Safe Assets in Emerging Market Economies

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Job Market Paper

Abstract

Investors pay a premium for the safety and liquidity of U.S. Treasuries compared to private comparable U.S. debt. I estimate that local investors pay more than 30 basis points for the safety and liquidity of local-currency sovereign bonds in a group of nine emerging economies. The premium is procyclical with respect to the global financial cycle. Empirical evidence suggests that this procyclicality is driven by the availability of alternative global safe assets like the U.S. Treasury. In an extension of the real-small open economy model where both a foreign and a local sovereign bond work as safe assets, I find that demand for safety and procyclical convenience yields significantly increase business cycle volatility. The model also provides policy implications: unconventional monetary policy in the form of local-currency asset purchases (used by many emerging economies during 2020) is less effective when facing a downturn, as investors prefer the dollar liquidity; accordingly, bond market segmentation between local and foreign bonds improves the effectiveness of unconventional monetary policies.

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1 Introduction

Safe assets are assets for which investors pay a premium for their safety and/or liquidity services (beyond what standard asset pricing would predict for an asset with low credit or liquidity risk). This makes safe assets a money-like instrument that carry a non-pecuniary convenience yield compared to private assets that do not provide these safety/liquidity services. In the case of the U.S., for example, U.S. Treasuries enjoy such a safe asset status: their safety and liquidity makes them trade at a significantly lower yield than highly-rated debt from comparable U.S. companies. Do local-currency sovereign bonds in emerging market economies (EMEs) share this safe asset status? I estimate local-currency convenience yields in nine EMEs between 2007 and 2021 and find that investors pay a sizeable premium for their safety and liquidity. I also find that this local-currency convenience yield is procyclical, which I show has important implications for local business cycles volatility and local central banks' unconventional interventions in EMEs.

This question is particularly relevant as local-currency bonds now represent the lion's share of outstanding sovereign bonds in EMEs, and many EMEs deployed unconventional monetary policies during the Covid crisis (Arslan et al., 2020). This paper emphasizes that investors have a special demand for assets that can promise a stable nominal repayment (safety) or for which they can always find a buyer without steep price discounts (liquidity). In emerging markets, government bonds can be a local safe asset, but they might compete with other global sources of safety (Brunnermeier et al., 2020). Recently, Kekre and Lenel (2021) showed that shocks to safety demand accounted for 25% of output volatility in the U.S. and 6% of output volatility in the rest of the world. From the perspective of emerging markets, to this date there is no empirical work on the role of their local debt as safe asset and on the international competition among safe assets and their interaction with global risk appetite.

In the first part of this paper, I estimate the EME local-currency convenience yields. The ideal measure would be to take the spread between a local-currency sovereign bond against debt in local currency issued by local companies of similar credit risk, maturity, duration, etc. However, reliable data on local-currency private debt of highly-rated companies is scarcely available for these countries. Instead, I calculate the convenience yield of a synthetic dollar bond (a local-currency EME bond with its cash flows swapped into dollars) against non-Treasury safe dollar bonds (such as highly rated U.S corporate or U.S. agency bonds). Since both bonds are in dollars there is no currency risk. This allows me to build on the methodology used by Du and Schreger (2016) and Du et al. (2018), who relied on the decomposition of covered interest parity deviations to study sovereign bonds. After taking this spread, I can account for differential credit risk using CDS data. Additionally, I extend the methodology in Du et al. (2018) to account for the risk of capital controls (such as taxes or currency convertibility restrictions), and the response of the currency during these events. The remaining spread between the two bonds measures how much investors are willing to pay for the safety and liquidity of an EME bond compared to non-Treasury U.S. safe bonds.

I find that among the nine countries in my sample, the EME local-currency convenience yield has an average of more than 30 basis points, which amounts to almost 10% of their total yield. This premium is mostly driven by local investors (consistent with EMEs not sharing the property of a global reserve currency), and capital inflows have little effect. This is an important distinction as foreigners have increased their participation in the ownership of EME local-currency bonds (see recent trends in Appendix A). Furthermore, in stark contrast with U.S. Treasuries, the EME local-currency convenience yield drops during downturns and episodes of high global risk aversion. I analyze two exogenous adverse shocks to EMEs (the Taper Tantrum and the Covid pandemic) to gain insight into the mechanism. These episodes suggest that the safety status of EME sovereign bonds drops because of the availability of alternative global safe assets (such as U.S. Treasuries) to investors.

In the second part of the paper, I extend the standard real small open economy model to include demand for safe assets by households (beyond standard precautionary savings demand). Safety demand can be satisfied with foreign bonds (whose price is world-determined) and local bonds (issued by the government and financed with taxes). The model matches the procyclicality of the EME local-currency convenience yield, it quantifies the role of safety demand on a small open economy, and allows me to draw policy implications for EMEs. The economy is subject to safety shocks: an exogenous increase in the foreign bond's convenience yield. This shock resembles a global flight to safety episode and it is calibrated as in Kekre and Lenel (2021). The larger foreign convenience yield increases the expected excess return of the local assets (both capital and the local bond). Regarding capital, this increased expected excess return is achieved through a drop in its price and a corresponding drop in investment and output. The result is that the foreign bond ends up paying well in a bad state of the world, which makes it an effective global safe asset. The local bond, on the other hand, is the opposite: the drop in consumption and the larger holdings of the foreign bond reduce its convenience yield, showing a positive covariance with the cycle.

Convenience yields on safe assets and the safety shock have implications for business cycle volatility in the local economy. The yield on the foreign bond trades below the international interest rate (in this context, the international rate can be though of as the rate on a bond that does not enjoy a safe asset status), and this spread corresponds to the convenience yield of foreign bonds. Similarly, the yield on the local bond also trades below the international rate, and this spread corresponds to the convenience yield of the local bond. The international rate drives expected excess returns and is exogenous, so an exogenous increase in the foreign convenience yield that leaves the international rate unchanged is achieved through a drop in the yield of the foreign bond. Regarding the local bond, this shock produces a *drop* in the local-currency convenience yield, which can only be achieved through an *increase* in the local interest rate. The quantitative exercise shows that, compared to a standard SOE model with no convenience yields and no safety shocks, the current model increases the volatility of the local interest by 4.6%. Notice that this is due to the procyclicality of the convenience yield. Would it be countercylical, the volatility of the local rate would be lower than the volatility of the international rate. In turn, this explains 8.5% of the output volatilty and 3.1% of investment volatility in the small open economy.

Finally, I use the model to draw policy implications: the cyclicality of the EME local-currency convenience yield determines the effectiveness of unconventional liquidity policy. These policies have become common in advanced economies since 2008 and were used for the first time by EMEs during 2020. The local central bank can purchase capital from households in exchange for local bonds, which satisfies the demand for safety. In EMEs, central bank intervention under a safety shock is less effective as the local agents have access to a better global safe asset (the foreign bond). However, larger segmentation between foreign and local bonds -for example, in the form of capital controls- can increase the effectiveness of unconventional liquidity policy, as the household is less able to substitute local versus foreign liquidity.

Related Literature. To my knowledge, this paper is the first to estimate the safe asset status of local-currency sovereign bonds in EMEs and to analyze their determinants and implications. The empirical literature is ample in the study of the safety of U.S. Treasuries against comparable dollar private debt (Krishnamurthy & Vissing-Jorgensen, 2012; Greenwood et al., 2015; Del Negro et al., 2017a, Lenel et al., 2019) and against sovereign bonds of other advanced countries (Du et al., 2018; Jiang, Krishnamurthy, and Lustig, 2021; Jiang et al., 2021). Du and Schreger (2016) apply a similar methodology to analyze EMEs' sovereign bonds, but they aim to explain local versus foreign-currency credit spreads.

On the theoretical side, my approach is novel as it is the first to build on the small open economy model and to analyze the interaction of two competing safe assets (local and foreign bonds). Unlike my approach, the literature has focused on the international role of dollar debt as a global safe asset, as modeled by Brunnermeier and Sannikov (2019); Jiang, Krishnamurthy, and Lustig (2019); and Kekre and Lenel (2021). Jiang, Krishnamurthy, and Lustig (2019) analyzed the effects of the supply of dollar safe assets on the nominal dollar exchange rate. However, they did not consider their interaction with safe assets from other countries. Kekre and Lenel (2021) quantified the importance of dollar-safety shocks in a two-country model, where convenience yields on dollar assets were entirely exogenous, and assets from the rest of the world did not share the safe asset status.

The model also contributes with two novel policy implications. First, they extend closed-economy models where convenience yields are at the center of unconventional monetary policy transmission (Krishnamurthy and Vissing-Jorgensen, 2011; Del Negro et al., 2017b). These models and others, for example, Gertler and Karadi (2013) and Reis (2017), do not characterize the challenges faced by a small open economy whose local investors have access to an alternative source of convenience services. These papers take the position of an advanced economy and assume that the liquidity services of their government bonds are always valuable to investors. This allows their central banks to provide unlimited liquidity (through asset purchases) and affect interest rates.

Second, policy implications extend the literature on monetary policy for small open economies. By relying on foreign currency borrowing, this literature has focused on the effectiveness of reserve accumulation (Bianchi et al., 2018) or foreign exchange intervention (Fanelli & Straub, 2021). This paper is a first step toward studying macroeconomic policies that tackle local-currency liquidity, such as the deployment of the central bank's balance sheet. This is more relevant as some early empirical papers have found that unconventional policies in EMEs had positive economic effects during the Covid-19 crisis (Arslan et al., 2020; Sever et al., 2020; Fratto et al., 2021; Ha & Kindberg-Hanlon, 2021; Rebucci & Hartley, 2021). These papers applied the event study methodology to estimate the effects on yields, exchange rates, and other variables. However, they did not provide a model to understand the results. In general, these papers found that these policies effectively increased liquidity and lowered long-term yields, although there was considerable heterogeneity in the impacts among different EMEs.

Finally, this paper contributes to the literature on the global financial cycle (GFC) and international risk spillovers. Rey (2013) and Miranda-Agrippino and Rey (2021) documented strong global co-movements in capital flows, credit growth, and asset prices, driven by global risk aversion and U.S. monetary policy. Kalemli-Ozcan (2019) highlighted the role of risk spillovers in the transmission of U.S. monetary policy into emerging markets and studied the implications for currency regimes and local monetary policy rate decisions. Brunnermeier et al. (2020) conjectured monetary and macroprudential policy implications for EMEs, but theirs was not a full-fledged international model specific to developing countries. My paper estimates the impact of the GFC on the valuation of local-currency sovereign bonds and its implications for policy.

The paper proceeds as follows. Section 2 explains the calculation of convenience yields and shows a preliminary time series analysis. Section 3 undertakes a formal empirical analysis based on panel regressions and event studies. Section 4 presents the model, and Section 5 the quantitative and policy exercises. Section 6 then concludes.

2 EME local-currency convenience yields

2.1 Data and Derivation

I build on the methodology in Du and Schreger (2016) and Du et al. (2018), but extend it to fit emerging economies. Du et al. (2018) calculated the U.S. Treasury premium over sovereign bonds of other developed economies, that is, how much investors are willing to pay for the safety and liquidity of U.S. Treasuries compared to the sovereign bonds of G10 countries. When considering EMEs, this exercise proves to be incomplete. Not only because default risk is much larger, but also because local-currency sovereign bonds in EMEs carry a larger number of risks, like capital control risks and large currency depreciations during default or capital controls events.

Consider an investor from country i. Regardless of i, assume this investor cares about dollar returns. Consider the alternative of investing in a non-Treasury safe dollar bond (such as a highly rated corporate bond or an agency bond), whose yield is given in the following Proposition (all proofs are in the Appendix).

Proposition 1. *The yield in period* t *on a non-Treasury safe dollar bond,* y_t^{US}*, can be decomposed as follows:*

$$y_t^{US} \approx y_{rf,t}^{US} - \lambda_t^{US,i} + l_t^{US} - \xi_t^{US,i} \tag{1}$$

where $y_{rf,t}^{US}$ *is the dollar risk-free rate;* $\lambda_t^{US,i}$ *measures the marginal safety/liquidity services investor* i *derives from this bond (the convenience yield);* l_t^{US} *is the expected loss upon default and* $\xi_t^{US,i}$ *is the covariance between default risk and the convenience yield.*

Equation (1) highlights that the larger the convenience yield $\lambda_t^{US,i}$, the lower the yield on the bond: investor i is willing to accept a lower return, y_t^{US}, in exchange for the safety/liquidity services the bond provides. In addition, the yield of the bond is higher the larger the expected loss upon default, l_t^{US}, as investors require a compensation for this risk. The covariance $\xi_t^{US,i}$ measures how the convenience yield reacts to default risk. If the convenience yield drops in states where default risk is higher, the covariance is negative and investor i will require a higher yield on the bond, y_t^{US}.

Alternatively, the investor can purchase a local-currency sovereign bond from country j ($j \neq$ US) , with all the cash flows swapped into dollars. This is called a synthetic dollar bond, and it involves the purchase of the local-currency bond and a forward contract to set the future exchange rate at which the cash flows will be swapped.

Proposition 2. *The yield on the synthetic dollar bond can be calculated as the yield of the local-currency bond of country* j *(*$j \neq US$*) ,* y_t^j*, minus the forward premium between the local currency and the dollar,* $\rho_{j,t} = logF_{t+1} - logS_t$*, where* F_{t+1} *and* S_t *are the forward and spot exchange rates, respectively, both expressed as units of local currency per dollar.*
The total yield on the synthetic bond, $y_t^j - \rho_{j,t}$*, can be decomposed as:*

$$y_t^j - \rho_{j,t} \approx y_{rf,t}^{US} - \lambda_t^{j,i} + (l_t^j - q_t^j) + (k_t^j - p_t^j) - \xi_t^{j,i} - \psi_t^{j,i} \tag{2}$$

where $y_{rf,t}^{US}$ *is the dollar risk-free rate;* $\lambda_t^{j,i}$ *is the convenience yield investor* i *derives from this bond;* $l_t^j - q_t^j$ *is the expected loss upon default,* l_t^j*, net of the covariance between default and currency risk,* q_t^j*;* $k_t^j - p_t^j$ *are the expected losses upon the imposition of regulations,* k_t^j*, net of the covariance between the risk of regulations and currency risk,* p_t^j*; and the covariance of default risk and the convenience yield, and the covariance between the convenience yield and capital control risk,* $\xi_t^{j,i}$ *and* $\psi_t^{j,i}$*, respectively.*

Again, the larger the safety and liquidity services of the local-currency sovereign bond, the larger $\lambda_t^{j,i}$ and the lower the equilibrium yield on the synthetic bond. Equation (2) shows that the risk of regulations increases the yield on the synthetic bond. The term k_t^j captures the risk of actions by the local government that can impose additional losses upon investors: not only capital controls, but also currency convertibility restrictions, tax regime changes, etc. Both the default risk and k_t^j are net of their covariance with currency risk. Intuitively, when dollar investors invest in local-currency EME sovereign bonds, default or capital controls impose an extra loss on them. They not only receive fewer local currency back, but those cash flows are now worth less if the currency depreciates upon default. The yield on the synthetic bond does not capture the latter, as currency risk is being hedged. Therefore, the yield on the synthetic bond underestimates the risk of loss upon these events. The terms $\xi_t^{j,i}$ and $\psi_t^{j,i}$ show that when these covariances are negative (meaning the convenience yield drops when default risk or capital control risk increases), this increases the required yield on the synthetic bond.

Propositions 1 and 2 give the yields of two bonds denominated in dollars. Therefore, the spread between the two does not contain currency risk. Given these two decompositions, the premium investor i is willing to pay for the safety and liquidity of EME local-currency bonds against non-Treasury safe dollar bonds is given by $\lambda_t^{j,i} - \lambda_t^{US,i}$. The two expressions in (1) and (2) can be combined to give an expression for this premium:

$$\begin{aligned} \underbrace{\lambda_t^{j,i} - \lambda_t^{US,i}}_{\text{EME convenience yield}} \quad = \quad & \underbrace{y_t^{US} - (y_t^j - \rho_{j,t})}_{\text{Spread between the two bonds}} \\ & - \underbrace{(l_t^{US} - l_t^j)}_{\text{Differential default risk}} + \underbrace{k_t^j}_{\text{Capital control risk}} \underbrace{-q_t^j - p_t^j - \xi_t^{j,i} - \psi_t^{j,i}}_{\text{Covariances}} \end{aligned} \tag{3}$$

Equation (3) is intuitive. If the yield on the non-Treasury safe dollar bond, y_t^{US}, is higher than the yield on the synthetic bond, $y_t^j - \rho_{j,t}$, this has to be explained either because the former has higher default risk, $(l_t^{US} - l_t^j)$, or because of differences in capital control risks and other currency covariances. Once we account for those, any remaining positive spread between y_t^{US} and $y_t^j - \rho_{j,t}$ has to be explained by the larger safety/liquidity services of the synthetic bond, $\lambda_t^{j,i} - \lambda_t^{US,i}$. In other words, the EME local-currency convenience yield (on the left-hand side) is the residual once the spread between the non-Treasury dollar bond and the synthetic bond has been cleaned up of differences in default risk, risks of regulations, and other covariances.

The main challenge is to estimate the variables of capital control risk and the covariances in Equation (3). I rely on the spread between the synthetic bond and the bond denominated in foreign-currency issued offshore.

Proposition 3. *Let $\Phi_t^{FC,i}$ denote the spread between the yield of the synthetic bond, $y_t^j - \rho_{j,t}$, and* *the yield of the sovereign bond of country j ($j \neq US$) issued in dollars, $\hat{y}_t^j$. Then,*

$$\begin{aligned} \Phi_t^{FC,i} &\equiv y_t^j - \rho_{j,t} - \hat{y}_t^j \\ &\approx (\hat{\lambda}_t^{j,i} - \lambda_t^{j,i}) + (l_t^j - \hat{l}_t^j - q_t^j) + (k_t^j - p_t^j) - \xi_t^{j,i} - \psi_t^{j,i} \end{aligned} \tag{4}$$

where $\hat{\lambda}_t^{j,i}$ and $\hat{l}_t^j$ are the convenience yield and the default risk of the sovereign bond issued in dollars, respectively.

As long as $\hat{l}_t^j \approx l_t^j$ and $\hat{\lambda}_t^{j,i} \approx \lambda_t^{j,i}$, the expression $\Phi_t^{FC,i}$ will be approximate equal to the term on capital control risk plus covariances in (3). Intuitively, EME sovereign bonds denominated in foreign-currency do not carry the currency covariances. Furthermore, they do not carry the convenience yield of *local*-currency bonds. And finally, EME sovereign bonds denominated in foreign currency are almost entirely issued in foreign jurisdictions, and thus are not subject to many types of capital controls such as currency convertibility restrictions and differential taxation regimes.

The condition $\hat{l}_t^j \approx l_t^j$ requires that the default risk of the EME sovereign is approximately equal for local versus foreign currency-denominated debt (I discuss this in Appendix C). On the other hand, the condition $\hat{\lambda}_t^{j,i} \approx \lambda_t^{j,i}$ holds as long as the dollar investor derives approximately the same convenience services from EME sovereign bonds denominated in either currency. I will mantain this assumption henceforth. Previous evidence has found that swapped local-currency bonds are slightly more liquid than foreign currency-denominated debt. Du and Schreger (2016) studied a sample of EMEs and found a mean bid-ask spread of 11.1 basis points for the swapped bond versus 14.5 basis points for the foreign currency bond.

The term $\Phi_t^{FC,i}$ can be substituted in equation (3) to obtain the following:

$$\lambda_t^{j,i} - \lambda_t^{US,i} = y_t^{US} - (y_t^j - \rho_{j,t}) + (l_t^j - l_t^{US}) + \Phi_t^{FC,i} + \xi_t^{US,i} \tag{5}$$

On the left-hand side, I have the desired convenience yield of EME sovereign bonds against non-Treasury safe dollar bonds. Appendix C describes all data sources for each variable in the right hand side of equation (5). The empirical analysis in section 3 will be run using $\lambda_t^{j,i} - \lambda_t^{US,i}$ as the dependent variable.

The nine countries included in the rest of the paper are Brazil, Chile, Colombia, Indonesia, Mexico, Peru, the Philippines, South Africa and Turkey. This selection is based solely on data availability.

2.2 Analysis

Here I show the magnitudes and dynamics of the EME local-currency convenience yield, $\lambda_t^{j,i} - \lambda_t^{US,i}$. This spread represents how much investors are willing to pay for the safety and liquidity of EME sovereign debt over non-Treasury safe dollar debt. I compute this measure because it gives an estimate of the convenience yield of EME bonds against the most common "non-safe" benchmark in the literature. In terms of Equation (5), the following analysis still does not include a proxy for $\xi_t^{US,i}$. However, as default risk is minimal for the United States, the magnitude of $\xi_t^{US,i}$ is probably very small (see Appendix D for additional analysis on the evolution of the EME convenience yield computed against the convenience yield of the U.S. Treasury).

Figure 1 shows the result for the 5-year sovereign bond. Many patterns stand out. First, notice that local-currency convenience yield dropped sharply during crises (both the 2008 financial crisis and the Covid pandemic in 2020). In those episodes, the safety premiums turned significantly negative. Negative values must be interpreted as EME sovereign bonds providing less safety and liquidity than non-Treasury U.S. safe debt. This suggests that these sovereign bonds are not a good safe asset during global crises, unlike U.S. Treasuries. Second, there was a widespread increase in local-currency convenience yields around 2014-2016, followed by a persistent decline from then on. Third, not all countries seem to have been affected by the Covid crisis in a similar way. Large drops in local-currency convenience yields happened in Mexico, Peru, Chile, Indonesia, the Philippines, and South Africa, while Brazil did not experience a large drop.

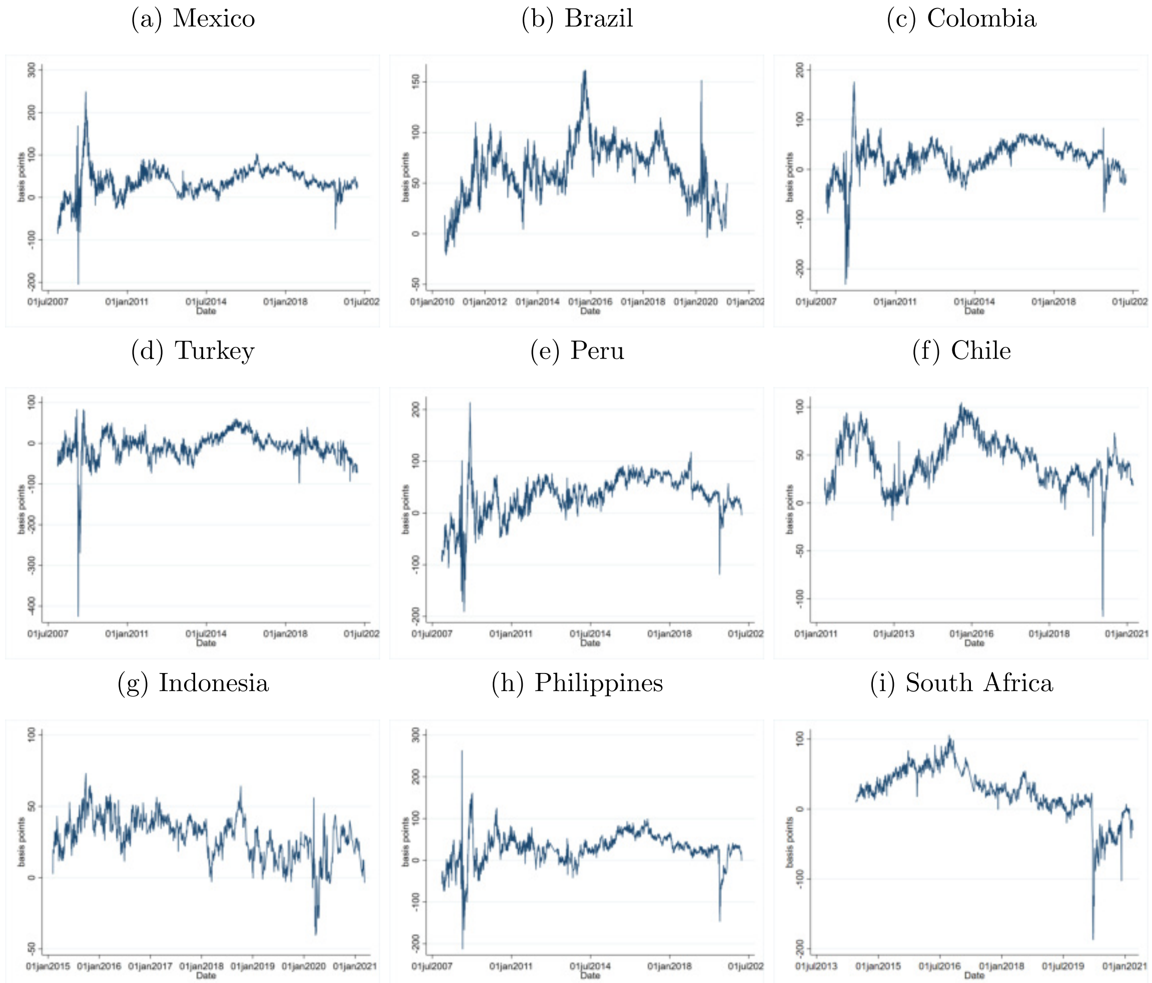
The series in Figure 1 shows large increases after large drops during the 2008 crisis, especially for Mexico, Colombia, Peru, and the Philippines. This noise might be explained by EME bonds becoming illiquid during periods of financial stress. In particular, during 2008, there was a significant increase in CDS spreads that might have been driven by mispricing of these contracts. This concern will be more formally addressed in the next subsection.

Table 1 shows summary statistics for this measure of the local-currency convenience yield of sovereign bonds. Columns 1 and 2 show the mean and the standard deviation of each country's convenience yield. Brazil stands out as the country with the highest premium, and Turkey with the lowest.

Column 3 reports the unconditional correlations of the EME local-currency convenience yield with the same premium of U.S. Treasuries, both set against the common benchmark of the non-Treasury U.S. safe assets. This correlation is in general negative, except for most of the Latin American economies. A negative correlation might be explained by investors attaching safety services to one sovereign at a time: In states of the world where investors flock to U.S. Treasuries, they lower their safety services attached to their local sovereign bonds. This evidence reinforces the intuition above that EMEs' sovereign bonds might not be an effective safe asset in periods of global crisis.

How economically relevant are these magnitudes? Figure 2 shows the local-currency convenience yield (as showed in Figure 1) as a proportion of the total yield of the local-currency bond. I also add the CDS to compare with the role of credit risk. Although credit risk accounts for a bigger share of the total yield, which is unsurprising for EMEs, local-currency convenience yields account for around 10% of the total yield, with the only exception of Turkey. Countries where it explains

Figure 1: Convenience Yield on 5-Year Local-Currency Sovereign Bonds



a larger proportion are Chile, Peru, and the Philippines. Even though Brazil has the largest mean convenience yield (see Table 1), it is one of the EMEs with the highest yields on its debt; overall, the convenience yield accounts for slightly less than 10% of the total yield.

2.3 The Role of Safety/Liquidity Services

Since the EME local-currency convenience yield was obtained as a residual, it is important to be sure that this residual actually captures a premium for safety/liquidity services. I follow Krishnamurhty and Vissing-Jorgensen (2012) and regress these convenience yields against variables related to the price and the supply of safe and liquid assets. The intuition here is as follows: if these residuals capture a demand for safety/liquidity services, then they should respond positively to the price of liquidity, and negatively to the supply of safe/liquid assets.

Accordingly, I proceeded by estimating panel regressions of the following form:

Table 1: Summary Statistics (5-Year Sovereign Bond)

		(1)	(2)	(3)
Country	Sample starts	Mean	Std	Corr w/U.S.
Brazil	June 2010	62.83	28.76	0.0326*
Colombia	December 2007	24.09	25.99	0.0566***
Mexico	December 2007	40.63	23.72	0.3535***
Peru	December 2007	39.40	27.89	-0.1248***
Turkey	December 2007	-3.42	25.32	-0.1897***
Chile	April 2011	43.72	25.11	0.2522***
Indonesia	February 2015	29.06	15.1	-0.2462***
Philippines	December 2007	34.55	27.71	-0.124***
South Africa	June 2014	23.62	36.63	-0.5615***
United States	February 2006	40.95	12.39	-

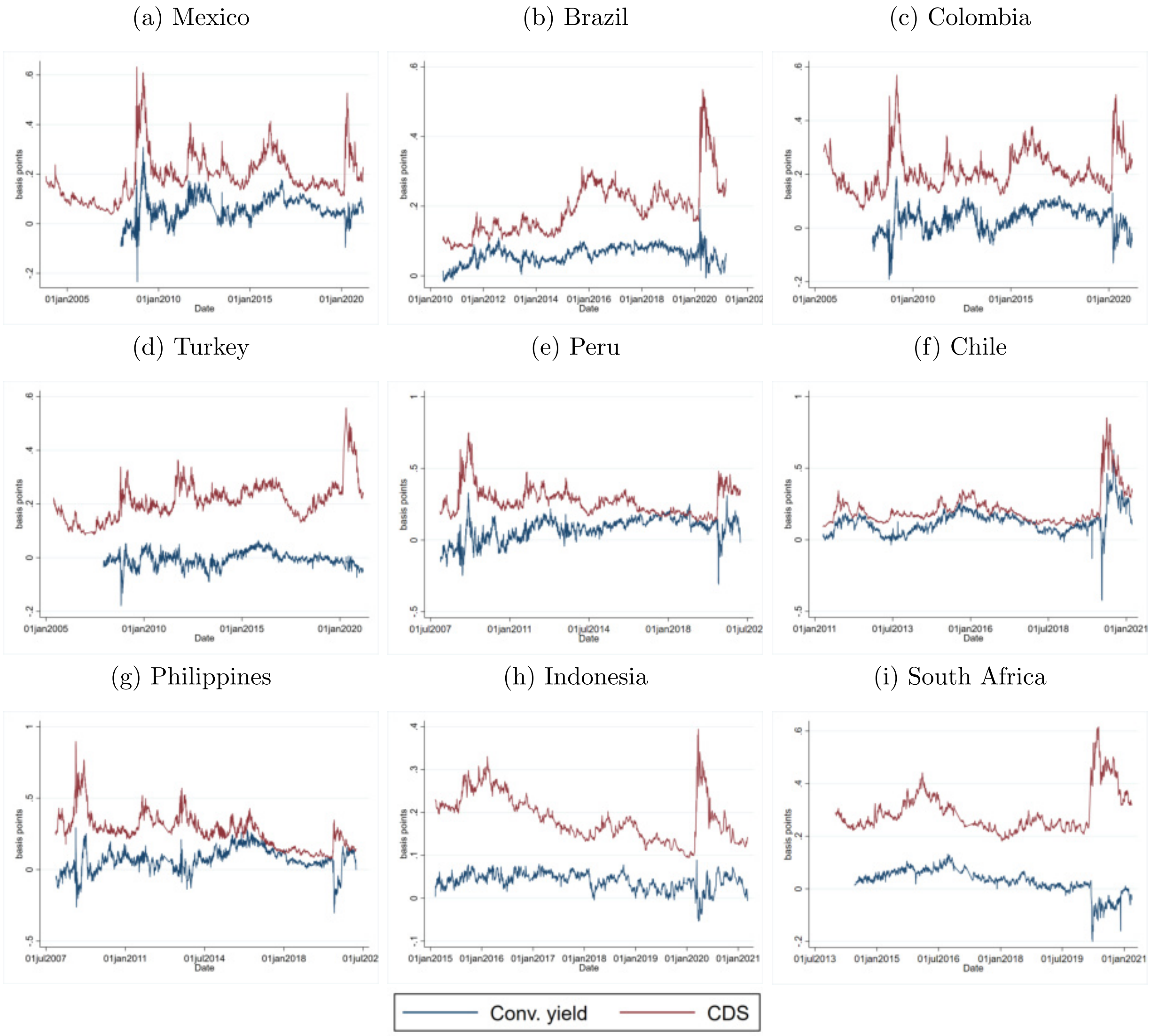
Notes: Daily frequency. Sample ends on March 9, 2021. Mean and std are calculated from 1/1/2010 onwards. *** p<0.01, ** p<0.05, * p<0.1

$$cy_{i,t} = \beta_1 i^{MP}_{t-1} + \beta_2(\text{Safe Asset supply/GDP})_{t-1} + \beta_3 i^{US}_t + c_i + \tau_t + \epsilon_{i,t} \tag{6}$$

where i is currency/country, t is time, and $cy_{i,t} = \lambda^{j,i}_t - \lambda^{US,i}_t$. The variable i^{MP} is the level of the local monetary policy rate, which intends to capture the price of overall liquidity in local currency set by the local central bank. (Safe Asset supply/GDP) is the supply of safe and liquid assets. Here I added both the local-currency sovereign debt supply as well as U.S. government debt supply. It is well known that U.S. Treasuries are the global safe asset, and in a small open economy their supply should have an impact on the price of liquidity attached to local-currency bonds. Both quantities are net of central bank holdings. Finally, I added the level of the U.S. federal funds rate, i^{US}_t. If dollar-denominated debt is the global safe asset, then not only its supply but also the price of dollar liquidity should have an impact on the local-currency bond premium. The independent variables are lagged one month to avoid endogeneity and reverse causality as much as possible (I address endogeneity more formally in Section 3.3). The variables c_i and τ_t are country and time fixed effects, respectively, that allow to control for time and country specific factors. I double clustered the standard errors across year and country.

Table 2 shows the results. In Column 1, both the local and the U.S. monetary policy rate have a positive effect. This is consistent with EME local-currency convenience yields arising from liquidity and safety services. The intuition, drawn from the closed-economy literature, is as follows: as central banks tighten the stance of monetary policy, liquidity in the form of currency and private deposits becomes scarcer and drives up the price of liquidity in all other liquid assets, such as

Figure 2: Convenience Yield and Credit Risk as Proportion of Total Yield



government debt.

The supply of of U.S. government debt reduces the local-currency convenience yield and the magnitude is large, which suggests that local-currency government bonds serve the same demand for safety and liquidity. The supply of local currency debt has a positive coefficient. Both debt and local GDP series can be noisy, but the sign of the coefficient is consistent with the idea that the *relative* supply of government debt affects the convenience yield. In Column 2, I added the supply of U.S. government debt to GDP divided by the local-currency debt supply to local GDP as a regressor. The negative coefficient on the relative supply of U.S. Treasuries is a key result; if the measure of local-currency convenience yield is actually capturing demand for safety and liquidity, then the estimated coefficient should be negative and statistically significant. This coefficient captures the

Table 2: Determinants of Convenience Yields (5-Year Sovereign Bond)

Dep. var: $cy_{i,t}$	(1)	(2)	(3)	(4)
MP rate_{t-1}	0.867*	0.988*	0.852*	0.990*
	(0.509)	(0.515)	(0.512)	(0.515)
U.S. fed funds_{t-1}	11.66***	13.64***	11.77***	13.70***
	(3.269)	(4.066)	(3.236)	(4.008)
$\log(\frac{\text{Local gov debt}}{GDP_{local}})_{t-1}$	14.33*		13.28*	
	(8.018)		(7.475)	
$\log(\frac{\text{U.S. gov debt}}{GDP_{US}})_{t-1}$	-131.0***		-127.7***	
	(39.74)		(38.88)	
$\log(\frac{\text{U.S. debt to GDP}}{\text{Local Debt to GDP}})_{t-1}$		-15.83**		-15.41**
		(7.874)		(7.261)
Local share			27.19*	30.21**
			(14.39)	(14.35)
Constant	-297.0***	-19.97	-291.4***	-21.16
	(71.78)	(36.42)	(70.27)	(34.24)
Observations	1,137	1,137	1,137	1,137
R-squared	0.670	0.658	0.674	0.663

Notes: Data are at monthly frequency. All columns include country and year fixed effects. Standard errors are double-clustered by country and year. Start dates vary among countries but ends in March 2021 for all. Both U.S. debt and EME local-currency debt-to-GDP variables are net of central bank's holdings. "Local share" is the share of EME debt owned by domestic investors (central bank, banks and nonbanks) *** p<0.01, ** p<0.05, * p<0.1

slope of the demand for safe assets: as supply increases, the price decreases by almost 16 basis points.

Results in Table 2 are robust to including a time trend (that controls for trends in the dependent variable) and to including the lagged dependent variable on the right-hand side. Since right-hand variables are lagged one period, autocorrelation in local-currency convenience yields can bias their coefficients. Inclusion of the lagged-dependent variable controls for endogeneity that may arise from persistence of the dependent variable. Since the data are at the monthly frequency and span more than ten years, adding the lagged dependent variable is unlikely to give rise to the Nickell (1981) bias.

Finally, I added the variable "local share", which measures the proportion of local debt in each country held by domestic investors including the local central banks, domestic banks, and domestic non-banks. Data comes from the IMF's Sovereign Debt Investor Base for Emerging Markets. This variable tests the intuition that the local financial intermediaries are the most likely to derive convenience services from local-currency sovereign bonds. Columns 3 and 4 in Table 2 show a positive correlation between the share held by local financial institutions and the convenience yield. While I cannot conclude that foreign investors derive actually *zero* convenience services, I take this result as evidence that their influence is negligible. The next subsection will provide further evidence on this point when I estimate the effect of capital inflows.

3 Empirical Analysis

Having estimated the size of the EMEs convenience yields and showed evidence that they actually come from investors' safety and liquidity demand, this section analyzes their local and global determinants.

3.1 EME Local-Currency Convenience Yield and the Global Financial Cycle

In this section, I extend the analysis above to study the dynamics of the local-currency convenience yield along global variables. To do this, I rely on the insights from the literature on the global financial cycle (Rey, 2013; Miranda-Agrippino and Rey, 2021). This literature has documented significant co-movements in asset prices, capital inflows, and credit growth across regions and countries, and has identified global risk aversion as the main driver. The following exercise can therefore be seen as an effort to extend this literature by analyzing the co-movements of the price of safety and liquidity across countries, which has not been studied so far.

Miranda-Agrippino and Rey (2021) documented that the VIX was strongly correlated with a global factor that explained about a quarter of the variance in risky asset prices and about 35% of the variance of gross capital flows. This evidence supports the wide acceptance of the VIX as a measure of global risk aversion and as the main driver of the global financial cycle. They also reviewed the findings linking the U.S. monetary policy decisions with perceptions of global risk aversion. Rey (2013) found that reductions in the federal funds rate were associated with reductions in the VIX after about 4 quarters. The mechanism would go as follows: the lower federal funds rate would decrease the cost of dollar funding, encouraging leverage in global banks, which increased credit flows and led to a lowering of the perception of risk.

These findings also might impact the interpretation of some of the results in the previous section. There, I found that increases in the federal funds rate increased the convenience yield of EMEs' sovereign bonds. To be sure that this captures the effect of the supply of dollar liquidity, I need to control for the impact of the federal funds rate on global risk aversion.

Table 3 shows the results. In Column 1 I added the VIX index. The coefficient on the VIX is negative and statistically significant. This suggests that the safety status of local-currency sovereign bonds decreases during periods of high risk aversion. In the next subsection, I will show evidence suggesting this is due to the local investors preferring the safety/liquidity of U.S. Treasuries. For now, I highlight that this is a striking result as it is the opposite of the response of convenience yields in advanced economies. In the United States, a rise in the VIX increases the convenience yield on its debt, driving dollar rates down and creating liquidity shortages.

Notice also that the federal funds rate loses most of its significance, and the magnitude is reduced by around half. This might suggest that the U.S. monetary policy works mainly through risk perceptions rather than through the supply of dollar liquidity. However, keep in mind that both the federal funds rate and the VIX are identified at the monthly frequency in the time series dimension. In Section 3.2, I will be able to better disentangle them.

Next, I controlled for capital inflows as a robustness check for the effect of the VIX. As mentioned earlier, the VIX is strongly correlated with a global factor that explains about 35% of the variance of gross capital flows. As the GFC literature suggests, a lower federal funds rate lowers dollar funding costs, lowering risk perception and encouraging credit and capital inflows. In Columns 2-4, I added capital inflows disaggregated by type (debt versus equity) and by the sector to which they are directed (government, bank, or corporate debt). Data for the latter comes from Adjiev et al. (forthcoming).

There are three important results in this exercise. First, the VIX kept its negative effect on the local bond convenience yield, which suggests that the effect comes from global risk perceptions and not from capital flows. Second, inflows into government debt did not affect the local-currency convenience yield, which adds further evidence for the role of local investors as the source of safety and liquidity demand. Third, inflows into bank debt significantly reduced the local-currency convenience yield. This is consistent with the empirical regularity of local banks being the largest holders of sovereign debt in EMEs. This result might be explained by banks having lower demand for collateral services from local sovereign bonds at times when foreigners flock to bank debt.

In Column 4, I controlled for the terms of trade for each country, measured as the commodity price index of exports over the equivalent for imports. This is an important robustness check as Miranda-Agrippino and Rey (2021) found that a global factor highly correlated with commodity indices and international trade was the second main factor for capital flows and additionally explained 31% of the variance of fluctuations in private liquidity worldwide. Column 4 shows that my results regarding the local-currency convenience yield were not driven by this global factor. More importantly, Column 4 provides further evidence that local-currency convenience yields are driven by risk perceptions rather than factors related to trade.

One last robustness exercise consists of introducing local secular factors that do not vary at the business cycle frequency. It is natural to expect that EMEs with better institutions, governance,

Table 3: Convenience Yields and the Global Financial Cycle (5-Year Sovereign Bond)

Dep. var: $cy_{i,t}$	(1)	(2)	(3)	(4)	(5)
MP rate$_{t-1}$	1.349**	1.407**	1.269**	1.234**	2.481***
	(0.543)	(0.551)	(0.547)	(0.544)	(0.737)
$\log(\frac{\text{U.S. debt to GDP}}{\text{Local Debt to GDP}})_{t-1}$	-18.45**	-18.94**	-17.66**	-16.72**	-13.13
	(7.867)	(7.712)	(7.655)	(7.890)	(9.034)
U.S. fed funds$_{t-1}$	5.351*	4.711	5.432*	5.336*	8.872**
	(3.021)	(2.888)	(2.992)	(3.005)	(3.885)
vix$_{t-1}$	-1.012***	-0.991***	-1.027***	-1.047***	-1.019***
	(0.307)	(0.291)	(0.304)	(0.300)	(0.387)
$(\frac{DebtInflow}{GDP})_{t-1}$		5.721			4.988
		(4.463)			(4.471)
$(\frac{EquityInflow}{GDP})_{t-1}$		6.230			9.815
		(11.05)			(10.97)
$(\frac{GovdebtInflow}{GDP})_{t-1}$			-1.530	-1.855	
			(1.913)	(1.902)	
$(\frac{BankdebtInflow}{GDP})_{t-1}$			-3.221**	-3.372***	
			(1.290)	(1.272)	
$(\frac{CorpdebtInflow}{GDP})_{t-1}$			1.653*	1.625*	
			(0.938)	(0.930)	
Terms of trade				-127.6	-122.1
				(83.94)	(94.49)
Diff. Inflation					-1.076
					(0.749)
Democratic risk					-9.810**
					(4.752)
Constant	51.20	56.25	45.78	629.2	549.1
	(40.53)	(39.86)	(39.41)	(380.1)	(425.5)
Observations	1,137	1,137	1,137	1,137	1,012
R-squared	0.680	0.683	0.686	0.688	0.708

Notes: Data are at monthly frequency. All columns include country and year fixed effects. Standard errors are double-clustered by country and year. Start dates vary among countries but ends in March 2021 for all. Capital inflows-to-GDP variables are standardized by mean and standard deviation of each country. "Diff. inflation" is yearly inflation rate in each country minus yearly inflation in the United States. "Democratic risk" measures political accountability (International Country Risk Guide, April 2019 version), and it is standardized by mean and standard deviation of each country (higher values reflect higher risk). *** p<0.01, ** p<0.05, * p<0.1

and higher levels of investor confidence would enjoy a higher local-currency convenience yield. It might be the case that the global determinants I have considered so far are just masking these local secular factors. To check this possibility, in the last column, I added the differential yearly inflation in each country with respect to the United States, and the differential index in democratic accountability, taken from the dataset of the International Country Risk Guide. I standardized this index so higher values mean higher political risk. The results show that higher political risk decreased the local-currency convenience yield, but, importantly, it did not account for the effect of the global determinants.

The results in this subsection are also robust to the inclusion of a time trend and to the inclusion of the lagged dependent variable as a regressor.

3.2 Event Studies

In this subsection, I address the possible endogeneity of the local monetary policy rate, the U.S. monetary policy rate, and the VIX index. The local monetary policy rate is the most likely to be endogenous, as an unobserved liquidity demand shock can affect both the local central bank's rate decisions and the local-currency convenience yield. The U.S. monetary policy rate and the VIX index are less likely to be endogenous, since financial developments in emerging markets seldom call for a policy response by the Fed or to an increase in global risk aversion.

To address these issues, I conducted event studies within narrow windows around monetary policy movements and risk-on events. In particular, I tested the panel specification:

$$\Delta cy_{i,t} = c_i + \tau_t + \gamma \times MPM_t^i + \beta \times MPM_t^{US} + \delta \times RP_t + \epsilon_{i,t} \tag{7}$$

In Equation (7), MPM_t^{US} is the change in the 2-year U.S. Treasury yield between the closing of the business day before and the day after each monetary policy meeting of the U.S. Federal Reserve. The rationale for this measure, proposed by Hanson and Stein (2015), is that the actual federal funds rate changes are infrequent and often anticipated by the market. Moreover, relevant information could be presented at each meeting about the course of monetary policy that would be missed if one used only the contemporaneous federal funds rate. For these reasons, the authors proposed using a relatively short-maturity yield for capturing changes in the stance of future monetary policy that could arise from information released during FOMC meetings. MPM_t^i is the analogous variable for local monetary policy, i.e., the change in the local-currency 2-year yield sovereign bond around monetary policy meetings of the local central bank.

RP_t is a global risk-on event, defined as a date on which the VIX had a daily variation (either positive of negative) larger than two standard deviations (computed on the daily average change in the period January 2003 through December 2019). Then, I defined the risk-on shock as the 2-day differential in the VIX around those days. c_i and τ_t are currency and year fixed effects, respectively, that control for common events that could affect yields. $\epsilon_{i,t}$ are clustered standard errors around currency and year.

The left-hand side of Equation (7) is the change in the local-currency convenience yield between the close of the business day after and the day before each monetary policy meeting and risk-on event. As before, this is the convenience yield on the 5-year local-currency sovereign bond.

Between December 2007 and March 2021, there were 103 FOMC meetings of the Fed, and an average of 144 local monetary policy meetings in emerging markets (most of which hold monthly meetings, whereas the Fed only conducts eight meetings a year). There were 1,073 risk-on events on the daily sample.

To interpret the results as causal forces affecting the local-currency convenience yield, the three events defined above must not overlap and should not be contaminated by other economic releases. Albagli et al. (2022), for a larger sample of emerging markets, showed that less than 2% of local monetary policy meetings overlapped with FOMC meetings, and less than 5% overlapped with risk-on events. Similarly, Albagli et al. (2019) showed that economic data releases in the U.S. and emerging markets (including inflation, industrial production, and unemployment new data releases) overlapped at most with 6% of local and U.S. monetary policy meetings.

Table 4 shows the results. Columns 1-3 provide different specifications for the fixed effects included in the estimation. Column 4 drops the 2008's financial crisis and the Covid pandemic to make sure results are not driven by mispricing during these extreme events (The sample in Column 4 runs from January 2010-December 2019).

Overall, previous results are robust: The local convenience yield significantly increased around local monetary policy tightenings. This supports that safety and liquidity are the sources of the local-currency convenience yield. As the central banks raises the price of liquidity, it also increases the premium investors are willing to pay for the liquidity of sovereign bonds.

Risk-on events significantly reduced the local-currency convenience yield, supporting the finding that global events reduce the safety value investors attach to these sovereign bonds. In Column 4, the coefficient lost its significance, but this is mostly explained by the sample used. Between January 2010 and December 2019, there were only 64 risk-on events, compared to 1,073 such events considered in Columns 1-3. Interestingly, these event studies were able to capture the isolated impact of the federal funds rate: U.S. monetary policy tightenings increased the value of the convenience service of local sovereign bonds. This suggests that the U.S. federal funds rate has an impact through the supply of dollar liquidity, which is different from its effect through risk perception. However, this effect is only slightly significant and lower in magnitude than the effect of risk-on events.

3.3 Local-Currency Convenience Yield's Cyclicality

Table 5 adds the local output gap on the right-hand side of the regression. In the U.S., the convenience yield of U.S. Treasuries has been shown to be countercyclical (i.e., the safety value increases in recessions), which puts downward pressure on interest rates during these crises. The

Table 4: Determinants of Convenience yields - Event Studies

$\Delta cy_{i,t}$	(1)	(2)	(3)	(4)
MPM_t^i	0.185***	0.183***	0.184***	0.167**
	(0.0585)	(0.0576)	(0.0576)	(0.0694)
MPM_t^{US}	0.401*	0.403*	0.403*	0.423*
	(0.212)	(0.210)	(0.210)	(0.219)
RP_t	-1.055***	-1.074***	-1.074***	-0.280
	(0.293)	(0.286)	(0.286)	(0.252)
Constant	-1.497	-2.409	-2.313	-1.541
	(1.506)	(1.558)	(1.568)	(1.505)
Currency FE	Y	N	Y	Y
Year FE	Y	Y	Y	Y
Month FE	N	Y	Y	N
Observations	22,695	22,695	22,695	20,309
R-squared	0.007	0.009	0.009	0.004

Notes: Data are at daily frequency. Standard errors are double-clustered by country and year. Column 4 excludes crises (January 2010-December 2019). MPM^i stands for local central banks' meetings, MPM^{US} stands for U.S. Fed's FOMC meetings. RP_t are risk-on events measured by the VIX intraday variation. *** p<0.01, ** p<0.05, * p<0.1

coefficient on the output gap will measure the cyclicality of the local-currency convenience yield conditional on the short-term policy rate, the public provision of safe assets, and demand shifters such as the VIX. I measured the output gap using the year-on-year change in the log of industrial production index. This index is available monthly only for seven of the countries considered (not available for Peru and the Philippines).

The results across Columns show that the local-currency convenience yield is mildly procyclical across all columns (i.e., coefficient is positive and significant at the 5% level). The estimated coefficient implies an increase of about 17 basis points in the local-currency bond premium with a 1% increase in output growth above trend.

Interestingly, the inclusion of the output gap makes both the local monetary policy rate and the supply of debt to become not statistically significant. This can be interpreted as the output gap not having an independent impact, but rather having an influence on the convenience yield *through* the response of monetary and fiscal policy. First, it implies that monetary policy is procylical: when

Table 5: Cyclicality of Convenience Yields

$cy_{i,t}$	(1)	(2)	(3)	(4)
Output gap	19.58**	14.12**	14.57**	13.25*
	(9.747)	(6.774)	(6.987)	(6.755)
MP rate$_{t-1}$	0.745	0.946*	1.018**	0.666
	(0.485)	(0.488)	(0.496)	(0.481)
$\log(\frac{\text{US debt to GDP}}{\text{Debt to GDP}})_{t-1}$	-5.314	-7.180	-7.333	
	(10.75)	(10.66)	(10.70)	
US fed funds$_{t-1}$	11.10*	4.875		3.334
	(5.898)	(4.355)		(3.855)
vix$_{t-1}$		-0.809**	-0.913**	-0.812**
		(0.374)	(0.420)	(0.365)
$\log(\frac{\text{EME debt}}{\text{GDP}})_{t-1}$				-0.261
				(10.54)
$\log(\frac{\text{US debt}}{\text{GDP}})_{t-1}$				-151.2***
				(53.33)
Constant	-45.69	9.262	33.50	-268.9***
	(50.06)	(53.96)	(55.65)	(94.60)
Observations	833	833	833	833
R-squared	0.685	0.698	0.697	0.713

Notes: Monthly frequency. Standard errors are clustered by country and year. All columns include currency and year fixed effects. Output gap is measured as the 12-month log difference in industrial production (OECD series). Data available for Brazil, Chile, Colombia, Mexico, Indonesia, South Africa, and Turkey. *** p<0.01, ** p<0.05, * p<0.1

the ouput gap is negative the central bank lowers the local interest rate. This increases private local-currency liquidity in the forms of reserves and private deposits, and therefore the convenience yield on other liquid assets (such as government debt) decreases. This is consistent with recent papers that have found that monetary policy is procyclical in emerging economies (De Leo et al., 2022).

As for fiscal policy, it implies that the effect of the debt-to-GDP ratio is mostly driven by the dynamics of the denominator. A lower output gap increases the debt-to-GDP ratio (the supply variable) and this reduces the convenience yield. This can be ameliorated or exacerbated by the cyclical response of the amount of outstanding debt (the numerator). If borrowing is procyclical (meaning that the government cannot borrow as much during recessions), then the drop in the debt-to-GDP ratio is even larger.

Available evidence points to the procyclicality of debt issuance in EMEs. It is a well documented fact that government spending in developing countries has often been procyclical (Frankel et al., 2013). In other words, government spending has increased in good times and contracted in bad times, thus exacerbating the underlying business cycle, which is the opposite of what has happened in developed countries. At the same time, tax revenues have been shown to be procyclical: The government raises less revenue during recessions. Vegh and Vuletin (2013) showed that this was due to tax policy: Governments in developing countries actually increased the tax *rate* during recessions. These empirical regularities suggest that the supply of government debt in EMEs is likely to be procyclical. In fact, the limited access to credit markets in bad times is one of the main explanations offered for government spending procyclicality in EMEs.

Overall, the evidence shows that convenience yields respond in the "right" direction along local business cycles: the safety status of local-currency government debt increases when the supply of safe assets (either private or public) decreases. However, the convenience yield drops during episodes of global uncertainty, as measured by the VIX index. A natural explanation would be that investors' demand for the safety of the local asset during *global* adverse episodes is driven by the availability of alternative global safe assets. The next subsection will present evidence supporting this mechanism and discuss alternative explanations.

3.4 Inspecting the Mechanism

This subsection explores possible mechanisms behind the safety status of EMEs' sovereign bonds by analyzing two identifiable exogenous shocks to EMEs: the Taper Tantrum and the Covid pandemic. These are widely accepted as exogenous and unanticipated adverse shocks to EMEs. The Taper Tantrum started with Fed Chairman Ben Bernanke's speech in May 2013, which triggered a sell-off of sovereign bonds both in the U.S. and in emerging markets. The Covid-19 episode likely represents many shocks; therefore, I will focus my analysis on the early months of the pandemic (March-June 2020). Both episodes involved an increase in risk and a capital inflow reversal for EMEs, but one difference is that, unlike the first months of the Covid shock, the Taper Tantrum did not trigger a flight to safety episode (understood as global investors buying U.S. Treasuries because of their safety). This can be seen in the response of the VIX index (which did not increase) and in the fact that it also drove a sell-off of U.S. Treasuries.

In Table 6 I interact the shocks with the explanatory variables to differentiate among possible channels. In the case of the Taper Tantrum, the coefficient of the interaction between the shock and the local monetary policy rate was significant. The monetary policy rate proxies the price of alternative private safe and liquid assets, such as local currency and private deposits. As the central bank tightens, the price of these other assets increases, driving up the price on close substitutes, such as government debt. Interestingly, the positive sign of this coefficient suggests that the convenience yield actually *increased* during the Taper Tantrum. This can be explained by the fact that there was no flight to safety, so local investors still valued the safety/liquidity of the local government bonds. Lastly, the coefficient of the interaction between U.S. debt supply and the Taper Tantrum measures any change in the slope of the demand for global safe assets. This coefficient is not significant, which is again consistent with the lack of a flight to safety episode.

Column 2 shows that the Covid shock significantly reduced the local-currency convenience yield. The interaction with debt supply was significantly negative, suggesting that the demand for global safe assets became significantly steeper. This is consistent with a global flight to the safety of U.S. Treasuries, and with local investors preferring this safe asset over the local one. Another mechanism at work was the overall risk aversion, as shown by the interaction with the VIX.

Are there other mechanisms that could be at play? A common alternative explanation rests on a financial repression mechanism. The government might want to force the local banks to hold its debt, and specially so during downturns. However, if financial repression drives down local yields and it is likely to be enforced during recessions, then it would show up in the data as a countercyclical convenience yield. Another one is inflation risk, since economic activity in EMEs is more likely to face adverse supply shocks. However, this and other risks are already part of the decomposition of local convenience yields in Section 2.

Of course, the mechanism highlighted in this section still leaves questions open. If it is true that the local-currency convenience yield is driven by the existence of alternative safe assets, it still needs to be explained what precise feature of the local-currency sovereign bond makes it a good hedge against shocks like the Taper Tantrum but less preferred than the alternatives during global shocks involving a flight to safety. This question goes beyond the scope of this paper, but it certainly represents a venue for future research.

3.5 Summary of Empirical Analysis

Let me briefly summarize the key takeaways from this and the previous section. Data on deviations of covered interest parity conditions show that investors are willing to pay more than 30 basis points for the safety and liquidity of EMEs' local-currency sovereign bonds, compared to non-Treasuries safe dollar bonds. However, this does not make them equivalent to a U.S. Treasury or a reserve currency country. The main difference is that their local-currency convenience yield is procyclical with respect to the global financial cycle, suggesting that their value as safe assets drops during episodes of increased global risk aversion. A comparison between the Taper Tantrum and the Covid shock suggests that the mechanism works through the availability of alternative global safe assets, and is at play for shocks involving global flights to safety.

Table 6: Effects of Taper Tantrum and Covid-19 Shocks

Dep. var: $cy_{i,t}$	(1)	(2)
MP rate$_{t-1}$	0.748***	0.838***
	(0.279)	(0.289)
$\log(\frac{\text{US debt to GDP}}{\text{Debt to GDP}})_{t-1}$	-10.82***	-11.49***
	(3.338)	(3.440)
vix$_{t-1}$	-0.361*	-0.405
	(0.203)	(0.262)
$(\frac{DebtInfl}{GDP})_{t-1}$	3.028	2.919
	(2.682)	(2.679)
$(\frac{EqtInfl}{GDP})_{t-1}$	1.629	2.042
	(5.474)	(5.401)
TT$_{t-1}$	3.191	
	(2.671)	
MP rate$_{t-1}$ × TT	1.899***	
	(0.632)	
$\log(\frac{\text{US debt to GDP}}{\text{Debt to GDP}})_{t-1}$ × TT	0.328	
	(0.479)	
vix$_{t-1}$ × TT	-0.554	
	(0.461)	
$(\frac{DebtInfl}{GDP})_{t-1}$ × TT	0.328	
	(0.479)	
$(\frac{EquityInfl}{GDP})_{t-1}$ × TT	-3.952	
	(14.18)	
Covid-19$_{t-1}$		-21.38***
		(5.394)
MP rate$_{t-1}$ × Covid-19		-2.387
		(1.510)
$\log(\frac{\text{US debt to GDP}}{\text{Debt to GDP}})_{t-1}$ × Covid-19		-2.824***
		(0.623)
vix$_{t-1}$ × Covid-19		0.722***
		(0.267)
$(\frac{DebtInfl}{GDP})_{t-1}$ × Covid-19		-2.636
		(5.972)
$(\frac{EquityInfl}{GDP})_{t-1}$ × Covid-19		-15.80
		(15.02)
Constant	43.91**	47.48**
	(17.11)	(18.38)
Observations	1,137	1,137
R-squared	0.686	0.688

Notes: See Table 3. *TT* is a dummy variable taking the value 1 from May to December 2013. Covid-19 is a dummy variable taking the value 1 from March to June 2020. All columns include country and year fixed effects *** p<0.01, ** p<0.05, * p<0.1

In the Appendix I ran a series of robustness tests for Sections 3.1-3.4. First, I ran the same regressions but with credit risk as a dependent variable, which is another component of CIP deviations. If my decomposition in Section 2 accurately disentangled local-currency bond premiums from default risk, then determinants should be different. The results of that exercise confirm this. In stark contrast with convenience yields, credit risk does not respond to the supply of safe assets, and debt inflows significantly reduce default risk. Second, I also addressed the concern that my results might be driven by periods of high illiquidity and mispricing of EME assets (either sovereign bonds, CDS contracts, or interest rate swaps). I reran the regressions by dropping both the 2008 and 2020 crises in order to only capture only "normal" periods. The results there suggest that the role of safety and liquidity demand as a source of EMEs ' convenience yields is robust to this smaller sample.

4 Model

The aim of this section is to build a model that achieves three goals: to match a procyclical convenience yield on local bonds, to quantify the role of safety on a small open economy's volatility, and to explore policy implications. The model builds on the standard SOE-RBC model. Three important extensions are needed to achieve the stated goals. First, the representative household has a preference for safe assets, which goes beyond the standard precautionary demand for consumption smoothing. This preference is introduced through a bonds-in-the-utility function specification. Second, safe assets include a local bond, issued by the local government and financed by taxes, and a foreign bond, whose price is world-determined. And third, I introduce a shock to safety demand as in Kekre and Lenel (2021), which they showed accounted for a sizeable portion of output volatility in the United States and the rest of the world.

Finally, I add two financial frictions which are not central to safety demand but their role is to match well known business cycle facts in EMEs: output shows larger volatilty than advanced economies, and consumption is more volatile than ouptut (Schmitt-Grohe and Uribe, 2017). These frictions are an endogenous collateral constraint on foreign borrowing for households (as in Bianchi and Mendoza, 2020), and working capital constraints for firms (as in Mendoza, 2010).

4.1 Households

The small open economy is inhabited by a large set of identical, infinitely lived households. The preference specification is:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t[u(c_t - N(L_t)) + v(b_t^{\$}, b_t; \zeta_t)]\right] \tag{8}$$

In this expression, $u(.)$ and $v(.)$ are standard twice-continously differentiable and concave period utility functions. Following GHH (1988), $u(.)$ is defined in terms of the excess of consumption relative to the disutility of labor, with the latter given by the twice-continuously differentiable convex function, $N(.)$. This assumption eliminates the wealth effect on labor supply by making the marginal rate of substitution between consumption and labor independent of consumption. $v(.)$ is defined in terms of the holdings of two type of bonds: foreign, $b_t^{\$}$, whose price fluctuates exogenously and which admits either short or long positions by the household, and local bonds, b_t, issued by the local government and for which the restriction $b_t \geq 0$ applies. The latter means that the household cannot borrow from the local government. Both bonds are 1-period bonds. ζ_t captures an exogenous shock to the demand for safety and liquidity of the foreign bond.

Households choose sequences of consumption and labor supply. Investment opportunities are domestic capital, k_{t+1}; local 1-period bonds, b_{t+1}; and foreign 1-period international bonds, $b_{t+1}^{\$}$. Decisions maximize (8) subject to the following period budget constraint:

$$(1+\tau_t)c_t + q_t k_{t+1} + q_t^b b_{t+1}^{\$} + p_t^b b_{t+1} = (d_t + q_t)k_t + w_t L_t + b_t^{\$} + b_t + T_t \tag{9}$$

Households take as given the dividend rate on capital holdings, d_t; the market price of capital, q_t; the wage rate, w_t; the price of the local bond, $p_t^b \equiv 1/R_t^b$; the price of the foreign bond, $q_t^b \equiv 1/R_t^{\$}$; and the stochastic international gross yield that drives expected excess returns, $R_t = Rexp(\epsilon_t^R)$. This international yield can be understood as coming from a foreign asset that does not provide safety/liquidity services. ϵ_t^R is an interest rate shock that follows a Markov process joint with the other shocks defined later.

The world credit market is imperfect. Lenders require households to guarantee their debt by offering domestic assets as collateral. The collateral constraint takes the form of the margin requirement proposed by Aiyagari and Gertler (1999) and commonly used in Mendoza (2010) or Bianchi and Mendoza (2020):

$$q_t^b b_{t+1}^{\$} \geq -(\kappa^h q_t k_{t+1} + \kappa^b p_t^b b_{t+1}) \tag{10}$$

Thus, households can borrow internationally up to a fraction κ^h of the market value of their capital and a fraction κ^b of the market value of the local bonds. The margin constraint is not derived from an optimal credit contract. Instead, the constraint is imposed directly as in the models with endogenous credit constraints examined in Kiyotaki and Moore (1997) or Aiyagari and Gertler (1999), even though a constraint like (10) can be endogenously modeled.

4.2 Firms

Firms are owned by households and discount future profits by taking as given the households' stochastic discount factors, Λ_t. Firms produce a tradable good that sells at a world-determined price (normalized to one for simplicity). They make plans for factor demands and investment. Net investment, $z_t = k_{t+1} - k_t$, incurs unitary investment costs determined by the function $\Psi(z_t/k_t)$, which is linearly homogenous in z_t and k_t. To this, I introduce working capital constraints. In particular, firms need working capital to pay for a fraction ϕ of their labor costs in advance of sales. Firms are required to guarantee working capital loans so working capital financing cannot exceed the fraction κ^f of the value of firms' assets. The role of working capital constraints is to allow for movements in interest rates to have an impact on contemporary output.

The firms' problem is to choose labor demand and investment so as to maximize their value:

$$E_0\left[\sum_{t=0}^{\infty}\left(\prod_{j=0}^{t}\Lambda_j^{j-1}\right)\left(A_tF(k_t,L_t)-w_tL_t-\delta k_t-\phi(R_t^b-1)w_tL_t-z_t\left[1+\Psi\left(\frac{z_t}{k_t}\right)\right]\right)\right] \tag{11}$$

subject to the law of motion for capital,

$$z_t = k_{t+1} - k_t \tag{12}$$

and the collateral constraint on working capital financing:

$$R_t^b\phi w_tL_t \leq \kappa^f q_tk_{t+1} \tag{13}$$

Gross output in (11) is defined by a constant-returns-to-scale technology, $A_tF(k_t, L_t)$, that requires capital, k_t, and labor, L_t, to produce the tradable good. The firm makes wage payments, w_tL_t, and payments on the interest of the working capital loans, $\phi(R_t^b-1)w_tL_t$. Working capital in (13) is a within-period loan contracted at the beginning of each period and paid off after the current output is sold at the end of the period. Hence, lenders set the limit on working capital considering that the market value of the assets offered as collateral must cover interest and principal on working capital loans.

4.3 Government

The government collects taxes on consumption and borrows from households. This borrowing, in turn, determines the supply of the local bond (1-period bond). At the same time, the government aims to keep a stable ratio of debt to GDP, which is a direct way to achieve a procyclical supply of the local bond (and thus match the evidence for developing countries discussed in the previous Section).

Every period, the government issues new bonds and adjusts the tax rate in order to pay for the maturing bonds from the previous period. Ricardian equivalence does not hold here because bond holdings provide a safety service for the households.. The tax rate will vary to satisfy the following budget constraint:

$$\tau_tc_t + p_t^bb_{t+1} = b_t \tag{14}$$

Equation (14) implies that tax rates are going to be higher both in states where output is higher and in states where the price of the local bond is lower. Therefore, tax rates are going to be procyclical, which is consistent with evidence for emerging markets (Vegh and Vuletin, 2013; Frankel et al., 2013). Concurrently, lower demand for the local bond will encourage the government to raise the tax rate.

Results and policy implications in the next section do not rely on the procyclicality of the supply of local bonds. These insights will be robust to alternative specifications, such as a constant tax rate or bond supply. I defer to Section 5 the modelling of unconventional liquidity policy, in which the government is able to buy capital from households in exchange for local bonds.

4.4 Equilibrium

There are two endogenous states, $\{k_t, b_t^{\$}\}$, and three exogenous states that correspond to the three exogenous shocks that work as driving forces (productivity, global safety, and interest rate shocks, described later). A competitive equilibrium for the small open economy is defined by decision rules $\{c_t, L_t, k_{t+1}, b_{t+1}^{\$}, b_{t+1}, z_t\}$ and prices $\{q_t, d_t, w_t, p_t^b, \Lambda_t\}$ such that: (a) households maximize (8) subject to (9) and (10), taking as given dividends, wages, equity and bond prices, and the world interest rate; (b) firms maximize their value subject to (12) and (13), taking as given wages, the world interest rate, and the household stochastic discount factor; and (c) the capital, bonds, labor, and goods markets clear.

The households' optimality conditions with respect to bond holdings yield the following Euler equations for the foreign and the local bond, respectively:

$$q_t^b = \beta E\left[\frac{\lambda_{t+1}}{\lambda_t}\left(1 + \frac{\upsilon_{F,t+1}}{\lambda_{t+1}}\right)\right] + \frac{\mu_t}{\lambda_t} \tag{15}$$

$$p_t^b = \beta E\left[\frac{\lambda_{t+1}}{\lambda_t}\left(1 + \frac{\upsilon_{L,t+1}}{\lambda_{t+1}}\right)\right] + \frac{\mu_t \kappa^b}{\lambda_t} \tag{16}$$

where λ_t and μ_t are the Lagrange multipliers for the budget constraint and the collateral constraint, respectively. As usual, λ_t equals the lifetime marginal utility of c_t. υ_i represents the first derivative of the $\upsilon(.,.)$ function in (8) with respect to $i \in \{L, F\}$, which stand for "local" and "foreign" bonds, respectively. The price of the bonds depends on the two reasons why households demand bonds. First, there is the intertemporal substitution motive. This is the typical motive in standard neoclassical models in which households demand bonds to smooth their consumption path.

Second, there is a safety motive, above and beyond the intertemporal substitution motive. This demand for safety is captured in a reduced-form way by the convenience yield, $CY_{i,t+1} \equiv \frac{\upsilon_{i,t+1}}{\lambda_{t+1}}$, $i \in \{L, F\}$. This term measures the marginal non-pecuniary convenience service of an extra bond.

This convenience yield drives a spread with respect to a bond that provides no safety/liquidity services. This means that both $R_t^{\$}$ and R_t^b will be lower than the international interest rate, $R_t \equiv 1/q_t^c = \beta E(\frac{\lambda_{t+1}}{\lambda_t})$, where q_t^c would be the price of a bond that does not provide safety/liquidity services. Put in a different way, the foreign and the local bond will have higher prices than this non-safe bond, depending on the magnitude of their convenience yields; respectively:

$$q_t^b - q_t^c = \beta E\left[\frac{\upsilon_{F,t+1}}{\lambda_t}\right] \tag{17}$$

$$p_t^b - q_t^c = \beta E\left[\frac{\upsilon_{L,t+1}}{\lambda_t}\right] \tag{18}$$

Even though it is a reduced-form specification, this captures the main empirical properties found in Section 3. First, the convenience yield lowers the equilibrium yield of the bonds, below the level that would be implied by the consumption smoothing demand alone. Second, it depends negatively on the supply of safe assets (through $\upsilon_{i,t+1}$), and positively on expected future consumption (through $1/\lambda_{t+1}$) which represents a wealth effect. Additionally, this specification has the benefit of making the equilibrium convenience yields fully endogenous (unlike, for example, the specification in Kekre and Lenel, 2021).

Equations (15) and (16) make clear that the introduction of the bonds in the utility function serves two important purposes. First, it allows a model counterpart for the convenience yields found in the empirical section. Second, it disentangles the prices of the two bonds. If $\upsilon_F = \upsilon_L = 0$, I would face the common issue with small open economy models where the local interest rate is equal to the world interest rate by arbitrage. Importantly, p_t^b would be exogenously determined, and thus I could not analyze the behavior of the local interest rate along the global financial cycle.

The expected excess return of capital with respect to the foreign bond is given by:

$$E[R_{t+1}^k - R_{t+1}^{\$}] = \frac{\mu_t(1-\kappa^f) - cov(\lambda_{t+1}, R_{t+1}^k) + cov(\lambda_{t+1}, CY_{F,t+1})}{E[\lambda_{t+1}]} \tag{19}$$

On the right-hand side, the first term in the numerator is the direct effect of the collateral constraint on the equity premium: The binding constraint increases the shadow price of borrowing by μ_t, and the fact that capital holdings allow one to borrow more reduces this cost by $\kappa\mu_t$. The second term is the standard covariance between consumption risk and capital return. Since this covariance is negative, consumption risk increases the equity premium. The third term captures the convenience service provided by the foreign bond, so it represents the foreign convenience yield. Therefore, expected excess return of capital is the sum of consumption risk premia, safety premia, and the risk of sudden stops. As the safety shock increases the third term, it is easy to see that an increase in the demand for safety will have an impact on q_t -and on investment - through the expected excess return of capital.

In addition, equations (15) and (16) can be worked out to deliver the following expression for the differences in prices of the two bonds:

$$q_t^b - p_t^b = \beta E\left[\frac{\lambda_{t+1}}{\lambda_t - \kappa^b \mu_t}\left(CY_{F,t+1} - CY_{L,t+1}\right)\right] \tag{20}$$

This expression is equivalent to the CIP deviation in the model since the model is set up in real terms and there is no default risk. The foreign bond will have a higher price than the local bond if its marginal convenience service is higher than the marginal convenience service provided by the local bond, the term inside the parentheses. This differential convenience yield is discounted at the stochastic discount factor, adjusted by the possibility of a sudden stop, $\frac{\lambda_{t+1}}{\lambda_t - \kappa^b \mu_t}$.

In general equilibrium, the equity market clears and asset prices adjust so that the households' investment plans are consistent with those formulated by firms. On the firms' side, the optimality conditions for k_{t+1} and z_t are:

$$1 + \Psi\left(\frac{z_t}{k_t}\right) + \frac{z_t}{k_t}\Psi'\left(\frac{z_t}{k_t}\right) = \eta_t \tag{21}$$

$$\begin{gathered} E_t[\Lambda_t(d_{t+1} + \eta_{t+1})] + \chi_t \kappa^f q_t = \eta_t \\ d_{t+1} \equiv A_{t+1}F_1(k_{t+1}, L_{t+1}) - \delta + \left(\frac{z_{t+1}}{k_{t+1}}\right)^2 \Psi'\left(\frac{z_{t+1}}{k_{t+1}}\right) \end{gathered} \tag{22}$$

where η_t and χ_t are the Lagrange multipliers on the investment Equation (12) and the working capital constraint (13), respectively.

Notice that, since firms discount at the households' stochastic discount factor, the forward solution of (22) yields asset prices consistent with the households' decision when $\eta_t = q_t$. The optimal choice for z_{t+1} (given k_t and q_t) implied by the firms' optimal investment condition (21) represents the firms' demand for investment resources (i.e., its equity supply function). Since (21) is a standard Tobin Q relationship, the fact that $\Psi(.)$ is increasing and convex implies that there is a positive relationship between investment demand and the equity price, or that the firms' equity supply function is upward sloping. This is because adjustment costs prevent firms from instantaneously adjusting the stock of capital to its long-run level. Hence, increases in demand for safety ultimately will have an impact on investment, and output, through this channel: Drops in q_t will make firms gradually reduce the capital stock and thus in firm investment.

Finally, the firms' first order condition with respect to labor gives the following expression:

$$A_t F_2(k_t, L_t) = w_t(1 + \phi(R_t^b - 1) + \phi R_t^b \chi_t) \tag{23}$$

On the right-hand side, the term $R^b_t \chi_t$ reflects the increase in the effective marginal financing cost of working capital caused by the collateral constraint. This allows shocks to bond yields to have a negative impact on contemporary output and employment.

Fisherian deflation as described in Bianchi and Mendoza (2020) is present in the model and affects all assets that serve as collateral, although it is harder to illustrate it in closed-form equations. When the collateral constraint binds, households respond by fire-selling equity and local bonds. When they sell equity, they meet with firms that feature an upward-sloping supply of equity because of Tobin's Q. These firms thus find it optimal to lower investment given the reduced demand for equity and higher discounting of future dividends, so equilibrium equity prices fall. But this only reinforces the tightness of the constraint, so a second round of sales takes place and Fisher's deflation mechanism is set into motion. In the case of the local bond, this effect can be (partially) offset by an increase in the demand for its convenience services.

4.5 Functional Forms

The functional forms for preferences and technology are the following:

$$u(c_t - N(L_t)) = \frac{\left[c_t - \frac{L_t^\omega}{\omega}\right]^{1-\sigma} - 1}{1-\sigma} \tag{24}$$

$$F(k_t, L_t) = A_t k_t^\gamma L_t^{1-\gamma} \tag{25}$$

$$\Psi\left(\frac{z_t}{k_t}\right) = \frac{a}{2}\left(\frac{z_t}{k_t}\right) \tag{26}$$

$$v(b_t^\$, b_t) = \alpha \frac{Q_t^{1-\sigma_v}}{1-\sigma_v} \tag{27}$$

where Q_t is the real stock of liquid assets that the household draws service flow from. As is now common in the literature (see Nagel, 2016), I assume this stock is a CES aggregate:

$$Q_t = \left[\theta\zeta_t(\max\{0, b_t^\$\})^\rho + (1-\theta\zeta_t)(b_t)^\rho\right]^{1/\rho} \tag{28}$$

The utility function in (24) is standard from DSGE-SOE models. The parameter σ is the coefficient of relative risk aversion, and ω determines the wage elasticity of labor supply. The Cobb-Douglas technology (25) is the production function for gross output, and Equation (26) is the net investment adjustment cost function.

Equation (27) is the preference function for safe assets and deserves a careful explanation. As explained above, ζ_t is exogenous and captures demand for global safe assets. Equation (27) assumes that demand for safety can be satisfied by the two available bonds. The parameter ρ controls the elasticity of substitution between the foreign and the local bond. With $\rho = 1$, both bonds are perfect substitutes. In the Cobb-Douglas limiting case, $\rho \to 0$, foreign and local bonds are neither substitutes nor complements. For any values $0 < \rho \leq 1$, they will be imperfect substitutes. The parameter θ is the relative weight of both bonds. Notice that only positive values of $b_t^\$$ enter into Equation (27), since it makes sense that foreign bonds only satisfy demand for safety when the household is holding an asset. Whenever $b_t^\$ < 0$, the household is borrowing abroad (representing capital inflows, in this case denominated in dollars), and therefore should not satisfy safety demand.

4.6 Driving Forces

Productivity $A_t = exp(\epsilon_t^A)$ is subject to a random shock ϵ_t^A that follows an AR(1) process with first-order autocorrelation ρ^A and standard deviation σ^A, which I calibrate according to the parameterization in Mendoza (2010).

The safety shock is modeled as an exogenous increase in the parameter ζ_t, which affects the convenience yield of the foreign bond. In particular, ζ_t follows an AR(1) process whose statistical moments are calibrated as in Kekre and Lenel (2021). This exogenous process captures the impact of global demand for dollar safe assets, on which the small open economy has little influence.

Finally, I add an interest rate shock, ϵ_t^R, that drives the dynamics of the international yield, $R_t = R^\$ exp(\epsilon_t^R)$. The importance of interest rate shocks for EMEs' business cycles is analyzed in Uribe and Yue (2006), where they find that these shocks explain around 20% of output variability in small open economies. In my model, this shock resembles movements in the interest rate that are unrelated to demand for safety. An exogenous increase in the world interest rate produces a capital inflow reversal, an increase in the current account, and a drop in output and investment. Importantly, this shock affects both the foreign and the local bond in a similar way, as it is not coming from demand for safety.

The shocks are modeled as a joint discrete Markov process that approximates the statistical moments of their actual times-series processes. Each shock has two realizations equal to plus/minus one standard deviation of each shock in the data, so I have eight posible shock combinations. I allow for a statistically significant correlation between ϵ_t^A and ϵ_t^R. The simple persistence rule produces an 8×8 matrix π which approximates autocorrelations in line with the data.

4.7 Discussion

Empirical counterparts. Most of the model elements can be justified as a way to match the empirical results in the previous section. The dependent variable in the regressions, the local-currency convenience yield for each country, can be traced in the model by the behavior of v_L/λ_{t+1}. In this case, the non-Treasury U.S. safe dollar bond in the data corresponds to the implied non-safe bond in the model, whose price is q_t^c. The effect of the VIX index, which is a proxy for global risk aversion, is captured in the model by the effect of the exogenous safety shock that affects the convenience yield of the foreign bond. As documented in Rey (2013), increases in the U.S. federal funds rate lead to increases in the VIX and to a reduction in capital and credit inflows. Capital inflows in the model are endogenous and correspond to negative values of $b_t^{\$}$.

Although the regressions included the local monetary policy rate, there is no explicit monetary policy rate in the model. This is because, as shown in Cuevas (2022), the effect of the monetary policy rate on convenience yields works through the supply of liquid assets (under a scarce reserve system). An increase in the interest rate induces commercial banks and financial intermediaries to reduce the supply of deposits and other alternative liquid assets, decreasing the overall supply and increasing the convenience yield on all remaining liquid assets. This effect in the model is well captured by the $v(.,.)$ function. Adding an explicit monetary policy rate would not add new intuitions, and to keep the model as simple as possible, I abstracted from it. Therefore, the $v(.,.)$ function should be broadly understood as a device to capture the effect of the overall supply of liquid assets in different areas of the economy.

Other modeling choices There are alternative ways of achieving a convenience yield in a tractable model. For example, Del Negro et al. (2017), for a closed-economy model, did not rely on bonds-in-the-utility-function. Rather, they achieved a convenience yield on government bonds by adding a resaleability constraint on risky equity. When a shock reduced the resaleability of equity, entrepreneurs increased their demand for government bonds, which they could sell to take idiosyncratic investment opportunities. My model can be seen as an open-economy extension of Del Negro et al. (2017), as the function $v(.,.)$ is a "reduced form" way to capture the same dynamics but in an open-economy setting. A second advantage is that my strategy simplifies the simulation of an ergodic set with local and global shocks and an occasionally binding constraint. In contrast, Del Negro et al. (2017) achieved tractability by making entrepreneurs always binding in their collateral constraint, so they were only able to simulate a one-time reduction in the resaleability of equity, holding all other shocks constant.

In addition, the positive covariance between the foreign bond and the stochastic discount factor can be achieved through the introduction of the real exchange rate. This is the modeling choice in Maggiori (2017), for whom U.S. bonds are safe because the dollar appreciates in bad times. A real exchange rate can be added to my model by including a non-tradable sector. I abstract from this in order to highlight the dynamics of convenience yields alone. My approach is closer to Kekre and Lenel's (2021), who introduced a shock to the demand for safety. However, many differences remain: Theirs was a two-country model, the convenience yield was fully exogenous, there was no role for the supply of safe assets, and their model did not account for the existence of two safe assets.

Fanelli and Straub (2021) also set up a real model for a small open economy with a local and

Table 7: Externally Set Parameters

Parameter	Value	Notes
β	0.97	
σ	2	
ω	1.846	
γ	0.306	
δ	0.088	
a	2.75	
ϕ	0.26	
κ	0.2	
ρ^A	0.537	
σ^A	1.34	

Notes: Parameters are from Mendoza (2010)'s calibration for the Mexican economy.

a foreign bond. The local bond was in zero net supply, as they modeled two agents and financial intermediaries. These features can be added to my model, but I rather rely on one representative household and no intermediaries in order to achieve simplicity since they are not strictly necessary to highlight the mechanism I am analyzing.

4.8 Calibration

Externally set parameters. I rely heavily on the calibration Mendoza (2010) completed for the Mexican economy. I do not intend this paper to be restricted to the Mexican case, but rather I take these parameters as representative of a developing economy. In addition, later this will allow me to compare business cycles moments with the model in that paper. The parameters taken from this source are listed in Table 7.

Calibrated parameters. Parameters left to be calibrated are related to the convenience yield, which comes from Equation (27). Parameters that need to be calibrated are α, σ_v, θ, and ρ. The first target is the proportion of the local-currency convenience yield to the total local-currency yield. In the model, this target will correspond to the mean convenience yield as a proportion of the local interest rate, $R_t^b \equiv 1/p_t^b$. The other targets are the standard deviation of the local-currency convenience yield, the U.S. Treasury premium (the difference between the foreign- and local-currency convenience yield), and the procyclicality of the EME local-currency convenience yield with respect to output. The latter is especially important as it captures the main empirical difference between EMEs and advanced economies.

Table 8: Targeted Moments and Calibrated Parameters

Parameter	Value	Moment	Data	Model
α	0.0014	$\text{mean}(CY_{Lt}/R_t^b)$	7.4%	7.35%
σ_v	1.9	$\text{std}(CY_{Lt})/\text{mean}(CY_{Lt})$	0.518	0.442
ρ	0.6	$\text{corr}(\text{GDP}, CY_{Lt})$	0.09	0.15
θ	0.48	$\text{mean}(CY_{Ft} - CY_{Lt})$	12 bp	19 bp

Notes: based on the simulation of 50,000 periods, dropping the first 10,000 as burn in. CY_{Lt} corresponds to the EME local-currency convenience yield, and CY_{Ft} to the convenience yield of U.S. Treasuries against comparable U.S. dollar bonds.

Both θ and ρ have a more direct influence on the U.S. Treasury premium and the procyclicality. The local-currency convenience yield will be more procyclical the closer substitutes the two bonds are and the larger the weight of foreign bonds in the liquidity aggregate. At the same time, the U.S. Treasury premium will be lower the lower the relative weight of the foreign bond. Parameters α and σ_v will more directly affect the mean proportion of convenience yield to total yield and the standard deviation. At the end, all four parameters affect the different targets, so I minimize the distance with respect to the empirical moments.

I solved the model with the global non-linear method of Cao et al. (2023). As the borrowing constraint is tied to the price of capital and the price of the local bond, a shock that reduces asset prices tightens the collateral constraint, leading to deleveraging and reductions in both investment and working capital, so the effect of the shocks gets amplified. The collateral constraint is occasionally binding in the ergodic set, and the equilibrium policy and state transition functions are highly nonlinear. The algorithm in Cao et al. (2023) relies on simultaneous transition and policy function iteration and is able to capture the nonlinearities accurately.

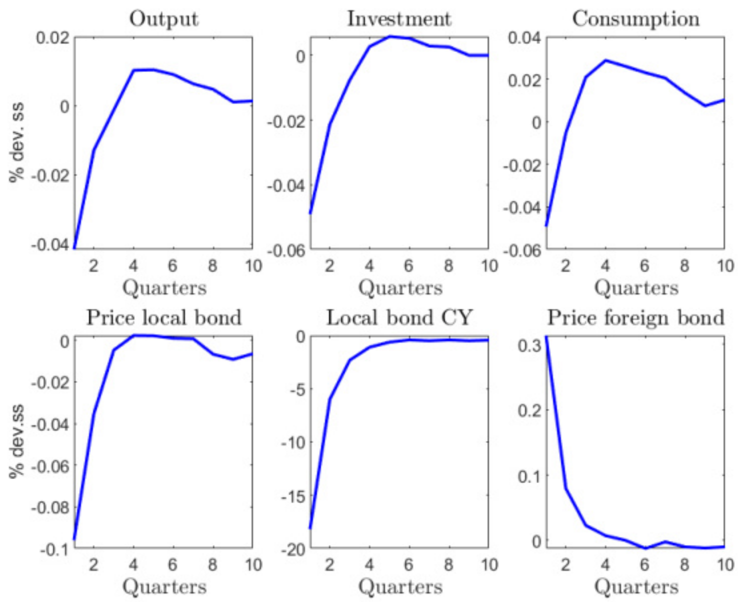
Quantitative performance. Table 8 shows the results. The calibration was able to match fairly well the mean convenience yield as a proportion of the local yield. The standard deviation is somewhat lower than in the data, but still substantial compared to real variables. In addition, the parameterization matched the procyclicality of the EME local-currency convenience yield. Interestingly, the calibration matched these moments with a value of θ below 0.5, which is consistent with some degree of home bias in bond holdings.

Impulse responses to a safety shock. To gain intuition, I show the response of the model to an exogenous increase in ζ_t, which increases the safety value of the foreign bond.

Figure 3 shows the impulse responses for a subset of the endogenous variables. The higher safety premium ζ_t increases the expected excess return on all assets, which is achieved by a drop in assets' prices. The drop in the price of capital, in turn, reduces investment.

Although the shock is exogenous, the covariance of the bonds with respect to the business

Figure 3: Impulse Responses to a Safety Shock



cycle is endogenous. In particular, the foreign bond is paying "well" in a bad state of the world, which makes it an effective safe asset. This prompts the households to increase their holdings of the foreign bond. The larger holdings of the foreign bond are also accommodated by a drop in consumption.

The larger holdings of the foreign bond more than satiate the demand for safety, and thus the convenience yield on the local bond drops. Given that there is no effect on the international rate R_t, the drop in the local convenience yield translates into an increase in the local interest rate, R_t^b, which tightens the working capital constraint for firms, and so output drops. The drop in output and consumption reinforce the foreign bond's positive covariance with the cycle, increasing its value as a safe asset against global shocks.

Notice that there is a second effect on the price of the local bond: the government reduces the supply of the local bond, which should increase its convenience yield. However, this effect is not strong enough given the high substitutability between the two bonds in the current parameterization. Therefore, the price of the local bond drops and this makes the local bond an ineffective safe asset when facing a global shock. Therefore, the foreign bond works as a better safe asset than the local bond.

5 Macroeconomic and Policy Implications

Safety shocks are an important contributor to global macroeconomic volatility. Kekre and Lenel (2021) show that safety shocks account for slightly more than 25% of output volatility in the U.S.

and around 6% of the volatility in the rest of the world. In this section I quantify the importance of demand for safety for business cycles in EMEs, and explore policy consequences for unconventional monetary policy in these economies.

5.1 Business cycle volatility

Convenience yields and the safety shock have implications for the business cycle in the local economy. The yield on the foreign bond, $R_t^{\$}$, trades below the international interest rate that governs consumption-savings decisions, R_t, and this spread corresponds to the convenience yield of foreign bonds. Similarly, the yield on the local bond, R_t^b, trades below the international rate R_t, and this spread corresponds to the convenience yield of the local bond. The international rate is exogenously determined, so safety shocks are fully accommodated by changes in the yields of the foreign and the local bond. The yield of the local bond, in turn, will have an effect on output, consumption, and investment decisions.

In particular, the exogenous increase in the foreign convenience yield is fully achieved by a drop in the yield of the foreign bond (not by an increase in the international rate). Since the safety value of the local bond is procyclical, the local convenience yield drops. This drop is achieved through an increase in local yields, which negatively impact output through the working capital constraints on firms. Therefore, the model implies that convenience yields increase the volatility of EMEs' business cycles. The reason is the procyclicality of the local-currency convenience yield, which compounds the adverse effect on output compared to an economy with a countercyclical convenience yield.

Table 9 summarizes the quantitative exercise. Column 1 shows the volatility of output, investment, and the local interest rate in the model of Mendoza (2010). That model is similar to mine but with no demand for safety, no local bonds, and no safety shocks. In my model I use the same externally calibrated parameters and I use the same approximation for the productivity and interest rate shock. Column 2 shows the volatility of my model. Overall, my model implies that these added features account for 8.5% and 3.1% of output and investment volatilty, respectively. The third row explores the role of the local interest rate, which is influenced by the local-currency convenience yield. In line with intuition, my model increases the volatility of the local interest rate by 4.6% compared to a model with no safety shocks and no convenience yields.

As a reference, Uribe and Yue (2006) estimate that U.S. interest rate shocks explain about 20% of movements in aggregate activity in emerging economies. These shocks do not distinguish among sources of movements in the U.S. interest rates. Compared to this, my results explore the role of one source of movements in interest rates, and therefore the 8.5% increase in output variability is a large number.

Table 9: Output and local interest rate volatility

	Mendoza (2010)	Model	% explained
σ_Y	3.88	4.21	8.5%
σ_I	13.3	13.71	3.1%
σ_{r^b}	1.96	2.05	4.6%

Notes: based on the simulation of 50,000 periods, dropping the first 10,000 as burn in.

5.2 Unconventional Liquidity Policy

In this section, I explore policy consequences of these results. Can local governments reduce the negative impact of safety shocks? The drop in economic activity is produced by the increase in the foreign convenience yield, which increases expected excess returns and so depresses asset prices. The root of the problem is a scarcity of safe assets in the economy. In a closed-economy framework, this problem has been analyzed in Del Negro et al. (2017). In their model, entrepeneurs have a special demand for the liquidity of government bonds. A shock that reduces the supply of liquidity leads to an increase in the convenience yield of government bonds that lowers interest rates to their zero lower bound, which compounds the adverse effect on consumption and investment. To avoid this, the government can purchase risky capital from entrepeneurs in exchange for liquid government debt (think of the nonstandard open market operations carried out by the Fed during 2008), reducing the convenience yield and ameliorating the adverse effects on economic activity.

In the remainder of this section, I analyze the effectiveness of the response of the local government to a safety shock in the context of my model. This resembles an increase in demand for safety/liquidity as in Del Negro et al. (2017), but with the important difference that in my model households have two sources of liquidity: not only the local bond (as in the closed-economy framework) but also a foreign bond. When faced with a shortage of liquid assets, asset purchases by the local government in exchange for local-currency bonds will be less effective than in Del Negro et al. (2017) if households satiate their demand for safety through a better source of liquidity in the form of the foreign bond. This is an interesting exercise because many central banks in EMEs carried out these policies during 2020. The exercise does not involve a welfare analysis, which is certainly relevant but is left for future research.

To add these policies to the model, I follow Del Negro et al. (2017) and allow the government to buy capital from the households, in exchange for local-currency bonds. Since capital does not provide convenience services, this policy should have the effect of increasing the supply of safe assets. I replace the government's budget constraint in (14) for the following:

$$q_t k_{t+1}^g + b_t = \tau c_t + (q_t + d_t) k_t^g + p_t^b b_{t+1} \tag{29}$$

The left-hand side sums the government expenses, e.g., the purchase of capital holdings, k_{t+1}^g, and the payment of outstanding bonds, b_t. The right-hand side sums the source of funds, e.g., consumption tax revenue, returns on existing capital holdings, and new debt issuance.

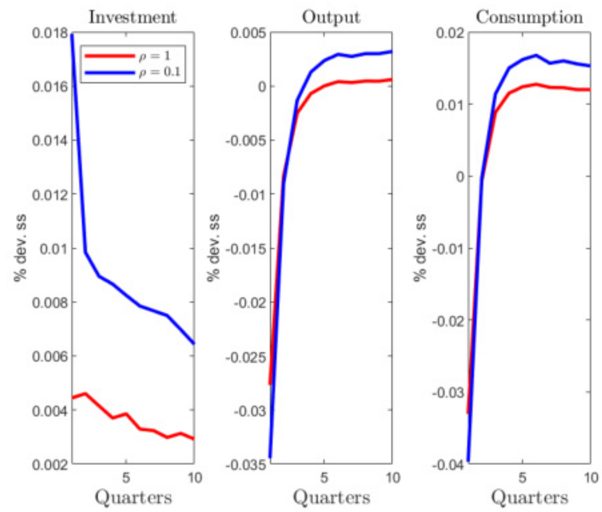
This framework adds two new state variables, k_t^g and b_t. τ is now a parameter, which I set equal to 0.17 to be consistent with the parameterization in Mendoza (2010). The policy variable k_{t+1}^g follows the rule $k_{t+1}^g = max\{\psi_k \zeta_t, 0\}$. As taxes are constant, the purchase is fully funded by new debt issuance. ψ_k is calibrated to deliver a liquidity injection of 0.6% of GDP, which is close to the average size of local-currency liquidity injections by EME central banks during 2020 (see Arslan et al, 2020).

The extent of market segmentation between foreign and local bond markets will be a key parameter for the analysis of this policy. In this section, I will deal with bond market segmentation in a reduced-form way, that is, not by modeling a micro foundation for bond market segmentation but by comparing the dynamics of the model under different values of the parameter ρ. In reality, such segmentation can arise from preferences or policy decisions. Regarding preferences, for example, it can be the case that a country has deeper trust or confidence in the local currency, and dollar-liquidity might not play the same role for cultural or historical reasons. Similarly, there are many policies that can create a specific demand for local-currency liquidity, for example, capital controls (by adding extra costs to the purchase of dollar-liquidity) or liquidity regulation (by requiring local banks to hold the local-currency sovereign debt).

Figure 4 shows the difference in IRFs to a safety shock with and without government intervention, for two different degrees of bond market segmentation. The panels show that central bank intervention has a different effect on the response of investment, output, and consumption depending on the value of ρ. Under perfect substitution ($\rho = 1$), the local bonds provided by the government only crowd-out foreign holdings, so this has little effect on the liquidity aggregate, Q_t. Intuitively, the local government is providing local-currency bonds in a state of the world where the value of such liquidity is falling, as investors are more than satiated with dollar liquidity instead.

When both bonds are imperfect substitutes ($\rho = 0.1$), intervention can have greater effectiveness. Under imperfect substitutability, the composition of the liquidity aggregate between foreign and local bonds matters. However, the increase in holdings of the foreign bond does not compensate the households for the fewer local bonds (the drop in output reduces the government's issuance). As a result, the demand and the convenience yield for local bonds increase. This allows the local-currency liquidity provision by the government to have an impact on asset prices. In particular, the left-most panel shows that the extra local bonds issued to finance the purchase of

Figure 4: IRF to a Safety Shock: With Intervention Minus IRF Without Intervention



Notes: the Figure shows the difference in IRFs to a safety shock for two different degrees of segmentation between local and foreign bonds: perfect substitutability, $\rho = 1$, and imperfect substitutability, $\rho = 0.1$.

capital satisfy the demand for safety and have a significant impact on the price of capital, and therefore on investment.

The other two panels show that the differential impacts on output and consumption are more modest. This is because the response of these two variables works through the effect on the local interest rates, while the response of investment adds the channel through asset prices.

Which of the two responses better matches the data? The calibrated value of ρ in the previous section is 0.6, and this matches average moments for the nine EMEs in the sample. This suggests that the buyer-of-last-resort policies enacted by EMEs' central banks during 2020 might have had a positive impact on investment and output, at a level between the two polar cases depicted in Figure 4. Of course, heterogeneity in local-currency convenience yields among these countries would translate into heterogenous effectiveness of these unconventional policies.

More research is needed to clarify the extent of segmentation and to disentangle its sources. Then a more formal micro foundation can be introduced into this model. As of now, the model, with a value of $\rho = 0.6$, is consistent with a somewhat close substitution. If we think of capital controls as a source of imperfect substitutability, then this is also consistent with the data. Annual data from Fernandez et al. (2016) show that most of the countries in this sample have some restriction on bond trading. Brazil, Colombia, Mexico, the Philippines, South Africa and Turkey have adopted some type of controls on bond purchases abroad by residents and on bond sales locally by nonresidents. Chile and Indonesia only have controls on purchases abroad, while Peru has none.

How would the model be different if nominal rigidities were to be included? The zero lower bound and nominal wages rigidities played a significant role in the model of Del Negro et al. (2017). There, the shock that increased the liquidity premium of government bonds decreased investment too, and the interest rate had to drop to encourage households to consume more. The increase in the convenience yield was an added downward force on the interest rate. When the interest rate hit the zero lower bound, consumption could not increase as much and the recession was worse, as both investment and consumption were depressed. This is an amplification mechanism that can play a role in EMEs when bond markets are segmented.

6 Conclusion

This paper shows that local-currency sovereign bonds in emerging market economies work as safe assets. However, a significant difference with sovereign bonds of advanced economies is that the local-currency convenience yields in EMEs drop during downturns and periods of high global risk aversion. Evidence suggests that the explanation rests on the competition such bonds face from alternative sources of safety and liquidity, such as U.S. Treasuries.

I extended the standard open economy-real business cycle model to include demand for safety and the existence of two alternative safe assets. The model is purposedly reduced-form and aims to match the empirical results and draw some policy conclusions. In a small open economy where the foreign bond is a global safe asset, the government has less room to deploy their balance sheets as advanced economies did during the crises of 2008 and 2020. However, these policies can be more effective when foreign and local markets are segmented.

This paper has aimed to show that local-currency convenience yields exist and are relevant for EMEs. As a result, more research is needed on them. Empirically, it would be relevant to know what specific feature of local-currency sovereign bonds drives investors to prefer the alternatives (either credit risk, primary surpluses, inflation, or others). In addition, it is necessary to understand better how policies common to EMEs interact with convenience yields, such as reserve accumulation, different forms of capital controls, or foreign exchange intervention. Theoretically, the model's simplicity in this paper tried to highlight the primary mechanisms, but it came at the cost of leaving many issues unaddressed. For example, a structural specification for the convenience yield would be valuable. Finally, the estimated local-currency convenience yields can be used as an input in fiscal capacity analysis for EMEs.

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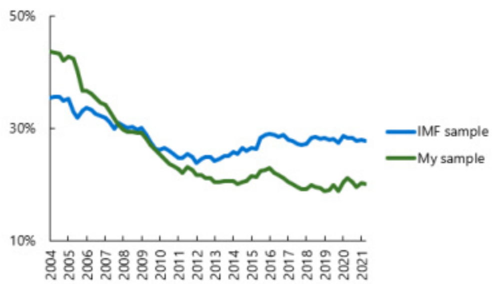
Appendix A Trends in EME's Local-Currency Sovereign Bonds

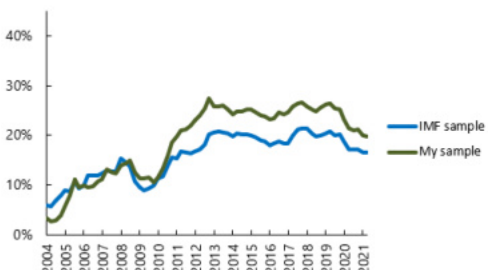
Figure 5 shows an upward trend in local-currency denomination of sovereign debt, and an increase in foreign ownership of these bonds. This evidence is consistent with evidence shown in Du and Schreger (2022) on currency denomination of sovereign external debt in EMEs.

Figure 5: EME Sovereign Debt, 2004-2021

(a) % of debt denominated
in foreign currency



(b) % of local-currency debt owned by foreigners



IMF sample includes Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, China, India, Indonesia, Malaysia, Philippines, Turkey, Bulgaria, Poland, Hungary, Romania, Egypt, Russia, South Africa, Thailand, and Ukraine.

Appendix B Proofs of Propositions in Section 2

I articulate the theory behind the Propositions in Section 2 by modifying a standard representative agent model to include a term whereby agents derive utility directly from holding a "convenience" asset (Sidrauski, 1967; Krishnamurthy and Vissing-Jorgensen, 2012). The representative investor of country i maximizes

$$E \sum_{t=1}^{\infty} \beta^t u(C_t) \tag{30}$$

Suppose that C_t is the sum of an endowment of c_t plus "convenience" benefits:

$$C_t = c_t + \nu_i(\theta_t^j, \mathrm{GDP}_t; \zeta_t) \tag{31}$$

The benefits are a function of the real holdings of convenience assets from country j, θ_t^j. One example is that the function $\nu_i(\cdot)$ captures the notion that holding more sovereign bonds from country j reduces costs that would otherwise be incurred by transacting in a less liquid security. The argument θ_t^j is the market value of the agent's real holdings of sovereign bonds of country j. Notice that $\nu_i(\cdot)$ varies with i, allowing for investors of different countries to have different valuations on the convenience of bonds depending on the country they were issued. The term ζ_t is a preference shock that affetcs how much utility is derived from convenience assets. The dollar income of the agent is GDP_t, which is measured in real terms.

Assume that the convenience function is homogeneous of degree one in GDP_t and θ_t^j. Thus define $v_i\left(\frac{\theta_t^j}{\mathrm{GDP}_t}; \zeta_t\right)\mathrm{GDP}_t \equiv \nu_i(\theta_t^j, \mathrm{GDP}_t; \zeta_t)$. Assume that the convenience function is increasing in $\theta_t^j/\mathrm{GDP}_t$ for all j, but the marginal convenience benefit is decreasing in $\theta_t^j/\mathrm{GDP}_t$, and $\lim_{\theta_t^j/\mathrm{GDP}_t \to \infty} v_i'(\theta_t^j/\mathrm{GDP}_t; \zeta_t) = 0$.

The convenience function $v_i(\cdot)$ is a reduced-form way to capture how superior liquidity and the certainty of nominal repayment of an asset will lead investors to pay a higher price for that asset, as in Krishnamurthy and Vissing-Jorgensen (2012).

Henceforth, for simplicity, assume the representative investor, regardless of her country of origin i, cares about the returns in dollars.

Proof of Proposition 1. Denote the price level at date t as Q_t, and let $j = \mathrm{US}$. If the investor buys a zero-coupon nominal non-Treasury safe U.S. bond for a dollar price P_t^{US}, her real holdings θ_t^{US} rise by P_t^{US}/Q_t. The first order condition for this bond holdings is then

$$-\frac{P_t^{US}}{Q_t} + \beta E_t\left[\frac{P_{t+1}^{US}}{Q_{t+1}}u'(C_{t+1})\right] + \frac{P_t^{US}}{Q_t}v_i'(\theta_t^{US}/\mathrm{GDP}_t; \zeta_t)u'(C_t) = 0 \tag{32}$$

Define the pricing kernel for nominal payoffs as

$$M_{t+1} = \beta\frac{u'(C_{t+1})}{u'(C_t)}\frac{Q_t}{Q_{t+1}} \tag{33}$$

so that, in the absence of default risk, we would have:

$$\begin{aligned} P_t^{US} &= E_t[M_{t+1}P_{t+1}^{US}] + P_t^{US}v_i'(\theta_t^{US}/\mathrm{GDP}_t; \zeta_t) \Rightarrow \\ P_t^{US} &= E_t[M_{t+1}P_{t+1}^{US}]\Lambda_t^{US,i} \end{aligned} \tag{34}$$

where $\Lambda_t^{US,i} \equiv 1/(1 - v_i'(\theta_t^{US}/\mathrm{GDP}_t; \zeta_t))$ captures the marginal benefits investor i derives from these non-Treasury safe bonds. A positive marginal value of convenience by investor i, $v_i'(\cdot)$, raises $\Lambda_t^{US,i}$, and therefore raises the price of the bond, P_t^{US}.

To add default risk, suppose that the issuer may default next period with probability π_t and in default pays $1 - L_{t+1}^{US}$, where L_{t+1}^{US} measures the amount of losses suffered in default (and is a random variable). If the bond does not default, it is worth P_{t+1}^{US}. Then, its price satisfies

$$P_t^{US} = \pi_t E_t[M_{t+1}\Lambda_t^{US,i}(1 - L_{t+1}^{US})|\text{Default}] + (1-\pi_t)E_t[M_{t+1}P_{t+1}^{US}\Lambda_t^{US,i}|\text{No Default}] \tag{35}$$

For simplicity, assume continuously compounded yields and consider the case of one-period bonds (so $P_{t+1}^{US} = 1$). Define $\tilde{L}_{t+1}^{US}$ as a random variable that is equal to zero if there is no default and equal to L_{t+1}^{US} if there is default. Then, the expression for the price of the bond is

$$\begin{aligned} e^{-y_t^{US}} = P_t^{US} &= E_t[M_{t+1}\Lambda_t^{US,i}] - E_t[M_{t+1}]E_t[\tilde{L}_{t+1}^{US}] - \text{cov}_t[M_{t+1}, \tilde{L}_{t+1}^{US}] - \text{cov}_t[\Lambda_t^{US,i}, \tilde{L}_{t+1}^{US}] \\ &\approx e^{\lambda_t^{US,i} - \pi_t(E_t[L_{t+1}^{US}] + \text{cov}_t[M_{t+1}, \tilde{L}_{t+1}^{US}]/E_t[M_{t+1}]) - \text{cov}_t[\lambda_t^{US,i}, \tilde{L}_{t+1}^{US}]/E_t[M_{t+1}]} E_t[M_{t+1}] \end{aligned} \tag{36}$$

where $\lambda_t^{US,i} \approx v_i'(\theta_t^{US}/\text{GDP}_t;\zeta_t)$ and $\text{cov}_t[M_{t+1}, \tilde{L}_{t+1}^{US}]/E_t[M_{t+1}]$ is a risk premium if default events coincide with bad states. Take logs on both sides to get :

$$y_t^{US} \approx y_{rf,t}^{US} - \lambda_t^{US,i} + l_t^{US} - \xi_t^{US,i} \tag{37}$$

where $y_{rf,t}^{US} = -\log M_{t+1}$ (no arbitrage condition); $l_t^{US} = \pi_t(E_t[L_{t+1}^{US}] + \text{cov}_t[M_{t+1}, \tilde{L}_{t+1}^{US}]/E_t[M_{t+1}])$ denotes the compensation for default (expected losses plus premium); $\lambda_t^{US,i}$ is the convenience yield (how much the total yield is reduced because of the marginal services provided by the bond); and $\xi_t^{US,i} = \text{cov}_t[\lambda_t^{US,i}, \tilde{L}_{t+1}^{US}]/E_t[M_{t+1}]$ denotes the covariance between default risk and the convenience yield. □

Proof of Proposition 2. Again, denote the price level at date t as Q_t and let $j \neq$ US. Let the price of the sovereign bond in local currency j be P_t^j. If the investor purchases one unit, her real holdings θ_t^j rise by $P_t^j/Q_t \times 1/S_t$. The first order condition for holdings of the synthetic bond is

$$-\frac{P_t^j}{Q_t}\frac{1}{S_t} + \beta E_t\left[\frac{P_{t+1}^j}{Q_{t+1}}\frac{1}{F_{t+1}}u'(C_{t+1})\right] + \frac{P_t^j}{Q_t}\frac{1}{S_t}v_i'(\theta_t^j/\text{GDP}_t;\zeta_t)u'(C_t) = 0 \tag{38}$$

As before, for simplicity, assume one-period bonds, so $P_{t+1}^j = 1$ and the forward rate is a one-period ahead rate, $F_{t+1} = F_t^1$. In the abscence of other risks, we would have:

$$\begin{aligned} P_t^j\frac{F_t^1}{S_t} &= E_t[M_{t+1}] + P_t^j v_i'(\theta_t^j/\text{GDP}_t;\zeta_t) \Rightarrow \\ P_t^j\frac{F_t^1}{S_t} &= E_t[M_{t+1}]\Lambda_t^{j,i} \end{aligned} \tag{39}$$

where $\Lambda_t^{j,i} \equiv 1/(1 - v_i'(\theta_t^j/\text{GDP}_t; \zeta_t))$ captures the marginal benefits investor i derives from the bond issued by the sovereign j.

Suppose that the sovereign of country j can default next period with probability π_t^j, and L_{t+1}^j measures the amount of losses suffered in default (a random variable). The synthetic bond faces an additional loss upon default. If the sovereign defaults, the currency hedging becomes imperfect, and the investor i loses L_{t+1}^j and still needs to unwind the swap position with unmatched local currency j cash flows. In the case of positively correlated default and currency risk, the local-currency depreciates more upon default relative to the nondefault state. The investor i holding the synthetic bond has a net long position in dollars in the event of default, which corresponds to additional currency gains. As a consequence, in the default state, the bond pays $[1 - L_{t+1}^j + L_{t+1}^j(1 - F_{t+1}/S_{t+1})]$.

Du and Schreger (2016) show that the pricing impact of the foreign exchange hedging error, $L_{t+1}^j(1 - F_{t+1}/S_{t+1})$, is exactly equal to $\frac{\text{cov}_t(1-L_t^j, 1/S_{t+1})}{E_t(1-L_{t+1}^j)E_t(1/S_{t+1})}$. I will denote this term q_t^j, and refer to it as the covariance between default risk and currency risk.

Analogously, assume that the sovereign of country j can enact regulations on local-currency assets with probability $\tilde{\pi}_t^j$ (for example, capital controls or currency convertibility restrictions), and this event imposes a loss of K_{t+1}^j on the investor (a random variable). This loss will also produce a hedging error in the swap position of the investor, as in the case of default losses. Equivalently, define the bond payoff in the event of capital controls as $[1 - K_{t+1}^j + K_{t+1}^j(1 - F_{t+1}/S_{t+1})]$. The hedging error term will be exactly equal to $\frac{\text{cov}_t(1-K_t^j, 1/S_{t+1})}{E_t(1-K_{t+1}^j)E_t(1/S_{t+1})}$, term which I will denote as p_t^j and refer to it as the covariance between capital control risk and currency risk.

At the end, the losses in the event of default and regulations impositions are $L_{t+1}^j - q_t^j$ and $K_{t+1}^j - p_t^j$, respectively. Define $\tilde{L}_{t+1}^j$ as a random variable that is equal to zero if there is no default and equal to $L_{t+1}^j - q_t^j$ if there is default. Equivalently, define $\tilde{K}_{t+1}^j$ as a random variable that is equal to zero if capital controls are not imposed and equal to $K_{t+1}^j - p_t^j$ if they are imposed.Then, the expression for the price of the synthetic bond is

$$
\begin{aligned}
e^{-y_t^j + \rho_{j,t}} = P_t^j \frac{F_{t+1}}{S_t} &= E_t[M_{t+1}\Lambda_t^{j,i}] - E_t[M_{t+1}]E_t[\tilde{L}_{t+1}^j] - E_t[M_{t+1}]E_t[\tilde{K}_{t+1}^j] \\
&- \text{cov}_t[M_{t+1}, \tilde{L}_{t+1}^j] - \text{cov}_t[M_{t+1}, \tilde{K}_{t+1}^j] - \text{cov}_t[\Lambda_t^{j,i}, \tilde{L}_{t+1}^j] - \text{cov}_t[\Lambda_t^{j,i}, \tilde{K}_{t+1}^j] \\
&\approx e^{\lambda_t^{j,i} - \pi_t^j(E_t[L_{t+1}^j] + \text{cov}_t[M_{t+1}, \tilde{L}_{t+1}^j]/E_t[M_{t+1}]) + q_t^j - \tilde{\pi}_t^j(E_t[K_{t+1}^j] + \text{cov}_t[M_{t+1}, \tilde{K}_{t+1}^j]/E_t[M_{t+1}])} \\
&\times e^{p_t^j - \text{cov}_t[\Lambda_t^{j,i}, \tilde{L}_{t+1}^j]/E_t[M_{t+1}] - \text{cov}_t[\Lambda_t^{j,i}, \tilde{K}_{t+1}^j]/E_t[M_{t+1}]} \times E_t[M_{t+1}]
\end{aligned} \tag{40}
$$

Taking logs on both sides gives:

$$
y_t^j - \rho_{j,t} \approx y_{rf,t}^{US} - \lambda_t^{j,i} + (l_t^j - q_t^j) + (k_t^j - p_t^j) - \xi_t^{j,i} - \psi_t^{j,i} \tag{41}
$$

where $y^{US}_{rf,t} = -\log M_{t+1}$; $\lambda^{j,i}_t \approx v'_i(\theta^j_t/\text{GDP}_t;\zeta_t)$ is the convenience yield on the local-currency bond; $l^j_t = \pi^j_t(E_t[L^j_{t+1}]+\text{cov}_t[M_{t+1},\tilde{L}^j_{t+1}]/E_t[M_{t+1}])$ and $k^j_t = \tilde{\pi}^j_t(E_t[K^j_{t+1}]+\text{cov}_t[M_{t+1},\tilde{K}^j_{t+1}]/E_t[M_{t+1}])$ are the extra yield demanded for default and regulatory losses; and $\xi^{j,i}_t = [\text{cov}_t[\Lambda^{j,i}_t,\tilde{L}^j_{t+1}]/E_t[M_{t+1}]$ and $\psi^{j,i}_t = [\text{cov}_t\Lambda^{j,i}_t,\tilde{K}^j_{t+1}]/E_t[M_{t+1}]$ are the covariances of the convenience yield with default risk and regulatory risk, respectively. □

Proof of Proposition 3. Following the same reasoning as in the two previous proofs, the price of a EME sovereign bond issued offshore in dollars, $\hat{P}^j_t$, is given by:

$$\hat{P}^j_t = E_t[M_{t+1}\hat{P}^j_{t+1}]\hat{\Lambda}^{j,i}_t \tag{42}$$

where $\hat{\Lambda}^{j,i}_t \equiv 1/(1-v'_i(\theta^{\hat{j}}_t/\text{GDP}_t;\zeta_t))$ increases with the marginal convenience services provided by this bond. Assume the local government can default on this bond with probability $\hat{\pi}^j_t$, imposing a loss of $\hat{L}_{t+1}$ on the investor. In this case, $\tilde{L}^j_{t+1}$ is a random variable taking the value $\hat{L}_{t+1}$ in the case of default and zero otherwise. However, since the bond is issued in dollars and offshore, the government cannot impose capital controls or currency convertibility restrictions. Therefore, assuming again one-period bonds and continous compounding, the price is given by

$$\begin{aligned} e^{-\hat{y}^j_t} = \hat{P}^j_t &= E_t[M_{t+1}\hat{\Lambda}^{j,i}_t] - E_t[M_{t+1}]E_t[\tilde{L}^j_{t+1}] - \text{cov}_t[M_{t+1},\tilde{L}^j_{t+1}] - \text{cov}_t[\hat{\Lambda}^{j,i}_t,\tilde{L}^j_{t+1}] \\ &\approx e^{\hat{\lambda}^{j,i}_t - \hat{\pi}_t(E_t[\hat{L}^j_{t+1}]+\text{cov}_t[M_{t+1},\tilde{L}^j_{t+1}]/E_t[M_{t+1}]) - \text{cov}_t[\hat{\lambda}^{j,i}_t,\tilde{L}^j_{t+1}]/E_t[M_{t+1}]} E_t[M_{t+1}] \end{aligned} \tag{43}$$

Taking logs on both sides gives:

$$\hat{y}^j_t \approx y^{US}_{rf,t} - \hat{\lambda}^{j,i}_t + \hat{l}^j_t \tag{44}$$

where variables have the same interpretation as in the previous two proofs. Now, define $\Phi^{FC,i}_t$ as the spread between the yield of the synthetic bond (Equation (41)) and the yield on the foreign currency-denominated bond (Equation (44)). Then,

$$\begin{aligned} \Phi^{FC,i}_t \equiv & y_{i,t} - \rho_{i,t} - \hat{y}^j_t \\ &\approx (y^{US}_{rf,t} - \lambda^{j,i}_t + (l^j_t - q^j_t) + (k^j_t - p^j_t) - \xi^{j,i}_t - \psi^{j,i}_t) - (y^{US}_{rf,t} - \hat{\lambda}^{j,i}_t + \hat{l}^j_t) \\ &= (\hat{\lambda}^{j,i}_t - \lambda^{j,i}_t) + (l^j_t - \hat{l}^j_t - q^j_t) + (k^j_t - p^j_t) - \xi^{j,i}_t - \psi^{j,i}_t \end{aligned} \tag{45}$$

□

Appendix C Data Sources

Recall from the main text the expression for the EME local-currency convenience yield:

$$\lambda^{j,i}_t - \lambda^{US,i}_t = y^{US}_t - (y^j_t - \rho_{j,t}) + (l^j_t - l^{US}_t) + \Phi^{FC,i}_t + \xi^{US,i}_t \tag{46}$$

The sources for each component are the following:

Bond yields and forward premia. For yields of non-Treasury safe dollar bonds, I used data of the Resolution Funding Corporation (Refcorp) bonds for various maturities. As suggested by Longstaff (2004), Refcorp bonds are effectively guaranteed by the U.S. government, and are subject to the same taxation, but are not as liquid as Treasuries. As in Longstaff (2004), I measured the yields by taking the differences between the constant maturity on the Bloomberg Fair Value curves for Refcorp zero-coupon bonds. Maturities available are 6-month, 1-, 2-, 3-, 4-, 5-, 7-, 10-, and 20-year. For robustness, I also used the yields for Aaa corporate bonds, which Krishnamurthy and Vissing-Jorgensen (2012) argued have very low default rate but alos are not as liquid as Treasuries. Data on these corporate bond spreads are available in FRED, but only provide a 20-year maturity benchmark. All these sources also include data on yields for U.S. treasuries, which I use in Appendix D.

The value of the forward premium for each country was taken from the database of Du et al. (2018). The authors provided estimations of CIP deviations of sovereign bonds for 10 developed and 18 developing countries with respect to U.S. Treasuries. The data are at daily frequency between approximately 2000 and March 9, 2021, although the start date varied among countries. Data are available for maturities at 3-months, 1-, 2-, 3-, 5- and 10-years.

I focused on their observations for developing countries. Their bond yields data came from Bloomberg and Thomson Reuters. Since forward contracts are in general not very liquid, they computed $\rho_{i,t}$ from a hedging strategy involving interest rate swaps and cross-currency swaps, according to the formula $\rho_{i,n,t} = irs_{i,n,t} + bs_{i,n,t} - irs_{US,n,t}$. $irs_{i,n,t}$ is the n-year interest rate swap for exchanging fixed currency i cash flows into the floating interbank rate benchmark in country i. $bs_{i,n,t}$ is the n-year cross-currency basis swap rate for exchanging the floating benchmark interbank rate in country i for the U.S. Libor rate, and $irs_{US,n,t}$ is the n-year U.S. Libor swap rate for exchanging fixed dollar cash flows into the U.S. Libor rate. The combination of these three swaps eliminates all floating cash flows. At the inception and maturity of the swap, only fixed cash flows remain between local-currency and U.S. dollars, which exactly replicates an n-term forward contract.

Default risk differentials ($l_t^{US} - l_t^j$). I proxied $l_{i,t}$ with data on CDS spreads. I obtained the CDS spread series for EMEs' sovereign bonds of different maturities from Bloomberg at daily frequency. However, some caveats apply. First, I used the CDS spreads for foreign-currency debt, as their data are more widely available and show greater liquidity than local-currency CDS. Therefore, I assumed that the risk of default on foreign-currency debt also applies to local-currency bonds. As discussed in Du and Schreger (2016), this assumption is not much different from reality as default events in EMEs since the late 1990s show that incidence of default on domestic-currency debt is comparable with the incidence of external foreign-currency defaults.

Spread between swapped local-currency bond and foreign-currency bond ($\Phi_t^{FC,i}$). I used the data from Du and Schreger (2016). For $\hat{y}_t^j$, I used the Bloomberg Fair Value curves (BFV) for the prices of foreign-currency sovereign bonds for each EME. These curves are at par yield curves, so they needed to be adjusted to represent zero-coupon yields. BFV prices are not available for some of the countries. In those cases, I estimated prices by collecting data for each individual bond and computing the overall zero-coupon yield curve using the methodology of Nelson and Siegel (1987).

Other adjustments. Another adjustment can be considered if I take into account that investors have a preference for dollar currency. Investment in the swapped local-currency bond involves buying a local-currency bond and then swapping the cash flows into U.S. dollars. If, from the perspective of the investor, this dollar cash flow fully converts the original local-currency bond into the equivalent of a dollar-bond, then the CIP deviation decomposition would show a zero convenience yield differential. Jiang et al. (2021) confirmed this result by showing how this specific dollar-currency preference led to an under-estimation of the convenience yield of local-currency bonds. However, they provided a method to adjust for this issue, which they performed for advanced economies.

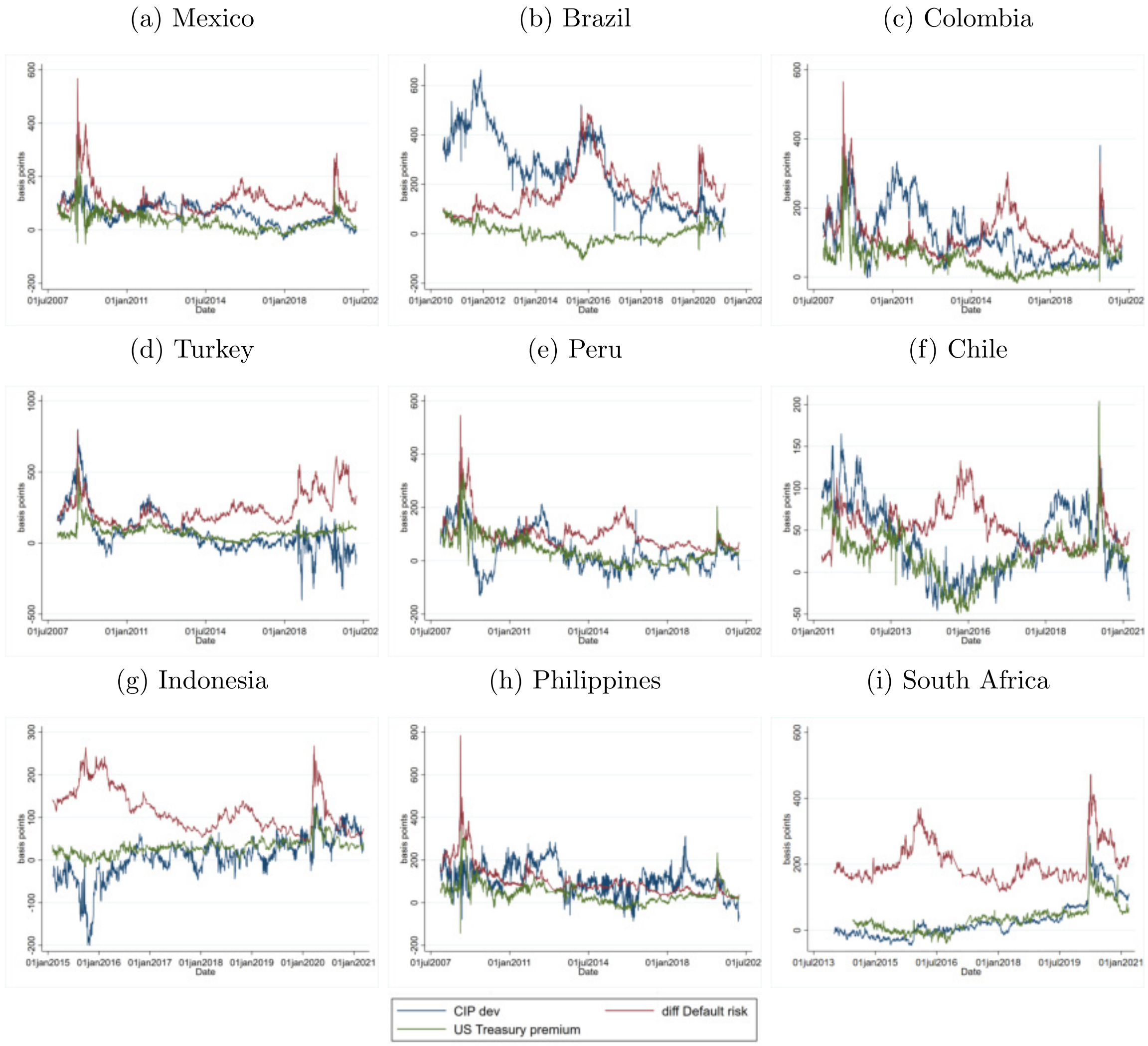
Appendix D Analysis of the U.S. Treasury Premium

I discuss the evidence for the differential convenience yield of U.S. Treasuries against EME sovereign bonds and compare it with the results for G10 countries shown in Du et al. (2018). I calculate the components of Equation (5) in the main text, but this time using the U.S. Treasury as the dollar bond. In this case, the term $\lambda_t^{US,i} - \lambda_t^{j,i}$ corresponds to the U.S. Treasury premium (how much investors pay for the safety/liquidity of U.S. Treasuries against EME local-currency bonds); and the term $y_t^{US} - y_t^j - \rho_{jt}$ corresponds to the CIP deviation between the two sovereign bonds. Figure 6 compares the evolution of CIP deviations and two of its components, differential default risk and the U.S. Treasury premium.

CIP deviations spiked during crises (i.e., in 2008 and 2020), and this was driven by both an increase in differential default risk and the U.S. Treasury premium. The increase in the U.S. Treasury premium is in line with intuition: During financial distress, investors prefer the liquidity and safety of U.S. Treasuries. After 2008, the U.S. Treasury premium steadily declined until 2015-2016. This means that during this period, investors were willing to pay a lower premium for the safety and liquidity of U.S. government debt versus comparable debt of EMEs. This premium then increased again until the end of the sample.

These patterns are in stark contrast with the G10 counterparts estimated in Du et al. (2018). In that paper, the authors showed that the U.S. Treasury premium for long maturities became consistently negative after 2010, meaning that investors were no longer willing to pay an extra price for the safety and liquidity of U.S. Treasuries when compared to the sovereign bonds of the

Figure 6: CIP Deviation and Components, 5-Year Local-Currency Sovereign Bonds



G10 countries. Based on this result, some authors have cast doubt on the safety status of long-term U.S. Treasuries. Figure 6 shows that this is not the case for EMEs, though. U.S. Treasuries are still seen as a safe asset compared to their EME counterparts.

Surprisingly, CIP deviations outside of financial crises followed closely the dynamics of the U.S. Treasury premium -and not the dynamics of default risk- for Mexico, Colombia, Peru, Chile, Indonesia, and South Africa. In these countries, even though differential credit risk significantly increased in 2015-16, CIP deviations decreased, following the dynamics of the U.S. Treasury premium. This is surprising as research on EMEs has predominantly focused on the determinants of default risk, not convenience yields. One final note of caution is needed for Turkey in 2018-2019. The series for CIP deviations became very noisy and turned negative. These were years of severe capital outflows and recession in Turkey, and the negative values of the CIP deviation likely arose because of market segmentation, in which only local investors predominantly hold local-currency sovereign bonds.

The role of capital control risk (absent in Du et al., 2018) can be seen in Figure 6 by the vertical distance between the CIP deviation (blue line) and the two components shown (red and green lines). This was accounted for by the sum of the capital control risk term plus the covariances term Equation (3). Two episodes in the data stand out: Brazil during 2010-2014 and Colombia soon after 2010. In the case of Brazil, the government imposed a tax on financial transactions in October 2009 to curb portfolio investment flows and cross-border derivative trading, but the tax was lifted in June 2013.

Appendix E Robustness for Section 3

If my decomposition of CIP deviations in Section 2 successfully disentangled differential default risk from differential convenience yields, then default risk should respond differently to the determinants of convenience yields analyzed in Section 3.

Table 10 replicates the regressions in Section 3 but with the CDS for each country and time as the dependent variable. The larger number of observations is due to the fact that I had data for CDS spreads for a few more countries than I had convenience yield estimates. Unlike the EME local-currency convenience yield, credit risk was not affected by relative safe asset supply, suggesting that the demand for safety and liquidity is accurately captured by the convenience yield. The level of the local monetary policy rate increased credit risk, since it likely increased the cost of servicing the debt. The VIX index also had a positive impact on credit risk, which is consistent with intuition. Interestingly, debt inflows to government debt significantly reduced credit risk, which is expected as foreigners' buying local debt increases the chance of repayment. The same happened with inflows into bank debt, which is consistent with sovereign debt's being mostly held by banks in EMEs. Overall, this evidence suggests that the decomposition of CIP deviations in Section 2 accurately distinguished between credit risk and convenience yields.

As a second robustness test, I re-ran the regressions in Section 3 with a shorter sample that did not include the 2008 financial crisis and the 2020 pandemic crisis. In particular, I replicated the regression with the sample starting in September 2009 and ending in December 2019. The goal was to confirm that results in Section 3 were not driven by these two crises and the possible mispricing of EME assets during those two events.

Table 11 shows that results held in this shorter sample. EME local-currency convenience yields increased when the local interest rate increased, and a larger relative supply of safe assets significantly reduced the convenience yield. The main difference is that the VIX index was insignificant. This result is likely explained by the absence of any global risk aversion episode in this period. The only exception could have been the Euro crisis in 2011-2012, but this event did not evolve into a global crisis like the 2008 or 2020 crises. Column 4 tests for the robustness of the procyclicality of

Table 10: Determinants of Credit Risk (5-Year Sovereign Bond)

Dep. var: $cds_{i,t}$	(1)	(2)	(3)	(4)	(5)
MP rate$_{t-1}$	11.94***	11.48***	11.65***	11.70***	6.214***
	(1.410)	(1.377)	(1.404)	(1.413)	(1.924)
$\log(\frac{\text{US debt to GDP}}{\text{Debt to GDP}})_{t-1}$	-8.027	-4.336	-8.776	-9.849	-30.78**
	(16.09)	(14.86)	(16.37)	(16.47)	(12.11)
US fed funds$_{t-1}$	-14.66**	-11.31	-13.86*	-14.09*	-11.77
	(7.115)	(7.349)	(7.149)	(7.177)	(7.894)
vix$_{t-1}$	4.575***	4.352***	4.429***	4.339***	4.271***
	(0.420)	(0.456)	(0.421)	(0.442)	(0.520)
$(\frac{DebtInfl}{GDP})_{t-1}$		-26.84***			-21.75***
		(6.746)			(7.064)
$(\frac{EqtInfl}{GDP})_{t-1}$		-30.39*			-13.49
		(15.58)			(14.77)
$(\frac{GovdebtInfl}{GDP})_{t-1}$			-6.065*	-6.690**	
			(3.167)	(3.198)	
$(\frac{BankdebtInfl}{GDP})_{t-1}$			-8.105**	-7.921**	
			(3.154)	(3.151)	
$(\frac{CorpdebtInfl}{GDP})_{t-1}$			-3.961*	-3.982*	
			(2.142)	(2.121)	
Terms of Trade				-241.4	-196.4
				(189.7)	(165.3)
Diff. Inflation					8.440***
					(2.229)
Democratic risk					-1.152
					(7.117)
Constant	-1.286	-28.20	-7.972	1,110	1,058
	(88.08)	(86.53)	(91.53)	(875.5)	(746.5)
Observations	1,338	1,338	1,338	1,338	1,213
R-squared	0.689	0.702	0.698	0.700	0.734

Notes: see Table 3. All columns include country and year fixed effects. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

the local-currency convenience yield.

Table 11: Determinants of Convenience Yields (Shorter Sample)

Dep. var: $cy_{i,t}$	(1)	(2)	(3)	(4)
MP rate$_{t-1}$	1.179**	1.210**	1.140**	1.078*
	(0.515)	(0.511)	(0.525)	(0.548)
$\log(\frac{\text{US debt to GDP}}{\text{Debt to GDP}})_{t-1}$	-16.71**	-17.42**	-16.95**	-11.27
	(8.318)	(8.076)	(8.155)	(11.85)
US fed funds$_{t-1}$	-6.322*	-6.923*	-5.395	-7.775*
	(3.582)	(3.660)	(3.593)	(4.079)
vix$_{t-1}$	-0.0180	-0.0425	-0.0436	0.0223
	(0.264)	(0.250)	(0.263)	(0.318)
$(\frac{DebtInfl}{GDP})_{t-1}$		2.768		
		(2.471)		
$(\frac{EqtInfl}{GDP})_{t-1}$		6.451		
		(9.754)		
$(\frac{GovdebtInfl}{GDP})_{t-1}$			-0.706	
			(1.446)	
$(\frac{BankdebtInfl}{GDP})_{t-1}$			-2.173	
			(1.479)	
$(\frac{CorpdebtInfl}{GDP})_{t-1}$			1.596**	
			(0.718)	
Output gap				6.659**
				(3.219)
Constant	98.06**	102.9**	98.58**	83.33
	(42.77)	(41.31)	(41.93)	(58.90)
Observations	979	979	979	729
R-squared	0.726	0.728	0.730	0.749

Notes: see Table 3. All columns include country and year fixed effects.
*** p<0.01, ** p<0.05, * p<0.1