainly focused on advanced economies, which partly reflects data constraints in emerging markets. Not so long ago, they used to issue bonds at short maturities and in foreign currency, but now it is more common for them to issue bonds with longer maturities and in local currency (LC). In fact, LC bonds 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).

This paper answers the question: how does the LC bond yields of emerging markets respond to monetary policy changes in the U.S.? To better answer this question, I characterize the response of the yields in terms of their components. Yield decompositions provide valuable information because they compensate investors for bearing risks. I show that the yields of emerging markets can be decomposed into an expected future short-term interest rate, a term premium and a credit risk compensation.[1] This last component is characteristic of emerging markets and, to the best of my knowledge, it has not been accounted for in the literature that decomposes their bond yields.

The credit risk compensation acknowledges that not all sovereign bonds are equal. Contrary to the debt issued by advanced countries, international investors demand a credit risk compensation to hold bonds issued by emerging markets (Du and Schreger, 2016a). Indeed, even though countries have the ability to print their own currency to

[1] The term premium compensates investors for bearing interest rate risk, and the credit risk compensation addresses the risk of not receiving the promised payments. Credit risk here is broadly defined 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.

avoid defaulting on their debt, emerging markets are prone to default (Reinhart and Rogoff, 2011; Erce and Mallucci, 2018).[2] To account for credit risk, I use synthetic LC yield curves, which essentially swap the U.S. yield curve into a LC, something akin to the U.S. issuing bonds in that currency.[3] These synthetic yields can be seen as being free of credit risk and can thus be decomposed into a future expected short-term interest rate and a term premium. The difference between the nominal (or actual) yields and the synthetic ones captures the credit risk compensation in the LC debt of emerging markets (Du and Schreger, 2016a).

I show that the proposed decomposition of emerging market yields is sensible. Affine term structure models are the standard tool to decompose bond yields, but the decompositions can be unstable (Cochrane, 2007). Guimarães (2014) shows that incorporating survey data on interest rate forecasts in the estimation provides robust decompositions of the U.S. and U.K. yield curves. I then use data on survey forecasts to obtain robust decompositions of the synthetic yield curves of emerging markets. Accordingly, the model-implied expectation of the short rate for the 10-year maturity tracks the long-term interest rate forecasts reasonably well.[4] Since it is based on synthetic yields, the resulting term premium is genuine in terms of not been contaminated by credit risk (as would be the case if it were obtained from nominal yields). Wright (2011) documents a downward trend in the term premia of advanced countries that owes in part to a decline in inflation uncertainty. The estimated term premia reported here shows a similar trend and their association with inflation uncertainty is even stronger, consistent with the fact that inflation in emerging markets tends to be higher and more volatile than in advanced countries (Ha et al., 2019). Finally, the decomposition also shows a negative correlation between the term premium and the credit risk compensation, suggesting a trade-off between implicit (diluting debt repayments via inflation) and explicit (actual) defaults.

[2] Examples of actual defaults in LC debt include El Salvador (2017), Ecuador (2008), Argentina (2001), Russia (1998); and in 1999 after an earthquake, Turkey retroactively taxed its debt. Du and Schreger (2016b) and Ottonello and Perez (2019) provide theoretical explanations for these episodes.

[3] This implicitly assumes that the U.S. yield curve and the financial instruments used to swap it are free of credit risk. I argue that these are reasonable assumptions in section 2.

[4] In addition, the levels of the implied long-term expected real interest rates are also in line with the evidence for advanced countries (Holston, Laubach, and Williams, 2017).

To analyze the spillover effects of U.S. monetary policy, I consider three types shocks. They capture unanticipated changes to the current policy rate, to its future path and to the large-scale asset purchase (LSAP) programs that were implemented by the U.S. Federal Reserve (Fed) as part of its unconventional monetary policy response to the global financial crisis (GFC). The shocks are identified using high-frequency data around the Fed's monetary policy announcements, which is by now a well-established strategy to overcome endogeneity concerns because it isolates the surprise component of monetary policy decisions (Gürkaynak and Wright, 2013; Nakamura and Steinsson, 2018).

The main finding of this paper is that U.S. monetary policy has a strong and persistent effect on the yields of emerging markets, despite a moderate initial reaction. The nominal yield decompositions help to better understand how the yields respond. I show that the Fed's monetary policy decisions influence each of the components of emerging market yields. The magnitude of the initial response of nominal yields is lower than the response of U.S. yields, some yield components do not even respond initially. However, the effects are sluggish and amplify over time (for up to 2 months) to such an extent so as to become a one-to-one response, or even more in the case of LSAP shocks. In fact, path and LSAP shocks—more prevalent since the GFC—have larger and longer effects on emerging market yields.

I also find that Fed's decisions impact the credit risk compensation in emerging markets, where the direction of the effect depends on the type of shock. The credit risk compensation increases in response to target and path shocks given that a lower forward premium reduces the compensation for a future currency depreciation, thereby decreasing the cost of borrowing in LC at the risk-free rate. By contrast, the credit risk compensation decreases in response to LSAP shocks because the compensation for a future currency depreciation goes up. Unlike the delayed response in nominal yields and the components of synthetic yields, the reaction by the credit risk compensation is short lived, generally only at the time of the shock due to a similarly short response of the forward premium. All in all, surprises in Fed's policy decisions give rise to a reassessment of policy rate expectations in emerging markets and a repricing in their interest and credit risks.

This paper contributes to different branches of the literature. It pioneers the application of term structure models on synthetic yields, which have been widely used recently to study deviations from covered interest parity (CIP).[5] Instead of concentrating on the CIP deviations, this paper focuses on the synthetic yields themselves to decompose the nominal bond yields of emerging markets more finely. It also contributes to the literature on the international comparison of sovereign yields (Dahlquist and Hasseltoft, 2016)—so far mainly focused on advanced economies. On the spillover effects of U.S. monetary policy, this paper extends the work of Gilchrist, Yue, and Zakrajšek (2019) by studying its effects not only on sovereign yields but on its components, as in Curcuru, Kamin, Li, and Rodriguez (2018) and Adrian, Crump, Durham, and Moench (2019), but focusing on the yields of emerging markets and adjusting for their credit risk.

The rest of the paper proceeds as follows. Section 2 explains how the LC yield curves are constructed. Section 3 presents the affine term structure model used to decompose them. Section 4 assesses the yield decompositions. Section 5 analyzes the spillovers from U.S. monetary policy to the yields of emerging markets. The last section concludes.

2 Local Currency Yield Curves

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This section explains how to construct the nominal and synthetic LC yield curves of emerging markets, and explains that the difference between the two captures a credit risk compensation. In the next section, the *synthetic* yield curve will be decomposed into an expected future short-term interest rate and a term premium. The decomposition of the *nominal* yield curve will then be used to characterize the response of emerging market yields to U.S. monetary policy.

[5] Du, Tepper, and Verdelhan (2018c) show that there are persistent and systematic deviations from CIP reflecting a higher regulatory burden for financial intermediaries. Du, Im, and Schreger (2018b) show that CIP deviations reflect differences in the convenience yield of advanced countries relative to the U.S. Du and Schreger (2016a) meanwhile show that CIP deviations capture a credit risk compensation for emerging markets.

2.1 Construction of Synthetic Yield Curves

The main idea to construct the synthetic LC yield curves is to swap the U.S. yield curve into LC using the forward premium at each maturity (see Du, Im, and Schreger, 2018a). The forward premium compensates investors for the expected depreciation of a currency, an increase in the exchange rate when it is expressed in LC per U.S. dollar (USD), as is used throughout this paper. The key assumption behind this approach is that the U.S. yield curve is free of default risk; as such, it serves as the benchmark for all the other countries in the sample.

The calculation of the forward premium depends on the maturity. For maturities of less than one year, the forward premium is calculated as the annualized difference between the forward and the spot exchange rates. For maturities equal or larger than one year, the forward premium is calculated using cross-currency swaps (XCS) since outright forwards are less liquid. Although, the fixed-for-fixed XCS 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 start by swapping fixed payments in LC into floating-rate cash flows in USD using cross-currency basis swaps (referenced to the Libor—London interbank offered rate—in USD), and swap them into fixed-rate cash flows also in USD using interest rate swaps. Both types of swaps are liquid and collateralized instruments and so the bilateral counterparty risk in XCS is small.

Let $y_{t,n}^{US}$ denote the zero-coupon yield for an n-period U.S. Treasury security at time t, and $\rho_{t,n}$ the n-period forward premium from USD to LC at time t. The zero-coupon synthetic LC yield for the n-period bond at time t, $\widetilde{y}_{t,n}^{LC}$, is calculated as

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

In contrast, the actual or nominal zero-coupon yield, $y_{t,n}^{LC}$, can be obtained directly from the quotes of the bonds traded in the market. Notice that the construction of the synthetic yield curve $\widetilde{y}_{t,n}^{LC}$ does not require information about the nominal yield curve $y_{t,n}^{LC}$,[6] as it relies on the U.S. yield curve and XCS rates.

[6]For the U.S., $\widetilde{y}_{t,n}^{US} = y_{t,n}^{US}$ since there is no forward premium for the USD relative to the USD.

According to the CIP condition, the nominal (direct) and the synthetic (indirect) LC interest rates should be equal. Thus, CIP implies that an issuer should be able to borrow directly or indirectly (synthetically) in LC at the same yield. Du, Tepper, and Verdelhan (2018c) show, however, that there are persistent and systematic deviations from CIP. The spread between the nominal and synthetic yields ($y_{t,n}^{LC} - \widetilde{y}_{t,n}^{LC}$) therefore measures CIP deviations in sovereign yields. In the case of advanced countries, Du, Im, and Schreger (2018b) argue that the CIP deviations reflect differences in convenience yields relative to the U.S.

CIP deviations have a different interpretation for emerging markets. Whereas the nominal yields of advanced countries are usually considered free of credit risk, it is reasonable for the nominal yields of emerging markets to include a credit risk compensation since emerging markets are prone to default (Reinhart and Rogoff, 2011; Erce and Mallucci, 2018). The credit risk in the components of the synthetic yields in equation (1) is small, a synthetic yield can therefore be seen as the borrowing rate paid by a hypothetical issuer in LC with no credit risk. Du and Schreger (2016a) indeed show that the nominal-synthetic spread captures a credit risk compensation in the sovereign yields of emerging markets. In particular, the spread is highly correlated with the rates of credit default swaps (CDS) (CDS)—financial derivatives aimed to protect investors against default by a bond issuer.

CDS spreads are not used in this paper to account for LC credit risk because they do not adequately characterize it since defaults on LC bonds governed under domestic law do not trigger CDS in emerging markets.[7] CDS spreads have been used, however, to study sovereign risk in foreign currency denominated debt (Longstaff et al., 2011).

2.2 Construction of Nominal Yield Curves [Go2ToC]

I use the Bloomberg Fair Value (BFV) curves to estimate the nominal yield curve $y_{t,n}^{LC}$. Since these curves report coupon-equivalent par yields, I convert them into continuously-

[7]See the Credit Derivatives Physical Settlement Matrix published by the International Swaps and Derivatives Association.

compounded yields (see Gürkaynak, Sack, and Wright, 2007) to obtain the implied zero-coupon curves.[8] This is done for all but two countries for which there are no BFV curves. For Brazil and Israel, Bloomberg provides zero-coupon yields with coupon-equivalent compounding. I also convert these yields, known as IYC curves, into continuously-compounded yields.[9]

The resulting continuously-compounded zero-coupon curve for each country is what this paper refers to as the nominal yield curve $y_{t,n}^{LC}$.

2.3 Yield Curve Data [Go2ToC]

Nominal and synthetic yield curves are constructed for 15 emerging markets and, to compare the results, 10 advanced economies.[10] The countries are selected based on data availability. It is worth noting that all of the emerging markets in the sample, with the exception of Malaysia, have adopted an inflation targeting regime.[11] In fact, the central banks in Hungary, Philippines, Indonesia, Russia and Turkey adopted inflation targeting during the sample period.[12]

The data for nominal and synthetic yields is available daily. The sample starts in January 2000 and ends in January 2019; the starting dates, however, vary by country. All the yields for advanced countries start no later than September 2001, but the sample sizes for emerging markets are generally smaller. The nominal yields of 9 and the synthetic

[8] As a robustness check, I estimate the nominal yield curves from actual prices for some of the countries in the sample following Nelson and Siegel (1987). These estimated yield curves follow those reported by Bloomberg closely.

[9] For some emerging markets, Bloomberg reports both BFV and IYC curves. BFV curves are preferred for several reasons: they have a longer history than IYC curves, IYC curves are not available for advanced countries—the benchmark for some of the results reported later—and, compared to the BFV curves, the short end of the IYC curves seems disconnected from the rest of the curve for some countries and dates.

[10] For each of the following countries, the currency identifier is shown in parenthesis. The 15 emerging markets are: 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). The 10 advanced economies are: Australia (AUD), Canada (CAD), Denmark (DKK), Germany (EUR), Japan (JPY), Norway (NOK), New Zealand (NZD), Sweden (SEK), Switzerland (CHF) and the U.K. (GBP).

[11] Although Malaysia does not follow an inflation targeting regime, it has several characteristics that are aligned with such a regime, see Pennings, Ramayandi, and Tang (2015).

[12] Hungary in June 2001, Philippines in January 2002, Indonesia in July 2005, Turkey in January 2006 and Russia in 2014. Also, Hungary and Poland were accepted to join the European Union in April 2003.

yields of 7 emerging markets start before March 2004; both types of yields for the rest of the countries start no later than June 2007. Thus, there are at least 10 years of data for most of the emerging markets in the sample.[13] In principle, this is a reasonable time period for the estimation of the affine term structure model presented in section 3.1, but in practice there may be too few interest rate cycles per country. This small sample problem is addressed using surveys of professional forecasters in section 3.3.

The yields have maturities of 3 and 6 months, and 1 through 10 years, ranging from a minimum of nine to a maximum of twelve maturities per country.[14] The maximum maturity considered is 10 years because bonds and swaps with larger maturities tend to have less history and be less liquid, especially for emerging markets who do not issue longer-term bonds as often as advanced countries.

The construction of the LC synthetic yield curves involves data from the U.S. yield curve and the forward premium for different maturities, as explained in section 2.1. Data for the U.S. zero-coupon yield curve is obtained from two sources. For maturities of one through ten years, the yields come from the dataset constructed by Gürkaynak, Sack, and Wright (2007) (hence GSW).[15] Treasury securities with less than one year to maturity are less actively traded than longer-maturity ones. The estimates from the Center for Research in Security Prices (CRSP) are thought to be more robust at the short end of the curve (Duffee, 2010). Specifically, the 3- and 6-month yields are the annualized 13- and 26-week rates (bid/ask average) in the CRSP Risk-Free Rates Series.[16]

As mentioned before, the calculation of the forward premium varies by maturity. For maturities of less than one year, I use data on the spot exchange rate along with 3- and 6-month forwards from Bloomberg for all but three countries; for Korea, Philippines and Thailand the data is obtained from Datastream. To construct the XCS rates, I use data

[13] For Turkey, the nominal yields with a maturity of up to 10 years start on June 2010, although its synthetic yields start on May 2005. For Russia, data on both types of yields start in 2007 but due to low liquidity at the beginning of the sample, it starts in July 2009.

[14] All countries have data from 3 months to 5 years and 10 years. All countries except Brazil have data for the 7-year maturity. Data for 6, 8 and 9 years vary per country.

[15] Available at: https://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html.

[16] The 3- and 6-month yields implied by the GSW fitted model are highly correlated with the CRSP yields (0.9985 and 0.9995, respectively) but the former are on average higher (by 16 and 10 basis points, respectively) using data since 1983.

on cross-currency basis swaps and interest rate swaps for each available maturity from one through ten years. The data for the swap curves comes from Bloomberg.[17]

Table 1 reports descriptive statistics for different tenors of the nominal and synthetic yield curves of the emerging markets and advanced countries in the sample. higher std of the short end of the EM curves. Yields (and components) are more volatile in EM than in AEs. The two types of YCs are upward sloping.

2.3.1 Timing

The parameters of the affine term structure models are estimated using end-of-month data, as explained in section 3.3. Since the U.S. yield curve is the benchmark for the synthetic yield curves, those dates are the last business days of each month according to the U.S. calendar.

Getting the timing right is key to adequately measure the responses of emerging market yields to U.S. monetary policy shocks. The analysis of monetary policy spillovers in section 5.3.2 uses daily changes in nominal and synthetic yields, which need to correctly capture the surprises in Fed announcements. Since the nominal yields reported by Bloomberg are pulled at around 16 hours New York time, they are shifted one day forward for the non-Western Hemisphere countries so that their daily changes adequately capture surprises in Fed announcements. The credit risk compensation for those countries is calculated using the shifted nominal yields.

3 Methodology [Go2ToC]

This section describes the affine term structure model used to decompose the yield curve of each country in the sample. It discusses the difficulty in estimating the parameters of the model and how survey data helps in the identification. The next section will assess the decomposition, so that it can later be used to characterize the response of

[17] A spreadsheet with the 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) similar files kindly posted online in Wenxin Du and Jesse Schreger's websites.

emerging market yields to U.S. monetary policy.

3.1 Affine Term Structure Model

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

If there is no arbitrage, there exists a strictly positive stochastic discount factor (SDF) that prices all nominal bonds. Let M_{t+1} be the nominal SDF. Accordingly, the bond price today is recursively defined as follows:

$$P_{t,n} = \mathrm{E}_t^{\mathbb{P}} \left[M_{t+1} P_{t+1,n-1} \right], \tag{2}$$

where $\mathrm{E}_t^{\mathbb{P}}[\cdot]$ denotes the conditional expectation at time t of a random variable taken using the actual or physical probability measure, $\mathbb{P}$, that generates the data. The existence of the SDF also implies that there exists a theoretical risk-neutral or risk-adjusted pricing measure, $\mathbb{Q}$—different from the $\mathbb{P}$ measure—that is defined as follows:[18]

$$P_{t,n} = \mathrm{E}_t^{\mathbb{Q}} \left[\exp\left(-i_t\right) P_{t+1,n-1} \right], \tag{3}$$

where $\mathrm{E}_t^{\mathbb{Q}}[\cdot]$ also denotes conditional expectation at time t but taken using the $\mathbb{Q}$ measure.

A discrete-time affine term structure model assumes that the dynamics of a $\mathrm{K} \times 1$ vector of unobserved pricing factors or state variables, X_t, follow a first-order vector autoregression, VAR(1), under the risk-neutral measure $\mathbb{Q}$:

$$X_{t+1} = \mu^{\mathbb{Q}} + \Phi^{\mathbb{Q}} X_t + \Sigma \nu_{t+1}^{\mathbb{Q}}. \tag{4}$$

where $\mu^{\mathbb{Q}}$ is a $\mathrm{K} \times 1$ vector and $\Phi^{\mathbb{Q}}$ is a $\mathrm{K} \times \mathrm{K}$ transition matrix, Σ is a $\mathrm{K} \times \mathrm{K}$ lower triangular matrix with positive diagonal elements, and $\nu_{t+1}^{\mathbb{Q}}$ is a $\mathrm{K} \times 1$ independent and identically distributed, normal vector with zero mean and covariance equal to the identity matrix conditional on the pricing factors, which is written as $\nu_{t+1}^{\mathbb{Q}} | X_t \sim \mathcal{N}_{\mathrm{K}}\left(0, I\right)$.

[18]Since the price at maturity of a zero-coupon bond is 1, recursive substitution of equations (2) and (3) implies that $P_{t,n} = \mathrm{E}_t^{\mathbb{P}} \left[\Pi_{j=1}^{n} M_{t+j} \right] = \mathrm{E}_t^{\mathbb{Q}} \left[\exp\left(-\Sigma_{j=0}^{n-1} i_{t+j} \right) \right]$.

The dynamics of the one-period interest rate are driven by the pricing factors:

$$i_t = \delta_0 + \delta_1' X_t, \tag{5}$$

where δ_0 is a scalar and δ_1 is a K $\times$ 1 vector of parameters.

These assumptions imply that the bond price is an exponentially affine function of the pricing factors:

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

such that the corresponding continuously compounded yield of the bond is an affine function of those factors:

$$y_{t,n}^{\mathbb{Q}} = A_n^{\mathbb{Q}} + B_n^{\mathbb{Q}} X_t, \tag{6}$$

where $A_n^{\mathbb{Q}} = -\frac{1}{n} A_n$, $B_n^{\mathbb{Q}} = -\frac{1}{n} B_n$, where in turn the scalar $A_n = \mathcal{A}(\delta_0, \delta_1, \mu^{\mathbb{Q}}, \Phi^{\mathbb{Q}}, \Sigma, n)$ and the $1 \times$K vector $B_n = \mathcal{B}(\delta_1, \Phi^{\mathbb{Q}}, n)$ are loadings that satisfy the recursive equations:[19]

$$A_{n+1} = -\delta_0 + A_n + B_n' \mu^{\mathbb{Q}} + \frac{1}{2} B_n' \Sigma \Sigma' B_n, \quad A_0 = 0, \tag{7}$$

$$B_{n+1} = -\delta_1 + \Phi^{\mathbb{Q}\prime} B_n, \quad B_0 = 0. \tag{8}$$

The yields $y_{t,n}^{\mathbb{Q}}$ are the model's fitted yields, which means that the risk-neutral measure $\mathbb{Q}$ is sufficient for pricing bonds. However, to be able to decompose the yields into a future expected short-term interest rate and a term premium, the model needs to specify the dynamics for the market prices of risk, which control the transformation between the $\mathbb{Q}$ and $\mathbb{P}$ measures. In this sense, the SDF is assumed to be conditionally lognormal:

$$M_{t+1} = \exp\left(-i_t - \frac{1}{2} \lambda_t' \lambda_t - \lambda_t' \nu_{t+1}^{\mathbb{P}}\right), \tag{9}$$

where λ_t is a K $\times$ 1 vector of market prices of risk. Following Duffee (2002), it is also assumed to be an affine function of the pricing factors:

$$\lambda_t = \lambda_0 + \lambda_1 X_t, \tag{10}$$

[19] The price coefficients are obtained recursively after combining the no-arbitrage condition and the functional form for bond prices.

where λ_0 is a $\mathrm{K} \times 1$ vector and λ_1 is a $\mathrm{K} \times \mathrm{K}$ matrix of parameters.

A well-known implication of this structure for the market prices of risk is that the dynamics of the pricing factors under the physical measure $\mathbb{P}$ can also be described by a VAR(1) as follows:[20]

$$X_{t+1} = \mu^{\mathbb{P}} + \Phi^{\mathbb{P}} X_t + \Sigma \nu^{\mathbb{P}}_{t+1}. \tag{11}$$

where $\mu^{\mathbb{Q}} = \mu^{\mathbb{P}} - \Sigma\lambda_0$, $\Phi^{\mathbb{Q}} = \Phi^{\mathbb{P}} - \Sigma\lambda_1$, $\nu^{\mathbb{P}}_{t+1}|X_t \sim \mathcal{N}_{\mathrm{K}}(0, I)$. Note that the covariance matrix of the shocks is the same under both measures; that is, it is measure independent.

The yields consistent with the expectations hypothesis of the yield curve—as if investors were actually risk-neutral ($\lambda_0 = \lambda_1 = 0$)—are obtained as:

$$y^{\mathbb{P}}_{t,n} = A^{\mathbb{P}}_n + B^{\mathbb{P}}_n X_t,$$

where $A^{\mathbb{P}}_n = -\frac{1}{n} A_n$, $B^{\mathbb{P}}_n = -\frac{1}{n} B_n$, and the loadings $A_n = \mathcal{A}(\delta_0, \delta_1, \mu^{\mathbb{P}}, \Phi^{\mathbb{P}}, \Sigma, n)$ and $B_n = \mathcal{B}(\delta_1, \Phi^{\mathbb{P}}, n)$ satisfy the same recursions as those above but using the parameters of the law of motion of the pricing factors under the $\mathbb{P}$ rather than the $\mathbb{Q}$ measure.

Finally, the term premium for maturity n at time t, $\tau_{t,n}$, can then be estimated as the difference between the yields obtained under the $\mathbb{Q}$ and $\mathbb{P}$ measures:[21]

$$\tau_{t,n} = y^{\mathbb{Q}}_{t,n} - y^{\mathbb{P}}_{t,n}. \tag{12}$$

A key assumption behind this model is that the yield $y_{t,n}$ is free of credit risk, a reasonable assumption for advanced but not for emerging countries since investors demand a credit risk compensation from them (Du and Schreger, 2016a). This implies that while the nominal yield curve $y^{LC}_{t,n}$ is the relevant one for advanced countries, it is not so for emerging markets because it is not free of credit risk. In that case, the synthetic yield curve $\widetilde{y}^{LC}_{t,n}$ better aligns with the risk-free assumption and, in turn, with the affine model.

3.2 Informational Deficiency

[20] The SDF in equation (9) and the law of motion of the vector of pricing factors in equation (11) can be formalized separately or jointly, see Gürkaynak and Wright (2012). For instance, in a utility maximization framework, the SDF is usually interpreted as the intertemporal marginal rate of substitution.

[21] Note that $\tau_{t,n}$ can also be written as $(A^{\mathbb{Q}}_n - A^{\mathbb{P}}_n) + (B^{\mathbb{Q}}_n - B^{\mathbb{P}}_n)X_t$; that is, the term premium is also an affine function of the pricing factors.

[Go2ToC]

In principle, the estimation of the parameters in the affine term structure model only requires zero-coupon bond yields as an input. This is enough to estimate the pricing coefficients under the $\mathbb{Q}$ measure, $\{\mu^{\mathbb{Q}}, \Phi^{\mathbb{Q}}\}$, but not to pin down the parameters under the $\mathbb{P}$ measure, $\{\mu^{\mathbb{P}}, \Phi^{\mathbb{P}}\}$, which are necessary to estimate the term premium.

This informational deficiency problem owes to the high persistence of bond yields, which results in small sample bias (Kim and Orphanides, 2012). In fact, there might be too few interest rate cycles per country. In that case, the dynamics of the pricing factors will tend to mean-revert too quickly, overestimating the stability of the expected path of the short rate and attributing much of the variability in yields to fluctuations in the term premium. The instability in the decomposition of the yield curves of advanced countries is a well-known phenomenon (Cochrane, 2007).[22] Guimarães (2014) shows that incorporating survey data on interest rate forecasts in the estimation provides robust decompositions of the U.S. and U.K. yield curves.[23]

The importance of survey data is particularly relevant to get reliable decompositions for emerging markets since the sample size for these countries is relatively shorter, compared with data from advanced countries. In addition, surveys are also used to obtain a model-free estimate of the term premium, which serves as a robustness check for the one obtained from the model.

3.2.1 Survey Data

[Go2ToC]

Long-term forecasts are particularly helpful to pin down the parameters of the model under the $\mathbb{P}$ measure, $\{\mu^{\mathbb{P}}, \Phi^{\mathbb{P}}\}$. Twice a year Consensus Economics provides 5-year ahead and long-term (between 6 and 10 years ahead) forecasts for consumer inflation and real

[22] Different solutions have been proposed in the literature, including restrictions on parameters (Duffee, 2010), bias-corrected estimators (Bauer et al., 2012) and complementing bond yield data with survey forecasts of future interest rates (Kim and Wright, 2005; Kim and Orphanides, 2012).

[23] He finds that the term premium estimated with the aid of surveys remains essentially the same after varying the number of pricing factors (from 3 to 5) and the sample periods, even with a sample starting in 1972, which includes the U.S. Great Inflation period.

GDP growth for most of the emerging countries in the sample; the data is available from March 2001 to October 2017.[24] Figure 1 plots the long-horizon forecasts for inflation. With the exception of Brazil and Turkey, inflation expectations in emerging markets have been stable or even declining, and are generally within the upper and lower bounds for the domestic inflation target.

Although there is no source for long-term forecasts for the short rate of emerging markets, they can be inferred from existing data. For this purpose, I treat emerging markets as small open economies. Specifically, the implied forecasts for the short rate equal the expected average inflation as reported by Consensus Economics, plus the expected global real rate over the same horizon, inferred by a combination of survey forecasts of future short-term U.S. Treasury bill yields and of future U.S. inflation as follows:

$$i_{t,n} = \pi_{t,n}^{CEsurvey} + r_{t,n}^{*} = \pi_{t,n}^{CEsurvey} + \left(i_{t,n}^{SPFsurvey} - \pi_{t,n}^{SPFsurvey} \right),$$

where the required data for the U.S. is available quarterly from the Survey of Professional Forecasters. I use the 5- and 10-Year CPI inflation forecasts and, for the T-bill rate, the 10-year forecast and the second longest available one since there is no 5-year forecast for the T-bill rate.[25] The 5- and 10-year implied forecasts for the U.S. real rate obtained from surveys are closely aligned to the respective zero-coupon real yields derived using U.S. TIPS market data by Gürkaynak et al. (2010);[26] however, TIPS yields are not used as the benchmark due to the well-known liquidity problems of TIPS. Figure 2 shows that the implied long-term forecasts for the short rates are sensible, their level is in line with the synthetic 10-year yield in each country. An alternative way to infer the embedded expectations for the policy rate is to use Taylor rule-type regressions, and assume that the estimated parameters for inflation and real GDP growth apply at each of the survey

[24] Data availability varies by country; for example, data for the Philippines starts in 2009, whereas it ends in October 2013 for Latin American countries. Although there is no survey data on long-term inflation forecasts for Israel and South Africa, appendix A shows that trend inflation is a good proxy.

[25] The specific series are CPI5YR, CPI10, BILL10 and TBILLD. The BILL10 series is released in the first-quarter surveys only, so I use linear interpolation for the second to fourth quarters in the respective year. Consensus Economics forecasts are considered at the end of the month in which they are published, at that time the most recent value for the U.S. real interest rate forecast is used to calculate the implied forecast for the domestic short rate.

[26] For the 10-year horizon, the correlation of the two series is 0.91, yet the TIPS series is twice as volatile as the survey series.

maturities.[27] The two approaches yield similar values for the implied forecasts for the domestic short-term rates, the correlation between them is 0.75 and 0.83 for the 5- and 10-year tenors, respectively.

I assume that 5-year ahead (implied) forecasts for the short rate of emerging markets equal the expected average short rate under $\mathbb{P}$ given by

$$y^e_{t,n} = \frac{1}{n}\mathrm{E}^{\mathbb{P}}_t\left[\sum_{j=0}^{n-1} i_{t+j}\right] = A^e_n + B^e_n X_t,$$

where $A^e_n = -\frac{1}{n}A_n$, $B^e_n = -\frac{1}{n}B_n$, where in turn $A_n = \mathcal{A}(\delta_0, \delta_1, \mu^{\mathbb{P}}, \Phi^{\mathbb{P}}, 0, n)$ and $B_n = \mathcal{B}(\delta_1, \Phi^{\mathbb{P}}, n)$; that is, A^e_n and B^e_n also satisfy the recursions under the $\mathbb{P}$ measure but setting $\Sigma = 0$ (see Appendix C of Guimarães (2014)).[28]

Long-term (implied) forecasts are in turn matched to the 5-year forward rate starting 5 years hence. In the model, the forward rate from n to m periods hence given by $f_{t,n|m} = (my_{t,m} - ny_{t,n}) / (m - n)$ becomes

$$f^e_{t,n|m} = \frac{1}{m-n}\mathrm{E}^{\mathbb{P}}_t\left[\sum_{j=n}^{m-1} i_{t+j}\right] = A^e_{t,n|m} + B^e_{t,n|m} X_t.$$

where $A^e_{t,n|m} = (mA^e_m - nA^e_n) / (m - n)$ and $A^e_{t,n|m} = (mB^e_m - nB^e_n) / (m - n)$.

3.3 Estimation [Go2ToC]

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

[27] I regress the policy rate on its lag, the year-on-year consumer price inflation and the year-on-year real GDP growth for all the countries except Israel and South Africa. The coefficient for the lag of the policy rate is a smoothing parameter that improves the fit of the model to the data. A potential drawback of this approach is precisely that it requires to know the expectation of the policy rate for the previous forecast horizon. Nevertheless, it is reasonable to assume stationarity for the long-term forecasts (5 and 10 years), in which case only survey data for inflation and GDP growth are needed after dividing their coefficients by 1 minus the coefficient for the lag of the policy rate (due to stationarity). Data from the policy rate statistics of the Bank for International Settlements is used for the dependent variable.

[28] The difference between $y^{\mathbb{P}}_{t,n}$ and $y^e_{t,n}$ is a convexity term due to Jensen's inequality, which increases with maturity. In practice, however, this term usually becomes relevant for maturities beyond ten years. Further, the term is constant across maturities in homoskedastic models like the ones used in this paper.

The JSZ normalization allows for the near separation of the model's likelihood function into the product of the $\mathbb{P}$ and $\mathbb{Q}$ likelihood functions, and reduces the dimension of the parameter space from $(\delta_0, \delta_1, \mu^{\mathbb{Q}}, \Phi^{\mathbb{Q}}, \Sigma)$ to $(i^{\mathbb{Q}}_{\infty}, \lambda^{\mathbb{Q}}, \Sigma)$, where $i^{\mathbb{Q}}_{\infty}$ is the short rate under $\mathbb{Q}$ in the long-run and $\lambda^{\mathbb{Q}}$ is a $\mathrm{K} \times 1$ vector of ordered eigenvalues of $\Phi^{\mathbb{Q}}$. It is common to assume that K linear combinations of the N observed bond yields are measured without error, $\mathrm{K} < \mathrm{N}$, whereas $\mathrm{N} - \mathrm{K}$ linear combinations of yields are measured with error. Following JSZ, I consider that the first three principal components of the yield curve in each country are the linear combinations of yields measured without error. Litterman and Scheinkman (1991) referred to these as the level, slope and curvature of the yield curve.[29]

The affine model is estimated using the JSZ normalization following a two-step procedure. First, the $\mathbb{P}$ parameters are estimated by OLS of the VAR in equation (11) using the K principal components of the yield curve. This provides initial values for the maximum likelihood estimation of the matrix Σ. Then, taking $\widehat{\mu}^{\mathbb{P}}$ and $\widehat{\Phi}^{\mathbb{P}}$ as given, the $\mathbb{Q}$ parameters can be estimated by maximum likelihood.

The estimation uses end-of-month data. The relevant (risk-free) yield curve for advanced countries is the nominal one $y^{LC}_{t,n}$, whereas for emerging markets it is the synthetic one $\widetilde{y}^{LC}_{t,n}$. For advanced countries, only yield data was available. For emerging markets, however, the model is augmented with survey data on the last day of the month for which the data was published.[30] Since yield data is monthly and survey data is available twice a year, the latter is regarded as missing in non-release dates.

[29] On average, they explain more than 99.5% of the variation in the synthetic yields of emerging markets and 99.9% in the nominal yields of advanced countries.

[30] From 2001 to 2014, data for countries covered in the Eastern European release is available in March and September; starting in October 2014, it is released on April and October. For the rest of emerging markets the forecasts have always been released on April and October. The model for advanced countries in the sample is not augmented with survey data because I do not have access to it. They are, however, not the main focus of this paper, the affine model is estimated for them just for comparison purposes. Moreover, the results reported later for them are more comparable with other studies that do not use survey data. Finally, there are less concerns about small sample sizes for advanced countries and, for some of them, even for a regime change during the sample period.

3.3.1 Survey-Augmented Model

The Kalman filter is well-suited to handle missing data. The transition equation is the law of motion of the pricing factors under the $\mathbb{P}$ measure given in equation (11). The dimension of the observation equation varies depending on the availability of survey data.

On months in which there is no data on survey expectations, the observation equation adds measurement error to the fitted yields in equation (6) for each of the N maturities:

$$\mathbf{y}_t = \mathbf{A} + \mathbf{B}X_t + \mathbf{\Sigma}_Y \mathbf{u}_t, \tag{13}$$

where $\mathbf{y}_t$ is an $\mathrm{N} \times 1$ vector of observed bond yields, $\mathbf{A}$ is an $\mathrm{N} \times 1$ vector with elements $A_n^{\mathbb{Q}}$, $\mathbf{B}$ is an $\mathrm{N} \times \mathrm{K}$ matrix with rows equal to $B_n^{\mathbb{Q}}$ for $n = 1, \ldots, \mathrm{N}$, $\mathbf{u}_t \sim \mathcal{N}_{\mathrm{N}}(0, I)$ and $\mathbf{\Sigma}_Y$ is a lower triangular $\mathrm{N} \times \mathrm{N}$ matrix with positive elements on the diagonal.

On months when survey data is available, the observation equation increases by the number of survey forecasts S as follows:

$$\begin{bmatrix} \mathbf{y}_t \\ \mathbf{y}_t^S \end{bmatrix} = \begin{bmatrix} \mathbf{A} \\ \mathbf{A}^S \end{bmatrix} + \begin{bmatrix} \mathbf{B} \\ \mathbf{B}^S \end{bmatrix} X_t + \begin{bmatrix} \mathbf{\Sigma}_Y \mathbf{u}_t & \mathbf{0} \\ \mathbf{0} & \mathbf{\Sigma}_S \mathbf{u}_t^S \end{bmatrix} \tag{14}$$

where $\mathbf{y}_t^S$ is a $\mathrm{S} \times 1$ vector of survey forecasts with elements $i_{t,n}^{survey}$, $\mathbf{A}^S$ is a $\mathrm{S} \times 1$ vector with elements A_n^e, $\mathbf{B}^S$ is a $\mathrm{S} \times \mathrm{K}$ matrix with rows equal to B_n^e for $n = 1, \ldots, \mathrm{S}$, $\mathbf{u}_t^S \sim \mathcal{N}_{\mathrm{S}}(0, I)$ and $\mathbf{\Sigma}_S$ is a lower triangular $\mathrm{S} \times \mathrm{S}$ matrix with positive elements on the diagonal.

To estimate the survey-augmented model, I follow Guimarães (2014) and Lloyd (2020) in two aspects. First, I use the estimated parameters from the JSZ normalization as initial values for the Kalman filter. Second, I assume homoskedasticity in yields and survey errors, so that $\mathbf{\Sigma}_Y = \sigma_y I_{\mathrm{N}}$ and $\mathbf{\Sigma}_S = \sigma_s I_{\mathrm{S}}$, where I_{N} and I_{S} are $\mathrm{N} \times \mathrm{N}$ and $\mathrm{S} \times \mathrm{S}$ identity matrices, respectively. This reduces the number of parameters to be estimated.

It is important to acknowledge that although surveys have good forecasting properties and helps to discipline the model, they are not a panacea. For instance, surveys might not be representative of market expectations nor of the expectations of the marginal investor, they are also subject to measurement error[31] and relying too much on them can be

[31] In particular, recall that Consensus Economics does not report long-term forecasts for the short rate of emerging markets, so they were inferred from available data.

counterproductive as it may lead to overfitting. Thus, although surveys certainly contain useful information, I consider them as imperfect or 'noisy' measures of expectations. As such, I follow Kim and Orphanides (2012) and fix σ_s at a conservative level of 75 basis points; as a reference, when σ_s is allowed to be estimated, its average value among all emerging markets is 31 basis points.

3.3.2 Estimating Daily Pricing Factors [Go2ToC]

The parameters of the model are estimated using end-of-month data because at the daily frequency there is noise that can undermine the estimation. However, once the parameters are estimated with monthly data, they can be used to estimate the pricing factors at the daily frequency (Adrian et al., 2013).

The maximum likelihood estimation procedure explained above gives estimates for both the parameters and the pricing factors. I regress the estimated monthly pricing factors on the end-of-month observed yields to obtain the matrix of loadings implied by those pricing factors, which is then applied to the daily yields to estimate the daily pricing factors. Finally, the estimated parameters (with monthly data) along with the estimated daily pricing factors are used to fit—and decompose—the yields at the daily frequency.

4 Decomposing the Yields of Emerging Markets [Go2ToC]

This section argues that the yield decomposition obtained with the survey-augmented model is sensible. It highlights the benefits of using synthetic curves and survey data when analyzing the yields of emerging markets. The next section will use the decomposition to characterize the response of their yields to U.S. monetary policy.

4.1 Model Fit [Go2ToC]

Figure 3 illustrates the fit of the model for the 10-year synthetic yields. The model fits the data reasonably well for most of the countries. The squared root of the average (across months and maturities) squared difference between the actual and the fitted yields is commonly used to summarize the fitting errors. For the advanced countries in the sample, those fitting errors are small at around 5 basis points in line with other studies (Wright, 2011; Adrian et al., 2019). The dynamics of emerging market yields, however, are relatively harder to capture, reflected in an average fitting error of 16 basis points, Although this is still a reasonable fit, it is important to keep in mind that large fitting errors might indicate less liquid and deep markets. In fact, Hu et al. (2013) propose to use cross-sectional pricing errors in U.S. Treasuries as a measure of overall market illiquidity.

4.2 Robustness

Once the model has been estimated, it can be used to decompose the yields. However, the relevance of any subsequent application of the decomposition and its ability to provide valuable insights hinges on how reliable it is. To assess its robustness, I compute the standard errors for each component using the delta method. Specifically, since each yield component Ψ is a function of the parameters of the model θ, $\Psi = h(\theta)$, its distribution is calculated based on the following

$$\sqrt{\mathrm{N}}\left(\widehat{\Psi} - \Psi\right) \xrightarrow{d} \mathcal{N}\left(0,\, \Gamma\,\Omega\,\Gamma'\right),$$

where Ω is the asymptotic covariance matrix of the estimator $\widehat{\theta}$ and Γ is the Jacobian matrix of partial derivatives calculated numerically. Ω is estimated using the sample Hessian estimator $\widehat{\Omega} = \widehat{\mathcal{H}_\theta}^{-1}$, where $\widehat{\mathcal{H}_\theta}$ is the the second derivative matrix of the log-likelihood function evaluated at the optimum and is also calculated numerically.[32]

In practice, there is uncertainty in the estimation of both the parameters and the pricing factors; however, the effect of uncertainty associated with the pricing factors on each component is relatively small. To assess this, at each period, I compute the standard errors by pre- and post-multiplying the variance of the pricing factors (generated by the

[32] $\widehat{\mathcal{H}_\theta}$ can be estimated using the joint log density or the individual log densities since $\widehat{\mathcal{H}_\theta} = -\frac{1}{\mathrm{N}}\sum_{i=1}^{\mathrm{N}} \frac{\partial^2 \log f(X_i|\widehat{\theta})}{\partial\theta\partial\theta'} = -\frac{1}{\mathrm{N}}\frac{\partial^2 \ell_{\mathrm{N}}(\widehat{\theta})}{\partial\theta\partial\theta'}$. Here, I report confidence bands using the individual log densities. In unreported results, the bands generated using the joint log density are slightly tighter for some countries.

Kalman filter) by the respective loadings for the fitted yields, the expected future short term rate and the term premium. The average standard error over time and across emerging markets is less than 9 basis points for the fitted yields and the components; for advance countries, the average standard error is less than 3 basis points. Therefore, I assume that the pricing factors are known with certainty and proceed to apply the delta method as explained in the previous paragraph.

Figures 4 and 5 illustrate the benefits of using survey data for emerging markets. They display the term premium and the credit risk compensation along with their confidence bands of ± 2 standard errors.[33] In general, the decompositions are robust, consistent with the findings of Guimarães (2014) for the U.S. and the U.K.

4.3 Decomposition Assessment [Go2ToC]

Figure 6 shows the decomposition of the 10-year yields;[34] which are used to report the results for the sake of brevity. Two patterns immediately emerge from the figure. First, the main component of the nominal yields of most countries is the expectation of the future short rate, for which a downward trend over the sample period can be seen for most of the countries, consistent with evidence for advanced economies (Adrian et al., 2019). Second, the credit risk compensation and the term premium are time-varying and both play an important role in the dynamics of emerging market yields. Although the term premium plays a relatively bigger role in explaining yield variation for most countries, the relative importance of the two risk associated parts varies by country and can even change over time, as can be seen for Hungary and the Philippines.

4.3.1 Expected Short Rate [Go2ToC]

[33] The confidence bands for the expected future short term interest rate are shown in the appendix. Equivalent information, however, is reported in figure 7.

[34] The decomposition for advanced countries is not displayed for two reasons. First, it has already been studied previously, see for instance Wright (2011) and Adrian et al. (2019). Second, the dataset does not include survey data for advanced countries and so their decompositions may not be robust. They are, however, used as a benchmark to assess some results (e.g. fitting errors).

Figure 7 shows that the 10-year expected future short rate tracks the (implied) long-term interest rate forecasts reasonably well, even though the model does not rely too much on them given the conservative value used for σ_s.

The expected future short rate implied by the model can also be assessed in terms of real interest rates, key variables to assess the monetary stance in a country and the suitability of the central bank's monetary policy decisions. Since the implied long-term forecasts for the short rate are based on the long-term U.S. real interest rate (see section 3.2.1), the expected future *real* interest rate—the difference between the future expected short rate implied by the model and the domestic long-term inflation forecast—should be similar across countries. Figure 8 verifies this. It shows that, once correcting for credit risk and inflation, the real interest rates of emerging markets fluctuate around zero. It is worth pointing out that this is consistent with estimates of the real rate for advanced countries. Holston et al. (2017) show that real interest rates in those countries have converged toward zero over the past years, a phenomenon that is partly explained by the increase in savings from East Asian countries following the regional crises of the late-1990s (Obstfeld, 2020).

4.3.2 Term Premium [Go2ToC]

In advanced countries, the (bond) risk premium is usually associated with the term premium. For emerging markets, however, the two concepts are different. The purpose of leveraging on synthetic yields (and surveys) is to estimate a genuine term premium.

One commonly used model-free measure to assess the term premium obtained by the model is the survey-based term premium—the difference between the synthetic yield and the short rate forecast over the same horizon. Since the model-implied expectations track the interest rate forecasts closely (see figure 7), the model-implied and the survey-based term premia comove.

Wright (2011) documents a downward trend in the term premia of advanced countries and argues that it owes in part to a reduction in inflation uncertainty. Figure 4 shows that, after correcting for credit risk, the term premia in some emerging markets decreased over the sample period. Since inflation in emerging markets tends to be higher and more volatile than in advanced countries (Ha et al., 2019), one would expect that the relationship between the term premia and inflation uncertainty to be even more relevant in emerging markets than in advanced countries. To test this hypothesis, I run panel regressions of the model-implied term premium on a measure of inflation uncertainty, namely the standard deviation of the permanent component of inflation based on the unobserved components stochastic volatility (UCSV) model proposed by Stock and Watson (2007). The UCSV model assumes that inflation has permanent and transitory components subject to uncorrelated shocks that vary over time. Following Wright (2011), I fit the UCSV model to quarterly data for each country. Table 4 reports the coefficient estimates for different tenors. The standard deviation of the permanent component is significant for medium- to long-term maturities, and its effect increases with maturity. Further, the result becomes stronger after controlling for the business cycle (proxied by the real GDP growth in each country). It is important to acknowledge that the specification might be subject to econometric problems since it involves persistent variables and ignores the fact that the regressor of interest is estimated. Nevertheless, the result is at least aligned with the view that the term premium in emerging markets compensates investors for bearing inflation uncertainty.

Finally, a term premium becomes negative when investors see bonds as hedges and are therefore willing to give up some investment return. This phenomenon has been reported for different advanced countries before and, especially, after the global financial crisis. Figure 6 shows that negative term premia are not restricted to advanced countries. In particular, some emerging Asian countries experienced episodes of negative term premia in the long end of their yield curves after the global financial crisis. Moreover, the term premia can be compared across maturities for each country. Figure 9 not only shows that term premia tend to increase with maturity—indicating that longer-term bonds are seen as riskier than short-term bonds—but that other countries also experienced negative term premia in the short end of their yield curves. This suggests that international and domestic investors in LC bond markets seem to have had a particular preference for short-term LC bonds after the global financial crisis.

4.3.3 Credit Risk Compensation [Go2ToC]

The dynamics of the credit risk compensation are in line with the results reported by Du and Schreger (2016a) who, in particular, show that it is highly correlated with the CDS of the respective country. Unlike the term premium, no clear trend is visible for the credit risk compensation, nor a pattern is detected when looking across maturities.

Since the role of the credit risk compensation in explaining yield variation is non-negligible, it matters which curve is used (nominal or synthetic) for decomposing the yields of emerging markets. Although its unconditional mean is positive, there have been brief episodes in which the credit risk compensation has been negative. These situations are unrealistic and can reflect financial market frictions (Du and Schreger, 2016a), including market segmentation between foreign and local investors and short selling constraints. Nevertheless, although far from perfect, it is a valid measure of credit risk, and definitely better than ignoring it. Otherwise, estimates of the term premium would be contaminated with credit risk.

Given that both the term premium and the credit risk compensation help explain yield variation in emerging markets, a natural question is whether and how they are related. However, while the term premium compensates investors for bearing the uncertainty that interest rates might suddenly increase, the credit risk compensation rewards them for two things. One compensates them for expected losses owing to default, and the other is compensates them for bearing the uncertainty that defaults might be larger than expected. Attempting to decompose the two parts is beyond the scope of this paper. Therefore, interpreting any potential correlation between the term premium and the credit risk compensation is not straightforward. One the one hand, it is reasonable to expect that the term premium and the uncertainty component of the credit risk compensation move in the same direction; on the other hand, the future expected short rate and the expected component of the credit risk compensation are likely to move in opposite directions. In the data, the correlation between the term premium and the credit risk compensation is negative for most countries, which suggests that the expected component of the credit risk compensation might be behind it. In the data, the future expected short rate and the credit risk compensation are also negatively correlated, supporting the view that the expected component of the credit risk compensation is relatively more relevant. Intuitively, a country facing difficulties to service their bond payments can either inflate away its debt or default, which can be referred to as implicit and explicit defaults. Inflating away the debt reduces the need to default, in which case they would be seen as substitutes. The evidence thus points to a trade-off between explicit and implicit defaults for most emerging markets.

5 Understanding the Yields of Emerging Markets [Go2ToC]

This section documents a strong and persistent response of the sovereign yields of emerging markets to U.S. monetary policy shocks. Yields respond differently depending on the type of shock.

5.1 Comovement [Go2ToC]

To some extent, the response of emerging market yields to U.S. monetary policy shocks depends on how connected are the sovereign yields of emerging markets. One way to address this question is to pool all yields together and see whether there is a global-level factor, associated with the first principal component. A global factor explains more than 90% of the variation in the yields of advanced countries, whereas it only explains around 50% of the variation in the yields of emerging markets.

A more formal way to analyze the comovement of yields is to measure the degree of connectedness among them. Diebold and Yilmaz (2014) propose a system-wide measure of connectedness that assesses shares of forecast error variation in a country's bond market due to shocks arising elsewhere. The connectedness index fluctuates between 0 and 100 percent, with higher numbers indicating a higher degree of comovement. Following Adrian et al. (2019) and Bostanci and Yilmaz (2020), I obtain the connectedness index using a vector autoregression of order 1, with a forecast horizon of 10 days and a rolling window of 150 days for the daily changes of the 10-year nominal yield and each of its components. Adrian et al. (2019) report that the connectedness index fluctuates around 80% for advanced countries. In contrast, figure 10 shows that index for the yields of emerging markets fluctuates around 30%, with notable spikes around the taper tantrum episode in 2013, and after the 2016 U.S. presidential election.[35] This evidence of highly connected yields in advanced countries and low connected yields in emerging markets is consistent with a view in which global bond markets essentially operate under a core-periphery structure, in which the bond markets of advanced countries constitute the (highly interconnected) core and those of emerging markets represent the (less connected) periphery. Countries in the periphery are in turn connected to the network mainly through countries in the core.[36] According to this, shocks to emerging market yields are mainly idiosyncratic—reflected in less comovement—so what matters for them are not spillovers originating in other emerging markets but in advanced countries.

The connectedness index shows no clear trend for either the nominal or synthetic yields nor their components. In contrast, Adrian et al. (2019) document that the increase in the connectedness of the yields of advanced countries has been driven by an increase in the connectedness of their term premia. Nevertheless, the term premia in emerging markets has been slightly more connected since 2013, whereas the credit risk compensation is relatively less connected (see figure 10b). In fact, the level of the index for the synthetic yields tends to be higher than that for the nominal yields (see figure 10a), suggesting that credit risk is indeed a more idiosyncratic component of the yields.

A related question is whether the connectedness of yields is the same throughout the term structure or whether some sections of the curves are more connected than others. Obstfeld (2015) argues that long-term bonds are more globally connected than

[35]Notice that low connectedness among the yields of emerging markets estimating the models for their yield curves separately instead of jointly.

[36]The core-periphery structure has been shown to be a good description of different networks in economics and finance. Craig and von Peter (2014) show, for example, that the interbank market operates under such a structure.

short term ones. On the other hand, Kalemli-Özcan (2019) argues that short-term yields suffer more the effects of global influences. Figure 11 plots the connectedness index for different maturities. It shows that the long end is relatively more connected than the short end, similar to what is observed for advanced countries, although this pattern became relevant for emerging markets after the taper tantrum episode. The figure also shows that the connectedness of the short end of the yield curves is similar between advanced and emerging markets. The difference in connectedness between the two groups of countries is therefore driven by the medium and long end of their yield curves. Although foreign participation in LC bond markets has increased, it is still mostly held by local investors, especially medium- and longer-term bonds as suggested by figure 11, and are therefore more responsive to local factors.

5.2 Drivers

[Go2ToC]

To understand the potential drivers of emerging market yields and the role of their components, I run the following regressions

$$y_{i,t} = \alpha_i + \beta' z_{i,t} + u_{i,t}, \tag{15}$$

for country i in month t, where α_i are country fixed effects, $z_{i,t}$ is a vector of global and domestic variables that are likely to drive emerging market yields, and $u_{i,t}$ is the error term. The dependent variables $y_{i,t}$ are the nominal yields and their three components for the 2- and 10-year maturities.

Different variables are included in the vector $z_{i,t}$ as potential drivers. Synthetic yields are constructed from the U.S. yield curve, so movements in the latter will likely influence the yields of emerging markets. Moreover, decomposing the U.S. yields can be even more insightful. I use the decomposition based on the Kim and Wright (2005) model, which decomposes the yields into an expected future short rate and a term premium, and addresses the small sample problem using survey forecasts of future interest rates. Rey (2013) highlights the role of the Cboe's volatility index (Vix) as an important driver of the global financial cycle. The Vix reflects the implied volatility in stock option prices and is usually considered as a measure of risk aversion and economic uncertainty; given the sudden spikes in the index, it is common to use it in logs. Baker et al. (2016) construct a news-based economic policy uncertainty (EPU) index that has been replicated for different countries, which would allow to account for domestic political uncertainty. Unfortunately, it is only available for five of the emerging markets in the sample,[37] so its not included as an explanatory variable. Instead, the global and U.S. versions of the EPU index are used as alternative measures of global uncertainty. The index of economic activity based on world industrial production proposed by Hamilton (2019) reflects global real economic activity. Domestic inflation and unemployment rates will capture local macroeconomic conditions. Finally, the exchange rate (LC per USD) is included to rule out explanations of changes in yields based on currency movements; the exchange rate is standardized for each country over the sample period.

Tables 6 and 8 report the results for the full specification of the model.[38] The role of the components of the U.S. yield curve already indicate potential spillover effects from the Fed's policy decisions to emerging market yields. Increases in the future expected short rate in the U.S. are positively associated with future expected policy rates in emerging markets, whereas increases in the U.S. term premium relate to increments in the term premia of emerging markets. Moreover, the association between the U.S. components and the synthetic yields is larger than with the nominal yields. This in turn explains the negative association of the U.S. components with the credit risk compensation. Larger increases in synthetic relative to nominal yields, mechanically decrease the credit risk compensation. Therefore, the trade-off between explicit and implicit defaults highlighted before can be seen in table 8 through the connection between the U.S. term premium and the credit risk compensation. In addition, there are also cross effects. The expected short rate in emerging markets reacts to changes in the U.S. term premium. This is consistent with the U.S. risk spillovers channel described by Kalemli-Özcan (2019). The signs for

[37] Brazil, Colombia, Mexico, Russia and South Korea.

[38] The effects of the variables remain broadly similar across specifications of the model that progressively include the regressors for each dependent variable.

the rest of the drivers are reasonable.

The results shows that inflation and unemployment are key domestic variables. The evidence in table 8 suggests that the term premia in emerging markets is countercyclical. Investors demand a higher term premium during recessions, when the unemployment rate increases. Moreover, the positive association between inflation and the term premium conforms with the idea that inflation erodes the value of nominal bonds and so, in periods of rising inflation investors expect the central bank to tighten its monetary stance going forward and demand a higher term premium. More generally, changes in inflation are associated with changes in all of the dependent variables except for the credit risk compensation. In particular, the magnitudes are similar for nominal and synthetic as well as for the forward premium.

Lastly, there is evidence on the risk-taking channel of exchange rates documented by Hofmann et al. (2019).[39] Accordingly, a currency appreciation is associated with easier financial conditions and compressed sovereign bond spreads. However, here it works through the term premium instead of the credit risk compensation as they argue.

Although the yield decompositions provide valuable information on the driving forces behind the sovereign yields of emerging markets, it is important to acknowledge that the model in equation (15) may suffer from econometric problems such as reverse causality and omitted variables as well as the use of persistent variables. Issues that are addressed next.

5.3 Response to U.S. Monetary Policy

This section first explains how the monetary policy shocks are calculated and then analyzes the responses of emerging market yields to those shocks.

5.3.1 Identification of Monetary Policy Shocks [Go2ToC]

[39] According to the standard view based on the trade-channel effect, a depreciation is expansionary because it stimulates exports and discourages imports, increasing the trade balance.

Gürkaynak et al. (2005) and Swanson (2018) show that monetary policy has more than one dimension since asset prices respond to different types of news about monetary policy. I consider three types of shocks, namely unexpected changes to the current policy rate (Kuttner, 2001), surprise changes to the future path of the policy rate (Gürkaynak et al., 2005), and unanticipated announcements about the Fed's LSAP programs (Swanson, 2018). They will be referred to hereinafter as target, path and LSAP shocks, respectively.

The shocks are identified using high-frequency data around Fed's monetary policy announcements. These shocks are essentially surprises in monetary policy decisions that represent a change in the information set of market participants (Gürkaynak and Wright, 2013; Nakamura and Steinsson, 2018). The construction of the shocks therefore requires to calculate changes in asset prices that capture market expectations of monetary policy decisions. These changes are measured in windows containing monetary policy decisions starting 15 minutes before to 1 hour and 45 minutes after each Federal Open Market Committee (FOMC) meeting since 2000 giving a total of 162 events.[40] In days with no FOMC meeting, the shocks are set to zero. Unlike Ferrari et al. (2017), who include releases of minutes and speeches by Fed officials, the dataset here includes monetary policy announcements only.

To compute the shocks, I use the current federal funds rate future (FF0) contract, the 8-quarters ahead eurodollar future (ED8) contract and the yield of the 10-year U.S. Treasury bond. The target shock uses rescaled changes in the price of the FF0 contract as in Gürkaynak et al. (2005), who implement an intraday version of the daily measure proposed by Kuttner (2001). Price changes in the ED8 contract measure surprises in the federal funds rate two years into the future. The path shock is the residual of a regression of the intraday change in the ED8 contract on the target shock, and is highly correlated with the path factor in Gürkaynak et al. (2005).[41] Finally, in line with Swanson (2018), the LSAP shock is the residual of a regression of the intraday change in the 10-year

[40]Following Gürkaynak et al. (2005) and Nakamura and Steinsson (2018), I exclude from the analysis the meeting of September 2001 that followed the terrorist attacks in New York.

[41]The change in the 4-quarters ahead eurodollar future (ED4) contract could also be used to capture the path shock. However, intraday changes in ED4 became essentially zero after 2011 since market participants expected the policy rate to remain at zero for at least a year.

yield on the target and path shocks. A positive value in any of the shocks represents a tightening of the monetary policy stance, and vice versa.

The relevance of the shocks has varied over time. After 2008, there were no surprise changes in the current policy rate, so target shocks have been essentially zero. By contrast, the meaning of LSAP shocks is unclear before 2008. Path shocks have nevertheless been relevant before and after the GFC. As a result, target shocks are only considered from 2000 to 2008, LSAP shocks are considered starting in 2009, and path shocks span the whole sample period. Table 9 reports descriptive statistics of the three types of shocks on monetary policy announcement days. By construction, the shocks are not correlated. In general, the Fed is more aggressive in stimulating than in contracting the U.S. economy, easing shocks are larger on average and more common than tightening shocks.

5.3.2 U.S. Monetary Policy Spillovers [Go2ToC]

The impact of U.S. monetary policy on emerging market yields is estimated using panel local projections for the daily changes in the yields and their components. These regressions are useful to understand not only how the yields respond to the policy surprise at the time of the shock but over subsequent periods, see Hofmann et al. (2019) and Adrian et al. (2019) for recent applications.

Following Jordà (2005), the panel local projections are:

$$y_{i,t+h} - y_{i,t-1} = \alpha_{h,i} + \sum_{j=1}^{3} \beta_h^j \epsilon_t^j + \gamma_h \Delta y_{i,t-1} + \phi_h s_{i,t-1} + u_{i,t+h}, \qquad (16)$$

where i and t are respectively the country and time indexes, h indicates the horizon (in days) with $h = 0, 1, \ldots, 60$, $\alpha_{h,i}$ is a country fixed effect, each ϵ_t represents a type of monetary policy shock that is set to zero in non-announcement days or in periods outside of the considered range (e.g. before 2009 for LSAP shocks), $s_{i,t-1}$ is a one-day lag in the exchange rate (LC per USD) and $u_{i,t+h}$ is the error term. The regressions are done for the 2- and 10-year nominal yields and each of their components.[42]

[42]By definition, the shocks are unanticipated by the market and thus there is no need to control for past or future shocks. Also, although there is no need to control for the other types of shocks since they are uncorrelated by construction, the estimation is more efficient when all the shocks are included.

The parameters of interest, β_h^j, measure the average response of the nominal yield (or one of its components) to monetary policy shock j at horizon h. The contemporaneous effects of the shocks are obtained by setting $h = 0$ in equation (16). All responses are assessed relative to a one basis point reduction (an easing) in any of the shocks, since the Fed has been more aggressive in that direction during the sample period.

The response of the U.S. yields and its components to the three shocks are used as a benchmark to assess the responses of the yields of emerging markets.[43] The first column of figures 12 and 13 shows the responses of the 2- and 10-year yields, respectively, to all three shocks. The on-impact effect of the 2-year yield to any of the three shocks is similar at around 5 basis points for a 10 basis point increase in any of the shocks. By contrast, the 10-year yield only increases in response to path and LSAP shocks contemporaneously, with LSAP shocks having a more than one-to-one impact. The magnitudes are in line with previous literature. The duration of the effects ranges from a couple of days up to a few days past a month, where the delayed response can be larger that the initial reaction, consistent with the evidence in Brooks et al. (2019). The decomposition allows for a better characterization of the response. For instance, one of the goals of the unconventional monetary policy tools was to influence (decrease) long-term bond yields and, in particular, the term premium (see Kuttner, 2018). The right hand panels in figures 13b and 13c confirm this. Meanwhile, the main effects of target shocks are seen on the expected short rate, especially at the 2-year maturity (middle panel of figure 12a). Fed's decisions therefore impact both expectations about its policy rate in the future and the compensation required by investors to hold long-term bonds.

I now turn to analyze how the sovereign yields of emerging markets respond to U.S. monetary policy. The first column of figures 14 and 15 shows the responses of their 2- and 10-year nominal yields, respectively, to all three shocks. Those yields go up by about 2 basis points on-impact for a 10 basis point increase in any of the shocks. Thus, the magnitude of the initial response is lower than the response of U.S. yields. However, the response increases over time, it can last for up to 2 months and intensify to such an

[43]As before, the U.S. yields come from the dataset of Gürkaynak et al. (2007), and the components from the decomposition proposed by Kim and Wright (2005).

extent so as to become a one-to-one response, or even more in the case of LSAP shocks. The response of the yields of emerging markets therefore lasts relatively longer than the response of U.S. yields. Adrian et al. (2019) documents a similar finding for a sample comprised mostly by advanced countries. For the U.S., Brooks et al. (2019) attribute this delayed response to a portfolio rebalancing channel.

To better understand the spillover effects of the Fed's decisions on emerging markets, I leverage on the yield decompositions at the daily frequency. The responses of each component are displayed in the second to last column of figures 14 and 15. Several things are worth pointing out about the response of the 2-year yield. First, no shock impacts the term premium. Second, the expected short rate only responds on-impact to LSAP shocks, but it has a substantial delayed response to target and path shocks. Third, although the expected short rate and the term premium do not respond on impact to target and path shocks, nominal yields do respond but as a result of an increase in the credit risk compensation. Fed policies can therefore influence the compensation for credit risk in emerging markets.

Before analyzing the response of the 10-year yield decomposition, it is helpful to first look at the response of the forward premium to the shocks. Remember that synthetic yields add a forward premium to the U.S. yield curve. Since exchange rates are expressed in LC per USD, a decrease in the premium implies that the forward exchange rate is lower than the spot. Figures 18 and 19 show the responses of the forward premium for emerging and advanced countries, respectively. In all cases, the forward premium declines (sometimes even one-to-one) on impact in response to a shock but it remains below zero in subsequent days only for advanced countries, whereas there is only an on-impact response for emerging markets in general. It is well documented that following a monetary tightening the dollar appreciates (Ferrari et al., 2017). This is consistent with a decline in the forward premium (when the spot is higher than the forward), which implies a future expected appreciation of the domestic currency.

It can now be seen how the the 10-year yield respond to monetary policy decisions by the Fed. By construction, the effects on synthetic yields are linked to the responses of the

U.S. yield curve and the forward premium for corresponding maturities. Such responses have already been discussed above (see figures 13 and 18). The response of the synthetic yields is the net result of those two individual effects, which in turn will be reflected in the components of those synthetic yields, namely the expected short rate and the term premium. The expected short rate does not respond on-impact for target or path shocks; the term premium also does not respond on-impact to path shocks, only to target shocks. But their responses are sluggish and amplify over time.

The analysis of the 10-year yield shows that Fed's decisions not only impact the credit risk compensation but that it can affect them in both directions. The credit risk compensation increases in response to target and path shocks, while decreases in response to LSAP shocks. But why does the credit risk compensation increase in response to target and path shocks? Because synthetic yields *decline* on-impact. The reason is that a lower forward premium means a lower compensation for a future currency depreciation, reducing the cost of borrowing in LC at the risk-free rate.[44] With an increase in the nominal yield and a decrease in the synthetic yield in response to a monetary tightening, the credit risk compensation goes up (see the right panels of figures 14a and 14b).[45] That is, target and path shocks have opposite effects on the synthetic yield and on the credit risk compensation on impact. Similarly the credit risk compensation decreases in response to LSAP shocks because synthetic yields increase on impact. Even though the forward premium still declines following a path shock (see figure 18c), since the U.S. yield increases by more (see figure 13), the synthetic yield increases on impact, decreasing the credit risk compensation. Therefore, the direction of the response of the credit risk compensation depends on the type of shock, but in particular on the relative responses of the forward premium and U.S. yields. In any case, unlike the delayed response in nominal yields and the components of synthetic yields, the reaction by the credit risk compensation is short lived. Given that the forward premium for emerging markets only

[44]Mechanically, synthetic yields decline because the forward premium declines by more than the increase in U.S. yields, see figures 13 and 18.

[45]The exchange rate risk channel proposed by Hofmann et al. (2019) can be indirectly seen here. A monetary tightening in the U.S. would appreciate the dollar and depreciate the domestic currency. A currency appreciation would associated with an increase in the credit risk compensation and vice versa.

reacts on-impact, the effects on the nominal yields in the subsequent days are essentially driven by the responses of the expected short rate and the term premium. Finally, notice that the effects on the credit risk compensation can revert over time, which would explain the negative correlation reported in section 5.2.

6 Concluding Remarks

[Go2ToC]

This paper studies how emerging market sovereign bond yields respond to U.S. monetary policy shocks. I characterize the response based on a novel decomposition of the yields into an expected future short-term interest rate, a credit risk compensation and a (pure) term premium. I show that U.S. monetary policy influences each of the components of emerging market yields.

The responses of the yields and their components have several implications. Although the contemporaneous impact seems moderate relative to the response of U.S. yields, Fed's monetary policy decisions can have ripple effects depending on the type of shock. The effects on the expected short rate and on the term premium are sluggish and the spillover effects afterwards are substantial, whereas the effect on the credit risk compensation is short lived. Surprises in Fed's policy decisions give rise to a reassessment of policy rate expectations in emerging markets, and lead to a repricing in their interest and credit risks. Investors expect central banks in emerging markets to follow the U.S. monetary stance (loosening or tightening) in response to decisions by the Fed. Investors also adjust the compensation they demand to hold long-term bonds as well the compensation against default. U.S. monetary policy has therefore not only monetary but also fiscal implications for emerging markets.

Future research paths. Structure of the sovereign bond yield market: core-periphery? MPS from other advanced countries (e.g. ECB from Gurkaynak).

Table 1. Descriptive Statistics of Yield Curves

		3M	6M	1Y	2Y	5Y	10Y
Nominal Yields				Emerging Markets			
	Average	5.1	5.3	5.4	5.7	6.3	6.8
	S. Dev.	3.2	3.3	3.2	3.2	3.0	2.9
				Advanced Countries			
	Average	2.0	2.1	2.1	2.3	2.7	3.2
	S. Dev.	2.1	2.1	2.1	2.1	2.0	1.8
Synthetic Yields				Emerging Markets			
	Average	5.1	5.2	5.3	5.3	5.8	6.3
	S. Dev.	4.3	4.1	4.0	3.7	3.4	3.2
				Advanced Countries			
	Average	1.6	1.7	1.8	2.0	2.5	3.2
	S. Dev.	2.1	2.1	2.2	2.1	2.0	2.0

Notes: This table reports the average, the standard deviation, the minimum and the maximum values using end-of-month data for different tenors of the nominal and synthetic yields of the emerging markets and advanced countries in the sample. All figures are expressed in annualized percentage points.

Table 2. Descriptive Statistics of Yield Components: Emerging Markets

	3M	6M	1Y	2Y	5Y	10Y
	Expected Short Rate					
Average	5.1	5.2	5.2	5.1	4.8	4.3
S. Dev.	3.7	3.4	3.1	2.7	2.2	1.8
	Term Premium					
Average	0.0	0.0	0.1	0.3	1.0	2.0
S. Dev.	1.3	1.4	1.4	1.5	1.5	1.7
	Credit Risk Premium					
Average	0.3	0.5	0.6	0.7	0.9	0.8
S. Dev.	2.0	1.5	1.2	1.1	1.0	0.9

Notes: This table reports the average, the standard deviation, the minimum and the maximum values using end-of-month data for different tenors of the components of the emerging market nominal yields. All figures are expressed in annualized percentage points.

Table 3. Descriptive Statistics of Yield Components: Advanced Countries

	3M	6M	1Y	2Y	5Y	10Y
	Expected Short Rate					
Average	2.0	2.0	2.0	1.9	1.6	1.3
S. Dev.	2.1	2.1	2.0	1.9	1.7	1.4
	Term Premium					
Average	0.0	0.1	0.2	0.4	1.1	1.9
S. Dev.	0.0	0.1	0.2	0.3	0.7	0.9

Notes: This table reports the average, the standard deviation, the minimum and the maximum values using end-of-month data for different tenors of the components of the advanced country nominal yields. All figures are expressed in annualized percentage points.

Table 4. Term Premia and Inflation Volatility

	6 Months		1 Year		2 Years		5 Years		10 Years	
UCSV-Perm	93.0	75.3	85.7*	83.2	88.7***	97.8**	103.1***	124.2***	121.9***	151.3***
	(52.2)	(49.5)	(37.1)	(43.7)	(24.7)	(31.6)	(15.3)	(18.7)	(16.1)	(18.3)
GDP Growth		-2.56		-2.62		-1.91		-2.14		-3.97*
		(3.37)		(4.00)		(3.53)		(1.67)		(1.55)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lags	3	3	3	3	3	3	3	3	3	3
No. Countries	15	14	15	14	15	14	15	14	15	14
Observations	870	796	870	796	870	796	870	796	870	796
R^2	0.04	0.03	0.04	0.03	0.05	0.05	0.10	0.11	0.11	0.15

Notes: This table reports the slope coefficients of panel data regressions of the model-implied term premia for different maturities on the standard deviation of the permanent component of inflation according to the UCSV model (UCSV-Perm) and GDP growth. The sample includes quarterly data for 15 countries starting in 2000:I and ending in 2018:IV. The term premia is expressed in basis points. GDP growth is expressed in percent. All cases include country fixed effects. Driscoll-Kraay standard errors are in parenthesis. *, **, *** asterisks respectively indicate significance at the 10%, 5% and 1% level.

Table 5. Drivers of the Emerging Market 1-Year Nominal Yield and Its Components

	Nominal	E. Short Rate	Term Premium	Credit Rirsk
Yield	0.08*	0.07*	0.07*	-0.07
	(0.03)	(0.03)	(0.03)	(0.04)
Policy Rate	0.74***	0.71***	0.13***	-0.09**
	(0.03)	(0.04)	(0.03)	(0.03)
Inflation	7.07**	-2.18	8.28**	0.97
	(2.43)	(3.19)	(2.73)	(3.09)
Unemployment	5.45	-1.29	-3.24	9.98***
	(2.81)	(2.38)	(2.04)	(2.51)
LC per USD (Std.)	32.69***	32.44***	19.56***	-19.31***
	(5.00)	(6.47)	(4.66)	(5.64)
Log(Vix)	44.61***	-11.94	-13.49	70.05***
	(9.81)	(14.96)	(10.95)	(11.97)
Log(EPU U.S.)	3.75	-2.44	-10.40***	16.60**
	(4.02)	(5.53)	(3.10)	(5.15)
Log(EPU Global)	-71.30***	-64.96***	-8.48	2.14
	(13.19)	(13.31)	(9.54)	(14.77)
Global Ind. Prod.	1.54*	-0.96	-2.26*	4.76***
	(0.69)	(1.12)	(0.90)	(0.79)
Fixed Effects	Yes	Yes	Yes	Yes
Lags	4	4	4	4
No. Countries	15	15	15	15
Observations	2194	2194	2194	2194
R^2	0.81	0.74	0.25	0.20

Notes: This table reports the estimated slope coefficients of panel data regressions of the 1-year nominal yields and their components on selected explanatory variables. The sample includes monthly data for 15 emerging markets starting in 2000:1 and ending in 2019:12. The dependent variables are the nominal (Nominal) and synthetic (Synth.) yields, the expected short rate (ESR), the term premium (TP), the credit risk premium (CRP) and the forward premium (FP). All dependent variables are expressed in basis points. The explanatory variables are the U.S. expected short rate (US ER) and term premium (US TP) according to Kim and Wright (2005), domestic inflation and unemployment, the log of the Vix (Log(Vix)) and the global economic policy uncertainty index (Log(EPU)) based on Baker et al. (2016), the global activity index based in industrial production (Global IP) from Hamilton (2019) and the monthly returns of the exchange rate (FX), the Standard & Poor's stock market index (S&P) and the price of oil for the West Texas Intermediate benchmark (Oil). All cases include country fixed effects. Heteroskedasticity and autocorrelation consistent standard errors are in parenthesis. *, **, *** asterisks respectively indicate significance at the 10%, 5% and 1% level.

Table 6. Drivers of the Emerging Market 2-Year Nominal Yield and Its Components

	Nominal	E. Short Rate	Term Premium	Credit Rirsk
Yield	0.11**	0.13***	0.09**	-0.11***
	(0.04)	(0.03)	(0.03)	(0.03)
Policy Rate	0.64***	0.56***	0.13***	-0.05
	(0.03)	(0.03)	(0.02)	(0.03)
Inflation	8.57***	-0.51	7.27**	1.81
	(2.47)	(2.79)	(2.32)	(2.58)
Unemployment	10.14***	0.16	0.26	9.71***
	(2.93)	(2.25)	(1.67)	(2.18)
LC per USD (Std.)	32.05***	30.79***	19.59***	-18.33***
	(5.34)	(5.58)	(4.15)	(5.00)
Log(Vix)	62.53***	-3.40	-3.83	69.76***
	(11.13)	(14.46)	(8.30)	(11.39)
Log(EPU U.S.)	7.13	-2.03	-7.48**	16.65***
	(4.75)	(4.62)	(2.80)	(4.08)
Log(EPU Global)	-84.17***	-68.94***	-18.99	3.76
	(15.37)	(11.73)	(9.68)	(13.68)
Global Ind. Prod.	1.42	-0.89	-1.55**	3.85***
	(0.92)	(1.19)	(0.52)	(0.71)
Fixed Effects	Yes	Yes	Yes	Yes
Lags	4	4	4	4
No. Countries	15	15	15	15
Observations	2194	2194	2194	2194
R^2	0.79	0.74	0.34	0.28

Notes: This table reports the estimated slope coefficients of panel data regressions of the 2-year nominal yields and their components on selected explanatory variables. The sample includes monthly data for 15 emerging markets starting in 2000:1 and ending in 2019:12. The dependent variables are the nominal (Nominal) and synthetic (Synth.) yields, the expected short rate (ESR), the term premium (TP), the credit risk premium (CRP) and the forward premium (FP). All dependent variables are expressed in basis points. The explanatory variables are the U.S. expected short rate (US ER) and term premium (US TP) according to Kim and Wright (2005), domestic inflation and unemployment, the log of the Vix (Log(Vix)) and the global economic policy uncertainty index (Log(EPU)) based on Baker et al. (2016), the global activity index based in industrial production (Global IP) from Hamilton (2019) and the monthly returns of the exchange rate (FX), the Standard & Poor's stock market index (S&P) and the price of oil for the West Texas Intermediate benchmark (Oil). All cases include country fixed effects. Heteroskedasticity and autocorrelation consistent standard errors are in parenthesis. *, **, *** asterisks respectively indicate significance at the 10%, 5% and 1% level.

Table 7. Drivers of the Emerging Market 5-Year Nominal Yield and Its Components

	Nominal	E. Short Rate	Term Premium	Credit Rirsk
Yield	0.26***	0.27***	0.18***	-0.19***
	(0.06)	(0.03)	(0.04)	(0.04)
Policy Rate	0.40***	0.39***	0.06**	-0.04
	(0.03)	(0.02)	(0.02)	(0.02)
Inflation	12.64***	1.56	6.63***	4.45*
	(2.58)	(2.16)	(1.71)	(1.97)
Unemployment	20.18***	1.66	7.50***	11.01***
	(3.22)	(2.18)	(1.66)	(2.16)
LC per USD (Std.)	34.35***	28.70***	16.62***	-10.97**
	(5.89)	(4.28)	(3.71)	(3.97)
Log(Vix)	84.41***	0.28	33.51***	50.63***
	(12.17)	(12.24)	(9.00)	(9.41)
Log(EPU U.S.)	9.64	-1.59	-0.96	12.18**
	(5.85)	(3.36)	(3.60)	(3.73)
Log(EPU Global)	-88.59***	-55.72***	-32.41**	-0.46
	(18.62)	(9.58)	(10.49)	(10.13)
Global Ind. Prod.	0.57	-0.59	-1.32	2.48**
	(1.28)	(0.96)	(0.71)	(0.78)
Fixed Effects	Yes	Yes	Yes	Yes
Lags	4	4	4	4
No. Countries	15	15	15	15
Observations	2194	2194	2194	2194
R^2	0.72	0.72	0.38	0.27

Notes: This table reports the estimated slope coefficients of panel data regressions of the 5-year nominal yields and their components on selected explanatory variables. The sample includes monthly data for 15 emerging markets starting in 2000:1 and ending in 2019:12. The dependent variables are the nominal (Nominal) and synthetic (Synth.) yields, the expected short rate (ESR), the term premium (TP), the credit risk premium (CRP) and the forward premium (FP). All dependent variables are expressed in basis points. The explanatory variables are the U.S. expected short rate (US ER) and term premium (US TP) according to Kim and Wright (2005), domestic inflation and unemployment, the log of the Vix (Log(Vix)) and the global economic policy uncertainty index (Log(EPU)) based on Baker et al. (2016), the global activity index based in industrial production (Global IP) from Hamilton (2019) and the monthly returns of the exchange rate (FX), the Standard & Poor's stock market index (S&P) and the price of oil for the West Texas Intermediate benchmark (Oil). All cases include country fixed effects. Heteroskedasticity and autocorrelation consistent standard errors are in parenthesis. *, **, *** asterisks respectively indicate significance at the 10%, 5% and 1% level.

Table 8. Drivers of the Emerging Market 10-Year Nominal Yield and Its Components

	Nominal	E. Short Rate	Term Premium	Credit Rirsk
Yield	0.49***	0.36***	0.38***	-0.26***
	(0.07)	(0.02)	(0.04)	(0.06)
Policy Rate	0.22***	0.29***	-0.01	-0.06***
	(0.03)	(0.02)	(0.02)	(0.02)
Inflation	15.83***	1.90	7.62***	6.32***
	(2.32)	(1.62)	(1.55)	(1.78)
Unemployment	25.09***	1.54	11.94***	11.62***
	(3.52)	(2.16)	(1.88)	(2.23)
LC per USD (Std.)	39.66***	32.86***	20.14***	-13.34***
	(6.03)	(3.64)	(3.56)	(3.88)
Log(Vix)	65.57***	-15.14	45.89***	34.83***
	(13.15)	(10.69)	(10.37)	(9.41)
Log(EPU U.S.)	5.64	-4.75	-1.48	11.86**
	(6.08)	(2.59)	(4.14)	(4.22)
Log(EPU Global)	-62.30**	-40.35***	-22.03	0.07
	(20.03)	(7.37)	(11.99)	(11.41)
Global Ind. Prod.	-0.61	0.14	-1.76*	1.01
	(1.44)	(0.74)	(0.86)	(0.86)
Fixed Effects	Yes	Yes	Yes	Yes
Lags	4	4	4	4
No. Countries	15	15	15	15
Observations	2194	2194	2194	2194
R^2	0.67	0.71	0.45	0.22

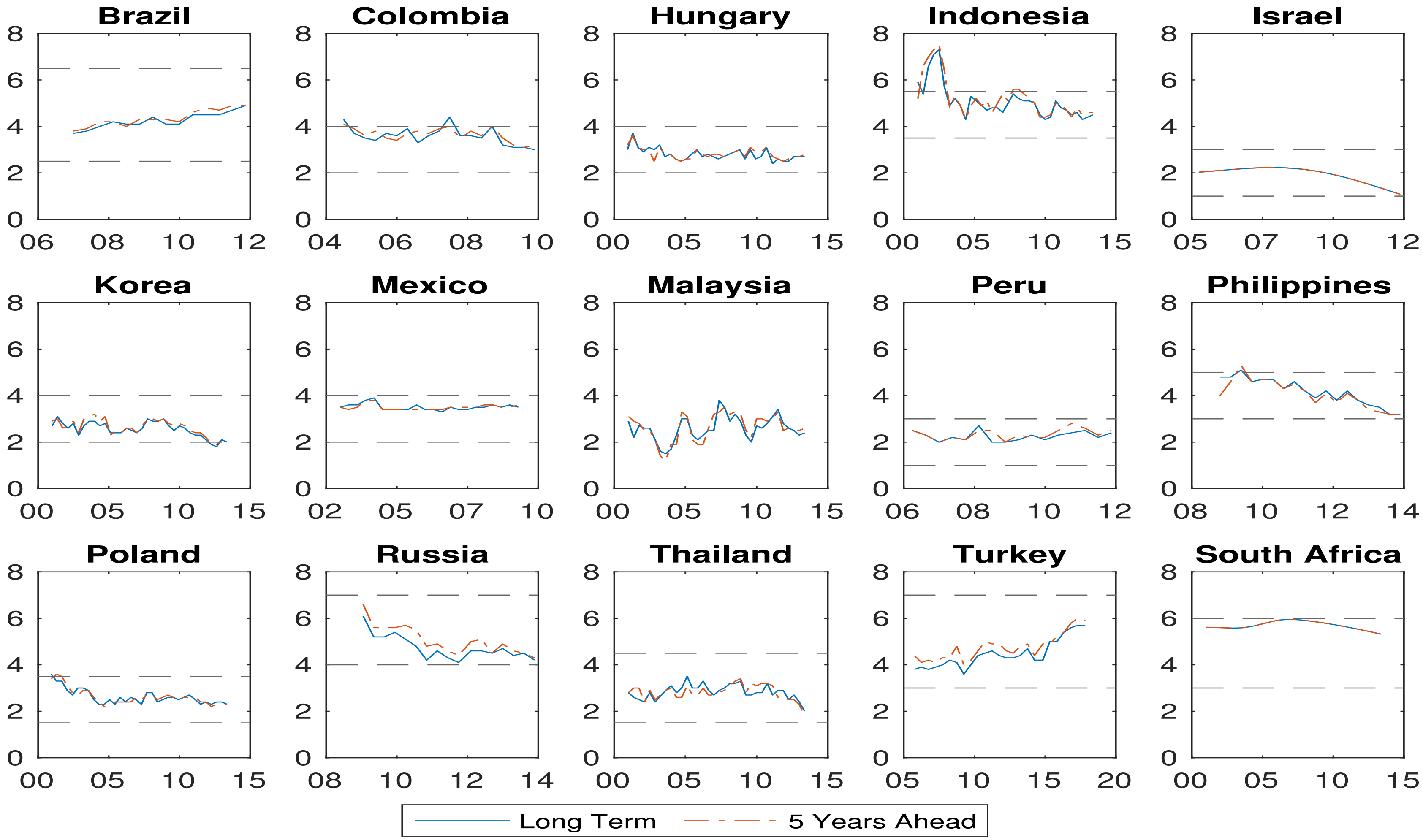
Notes: This table reports the estimated slope coefficients of panel data regressions of the 10-year nominal yields and their components on selected explanatory variables. The sample includes monthly data for 15 emerging markets starting in 2000:1 and ending in 2019:12. The dependent variables are the nominal (Nominal) and synthetic (Synth.) yields, the expected short rate (ESR), the term premium (TP), the credit risk premium (CRP) and the forward premium (FP). All dependent variables are expressed in basis points. The explanatory variables are the U.S. expected short rate (US ER) and term premium (US TP) according to Kim and Wright (2005), domestic inflation and unemployment, the log of the Vix (Log(Vix)) and the global economic policy uncertainty index (Log(EPU)) based on Baker et al. (2016), the global activity index based in industrial production (Global IP) from Hamilton (2019) and the monthly returns of the exchange rate (FX), the Standard & Poor's stock market index (S&P) and the price of oil for the West Texas Intermediate benchmark (Oil). All cases include country fixed effects. Heteroskedasticity and autocorrelation consistent standard errors are in parenthesis. *, **, *** asterisks respectively indicate significance at the 10%, 5% and 1% level.

Table 9. Descriptive Statistics of U.S. Monetary Policy Shocks

	Mean	Std. Dev.	Min.	Max.	Obs
Target Shocks (absolute values)	4.9	8.9	0.0	46.5	81
Target Shocks > 0	4.5	4.1	0.0	14.4	26
Target Shocks < 0	-8.3	12.3	-46.5	-0.5	34
Path Shocks (absolute values)	6.0	6.5	0.0	54.6	162
Path Shocks > 0	5.4	4.9	0.0	24.9	89
Path Shocks < 0	-6.7	8.0	-54.6	-0.0	73
LSAP Shocks (absolute values)	2.2	3.6	0.1	29.9	81
LSAP Shocks > 0	2.0	2.2	0.1	10.3	37
LSAP Shocks < 0	-2.4	4.5	-29.9	-0.1	44

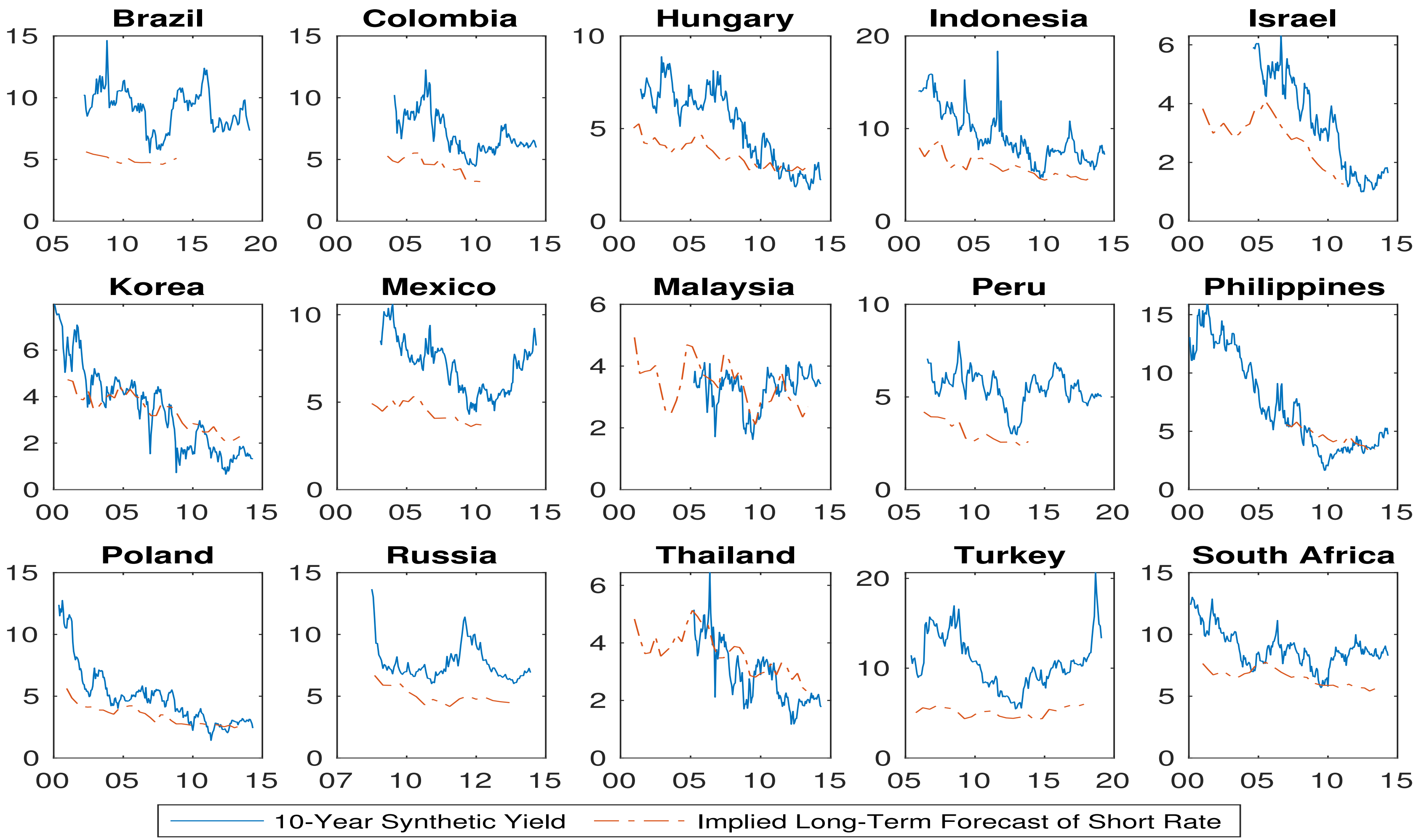
Notes: This table reports the average, the standard deviation, the minimum and the maximum values on monetary policy announcement days for the target, path and LSAP shocks, see section 5.3.1 for the definitions. Target shocks are considered from 2000 to 2008, LSAP shocks are considered from 2009 to 2019, and path shocks span the whole sample period.

Figure 1. Long-Horizon Forecasts of Inflation



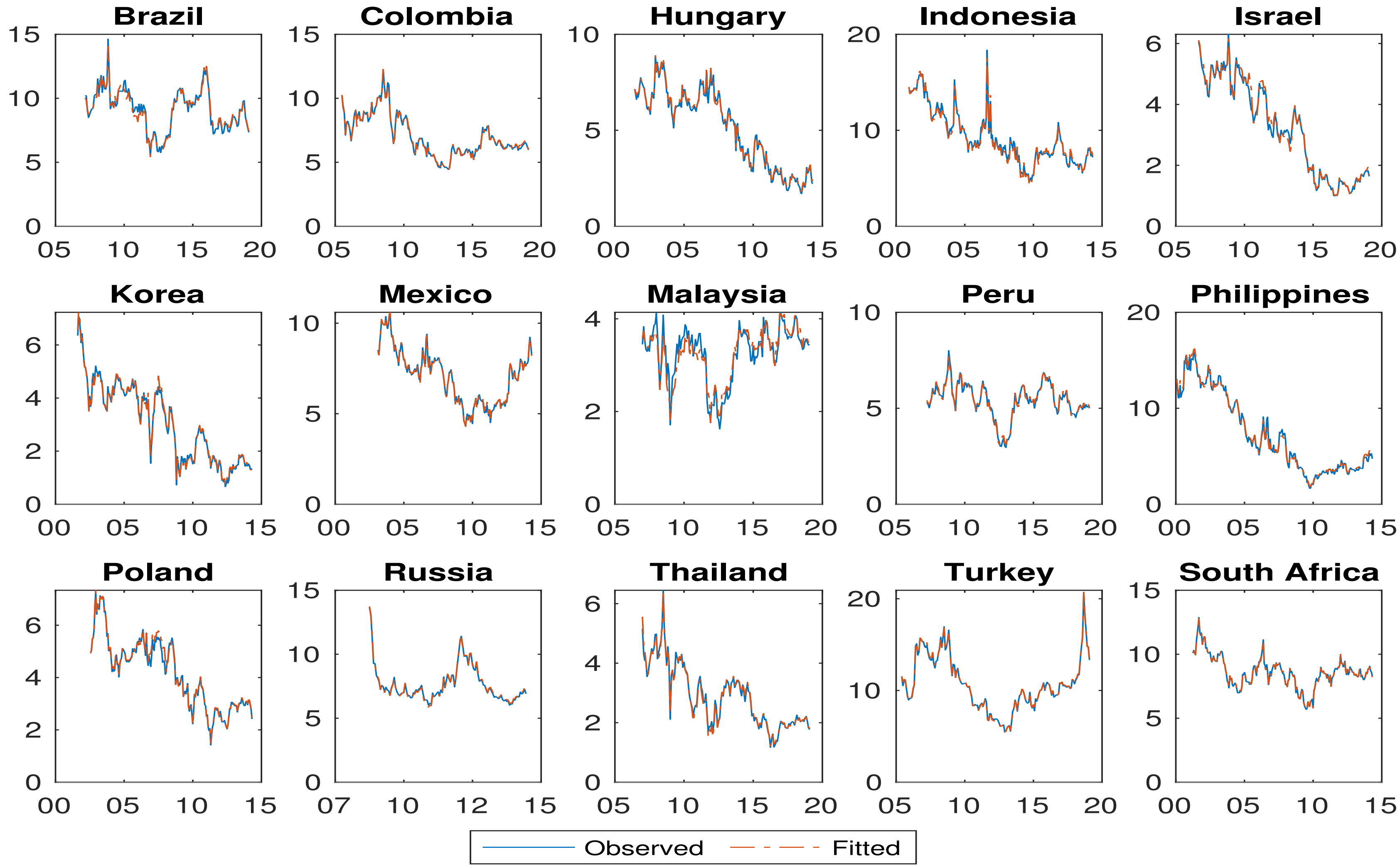
Notes: This figure plots the 5-years ahead (dashed line) and long-term (solid line) average consumer price inflation forecasts against the survey date. For Israel and South Africa, the figure shows the inflation trend, see appendix A. The figure also includes the upper and lower bounds for the domestic inflation target, where applicable. The upper and lower bounds are the most recent ones for each country. For Russia, the plotted band shows the highest and lowest bounds since 2009 since the country has updated its target range almost every year since early 2000s.

Figure 2. 10-Year Synthetic Yields and Long-Horizon Implied Forecasts of the Short Rate



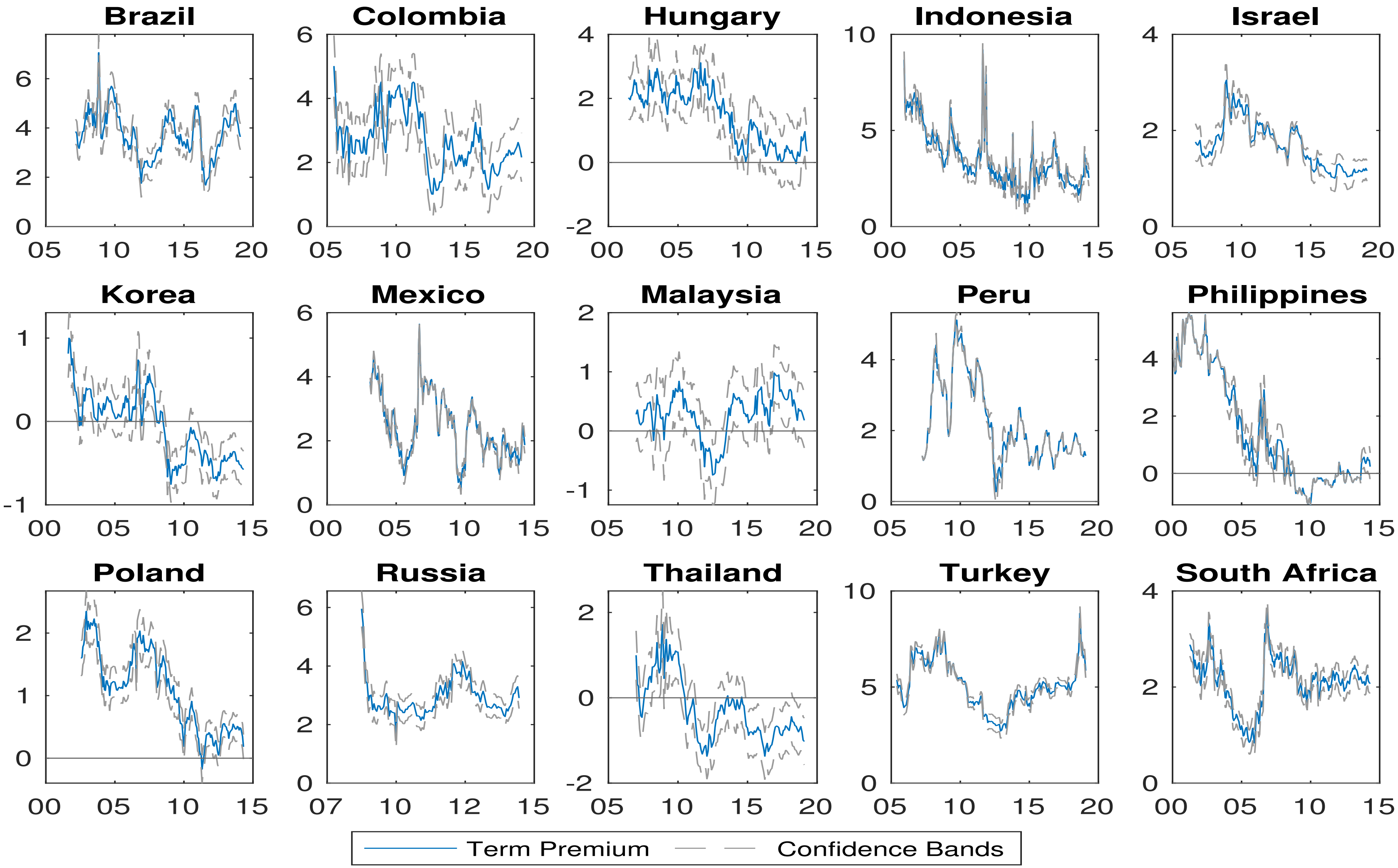
Notes: This figure plots the long-horizon implied forecast of the domestic nominal short-term interest rate (dashed line) and the 10-year synthetic yield (solid line). The implied forecast of the short rate is equal to the forecast of the U.S. real short-term rate plus the domestic consumer price inflation forecast for the same maturity. The forecast of the U.S. real short-term rate is equal to the difference between the forecast of the three-month U.S. Treasury bill rate and the forecast of the U.S. consumer price inflation for the same maturity.

Figure 3. Model Fit for Emerging Markets: 10-Year Synthetic Yields



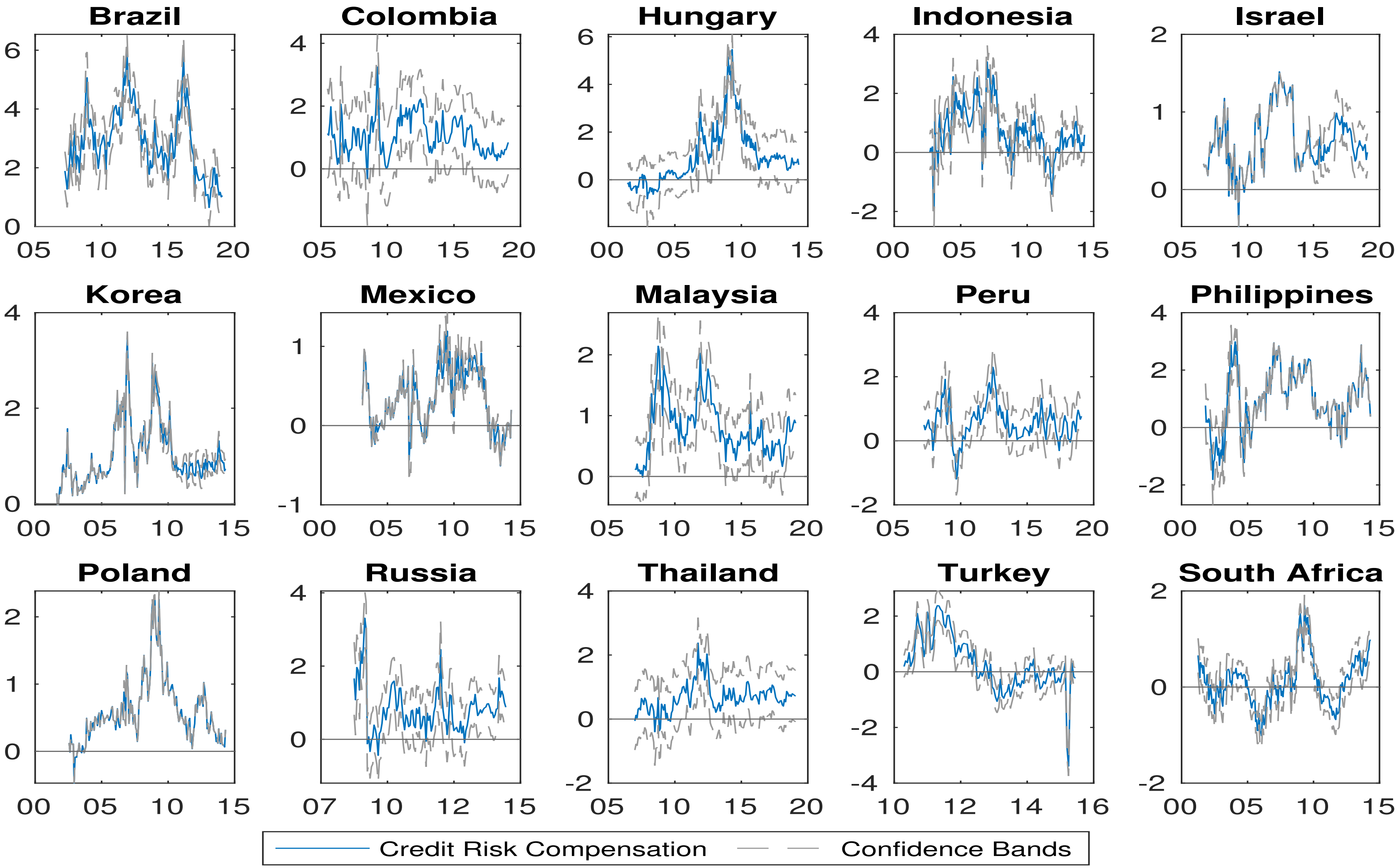
Notes: This figure plots the fitted (dashed line) and the actual (solid line) 10-year synthetic yields. The fitted yield is obtained after estimating the survey-augmented affine term structure model.

Figure 4. The 10-Year Term Premium of Emerging Markets



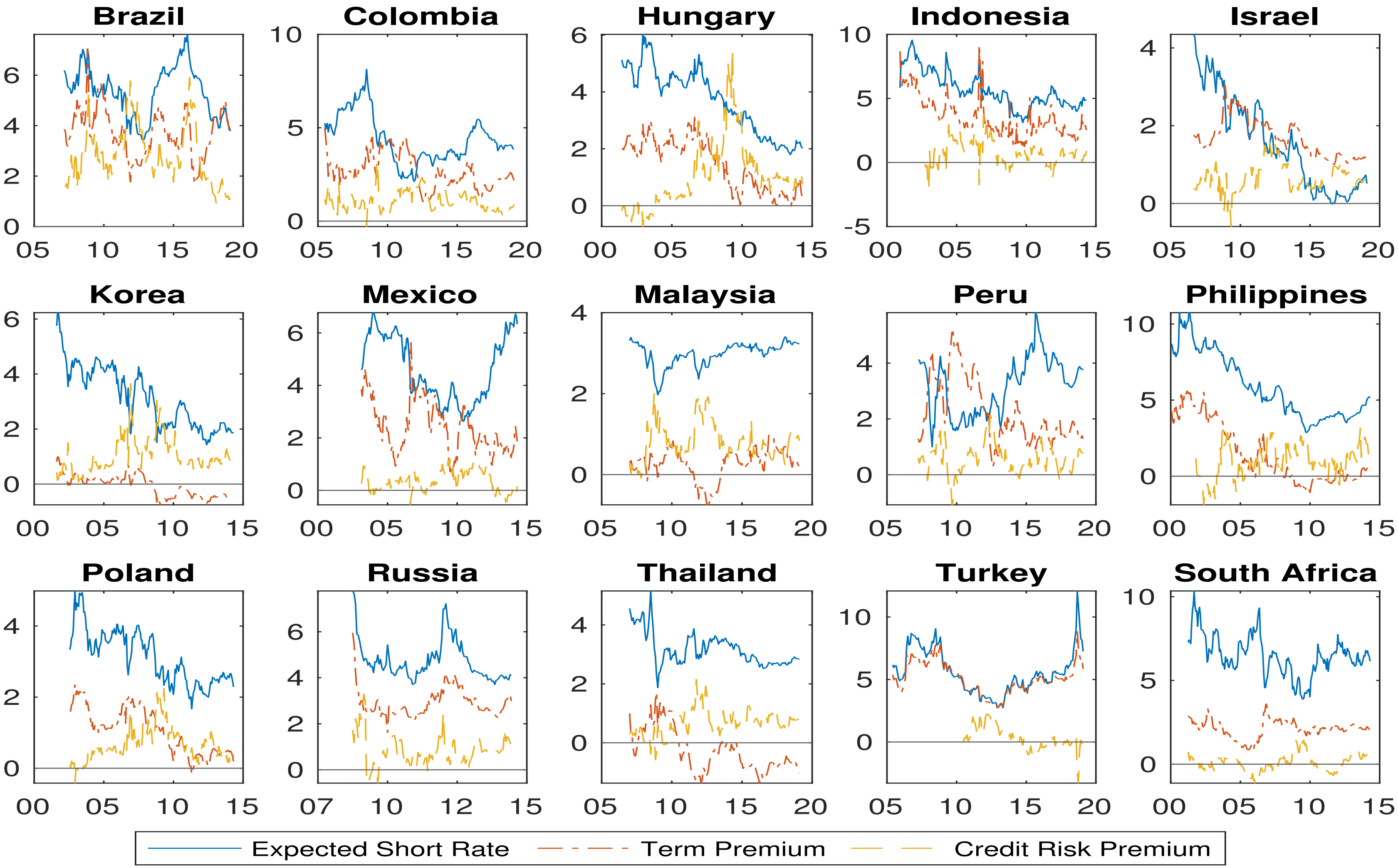
Notes: This figure plots the model-implied term premium of the emerging markets in the sample for the 10-year maturity (solid line) along with their confidence intervals equal to ± 2 standard errors (dashed lines). The standard errors are estimated using the delta method. The covariance matrix is estimated using the sample Hessian estimator calculated numerically from the joint log density.

Figure 5. The 10-Year Credit Risk Compensation of Emerging Markets



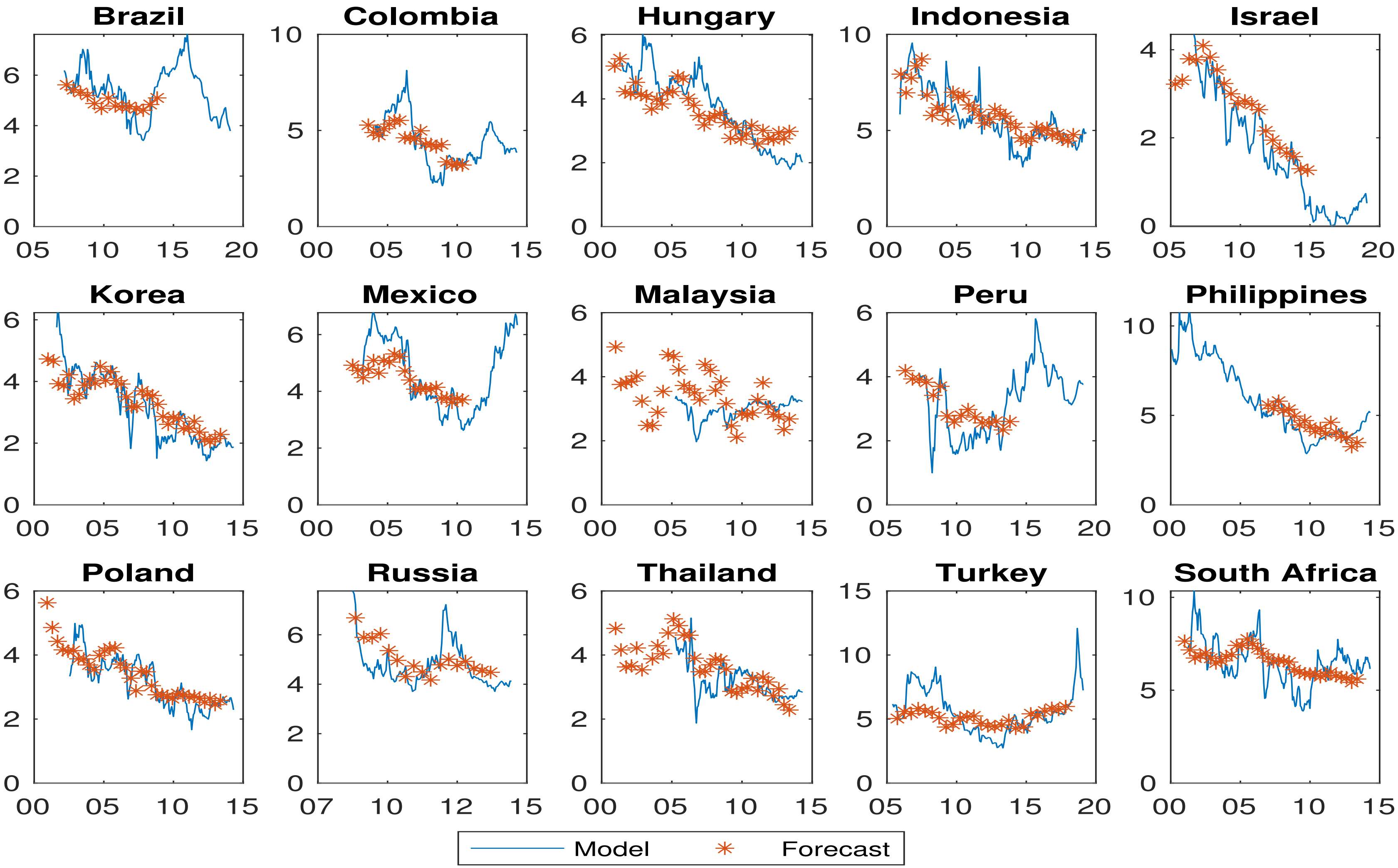
Notes: This figure plots the model-implied credit risk compensation of the emerging markets in the sample for the 10-year maturity (solid line) along with their confidence intervals equal to ± 2 standard errors (dashed lines). The standard errors are estimated using the delta method. The covariance matrix is estimated using the sample Hessian estimator calculated numerically from the joint log density.

Figure 6. Decomposition of the 10-Year Nominal Yields of Emerging Markets



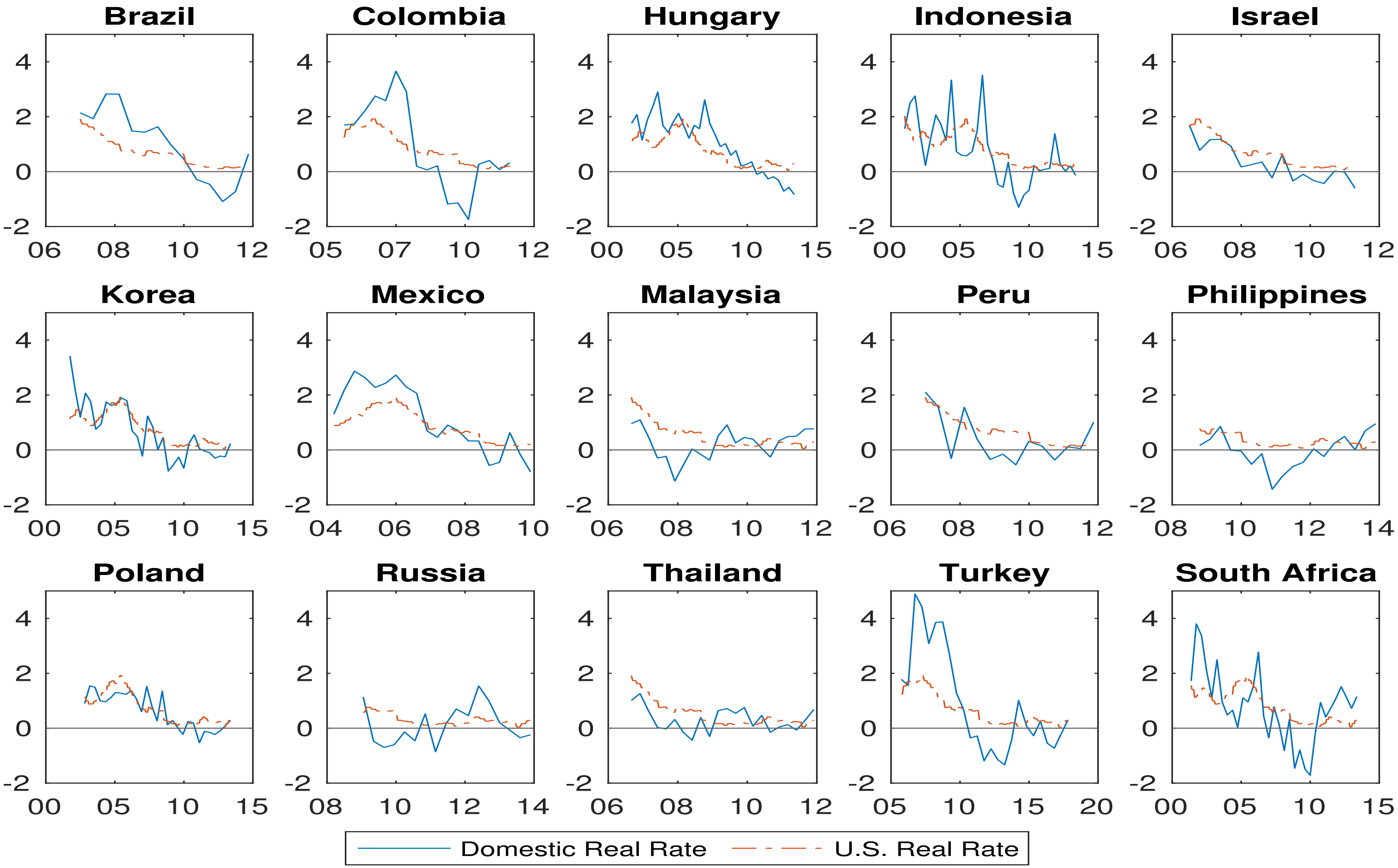
Notes: This figure plots the components of the 10-year nominal yields of emerging markets. The yields are decomposed into an expected future short-term interest rate (solid line), a term premium (dashed line) and a credit risk premium (dashed line).

Figure 7. Long Horizon Forecasts vs Model-Implied 10-Year Expectation of the Short Rate



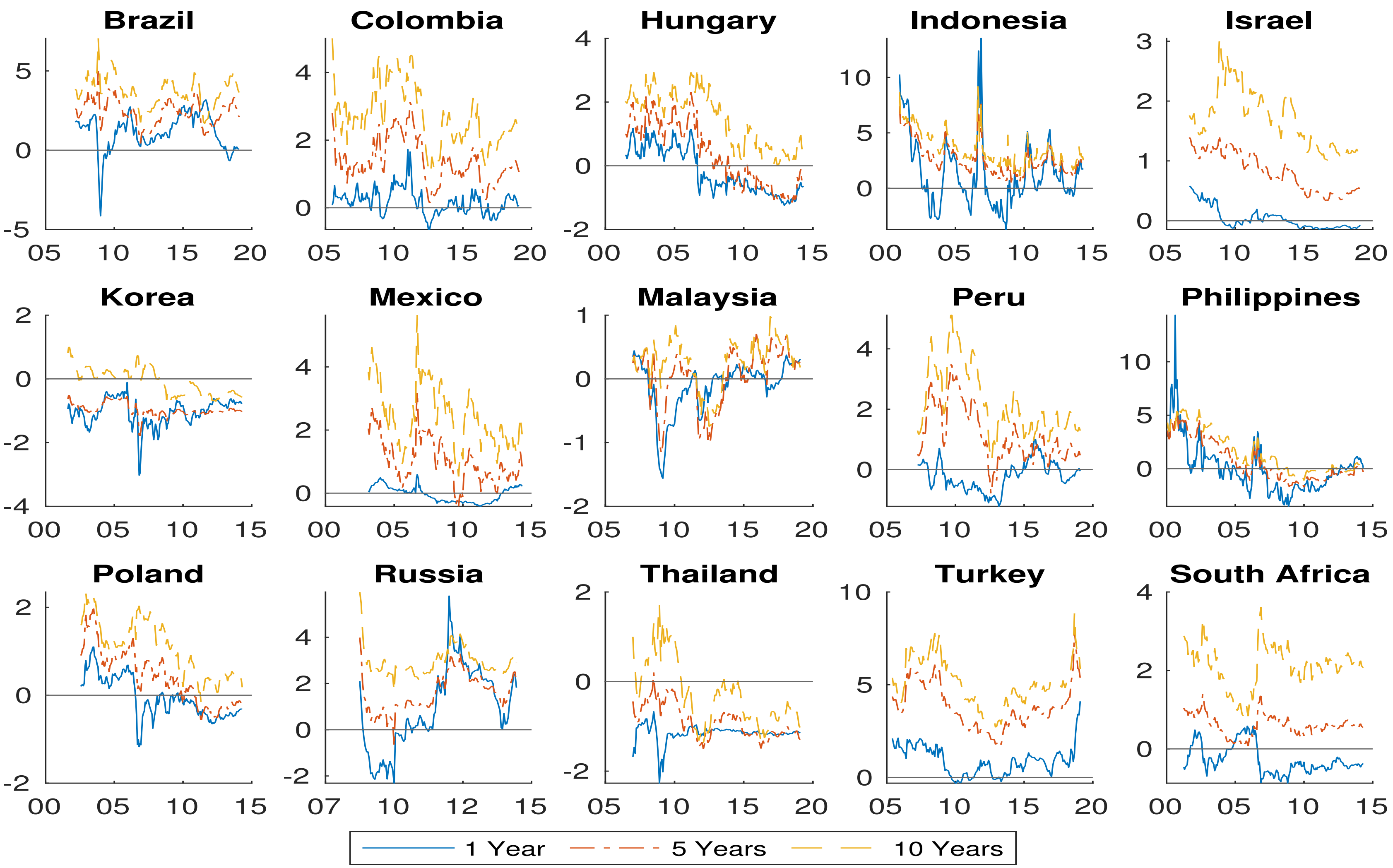
Notes: This figure plots the long-horizon forecast of the domestic short-term interest rate (asterisk) and the model-implied 10-year expectation of the short-term interest rate (solid line).

Figure 8. Model-Implied 10-Year Expectation of the Real Interest Rate



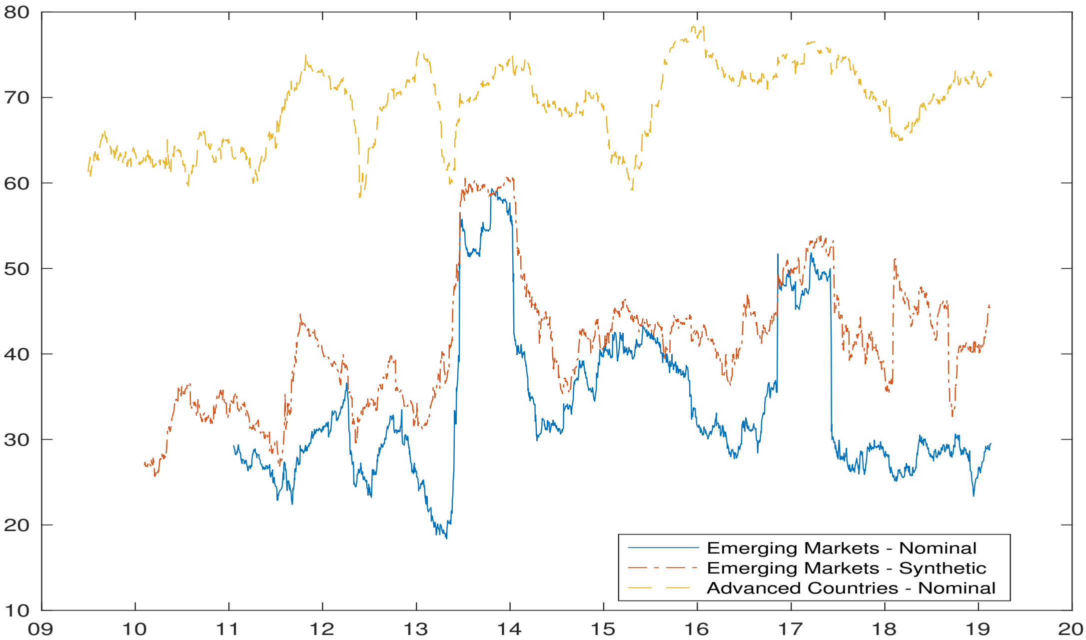
Notes: This figure plots the model-implied 10-year expectation of the domestic real interest rate. The real rate is equal to the difference between the model-implied 10-year expectation of the nominal interest rate and the long-term consensus forecast of consumer price inflation.

Figure 9. Term Structure of Term Premia

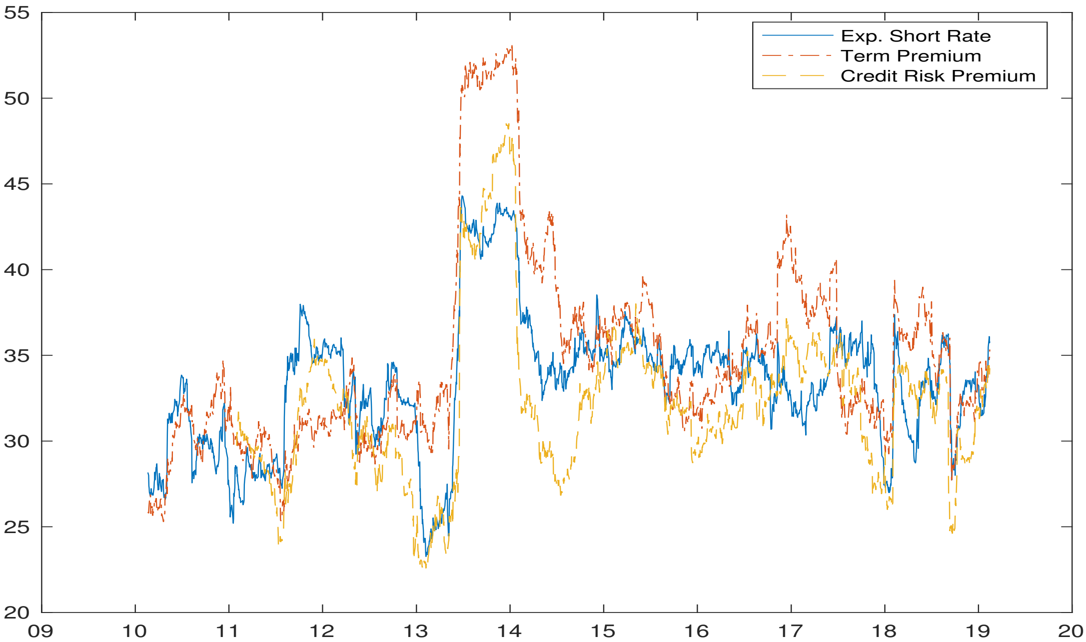


Notes: This figure plots the estimated term premia for 1 year (solid line), 5 years (dashed line) and 10 years (dash-dotted line).

Figure 10. Connectedness of Emerging Market 10-Year Yields



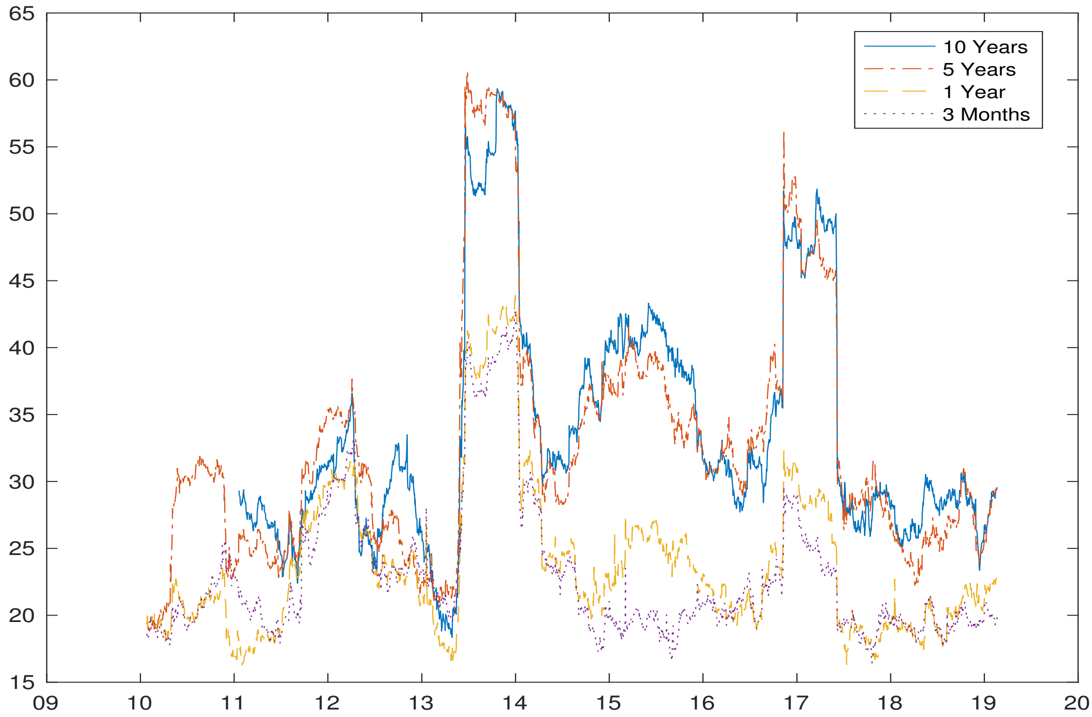
(a) Nominal and Synthetic Yields



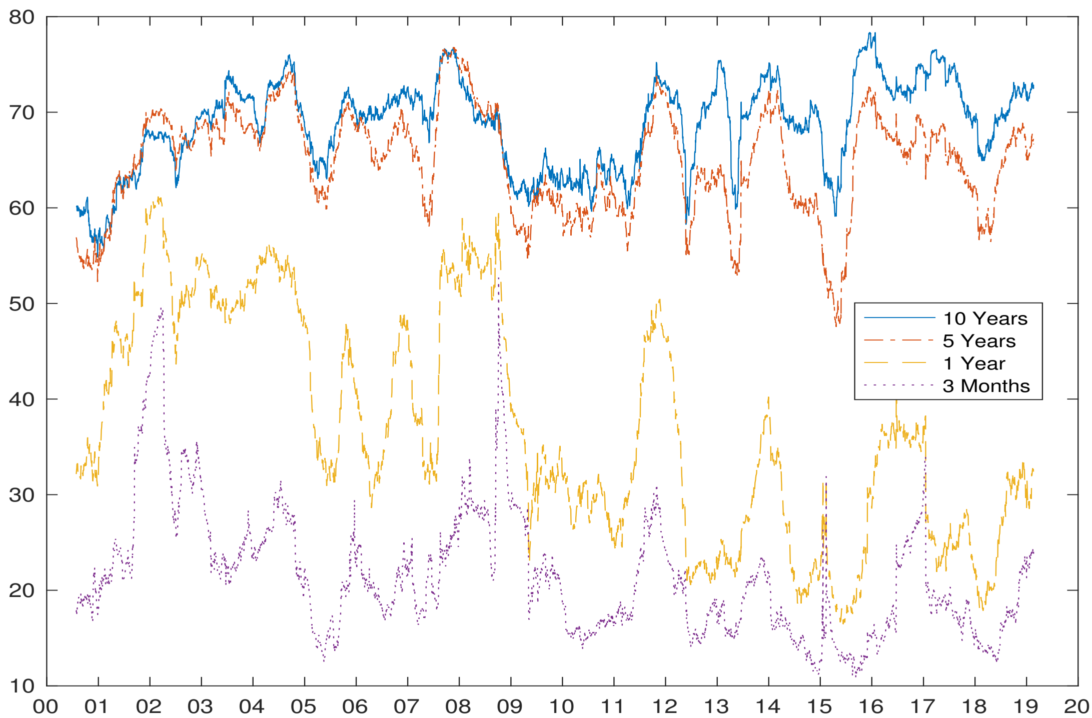
(b) Nominal Yield Components

Notes: This figure plots the connectedness index of Diebold and Yilmaz (2014) for the 10-year nominal yields of emerging markets. Panel (a) compares the connectedness of nominal yields (solid line) against that of synthetic yields (dashed-dotted line) and the nominal yields of advanced countries (dashed line). Panel (b) compares the connectedness of each component of the nominal yields: the expected future short rate (solid line), the term premium (dashed-dotted line) and the credit risk compensation (dashed line). The index is obtained using a vector autoregression of order 1, with a forecast horizon of 10 days and a rolling window of 150 days for the daily changes of the 10-year nominal yields and each of their components. The index for some components has a shorter history because its computation requires a balanced panel and the components do not start on the same date (e.g. the construction of the synthetic curves does not involve nominal yields).

Figure 11. Connectedness of the Term Structure



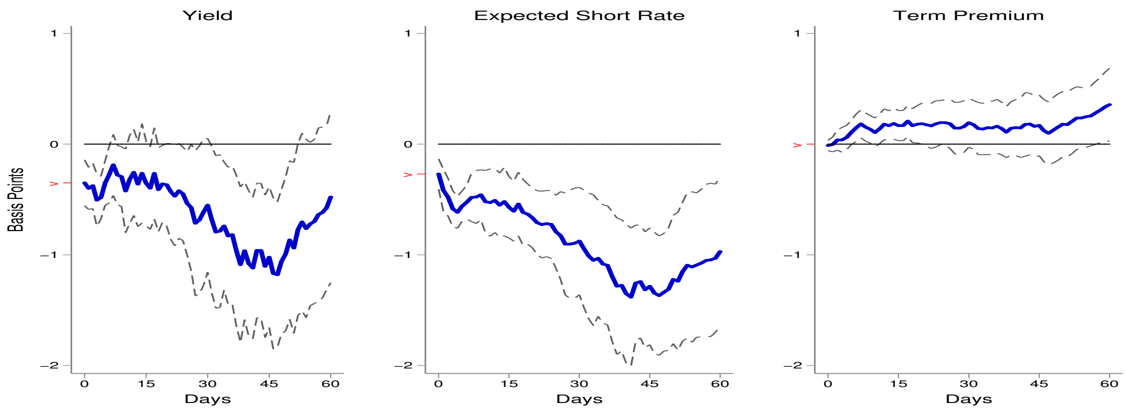
(a) Emerging Markets



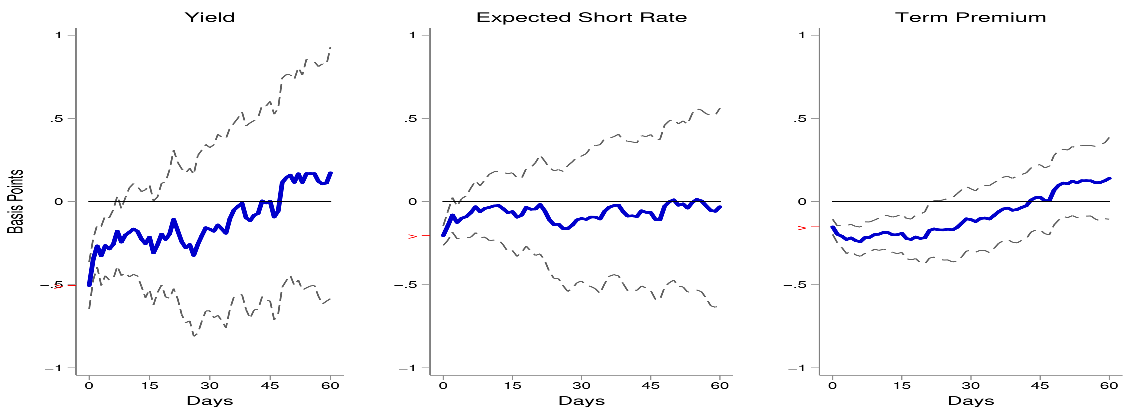
(b) Advanced Countries

Notes: This figure plots the connected index of Diebold and Yilmaz (2014) for nominal yields of emerging markets and advanced countries for 3 months (solid line), 1 year (line), 5 years (line) and 10 years (line). The index is obtained using a vector autoregression of order 1, with a forecast horizon of 10 days and a rolling window of 150 days for the daily changes of the nominal yields each maturity.

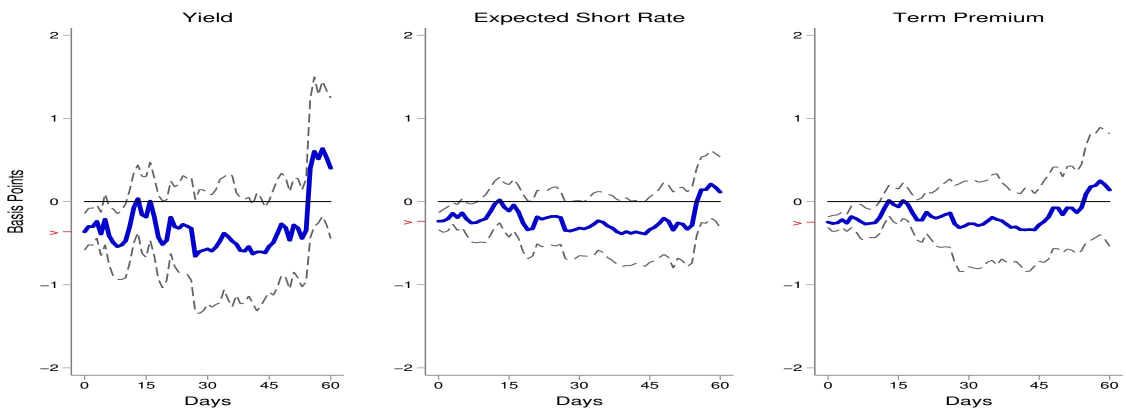
Figure 12. Response of 2-Year U.S. Yield to U.S. Monetary Policy Shocks



(a) Target Shock: 2000-2008



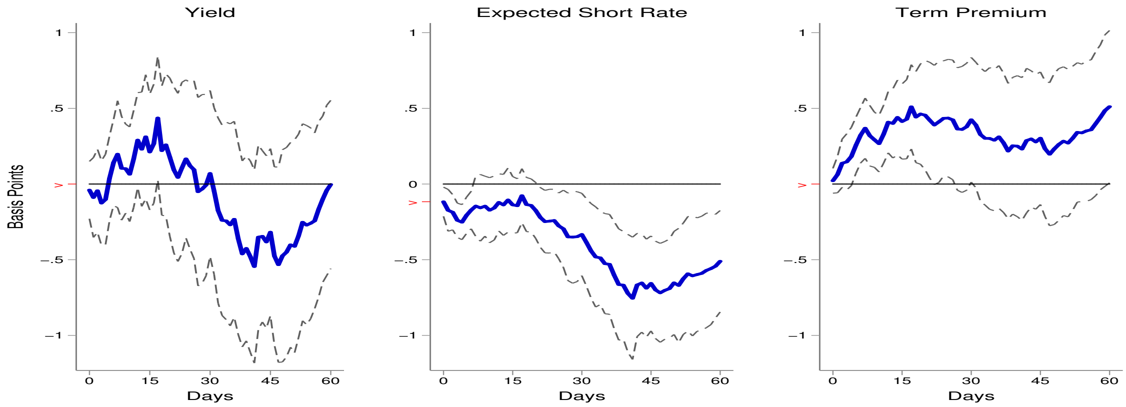
(b) Path Shock: 2000-2019



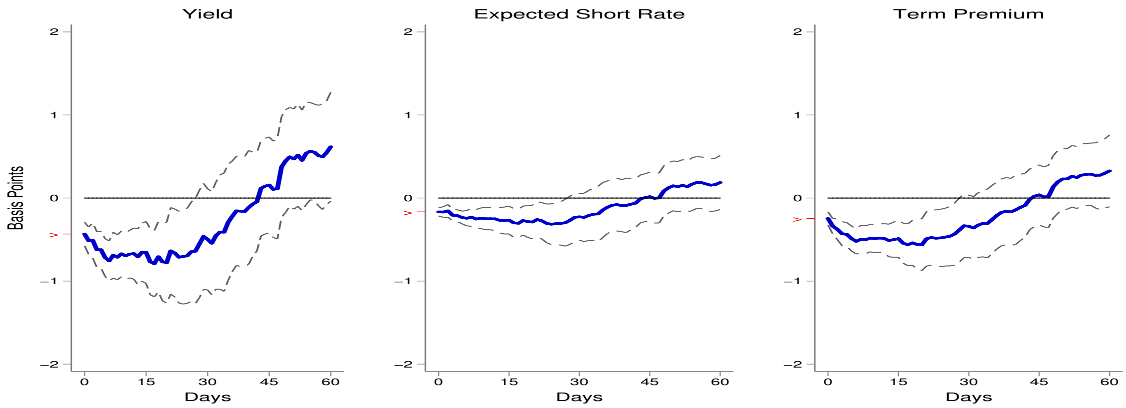
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 2-year U.S. yield and its components to U.S. monetary policy shocks. The U.S. yield is the zero coupon yield from Gürkaynak et al. (2007). The yield is decomposed into an expected future short-term interest rate and a term premium following Kim and Wright (2005). The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

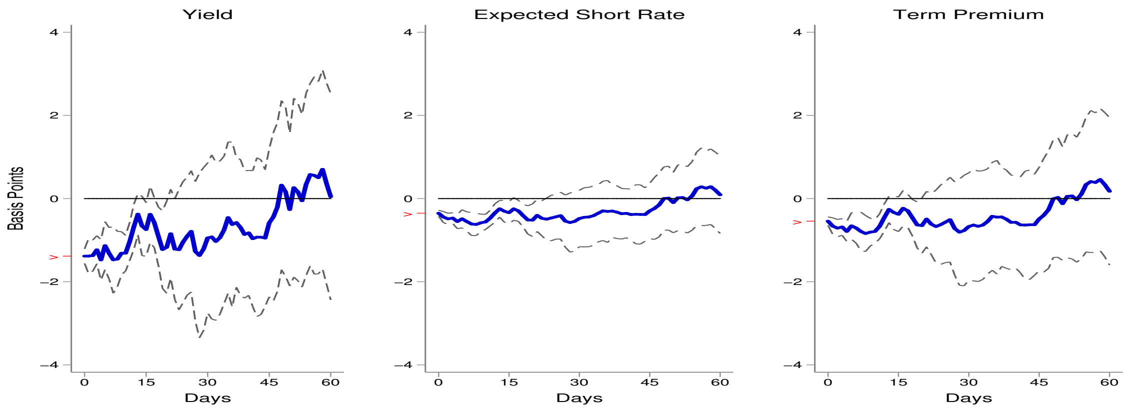
Figure 13. Response of 10-Year U.S. Yield to U.S. Monetary Policy Shocks



(a) Target Shock: 2000-2008



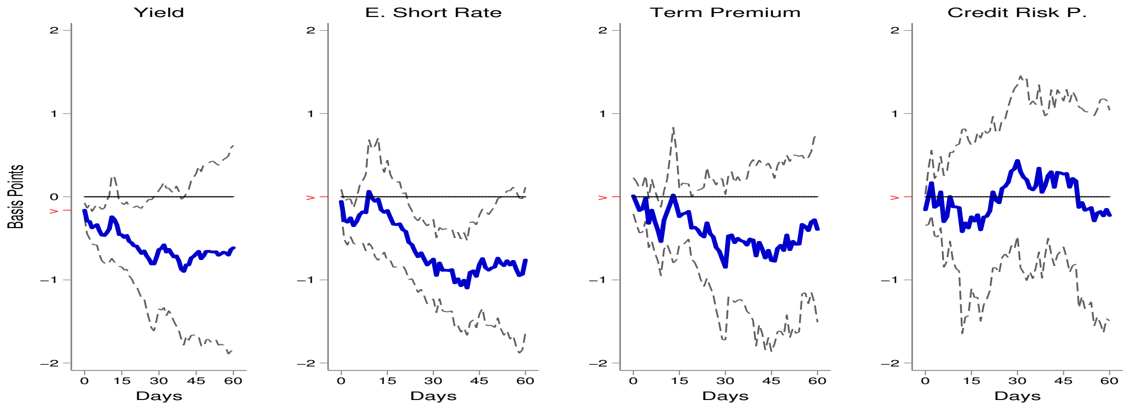
(b) Path Shock: 2000-2019



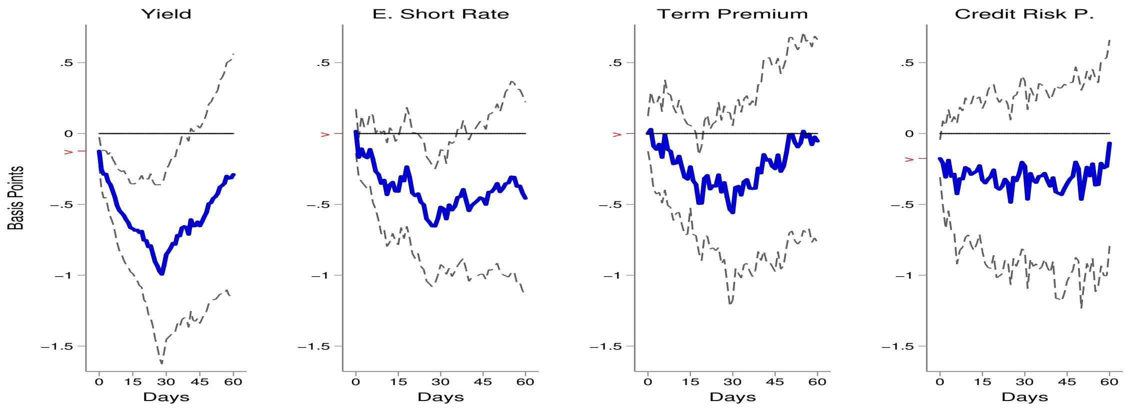
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 10-year U.S. yield and its components to U.S. monetary policy shocks. The U.S. yield is the zero coupon yield from Gürkaynak et al. (2007). The yield is decomposed into an expected future short-term interest rate and a term premium following Kim and Wright (2005). The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

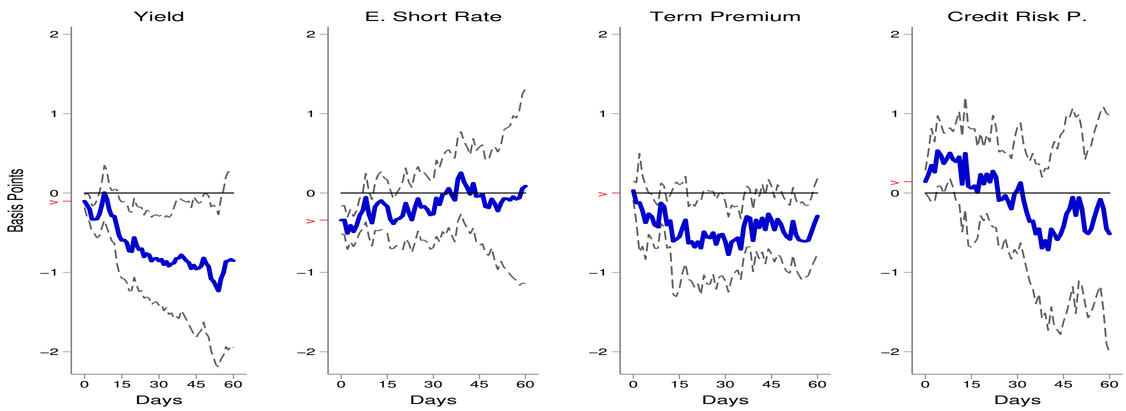
Figure 14. Response of 2-Year Emerging Market Yield to U.S. Monetary Policy Shocks



(a) Target Shock: 2000-2008



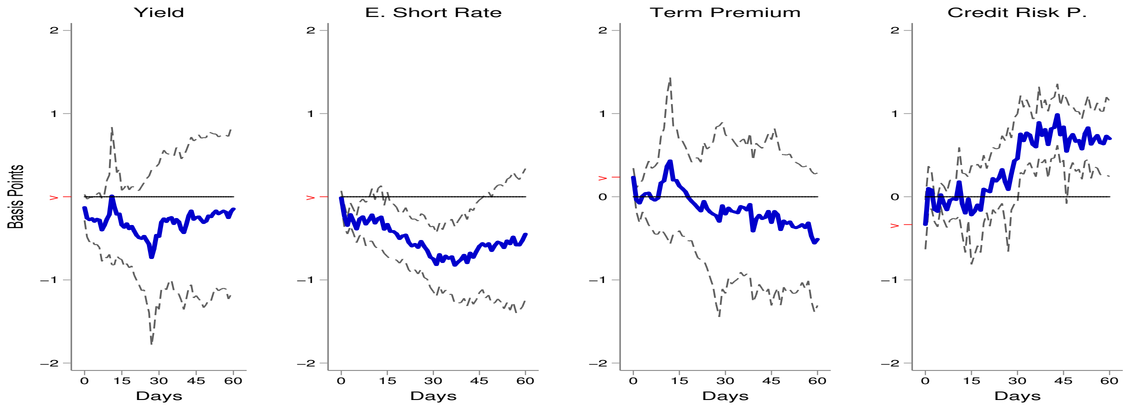
(b) Path Shock: 2000-2019



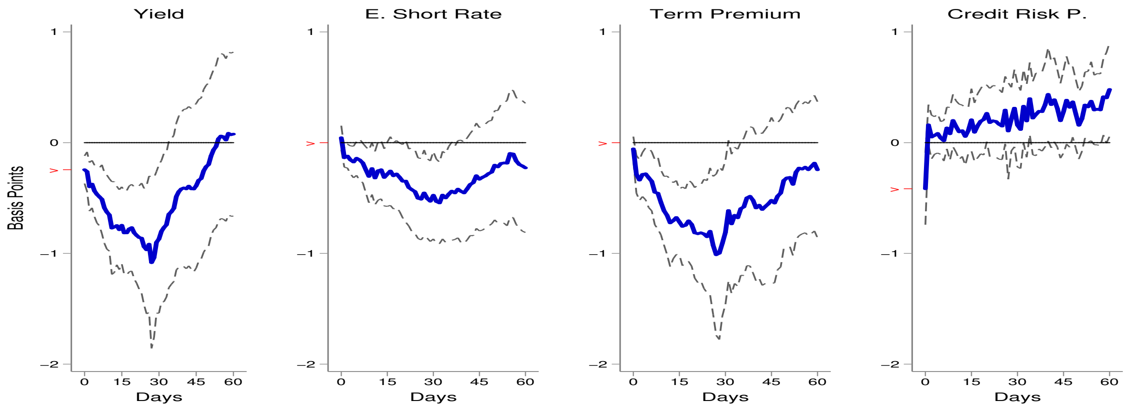
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 2-year emerging market nominal yield and its components to U.S. monetary policy shocks. The nominal yield is decomposed into an expected future short-term interest rate (ER), a term premium (TP) and a credit risk premium (CRP). The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

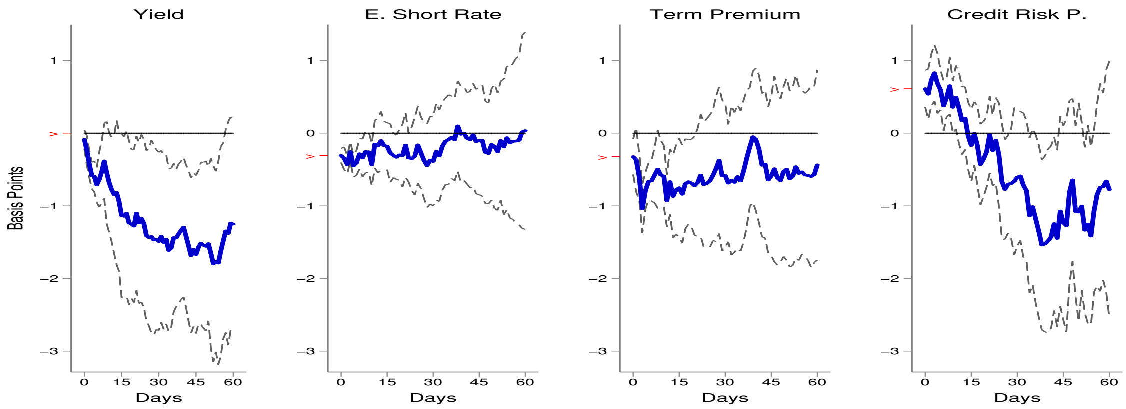
Figure 15. Response of 10-Year Emerging Market Yield to U.S. Monetary Policy Shocks



(a) Target Shock: 2000-2008



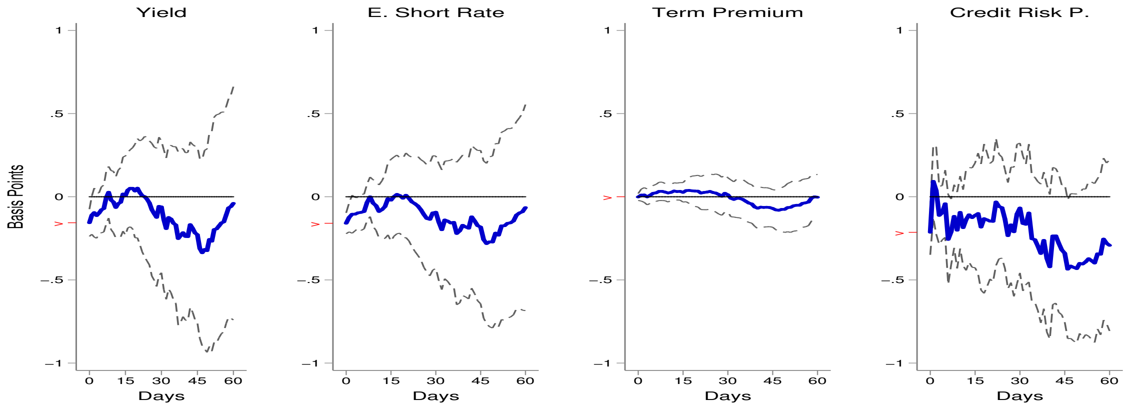
(b) Path Shock: 2000-2019



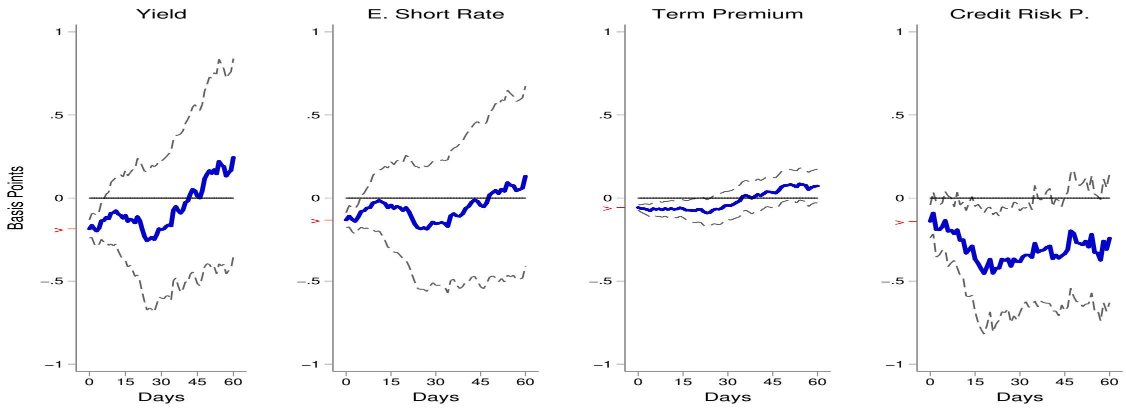
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 10-year emerging market nominal yield and its components to U.S. monetary policy shocks. The nominal yield is decomposed into an expected future short-term interest rate (ER), a term premium (TP) and a credit risk premium (CRP). The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

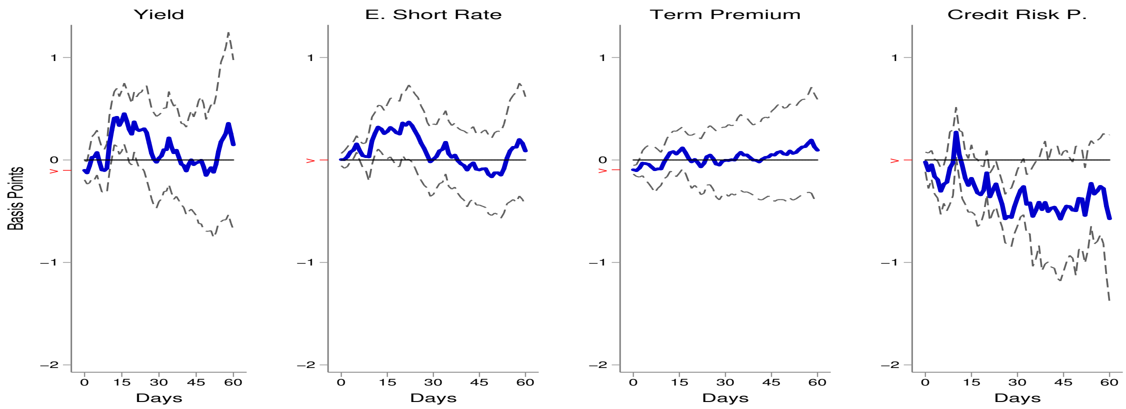
Figure 16. Response of 2-Year Advanced Country Yield to U.S. Monetary Policy Shocks



(a) Target Shock: 2000-2008



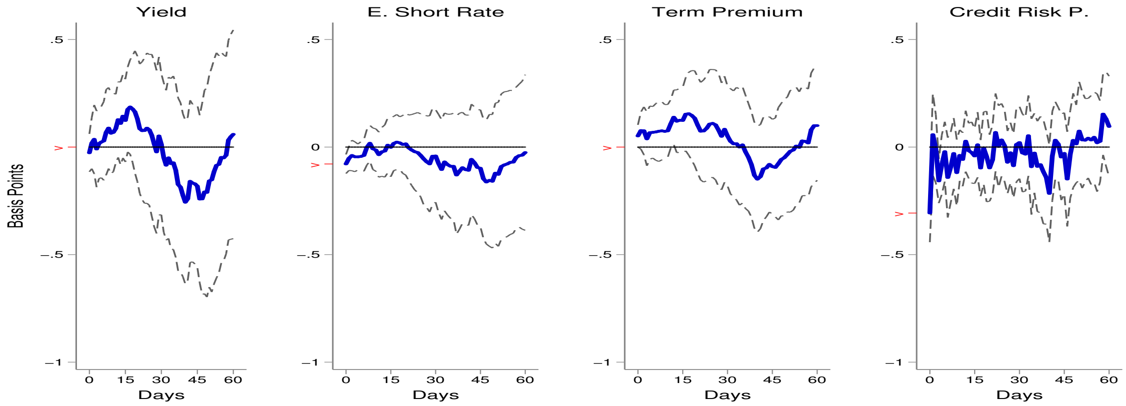
(b) Path Shock: 2000-2019



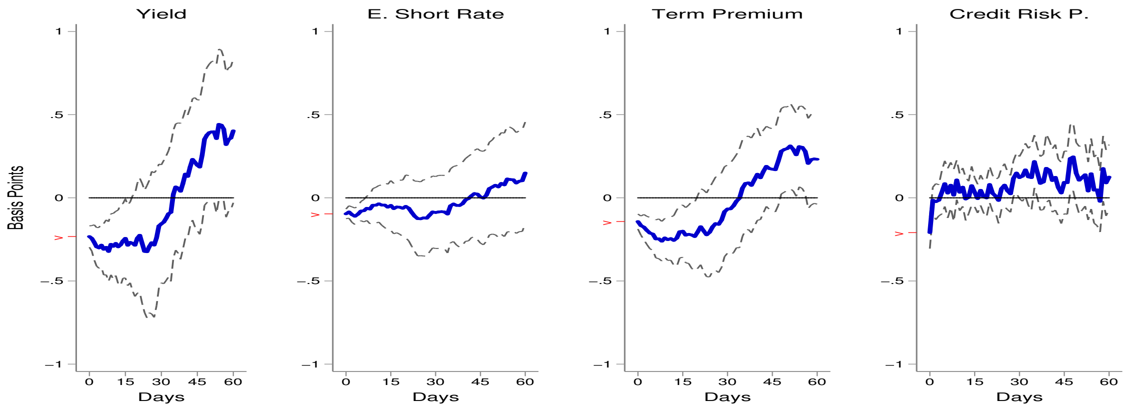
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 2-year advanced country nominal yield and its components to U.S. monetary policy shocks. The nominal yield is decomposed into an expected future short-term interest rate (ER) and a term premium (TP). The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

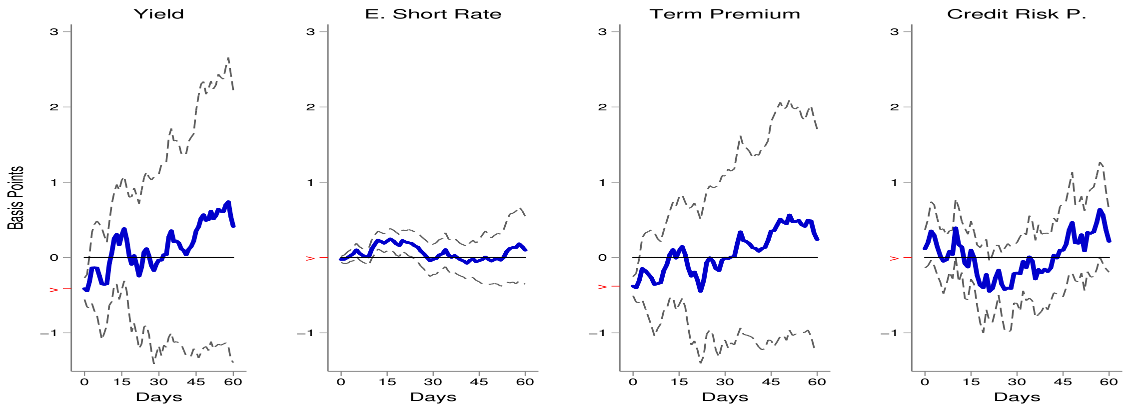
Figure 17. Response of 10-Year Advanced Country Yield to U.S. Monetary Policy Shocks



(a) Target Shock: 2000-2008



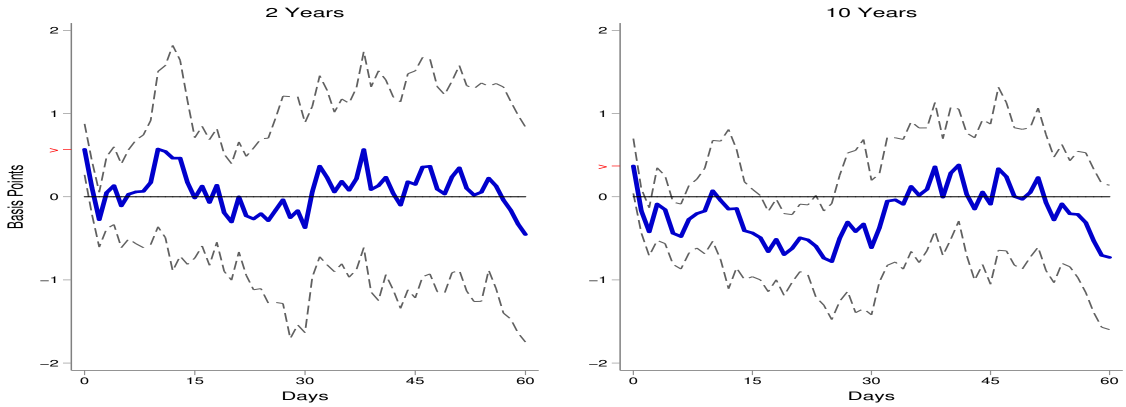
(b) Path Shock: 2000-2019



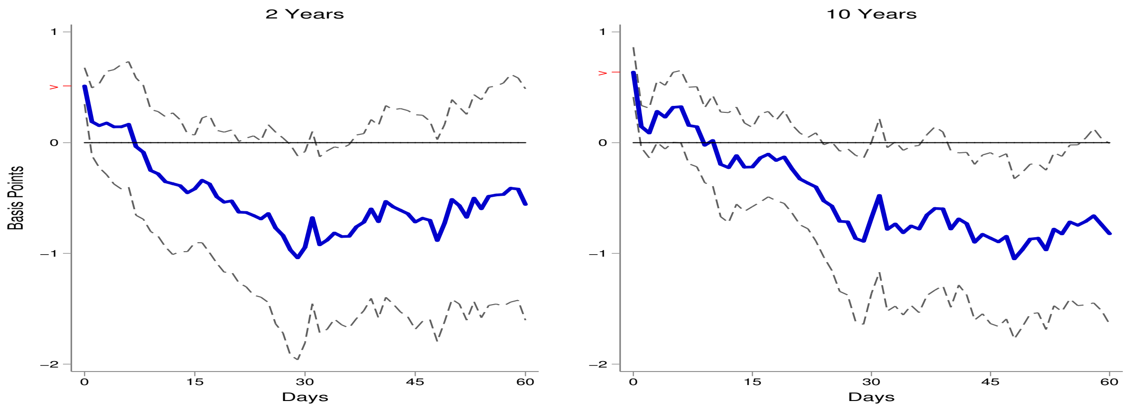
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 10-year advanced country nominal yield and its components to U.S. monetary policy shocks. The nominal yield is decomposed into an expected future short-term interest rate (ER) and a term premium (TP). The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

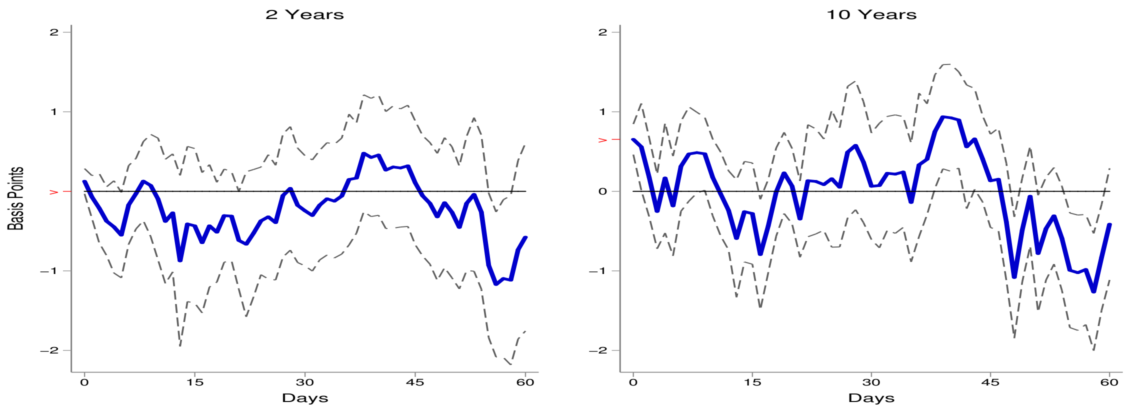
Figure 18. Response of the Forward Premium to U.S. Monetary Policy Shocks: EM



(a) Target Shock: 2000-2008



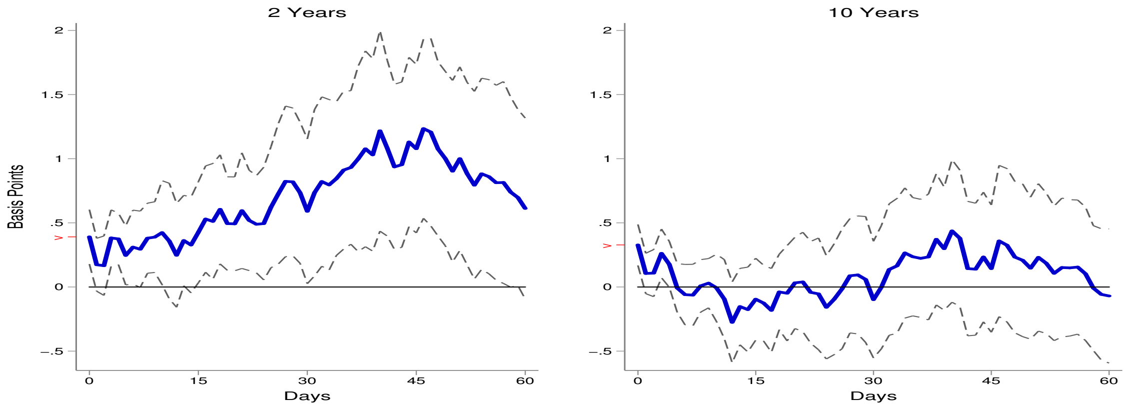
(b) Path Shock: 2000-2019



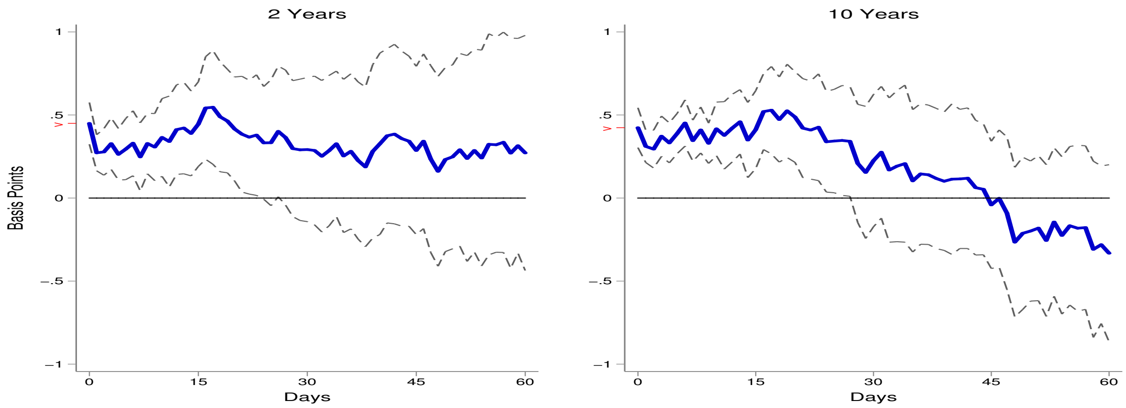
(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 2- and 10-year forward premium for emerging markets (EM) to U.S. monetary policy shocks. The forward premium is calculated using cross-currency swaps, which are in turn constructed using cross-currency basis swaps and interest rate swaps, see section 2.1 for details. The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

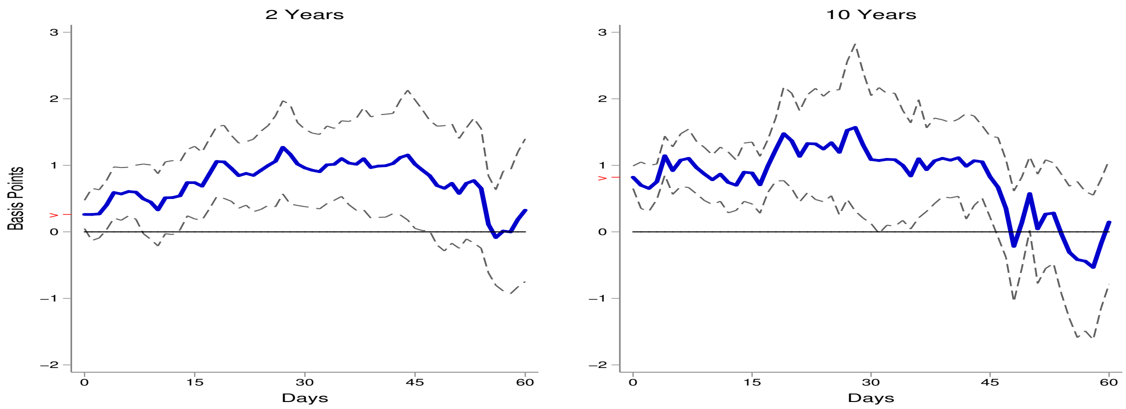
Figure 19. Response of the Forward Premium to U.S. Monetary Basis Policy Shocks: AE



(a) Target Shock: 2000-2008



(b) Path Shock: 2000-2019



(c) LSAP Shock: 2009-2019

Notes: This figure shows the response following Jordà (2005) of the 2- and 10-year forward premium for advanced countries (AE) to U.S. monetary policy shocks. The forward premium is calculated using cross-currency swaps, which are in turn constructed using cross-currency basis swaps and interest rate swaps, see section 2.1 for details. The target, path and LSAP shocks are identified using high-frequency data around Fed's monetary policy announcements, see section 5.3.1 for details.

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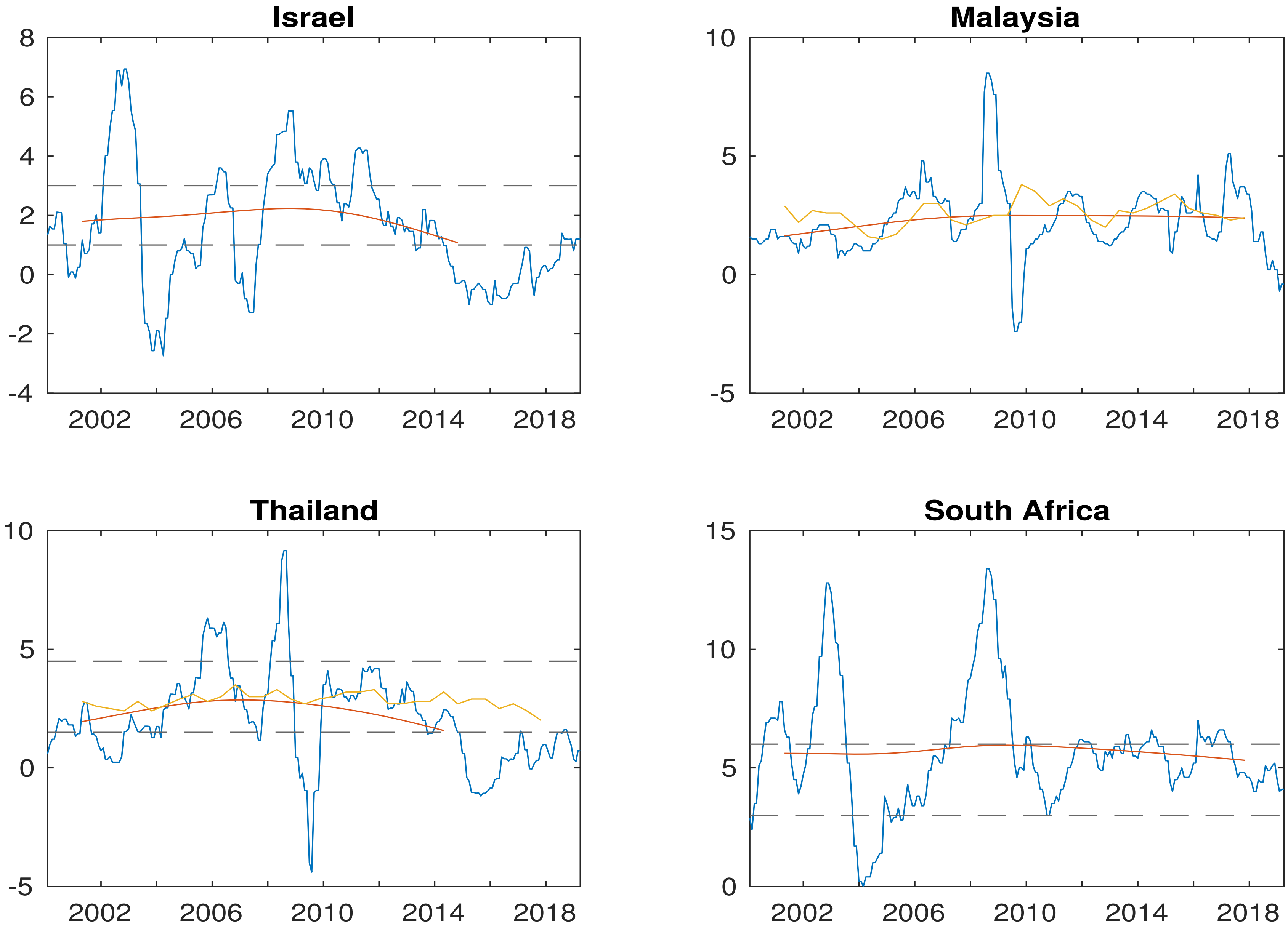
Appendix

[Go2ToC]

A Trend Inflation as a Proxy for Long-Term Inflation Forecasts

An advantage of the small open economy approach is that it only requires forecasts for inflation, or a proxy in the case of countries with no long-term forecasts available as is the case for Israel and South Africa. Inflation expectations are hoped to match measures of inflation that exclude unexpected shocks and better reflect the inflation environment. Different measures of core inflation exist. I use the inflation trend obtained by applying the Hodrick-Prescott filter to the series of realized inflation of each country. Of course, the filter is sensitive to the sample period used. The resulting trend can also be outside of the target inflation band due to the innate dynamics of the series, which would be at odds with survey data (see figure 1). Fortunately, unlike other countries, there is no marked upward or downward trend in the inflation of the two countries during the sample period. For each country, trend inflation is calculated for the whole period but only considered within the time range for which survey data is available for the rest of the countries, and as long as the trend is within the inflation target band. Figure 20 shows the realized and trend inflation for Israel and South Africa, and compares them with those of Malaysia and Thailand, two countries with a similar pattern for inflation (i.e. no marked trend) and for which survey data is available. Trend inflation seems to be a good proxy for the long-term inflation forecasts of Israel and South Africa. Finally, since the 5-year and long-term forecasts closely follow each other (see figure 1), I use trend inflation for both tenors.

Figure 20. Trend versus Long-Horizon Forecasts of Inflation



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