Limited arbitrage in the market for local currency emerging market debt *

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Abstract

Emerging markets governments increasingly rely on local currency denominated debt. Despite this recent development, the markets for foreign and local currency debts exhibit a substantial degree of segmentation. This paper investigates the causes and the consequences of market segmentation for debt prices and debt issuance. First, we show that deviations from the covered interest rate parity condition between local and foreign currency denominated debt are related to market segmentation. Second, we show that the demand for local currency debt from foreign investors is persistent and increases after an improvement in the relative credit rating vis-a-vis foreign currency denominated debt. We propose a simple model of partially segmented markets that replicates the observed empirical regularities. The model predicts that the covered interest rate parity hold only for perfectly integrated markets.

Keywords: sovereign debt, currency composition, covered interest parity, market segmentation

JEL Classification: E43, G12, F31, G11

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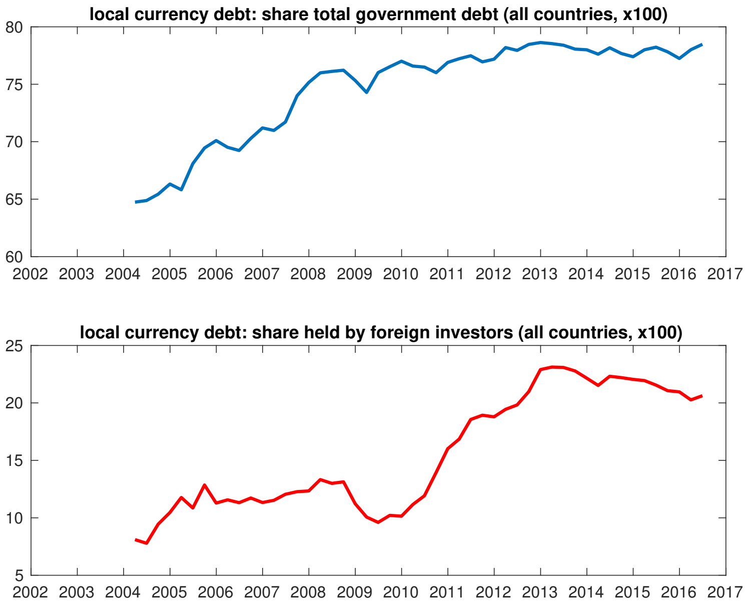
1 Introduction

Emerging markets have traditionally borrowed funds by issuing debt in foreign currency and under foreign jurisdiction. This is often called *original sin*: inability of emerging countries to issue debt in local currency, in contrast to most other advanced economies, which able to issue debt in the own currency. The common explanation of original sin is the luck of commitment, such as investors anticipated the risk that they would simply inflate the debt away (for example, Eichengreen et al. (2007)). However, in the last decade, a new trend has emerged and the market for local currency emerging market debt has gained importance (Hale et al., 2016). This is clear from casual inspection of figure 1. The top panel shows local currency government debt as a share of total marketable government debt which increased by about 15 percentage points in the period 2004 – 2016, in a large sample of emerging market countries. Note that, as countries started to issue a larger fraction of their debt in local currency, also foreign investors increased their share of the local currency government debt market. For example, the bottom panel of figure 1 shows that the share of local currency debt held by foreigners more than doubled over the period 2004–2016 and is now, on average, about 20 percent. Despite these recent developments, markets for local and foreign currency debt, in emerging markets, have not become fully integrated and there exist large differences in the participation of foreign investors across different emerging market countries (for example, in the second quarter of 2016, Argentina, Chile, China and India had shares of local currency debt held be foreigners below 5 percent). If markets are segmented, then the prices of assets that differ only with respect to the currency of denomination could depart even after controlling for expected changes in the exchange rate. Market segmentation is typically related with some kind of transaction costs, like those implied by capital controls, taxation, information acquisition, regulation, etc.

In this paper we show that, for a large set of emerging countries, returns on local currency denominated bond are not fully explained by returns in foreign currency bonds and the expected changes in the exchange rate. We find that there exist a minimum threshold of local currency debt held by foreigners that proxy for the degree of segmentation in the markets. When this share is large enough, then differences between local and foreign currency debt are smaller. We empirically investigate the determinants of market segmentation, as proxied by the share of local debt held by foreigners. We find that the share of local currency debt held by foreign investors is very persistent, indicating infrequent rebalancing. Our results suggest that foreign investors base their investment decisions mainly on the credit rating of local currency debt, country specific characteristics (i.e., size of debt market, quality of institutions, etc.), and the debts levels to GDP, both proxy of the default probabilities.

Figure 1: Share of local currency debt held by foreigners



Notes: This figure plots the cross-sectional mean local currency government debt as a share of total debt (top panel) and the cross-sectional mean share of local currency government debt held by foreign investors (bottom panel) for the following countries: Argentina, Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Perù, Philippines, Poland, Romania, Russia, South Africa, and Turkey. Data are quarterly from Arslanalp and Tsuda (2014) for the period 2002:Q1 – 2016:Q2.

Interestingly, these factors play no role in explaining returns on local currency bonds, after accounting for returns on foreign currency bonds issued by the same country and the forward discount. Finally, we build a simple model, based on recent work by Greenwood et al. (2016), that generates different prices for local and foreign currency bonds, with these difference being related to the participation of foreign investors in these markets. In particular, in the model there are three types of investors: first, specialized investors that invest only in the local currency debt market; second, specialized investors that invest only in the foreign currency debt market; third, a large group of generalized investors, that invest in both markets. The latter group is key for a cross-arbitrage condition to hold. However, as long as the share of the latter group of investors is not one, the risk adjusted prices in the two markets can be different, as delays in the portfolio rebalancing could prevent immediate cross-arbitrage. In the model, we focus on the demand of bonds by investors, taking the supply as given.

This paper contributes to two strands of the literature. The first, studies partially segmented markets and limits to arbitrage (for example, see the review paper by Gromb and Vayanos (2010) and references therein). This literature is interested in understanding why financial market anomalies arise and persist, and considers the possibility that sometimes investors lack the capital needed to arbitrage aways price discrepancies. Gromb and Vayanos (2002) write a model in which capital constrained arbitrageurs cannot fully exploit cross-market discrepancies of identical assets in segmented markets. Sarkar and Shrader (2010) studies the financial amplification mechanisms due to capital constraints of investors in partially segmented markets. Greenwood et al. (2016) explain how large supply shocks in one financial market affect asset prices in other markets when some investors are specialized in one market, while generalized investors guarantee cross-arbitrage but rebalance their portfolios only gradually. The second strand of the literature studies specifically local currency debt markets, and the choice of currency denomination of government debt. Burger and Warnock (2006) argue that better policies and laws are important in determining the size of domestic bond market and the fraction of local currency debt issues. Burger and Warnock (2007) study the participation of U.S. investors in local bond markets, and find that their participation is very limited, especially in emerging markets. Miyajima et al. (2015) argue that local factors, rather than global factors, are the main drivers of local currency bond yields. Peiris (2010) finds that higher foreign participation reduces long-term local currency government bond yields and volatility in a group of 10 emerging countries for the period 2000–2009. Du and Schreger (2016) construct a measure of local currency credit spread as the yield difference between the rate on local currency bonds and a synthetic local currency risk-free rate computed using cross-currency swaps. The authors find that the local currency spread is positive, and sizable and, contrary to foreign currency credit spreads, depend more on domestic, than global, conditions and have lower means and cross-country correlations. Hale et al. (2016) look at individual private, rather than sovereign, bonds issued in local currency. The authors find a large increase in bonds denominated in issuer's home currencies, with this trend accelerating after the Great Recession. Perez et al. (2016) studies the currency composition of sovereign external debt in emerging economies. In their model, foreign currency denominated debt acts as a discipline device to avoid the temptation of diluting debt through inflation. Paczos and Shakhnov (2016) have a model to explain why sovereigns borrow on both domestic and international markets and why sovereigns often default on international debt, but not on domestic one and vice a verso. They show that issuance of two debts and sellective default decisions are driven by two different shocks: productivity shock and tax distortion shock.

The remainder of this brief paper is organized as follows. In section 2 we present the data on emerging markets bond prices in local and foreign currency, and on the shares of local currency debt held by foreigners. In section 3 we present our empirical results. In section 4 we introduce a model with one country issuing debt both in local and foreign currency, and foreign investors that solve an optimal portfolio choice with markets that are possibly segmented. In section 5 we conclude.

2 Data

We collect end-of-month data for total return indices and yields of foreign and local currency denominated debt from J.P. Morgan. In particular, we use J.P. Morgan EMBI+ for foreign currency denominated debt (mostly US dollar denominated), and J.P. Morgan GBI-EM for local currency denominated debt. The J.P. Morgan Emerging Market Bond Index (EMBI) was formed in the early 1990s after the issuance of the first Brady bond and has become the most widely published and referenced index of its kind. The JPM GBI-EM indices track local currency bonds issued by Emerging Market governments[1]. The countries in our sample are Argentina, Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Perù, Philippines, Poland, Romania, Russia, South Africa, and Turkey. The sample is 31/12/2002 – 31/12/2016. At the end of 2015, the average duration for the EMBI indices was about 7 years, while it was 5 years for the GBI-EM indices (cf. figure A1 in the appendix). J.P. Morgan also publishes the ELMI+ indices, which also collect local currency debt, but from the money market and, therefore, with very short duration (on average, 0.15 years). The market capitalization, at the end of the sample, was about $675 billions for the EMBI indices, and $915 billions for the GBI-EM indices. Int the empirical estimation we work with quarterly frequency, and therefore use March, June, September and December end-of-month values of the local and foreign currency denominated bond indices. We also collect quarterly data on the shares of local currency debt held by foreigners, the ratios of official, total and local currency debt with respect to GDP, from Arslanalp and Tsuda (2014) for the period 2002:Q1 – 2016:Q2. In addition, we collect quarterly real GDP data, in local currency, from the IMF-IFS series, and end-of-month spot and forward exchange rates (with delivery after 3 months) from Thomson Reuters.

3 Empirical analysis

If financial markets are perfectly integrated, and emerging market countries could issue debt that is different in the currency denomination, but exactly identical in all other dimensions, such as default risk, maturity and etc, then some version of the interest parity should hold. For example, consider a US investor deciding to invest $1 in sovereign bonds issued by

[1] In particular, for most countries we use the GBI-EM Broad which is the all-encompassing index. It includes all eligible countries regardless of capital controls and/or regulatory and tax hurdles for foreign investors. In the appendix, we provide additional details on the data.

Table 1: Local currency bond returns

	mean	std	skewness	kurtosis	AC(1)	obs
Argentina	13.05	31.21	0.07	23.29	0.12	113
Brazil	12.74	6.46	-0.20	9.20	-0.03	179
Chile	3.19	2.50	-0.12	4.23	-0.03	75
China	3.91	3.48	-0.71	8.17	0.22	155
Colombia	10.22	6.38	-0.05	3.43	0.18	167
Hungary	8.17	7.16	-0.43	6.21	0.01	179
India	8.07	6.33	1.26	12.77	0.08	179
Indonesia	12.66	13.36	-0.09	9.93	0.07	167
Malaysia	3.95	3.14	-0.58	7.67	0.12	179
Mexico	8.52	5.79	-0.23	4.50	0.00	179
Peru	7.17	9.55	0.49	5.11	0.12	123
Philippines	5.74	9.32	-0.64	3.95	-0.04	74
Poland	6.45	3.81	-0.08	3.79	0.04	179
Romania	6.38	2.87	0.30	3.13	0.12	45
Russia	8.13	6.96	-1.39	15.02	0.12	142
South Africa	9.64	7.07	0.22	4.77	-0.09	179
Turkey	13.25	7.70	-0.05	4.25	0.09	152
All countries	8.31	7.83	-0.13	7.61	0.06	145

Notes: This table reports descriptive statistics of monthly returns on local currency sovereign bonds. In particular, the statistics are: mean, standard deviation, skewness, kurtosis, first order auto-correlation and number of observations. Means and standard deviations are annualized and in percentage. Data monthly from J.P. Morgan GBI-Broad from Datastream. The longest sample is 1/2000-12/2016. For some countries the sample is the longest available.

country j. Suppose further that country j issues bonds both in local currency (l) and US dollars (\$). The gross returns from buying the dollar denominated bond at time t and then selling it after one period is simply $R_{t+1}^{j,\$}$. If the same US investor decides instead to buy the local currency bond, it must first exchange dollars for local currency at time t, buy the bond, sell it at $t+1$ and exchange back local currency for dollars. Therefore, the gross return on the investment in the local currency denominated bond is $R_{t+1}^{j,l}\frac{S_t}{S_{t+1}}$, where S_t is the exchange rate in units of local currency per dollar. In the absence of transaction costs and other market imperfections, the expected, discounted, dollar returns from the two strategies must be the same[2]

[2] In principle, it is possible to use swap contracts to effectively hedge the currency risk and extract local currency risk premia as in Du and Schreger (2015).

Table 2: Foreign currency bond returns

	mean	std	skewness	kurtosis	AC(1)	obs
Argentina	8.00	29.78	-0.85	7.81	0.18	204
Brazil	11.07	15.80	0.38	12.96	-0.10	204
Chile	7.02	6.39	-0.54	5.70	-0.02	204
China	6.41	5.82	0.74	22.63	-0.14	204
Colombia	9.86	10.66	-0.40	6.60	0.06	204
Hungary	7.01	8.93	-2.12	22.05	-0.19	204
India	3.85	6.44	-1.30	7.47	-0.00	50
Indonesia	8.56	16.00	0.34	16.95	0.13	122
Malaysia	7.02	6.79	-1.38	14.70	-0.06	204
Mexico	9.98	12.22	-0.77	5.85	0.08	204
Peru	8.34	8.23	-0.04	6.30	-0.01	204
Philippines	9.79	8.52	-0.47	4.45	0.09	204
Poland	7.01	6.31	-1.23	10.70	-0.07	204
Romania	8.78	7.76	-0.33	3.19	0.04	58
Russia	14.28	12.10	0.90	9.15	0.24	204
South Africa	6.77	7.83	-1.38	13.40	0.08	176
Turkey	9.88	13.09	-0.65	6.03	0.02	204
All countries	8.45	10.74	-0.54	10.35	0.02	180

Notes: This table reports descriptive statistics of monthly returns on foreign currency sovereign bonds. In particular, the statistics are: mean, standard deviation, skewness, kurtosis, first order auto-correlation and number of observations. Means and standard deviations are annualized and in percentage. Data monthly from J.P. Morgan EMBI from Datastream. The longest sample is 1/2000 –12/2016. For some countries the sample is the longest available.

$$1 = E_t\left[M^{\$}_{t,t+1}R^{j,\$}_{t,t+1}\right] \tag{1}$$

$$1 = E_t\left[M^{\$}_{t,t+1}R^{j,l}_{t,t+1}\frac{S_t}{S_{t+1}}\right], \tag{2}$$

where $M^{\$}$ is the stochastic discount factor of the US investor. If markets are segmented, or if the local and foreign currency denominated bond differ with respect to additional features beside the currency of denomination, the Euler equations (1)–(2) do not have to hold[3]. Assuming that $M^{\$}_{t,t+1}$ and $R^{j,\$}_{t,t+1}$ are conditionally log-normal we get

$$E_t(\tilde{r}^{j,\$}_{t,t+1}) = -E_t(m^{\$}_{t,t+1}) - \frac{1}{2}\sigma^2_t(m^{\$}) - cov_t(m^{\$}_{t,t+1}, \tilde{r}^{j,\$}_{t,t+1}) \tag{3}$$

[3]For example, if bonds are issued under different legal systems, then they could offer different degrees of protection to investors.

Table 3: Descriptive Statistics

Variable	Nobs	Mean	SD	Min	Max
Total return index in LC	816	271.25	206.58	35.7	1279.63
Total return index in $	993	334.53	223.72	39.82	1275.89
Yield in LC	815	8.04	5.17	1.06	68.63
Yield in $	993	6.78	6.7	1.82	74.12
Forward-spot exchange rate	994	0.01	0.06	-0.68	0.34
Rating of debt in LC	1318	8.68	3.55	2	23
Rating of debt $	1486	10.42	3.38	4	23
GDP in bln LC	1200	3039.78	14272.66	0.1	1.20E+05
Total debt, % GDP	1200	40.27	20.9	3.35	117.93
Official debt, % GDP	1200	11.16	10.56	0.28	70.83
Total marketable debt, % GDP	1200	29.11	16.86	2.64	79.27
Total marketable debt in LC, % GDP	1118	20.39	12.75	0.54	50.62
Share of foreign investors in LC market. debt	1016	0.15	0.14	0	0.57

where $\tilde{r}$ denotes the log return corrected for the Jensens's inequality term and lower-case variables denotes logs (e.g., $m^{\$} = \log M^{\$}$)[4]. Similarly, assuming that $M^{\$}_{t,t+1}$, $R^{j,l}_{t,t+1}$ and S_t/S_{t+1} are conditionally log-normal we get

$$\begin{aligned} E_t(\tilde{r}^{j,l}_{t,t+1}) &= -E_t(m^{\$}_{t,t+1}) - \frac{1}{2}\sigma^2_t(m^{\$}) + E_t(\Delta s_{t+1}) - \frac{1}{2}\sigma^2_t(\Delta s) - cov_t(m^{\$}_{t,t+1}, \tilde{r}^{j,l}_{t,t+1}) + \\ &\quad + cov_t(m^{\$}_{t,t+1}, \Delta s_{t+1}) + cov_t(r^{j,l}_{t,t+1}, \Delta s_{t+1}), \end{aligned} \tag{4}$$

where Δs_{t+1} denotes the log change in the exchange rate (i.e., $s_{t+1} - s_t$). Note that (4) describes an expected return in local currency.

By taking the difference between (4) and (3) we obtain:

$$\begin{aligned} E_t(r^{j,e}_{t,t+1}) &= E_t(\Delta s_{t+1}) - \frac{1}{2}\sigma^2_t(\Delta s) - cov_t(m^{\$}_{t,t+1}, \tilde{r}^{j,l}_{t,t+1}) + cov_t(m^{\$}_{t,t+1}, \Delta s_{t+1}) + \\ &\quad + cov_t(r^{j,l}_{t,t+1}, \Delta s_{t+1}) + cov_t(m^{\$}_{t,t+1}, \tilde{r}^{j,\$}_{t,t+1}), \end{aligned} \tag{5}$$

where $r^{j,e}_{t,t+1}$ is the spread return between the local currency bond and the foreign currency bond issued by country j[5]. From equation (5) we conclude that the spread return is larger:

[4] Recall that $\ln[E(R)] = E(r) + (1/2)\sigma^2(r)$ if R is log-normally distributed and $r = \ln[R]$.

[5] Note that the literature on carry-trade in the foreign exchange market works off an equation very similar

- the larger is the expected depreciation of the local currency vis-a-vis the US dollar;
- the lower is the covariance between the return in local currency and the investor SDF (i.e., when return in local currency is on average low in bad times for the investor);
- the higher is the covariance between the change in exchange rate and the investor SDF (i.e., when local currency on average depreciates in bad times for the investor);
- the higher is covariance between the return in local currency and the change in exchange rate (i.e., when on average return in local currency are offset by local currency depreciation);
- the higher is the covariance between the investor SDF and the return in foreign currency (i.e., when on average return on the foreign currency bond are large in bad times for the US investor).

Guided by equation (5), we start by assuming that investors are risk-neutral, and then relax this assumption. With risk-neutral investors, all the covariance terms are equal to zero, and (5) collapses to the classic covered interest parity condition, where we replace the expected log change in the exchange rate by the log difference between forward and spot rates (i.e., $E_t(\Delta s_{t+1}) = f_t - s_t$, where with f_t we denote the forward rate at time t with delivery at time $t+1$) and estimate the following panel

$$r^l_{jqy} = \alpha^r r^{\$}_{jqy} + \alpha^{fs} f^{l,\$}_{jqy} + \epsilon_{jqy}, \tag{6}$$

where r^l_{jqy} are the returns in quarter q and year y of a bond issued by country j and denominated in local currency l; similarly, $r^{\$}_{jqy}$ are the returns in the same quarter and year on a bond issued by country j but denominated in foreign currency (i.e., US dollar); $f^{l,\$}_{jqy}$ is the forward discount in quarter q and year y. The forward discount is the log difference between the forward rate, at the end of quarter q, on a contract with delivery at the end of the next quarter, and the spot exchange rate at the end of quarter q.

Results from estimation of (6) are in table 4. We test whether the coefficients α^r and α^{fs} are equal to 1, and this hypothesis is rejected by the data. Therefore, we start adding factors in order to investigate the role of country-specific factors, possible risk-aversion of investors in emerging market debt (see, for example, Borri and Verdelhan (2011)), and partially segmented markets. Country fixed-effect plays no role. We use time fixed-effect (year-quarter) to capture the role of global factors, that proxy the impact of investors' risk aversion. Results in the second column of table 4 show that global factors are important

to the one in (5). For example, see Lustig and Verdelhan (2011) and Lustig et al. (2011).

and have a different impact on the returns on local and foreign currency denominated debt. The latter result could depend on differences in the covariances from equation (5), or partial segmentation of markets. We further add in the estimation debt levels and GDP growth rates to control for possible differences in default probabilities between bonds denominated in local and foreign currency (columns 3 and 4). Finally, in columns 5 and 6 we include a dummy that takes value of 1 if the share of local currency debt held by foreign investors is larger than 10%. We also interact this dummy with the returns on the foreign currency denominated debt, the forward discount, and the GDP growth rates. Hence, the equation, which we estimate in the more general case is

$$
\begin{aligned}
r^l_{jqy} = c_j + T_{qy} + \alpha^r r^\$_{jqy} + \alpha^s f^{l,\$}_{jqy} + \alpha^b b_{jqy} + \alpha^y y_{jqy} + \alpha^f SF_{jqy} + \\
\alpha^{rf} r^\$_{jqy} SF_{jqy} + \alpha^{sf} f^{l,\$}_{jqy} SF_{jqy} + \alpha^{rf} y_{jqy} SF_{jqy} + \epsilon_{jqy},
\end{aligned} \tag{7}
$$

where c_j is a country fixed effect, T_{qy} is a year-quarter effect, b_{jqy} debt to gdp levels (official debt, marketable debt and market debt in local currency), y_{jqy} is the GDP growth in local currency, SF_{jqy} is the share of foreign investors holding the market local currency debt.

As expected, both the coefficients on the return on the foreign currency denominated bond and the forward discount are significant, and have the right sign. If investors were risk-neutral and markets frictionless, they should be equal to 1. However, coefficients are significantly smaller than 1, indicating that we need a more complicated model to explain returns on the local currency denominated bonds, that could account for the risk aversion of investors, differences in the default probabilities, and the existence of market frictions. If investors are risk averse, covariances between their stochastic discount factors and returns matter. In part, these effects are already captured by the returns on the foreign currency denominated bond. To capture any additional time-varying common effect (i.e., global risk aversion, world interest rate, etc.), we also run the panel described in (6) adding a year and quarter fixed effect. Results are in column 2 of table 4, and show a marginal improvement in the estimates. If the bonds issued by country j, in local and foreign currency, have different default probabilities, then equations (1)–(2) should not hold exactly. Since probabilities of default are likely to depend on the levels of debt, in column 3 we include in the panel estimation the ratios between official debt, the market debt, and the market debt in local currency over GDP. Official debt denote liabilities with respect to official institutions, like the IMF, the World Bank, the so called *troika*, as well as direct loans from other government, for example a Russian loans to Ukraine. The coefficients on the debt ratios are not statistically

Table 4: Log difference of Total Return vs dummy of SF (10 %)

	(1) CE	(2) CE & YQE	(3) CE	(4) CE	(5) CE & YQE	(6) CE & YQE
α^r	0.598***	0.710***	0.616***	0.615***	0.509***	0.508***
	(0.0224)	(0.0292)	(0.0238)	(0.0244)	(0.0445)	(0.0445)
α^s	0.204***	0.208***	0.212***	0.212***	0.119**	0.136***
	(0.0323)	(0.0328)	(0.0347)	(0.0354)	(0.0378)	(0.0379)
α^y				-0.378**	-0.540***	-0.482*
				(0.126)	(0.160)	(0.189)
α^f				-0.0109	-0.0278***	-0.0225*
				(0.00560)	(0.00605)	(0.00881)
Official			0.000134	0.0000177	0.000145	
			(0.000578)	(0.000592)	(0.000543)	
Market.			-0.000254	-0.000501	-0.000695	
			(0.000639)	(0.000693)	(0.000648)	
Market., LC			0.000120	0.000304	0.00122	
			(0.000713)	(0.000781)	(0.000724)	
α^{rf}					0.317***	0.315***
					(0.0512)	(0.0514)
α^{sf}					0.678***	0.655***
					(0.109)	(0.108)
α^{yf}						-0.142
						(0.220)
N	731	731	665	623	623	623
r2_o	0.511	0.574	0.515	0.515	0.621	0.644
r2	0.516	0.579	0.528	0.548	0.660	0.659
F_f	1.156	1.097	0.662	1.082	1.148	1.194

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

different from zero. If investors in bonds issued by the same country, in different currencies, are different, then, again, the Euler equations (1)–(2) should necessarily hold. For example, in the limit case in which only domestic investors buy local currency denominated bonds, and foreign investors buy only foreign currency denominated bonds, we would need to consider different stochastic discount factors in the pricing of the two types of bonds. The differences in the holders of local and foreign currency denominated debt could depend on several factors, like home bias, capital controls, taxation, etc. In part, these effects are captured by the country fixed-effect (for example, the degree of home-bias, if it does not change much over time). However, data on the shares of local debt held by foreign investors show variations across countries and over time. Therefore, we introduce a dummy (SF) that is equal to 1 when, in a given quarter and for a given country, the shares of local currency debt held by foreigners is at least 10%. In column 4 we include our dummy together with a measure of deviations of GDP from trend[6] and maintain the country fixed effect. We find that the coefficient on the GDP is significant, and negative implying that the returns on local currency bonds are on average lower in good times. In column 5 and 6, we also include the interaction of our dummy with the returns on the foreign currency denominated bond, the forward discount, and the deviation of GDP from a trend, together with a country and time fixed-effect. Interestingly, in this case the dummy becomes negative and significant, indicating that the presence of foreign investors in the market for local currency debt, on average, lowers the returns. Also the interaction terms are significant. In particular, the presence of foreign investors in the local currency debt market brings a stronger positive correlation with respect to the return on the foreign currency denominated bond and with respect to the forward discount. We experimented the inclusion of dummies corresponding to lower and higher levels of the share of local debt held by foreigners and found that, for the effect to be significant, we need a small, but not too small of a share. For example, we present in the appendix results with a dummy equal 1 when the share is at least equal to 5%, and we find similar results, but significant at the 0.1% level only for the returns on foreign currency debt (see table 6), and at the 5% level for the forward discount. On the contrary, the interaction terms become not significant for dummies corresponding to larger shares, like 20% (see table 7). By comparing tables 6) and 4) we notice that the sum of $\alpha^r + \alpha^{rf}$, which measures the total impact of the return in foreign currency on the return is local currency, is roughly similar and is equal 0.82, but the split is substantially different. Hence, we can conclude that the increase of the share foreign investors from 5% to 10 % corresponds to doubling of the correlation of returns. The further increase to 20 % increases correlation only by 50 %. The similar true for the impact of exchange rate, which also increases with

[6] In particular, we regress real GDP on a linear and quadratic trend.

the share of foreign investors, but the increase is more moderate.

4 Model

In this section we present a model of defaultable bonds issued by the same sovereign in different currencies, and partially segmented markets. Greenwood et al. (2016) have a model with three different types of investors, two long-term assets, and a short-term risk-free asset. The two long-term assets differ because only one of them is default risk-free. In Greenwood et al., all assets are denominated in the same currency and investors differ because are either specialized in one of the two assets (specialists), or have a portfolio that combines the two assets (generalists), but rebalance only infrequently. We start off their model and make two key differences. First, in our model both long-term assets are defaultable bonds. Second, we introduce exchange rate risk. In fact, we assume that a sovereign issues long-term defaultable bonds denominated both in local and foreign currency. The two bonds have the same default risk properties, but changes in the exchange rate imply, from the point of view of foreign investors, an additional risk. We also consider a risk-free short-term security denominated in foreign currency. Investors are of three types. As in Greenwood et al., we have specialized investors, that invest either in the long-term bonds denominated in local, or foreign currency. In addition, we have generalized foreign investors, who invest in both the bonds denominated in local and foreign currency.

4.1 Defaultable perpetuities

We assume that a sovereign issues debt in local, and in foreign currency. In what follows, variables with the superscript $\star$ are in foreign currency, while variables in local currency have no superscripts. When knowledge of the currency is not essential, we also omit any superscript. We think of debt issued in local and foreign currency as two homogeneous portfolios of perpetual, defaultable bonds, each of which promises to pay a coupon, respectively, of C and $C^\star$. We denote these two assets as portfolios A and B. Suppose that a random fraction h_{t+1} of the bonds, equal for the local and foreign currency denominated assets, defaults at $t+1$ and are worth, respectively, $(1-L)(P_{A,t+1}+C_A)$ and $(1-L)(P^\star_{B,t+1}+C^\star_B)$, where $0 \leq L < 1$ is the exogenous loss-given-default as a fraction of market value. The remaining fractions $(1-h_{t+1})$ of the bonds do not default and are worth, respectively, $(P_{A,t+1}+C_A)$ and $(P^\star_{B,t+1}+C^\star_B)$. The holding period returns on the bond portfolios are

$$R_{A,t+1} = \frac{(1-Z_{t+1})(P_{A,t+1}+C_A)}{P_{A,t}}, \tag{8}$$

$$R^\star_{B,t+1} = \frac{(1-Z_{t+1})(P^\star_{B,t+1}+C^\star_B)}{P^\star_{B,t}}, \tag{9}$$

where $Z_{t+1} = h_{t+1}L$, satisfying $0 \le Z_{t+1} < 1$, is the portfolio default realization at time $t+1$. Note that we are assuming that the sovereign can only default simultaneously on bonds denominated in different currency. This assumption can be justified by the existence of *pari passu* clauses (ADD REFERENCES). Also, not that if $Z_{t+1} \equiv 0$, then the bond is default risk-free. From the point of view of foreign investors, the foreign currency returns from buying a local currency denominated bond are

$$R^{l,\star}_{A,t+1} = \frac{(1-Z_{t+1})(P_{A,t+1}+C_B)}{P_{A,t}}\frac{S_t}{S_{t+1}}, \tag{10}$$

where S_t is the exchange rate expressed in units of local currency for one unit of foreign currency. Note that an increase in S denotes a depreciation of the local currency vis-a-vis the foreign currency. Therefore, $R^{l,\star}_{A,t+1}$ is decreasing in S_t/S_{t+1} because the investor is exchanging back into foreign currency the bond's payoff at a less convenient rate. We use the classic Campbell and Shiller (1988) log-linear approximation of the portfolio returns to get

$$p_{A,t} = \frac{1}{1-\theta_A}\kappa_A + c_A - \sum_{i=0}^{\infty}\theta_A^i E_t\left[r_{A,t+i+1} + z_{t+i+1}\right], \tag{11}$$

$$p^\star_{B,t} = \frac{1}{1-\theta^\star_B}\kappa^\star_B + c^\star_B - \sum_{i=0}^{\infty}(\theta^\star_B)^i E_t\left[r^\star_{B,t+i+1} + z_{t+i+1}\right] \tag{12}$$

where $\theta_A = 1/(1+\exp(c_A - \bar{p}_A))$, $\kappa_A = -\log(\theta_A) - (1-\theta_A)\log(\theta_A^{-1}-1)$, $\theta^\star_B = 1/(1+\exp(c^\star_B - \bar{p}^\star_B))$, $\kappa^\star_B = -\log(\theta^\star_B) - (1-\theta^\star_B)\log((\theta^\star_B)^{-1}-1)$ are parameters from the log-linearization and lower-case variables are logs (i.e., $x = \log(X)$). We apply the approximations (11)–(12) to promised cashflows (i.e., $z_{t+i+1} = 0$ for all $i \ge 0$) and the yield-to-maturity, or more simply *yield*, defined as the constant return that equates bond prices to the present value of the promised cashflows, and get

$$p_{A,t} = \frac{1}{1-\theta_A}\kappa_A + c_A - \frac{1}{1-\theta_A} y_{A,t}, \tag{13}$$

$$p^\star_{B,t} = \frac{1}{1-\theta^\star_B}\kappa^\star_B + c^\star_B - \frac{1}{1-\theta^\star_B} y^\star_{B,t}, \tag{14}$$

where $y_{B,t}, y^\star_{B,t}$ denote the yields on the foreign and local currency denominated bond portfolios. By plugging (13)–(14) in the Campbell and Shiller (1988)'s approximation we get

$$r_{A,t+1} \approx \frac{1}{1-\theta_A} y_{A,t} - \frac{\theta_A}{1-\theta_A} y_{A,t+1} - z_{t+1} \tag{15}$$

$$r^\star_{B,t+1} \approx \frac{1}{1-\theta^\star_B} y^\star_{B,t} - \frac{\theta^\star_B}{1-\theta^\star_B} y^\star_{B,t+1} - z_{t+1} \tag{16}$$

$$r^{l,\star}_{A,t+1} \approx \frac{1}{1-\theta^\star_A} y^\star_{A,t} - \frac{\theta^\star_A}{1-\theta^\star_A} y^\star_{A,t+1} - z_{t+1} - \Delta s_{t+1} \tag{17}$$

where (17) is the approximate return, in foreign currency, on the local currency denominated bond portfolio and depends also on the expected (log) change in the exchange rate (i.e., Δs_{t+1}).

Assume now that there exists one short-term default risk-free bond, denominated in foreign currency only. For example, investors have access to a U.S. T-bill. We denote the return on this risk-free asset with $r^\star_t$, and the excess returns on investing in the local and foreign currency denominated bond portfolios with

$$rx_{A,t+1} \approx \frac{1}{1-\theta_A} y_{A,t} - \frac{\theta_A}{1-\theta_A} y_{A,t+1} - z_{t+1} - r^\star_t + \Delta s_{t+1}, \tag{18}$$

$$rx^\star_{B,t+1} \approx \frac{1}{1-\theta^\star_B} y^\star_{B,t} - \frac{\theta^\star_B}{1-\theta^\star_B} y^\star_{B,t+1} - z_{t+1} - r^\star_t, \tag{19}$$

$$rx^{l,\star}_{A,t+1} \approx \frac{1}{1-\theta_A} y_{A,t} - \frac{\theta_A}{1-\theta_A} y_{A,t+1} - z_{t+1} - \Delta s_{t+1} - r^\star_t \tag{20}$$

Note that portfolios A and B are only imperfect substitutes because, despite sharing the same default risk, they carry different exchange rate risk. The variance of the change in the exchange rate determines, in part, the degree of substitutability between assets A and B. In addition, we assume that the two assets differ in terms of supply shocks that we specify in the section 4.3.

4.2 Market participants

There are three types of investors, all with identical risk tolerance τ and a mean-variance objective. We assume that all the investors combine to mass unity, and the shares of each of the three types are exogenously given and equal to n_A (specialized local investors), n_B (specialized foreign investors), and $1 - n_A - n_B$ (generalists). Local specialized investors can choose a portfolio containing only local currency denominated long-term debt and a short-term risk-free asset which is denominated in foreign currency. The first two types we call specialists, because they specialize in one of the two markets. For example, they could be hedge funds specialized in each asset class, or investors that are constrained by institutional rules (e.g., pension funds that cannot invest in local currency denominated debt; or local investors that are prohibited from investing abroad by domestic regulation). Therefore, local specialized investors are prevented from buying domestic bonds issued in foreign currency and maximize

$$\max_{b_{A,t}} \left\{ b_{A,t} E_t[rx_{A,t+1}] - (2\tau)^{-1} b_{A,t}^2 Var_t[rx_{A,t+1}] \right\}, \tag{21}$$

where $rx_{A,t+1}$ is the log excess return defined in (18), and $b_{A,t}$ the quantity invested in the risky portfolio A by specialized local investors.

Foreign specialized investors, can choose a portfolio containing foreign currency long-term debt and a short-term risk-free asset, also denominated in foreign currency and maximize

$$\max_{b_{B,t}} \left\{ b_{B,t} E_t[rx^\star_{B,t+1}] - (2\tau)^{-1} b_{B,t}^2 Var_t[rx^\star_{B,t+1}] \right\}, \tag{22}$$

where $rx^\star_{B,t+1}$ is the log excess return defined in (19), and $b_{B,t}$ the quantity invested in the risky portfolio B by specialized foreign investors.

Finally, generalists hold both local and foreign currency denominated long-term debt and the risk-less short-term bond, denominated in foreign currency. We assume that generalists are foreign investors and, therefore, the ultimate objective of their investment is denominated in foreign currency. We denote the excess return of the portfolio of generalist investors as

$$rx^\star_{d_t,t+1} = d_{A,t} rx^{l,\star A,t+1} + d_{B_t} rx^\star_{B,t+1}, \tag{23}$$

where $rx^{l,\star A,t+1}$ is from equation (20), and $d_{A,t}$ and $d_{B,t}$ are the quantities invested in the long-term debt denominated, respectively, in local and foreign currency. This implies that generalist investors maximize

$$\max_{d_{A,t},d_{B,t}} \left\{ E_t[rx^\star_{d_t,t+1}] - (2\tau)^{-1} Var_t[rx^\star_{d_t,t+1}] \right\}, \tag{24}$$

Solving the maximization problems (21)–(23), we derive the demand functions of the three investors

$$
\begin{aligned}
b_{A,t} &= \tau \frac{E_t\left[rx_{A,t+1}\right]}{Var_t\left[rx_{A,t+1}\right]}, &(25)\\
b_{B,t} &= \tau \frac{E_t\left[rx^{\star}_{B,t+1}\right]}{Var_t\left[rx^{\star}_{B,t+1}\right]}, &(26)\\
\begin{bmatrix} d_{A,t} \\ d_{B,t} \end{bmatrix} &= \frac{\tau}{1-R^2_{A,B}} \begin{bmatrix} \frac{E_t\left[rx^{l,\star}_{A,t+1}\right]}{Var_t\left[rx^{l,\star}_{A,t+1}\right]} - \beta_{B|A}\frac{E_t\left[rx^{\star}_{B,t+1}\right]}{Var_t\left[rx^{\star}_{B,t+1}\right]} \\ \frac{E_t\left[rx^{\star}_{B,t+1}\right]}{Var_t\left[rx^{\star}_{B,t+1}\right]} - \beta_{A|B}\frac{E_t\left[rx^{l,\star}_{A,t+1}\right]}{Var_t\left[rx^{l,\star}_{A,t+1}\right]} \end{bmatrix}, &(27)
\end{aligned}
$$

where $\beta_{A|B}, \beta_{B|A}$ are OLS slope coefficients in regressions of $rx^{l,\star}_{A,t+1}$ on $rx^{\star}_{B,t+1}$, and vice-versa, and $R^2_{A,B}$ the corresponding R-square.

4.3 Risk factors

Investors in defaultable long-term bonds are exposed to different risks. Both the local and foreign currency denominated bonds are exposed to interest rate risk, default risk, and supply risk. In addition, foreign investors buying bonds that are denominated in local currency are exposed to exchange rate risk. Similarly, local investors are exposed to exchange rate risk since they buy bonds that are denominated in local currency, and the short-term risk-free asset, which is always denominated in foreign currency. We assume that these four types of risks have the following autoregressive processes

$$
\begin{aligned}
r^{\star}_{t+1} &= \bar{r}^{\star} + \rho_r(r^{\star}_t - \bar{r}^{\star}) + \epsilon_{r^{\star},t+1}, &(28)\\
z_{t+1} &= \bar{z} + \rho_z(z_t - \bar{z}) + \epsilon_{z,t+1}, &(29)\\
q_{A,t+1} &= \bar{q}_A + \rho_{q_A}(q_{A,t} - \bar{q}_A) + \epsilon_{q_A,t+1}, &(30)\\
q_{B,t+1} &= \bar{q}_B + \rho_{q_B}(q_{B,t} - \bar{q}_B) + \epsilon_{q_B,t+1}, &(31)\\
\Delta s_{t+1} &= \Delta\bar{s} + \rho_s(\Delta s_{t+1} - \Delta\bar{s}) + \epsilon_{\Delta s,t+1}, &(32)
\end{aligned}
$$

where $r^{\star}$ is the short-term interest rate, z captures the default losses, y_A, y_B are bond A and B supplies, and $\Delta s_{t+1} \equiv s_{t+1} - s_t$ is the (log) change in the exchange rate. We assume that $\epsilon_{r^{\star},t+1}, \epsilon_{z,t+1}, \epsilon_{q_A,t+1}, \epsilon_{q_B,t+1}, \epsilon_{\Delta s,t+1}$ are mutually orthogonal, with conditional variances, respectively, $\sigma^2_{r^{\star}}, \sigma^2_z, \sigma^2_{q_A}, \sigma^2_{q_B}, \sigma^2_{\Delta s}$.

4.4 Equilibrium yields

The market-clearing conditions for assets A and B are as follows

$$n_A b_{A,t} + (1 - n_A - n_B) d_{A,t} = q_{A,t} \tag{33}$$

$$n_B b_{B,t} + (1 - n_A - n_B) d_{B,t} = q_{B,t}. \tag{34}$$

We follow Greenwood et al. (2016) and use a guess and verify approach to solve the problem. We conjecture that the equilibrium yields and generalist demands are linear functions of a state vector $\mathbf{x}_t$

$$\mathbf{x}_t = \begin{bmatrix} r_t^\star - \bar{r}^\star \\ z_t - \bar{z} \\ q_{A,t} - \bar{q}_A \\ q_{B,t} - \bar{q}_B \\ \Delta s_t - \Delta \bar{s} \end{bmatrix},$$

with dimension (5×1).

Formally, we conjecture that the long-term yields in market A and B are

$$y_{A,t} = \alpha_{A0} + \boldsymbol{\alpha}'_{A1} \mathbf{x}_t, \tag{35}$$

$$y_{B,t} = \alpha_{B0} + \boldsymbol{\alpha}'_{B1} \mathbf{x}_t, \tag{36}$$

$$y_{A,t}^{l,\star} = \alpha_{C0} + \boldsymbol{\alpha}'_{C1} \mathbf{x}_t, \tag{37}$$

and the demands of generalists are

$$d_{A,t} = \delta_{A0} + \boldsymbol{\delta}'_{A1} \mathbf{x}_t, \tag{38}$$

$$d_{B,t} = \delta_{B0} + \boldsymbol{\delta}'_{B1} \mathbf{x}_t, \tag{39}$$

Given our assumptions, the state vector follows an AR(1) process with diagonal transition matrix $\boldsymbol{\Gamma}$

$$\mathbf{x}_{t+1} = \mathbf{\Gamma}\mathbf{x}_t + \boldsymbol{\epsilon}_{t+1} = \begin{bmatrix} \rho_{r^\star} & 0 & 0 & 0 & 0 \\ 0 & \rho_z & 0 & 0 & 0 \\ 0 & 0 & \rho_{q_A} & 0 & 0 \\ 0 & 0 & 0 & \rho_{q_B} & 0 \\ 0 & 0 & 0 & 0 & \rho_{\Delta s} \end{bmatrix} \begin{bmatrix} r_t^\star - \bar{r}^\star \\ z_t - \bar{z} \\ q_{A,t} - \bar{q}_A \\ q_{B,t} - \bar{q}_B \\ \Delta s_t - \Delta\bar{s} \end{bmatrix} = \begin{bmatrix} \epsilon_{r^\star,t+1} \\ \epsilon_{z,t+1} \\ \epsilon_{q_A,t+1} \\ \epsilon_{q_B,t+1} \\ \epsilon_{\Delta s,t+1} \end{bmatrix}$$

Note that, given our assumption of mutual orthogonality of the shocks to the risk factors, we have

$$\Sigma \equiv Var_t(\boldsymbol{\epsilon}_{t+1}) = \begin{bmatrix} \sigma^2_{r^\star} & 0 & 0 & 0 & 0 \\ 0 & \sigma^2_z & 0 & 0 & 0 \\ 0 & 0 & \sigma^2_{q_A} & 0 & 0 \\ 0 & 0 & 0 & \sigma^2_{q_B} & 0 \\ 0 & 0 & 0 & 0 & \sigma^2_{\Delta s} \end{bmatrix}$$

In what follows, we adopt the notation $\mathbf{e}_i$, with $i = r^\star, z, q_A, q_B, \Delta s$, to denote the basis vector, with dimension (5×1), with a 1 in position i-th and 0s elsewhere. Note also the following results that will be useful in the next sections and that depend from iterating forward the equilibrium yields from equations (18)–(20). We can compute closed-form expressions for some of the elements of the vectors $\boldsymbol{\alpha}_{A1}, \boldsymbol{\alpha}_{B1}$, and $\boldsymbol{\alpha}_{C1}$. In particular, denote with α_{ji}, and $i = r^\star, z, \Delta s$ and $j = A, B, C$, the elements of vector $\boldsymbol{\alpha}_{A1}$. From the first three terms of equation (40), we can back out, respectively, the expressions for $\alpha_{Ar^\star}, \alpha_{Az}$ and $\alpha_{A\Delta s}$

$$\begin{aligned} y_{A,t} \quad = \quad & \left[\frac{1-\theta_A}{1-\rho_{r^\star}\theta_A}\right](r_t^\star - \bar{r}^\star) + \left[\frac{1-\theta_A}{1-\rho_z\theta_A}\rho_z\right](z_t - \bar{z}) - \left[\frac{1-\theta_A}{1-\rho_{\Delta s}\theta_A}\rho_{\Delta s}\right](\Delta s_t - \Delta\bar{s}) \\ & + (\bar{r}^\star + \bar{z} - \Delta\bar{s}) + (1-\theta_A)\sum_{i=0}^{\infty}\theta_A^i E_t\left[rx_{A,t+1+i}\right]. \end{aligned} \tag{40}$$

From the first two terms of equation (41), we can instead back out the expressions for $\alpha_{Br^\star}$ and α_{Bz}.

$$\begin{aligned} y^\star_{B,t} \quad = \quad & \left[\frac{1-\theta_B^\star}{1-\rho_{r^\star}\theta_B^\star}\right](r_t^\star - \bar{r}^\star) + \left[\frac{1-\theta_B^\star}{1-\rho_z\theta_B^\star}\rho_z\right](z_t - \bar{z}) \\ & + (\bar{r}^\star + \bar{z}) + (1-\theta_B^\star)\sum_{i=0}^{\infty}(\theta_B^\star)^i E_t\left[rx^\star_{B,t+1+i}\right]. \end{aligned} \tag{41}$$

Note that (41) is independent on the exchange rate (CHECK THIS). Finally, from the first three terms in equation (42) we can back out the expressions for $\alpha_{Cr^\star}, \alpha_{Cz}$ and $\alpha_{C\Delta s}$.

$$\begin{aligned} y^{l,\star}_{A,t} &= \left[\frac{1-\theta_A}{1-\rho_{r^\star}\theta_A}\right](r^\star_t - \bar{r}^\star) + \left[\frac{1-\theta_A}{1-\rho_z\theta_A}\rho_z\right](z_t - \bar{z}) + \left[\frac{1-\theta_A}{1-\rho_{\Delta s}\theta_A}\rho_{\Delta s}\right](\Delta s_t - \Delta\bar{s}) \\ &\quad + (\bar{r}^\star + \bar{z} + \Delta\bar{s}) + (1-\theta_A)\sum_{i=0}^{\infty}\theta_A^i E_t\left[rx_{A,t+1+i}\right]. \end{aligned} \tag{42}$$

Note that from equations (40)–(42) we cannot back out the expressions for the constant terms (i.e., α_{A0}, α_{B0} and α_{C0}) as they are affected by bonds' supplies and must be pinned down using market clearing conditions. Note also that the yields of asset A, the bond denominated in local currency, expressed in local and foreign currencies in equations (40)–(42), differs only by a constant term. Taking the difference between these two equations we obtain the following additional restriction

$$\alpha_{A0} = \alpha_{C0} - 2\Delta\bar{s}. \tag{43}$$

4.5 Specialists demands

Combining equation (18) and the conjecture of equilibrium yield from equation (35), we have

$$rx_{A,t+1} = (\alpha_{A0} - \bar{r}^\star - \bar{z} + \Delta\bar{s}) + \left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{A1} - \mathbf{e}_{r^\star}\right)'\mathbf{x}_t - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{A1} + \mathbf{e}_z - \mathbf{e}_{\Delta s}\right)'\mathbf{x}_{t+1}. \tag{44}$$

From (44) we have

$$E_t[rx_{A,t+1}] = (\alpha_{A0} - \bar{r}^\star - \bar{z} + \Delta\bar{s}) + \left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{A1} - \mathbf{e}_{r^\star}\right)'\mathbf{x}_t - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{A1} + \mathbf{e}_z - \mathbf{e}_{\Delta s}\right)'\boldsymbol{\Gamma}\mathbf{x}_t,$$

and

$$Var_t[rx_{A,t+1}] = \left(\frac{\theta_A}{1-\theta_A}\right)^2 \boldsymbol{\alpha}'_{A1}\Sigma\boldsymbol{\alpha}_{A1} + \sigma^2_z + \sigma^2_{\Delta s}. \tag{45}$$

Note that, using the expressions for the coefficients pinned down by equations (40)–(42), we can write equation (45) as

$$Var_t[rx_{A,t+1}] = \left(\frac{\theta_A}{1-\rho_{r\star}\theta_A}\right)^2 \sigma^2_{r^\star} + \left(\frac{1}{1-\rho_z\theta_A}\right)^2 \sigma^2_z + \left(\frac{2\rho_{\Delta s}\theta_A - 1}{1-\rho_{\Delta s}\theta_A}\right)^2 \sigma^2_{\Delta s} + \left(\frac{\theta_A}{1-\theta_A}\alpha_{A,q_A}\right)^2 \sigma^2_{q_A} + \left(\frac{\theta_A}{1-\theta_A}\alpha_{A,q_B}\right)^2 \sigma^2_{q_B}. \tag{46}$$

The demand for the asset A, the local currency denominated bond, from the investors specialized in the local currency market is then

$$b_{A,t} = \tau\frac{E_t[rx_{A,t+1}]}{Var_t[rx_{A,t+1}]} = \left[\tau\frac{\alpha_{A0} - \bar{r}^\star - \bar{z} + \Delta\bar{s}}{\left(\frac{\theta_A}{1-\theta_A}\right)^2 \boldsymbol{\alpha}'_{A1}\Sigma\boldsymbol{\alpha}_{A1} + \sigma^2_z + \sigma^2_{\Delta s}}\right] + \left[\tau\frac{\left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{A1} - \mathbf{e}_{r^\star}\right)' - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{A1} + \mathbf{e}_z - \mathbf{e}_{\Delta s}\right)'\boldsymbol{\Gamma}}{\left(\frac{\theta_A}{1-\theta_A}\right)^2 \boldsymbol{\alpha}'_{A1}\Sigma\boldsymbol{\alpha}_{A1} + \sigma^2_z + \sigma^2_{\Delta s}}\right]\mathbf{x}_t \tag{47}$$

We proceed in a similar way for asset B, the portfolio of long-term bonds denominated in foreign currency. Given the conjecture form of equilibrium yields we have

$$rx^\star_{B,t+1} = (\alpha_{B0} - \bar{r}^\star - \bar{z}) + \left(\frac{1}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1} - \mathbf{e}_{r^\star}\right)'\mathbf{x}_t - \left(\frac{\theta^\star_B}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1} + \mathbf{e}_z\right)'\mathbf{x}_{t+1}. \tag{48}$$

Therefore, the expected excess return on asset B is

$$E_t[rx^\star_{B,t+1}] = (\alpha_{B0} - \bar{r}^\star - \bar{z}) + \left(\frac{1}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1} - \mathbf{e}_{r^\star}\right)'\mathbf{x}_t - \left(\frac{\theta^\star_B}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1} + \mathbf{e}_z\right)'\boldsymbol{\Gamma}\mathbf{x}_t, \tag{49}$$

and the variance of excess return is

$$Var_t[rx^\star_{B,t+1}] = \left(\frac{\theta^\star_B}{1-\theta^\star_B}\right)^2 \boldsymbol{\alpha}'_{B1}\Sigma\boldsymbol{\alpha}_{B1} + \sigma^2_z, \tag{50}$$

which can be also expressed as

$$Var_t[rx^\star_{B,t+1}] = \left(\frac{\theta^\star_B}{1-\rho_{r^\star}\theta^\star_B}\right)^2 \sigma^2_{r^\star} + \left(\frac{1}{1-\rho_z\theta^\star_B}\right)^2 \sigma^2_z + \left(\frac{\theta^\star_B}{1-\theta^\star_B}\alpha_{B,q_A}\right)^2 \sigma^2_{q_A} + \left(\frac{\theta^\star_B}{1-\theta^\star_B}\alpha_{B,q_B}\right)^2 \sigma^2_{q_B}. \quad (51)$$

The demand for the asset B, the portfolio of long-term bonds denominated in foreign currency, from the investors specialized in the market for foreign currency denominated bond is then

$$b_{B,t} = \tau\frac{E_t[rx^\star_{B,t+1}]}{Var_t[rx^\star_{B,t+1}]} = \left[\tau\frac{\alpha_{B0}-\bar{r}^\star-\bar{z}+}{\left(\frac{\theta^\star_B}{1-\theta^\star_B}\right)^2\boldsymbol{\alpha}'_{B1}\Sigma\boldsymbol{\alpha}_{B1}+\sigma^2_z}\right] + \left[\tau\frac{\left(\frac{1}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1}-\mathbf{e}_{r^\star}\right)'-\left(\frac{\theta^\star_B}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1}+\mathbf{e}_z\right)'\boldsymbol{\Gamma}}{\left(\frac{\theta^\star_B}{1-\theta^\star_B}\right)^2\boldsymbol{\alpha}'_{B1}\Sigma\boldsymbol{\alpha}_{B1}+\sigma^2_z}\right]\mathbf{x}_t \quad (52)$$

4.6 Generalist demand

The generalist investors solve the maximization problem in equation (24). It is convenient to open-up the expression for $rx^\star_{d_t,t+1}$ to explicit the role of the covariance between the two assets. This implies that generalist investors solve

$$\max_{d_{A,t},d_{B,t}} d_{A,t}E_t[rx^{l,\star}_{A,t+1}] + d_{B_t}E_t[rx^\star_{B,t+1}] - \frac{1}{2\tau}\left(d^2_{A,t}Var_t[rx^{l,\star}_{A_t,t+1}] + d^2_{B,t}Var_t[rx^\star_{B_t,t+1}] + 2d_{A_t}d_{B_t}Cov_t[rx^{l,\star}_{A,t+1}, rx^\star_{B,t+1}]\right) \quad (53)$$

which implies

$$\begin{bmatrix} d_{A,t} \\ d_{B,t} \end{bmatrix} = \tau\begin{bmatrix} V_A & C_{A,B} \\ C_{B,A} & V_B \end{bmatrix}^{-1}\begin{bmatrix} E_t[rx^{l,\star}_{A,t+1}] \\ E_t[rx^\star_{B,t+1}] \end{bmatrix} = \frac{\tau}{V_AV_B-(C_{A,B})^2}\begin{bmatrix} V_BE_t[rx^{l,\star}_{A,t+1}] - C_{A,B}E_t[rx^\star_{B,t+1}] \\ V_AE_t[rx^\star_{B,t+1}] - C_{A,B}E_t[rx^{l,\star}_{A,t+1}] \end{bmatrix}, \quad (54)$$

where we use the compact notation $V_A = Var_t[rx^{l,\star}_{A_t,t+1}]$, $V_B = Var_t[rx^\star_{B_t,t+1}]$, and $C_{A,B} =$

$Cov_t[rx^{l,\star}_{A,t+1}, rx^{\star}_{B,t+1}]$.

Realized excess returns on asset A after the conversion in foreign currency are

$$rx^{l,\star}_{A,t+1} = (\alpha_{C0} - \bar{r}^\star - \bar{z} - \Delta\bar{s}) + \left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{C1} - \mathbf{e}_{r^\star}\right)' \mathbf{x}_t - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{C1} + \mathbf{e}_z + \mathbf{e}_{\Delta s}\right)' \mathbf{x}_{t+1}, \quad (55)$$

and their expected value

$$E_t[rx^{l,\star}_{A,t+1}] = (\alpha_{C0} - \bar{r}^\star - \bar{z} - \Delta\bar{s}) + \left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{C1} - \mathbf{e}_{r^\star}\right)' \mathbf{x}_t - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{C1} + \mathbf{e}_z + \mathbf{e}_{\Delta s}\right)' \boldsymbol{\Gamma}\mathbf{x}_t.$$

Note that the variance of $rx^{l,\star}_{A,t+1}$ is different from the variance on $rx_{A,t+1}$ because of the different impact that exchange rate shocks have on the foreign currency returns on the local currency denominated bond. In particular, using (55), we compute the variance of $rx^{l,\star}_{A,t+1}$ as

$$\begin{aligned} Var_t[rx^{l,\star}_{A,t+1}] &= \left(\frac{\theta_A}{1-\rho_{r^\star}\theta_A}\right)^2 \sigma^2_{r^\star} + \left(\frac{1}{1-\rho_z\theta_A}\right)^2 \sigma^2_z + \left(\frac{1}{1-\rho_{\Delta s}\theta_A}\right)^2 \sigma^2_{\Delta s} \\ &\quad + \left(\frac{\theta_A}{1-\theta_A}\alpha_{A,q_A}\right)^2 \sigma^2_{q_A} + \left(\frac{\theta_A}{1-\theta_A}\alpha_{A,q_B}\right)^2 \sigma^2_{q_B}. \end{aligned} \quad (56)$$

For asset B, realized and expected returns are those of equations (48)–(49), and the variance of $rx^{\star}_{B,t+1}$ is defined in equation (50).

We need now to compute the covariance between the foreign currency returns on the portfolio of local currency bonds and the returns on the portfolio of bonds denominated in local currency

$$\begin{aligned} & Cov_t[rx^{l,\star}_{A,t+1}, rx^{\star}_{B,t+1}] = \\ & Cov_t\left[\left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{C1} + \mathbf{e}_z + \mathbf{e}_{\Delta s}\right)' \mathbf{x}_{t+1}, \left(\frac{\theta^\star_B}{1-\theta^\star_B}\boldsymbol{\alpha}_{B1} + \mathbf{e}_z\right)' \mathbf{x}_{t+1}\right] \end{aligned} \quad (57)$$

Note that equation (57) can be also written as

$$C_{A,B} = \frac{\theta_A \theta_B^\star}{(1-\rho_{r\star}\theta_A)(1-\rho_{r\star}\theta_B^\star)}\sigma_{r^\star}^2 + \frac{1}{(1-\rho_z\theta_A)(1-\rho_z\theta_B^\star)}\sigma_z^2 + \frac{\theta_A\alpha_{A,q_A}\theta_B^\star\alpha_{B,q_A}}{(1-\theta_A)(1-\theta_B^\star)}\sigma_{q_A}^2 + \frac{\theta_A\alpha_{A,q_B}\theta_B^\star\alpha_{B,q_B}}{(1-\theta_A)(1-\theta_B^\star)}\sigma_{q_B}^2. \quad (58)$$

We now derive the coefficients for our conjectures of the demands for generalist investors using the solutions of their optimization problem in (54). Given our conjectures, the generalist demands will take the following linear forms

$$\delta_{A0} = \tau\frac{V_B(\alpha_{C0} - \bar{r}^\star - \bar{z} - \Delta\bar{s}) - C_{A,B}(\alpha_{B0} - \bar{r}^\star - \bar{z})}{V_A V_B - (C_{A,B})^2}, \quad (59)$$

$$\delta_{B0} = \tau\frac{V_A(\alpha_{B0} - \bar{r}^\star - \bar{z}) - C_{A,B}(\alpha_{C0} - \bar{r}^\star - \bar{z} - \Delta\bar{s})}{V_A V_B - (C_{A,B})^2}, \quad (60)$$

$$\boldsymbol{\delta}_{A1}' = \tau\frac{\begin{pmatrix} V_B\left[\left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{C1} - \mathbf{e}_{r^\star}\right)' - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{C1} + \mathbf{e}_z + \mathbf{e}_{\Delta s}\right)'\boldsymbol{\Gamma}\right] \\ -C_{A,B}\left[\left(\frac{1}{1-\theta_B^\star}\boldsymbol{\alpha}_{B1} - \mathbf{e}_{r^\star}\right)' - \left(\frac{\theta_B^\star}{1-\theta_B^\star}\boldsymbol{\alpha}_{B1} + \mathbf{e}_z\right)'\boldsymbol{\Gamma}\right]\end{pmatrix}}{V_A V_B - (C_{A,B})^2} \quad (61)$$

$$\boldsymbol{\delta}_{B1}' = \tau\frac{\begin{pmatrix} V_B\left[\left(\frac{1}{1-\theta_B^\star}\boldsymbol{\alpha}_{B1} - \mathbf{e}_{r^\star}\right)' - \left(\frac{\theta_B^\star}{1-\theta_B^\star}\boldsymbol{\alpha}_{B1} + \mathbf{e}_z\right)'\boldsymbol{\Gamma}\right] \\ -C_{A,B}\left[\left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{C1} - \mathbf{e}_{r^\star}\right)' - \left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{C1} + \mathbf{e}_z + \mathbf{e}_{\Delta s}\right)'\boldsymbol{\Gamma}\right]\end{pmatrix}}{V_A V_B - (C_{A,B})^2} \quad (62)$$

4.7 Equilibrium

To find the equilibrium of the model with need to impose market-clearing conditions for both the A and B assets in a way that is consistent with A-specialists, B-specialists, and generalist investors. In addition, the coefficients of α_{C0} and $\boldsymbol{\alpha}_{C1}$ will be constrained by those from α_{A0} and $\boldsymbol{\alpha}_{A1}$ and equation (42).

The market-clearing condition for market A is

$$AD_{A,t} \equiv (1 - n_A - n_B)d_{A,t} + n_A b_{A,t} = q_{A,t}, \quad (63)$$

where $AD_{A,t}$ denotes the aggregate demand for asset A and is equal to

$$
\begin{aligned}
AD_{A,t} &= (1-n_A-n_B)\delta_{A,0} + n_A\left[\tau\frac{\alpha_{A0}-\bar{r}^{\star}-\bar{z}+\Delta\bar{s}}{\left(\frac{\theta_A}{1-\theta_A}\right)^2\boldsymbol{\alpha}'_{A1}\Sigma\boldsymbol{\alpha}_{A1}+\sigma_z^2+\sigma_{\Delta s}^2}\right] \\
&+ \left[(1-n_A-n_B)\boldsymbol{\delta}'_{A,0}+n_A\tau\frac{\left(\frac{1}{1-\theta_A}\boldsymbol{\alpha}_{A1}-\mathbf{e}_{r^\star}\right)'-\left(\frac{\theta_A}{1-\theta_A}\boldsymbol{\alpha}_{A1}+\mathbf{e}_z-\mathbf{e}_{\Delta s}\right)'\boldsymbol{\Gamma}}{\left(\frac{\theta_A}{1-\theta_A}\right)^2\boldsymbol{\alpha}'_{A1}\Sigma\boldsymbol{\alpha}_{A1}+\sigma_z^2+\sigma_{\Delta s}^2}\right]\mathbf{x}_t.
\end{aligned}
$$

The market clearing condition for market B is

$$
AD_{B,t} \equiv (1-n_A-n_B)d_{B,t} + n_B b_{B,t} = q_{B,t}, \tag{64}
$$

where $AD_{B,t}$ is the aggregate demand for asset B and is equal to

$$
\begin{aligned}
AD_{B,t} &= (1-n_A-n_B)\delta_{B,0} + n_B\left[\tau\frac{\alpha_{B0}-\bar{r}^{\star}-\bar{z}+}{\left(\frac{\theta_B^\star}{1-\theta_B^\star}\right)^2\boldsymbol{\alpha}'_{B1}\Sigma\boldsymbol{\alpha}_{B1}+\sigma_z^2}\right] \\
&+ \left[(1-n_A-n_B)\boldsymbol{\delta}'_{B1}+n_B\tau\frac{\left(\frac{1}{1-\theta_B^\star}\boldsymbol{\alpha}_{B1}-\mathbf{e}_{r^\star}\right)'-\left(\frac{\theta_B^\star}{1-\theta_B^\star}\boldsymbol{\alpha}_{B1}+\mathbf{e}_z\right)'\boldsymbol{\Gamma}}{\left(\frac{\theta_B^\star}{1-\theta_B^\star}\right)^2\boldsymbol{\alpha}'_{B1}\Sigma\boldsymbol{\alpha}_{B1}+\sigma_z^2}\right]
\end{aligned}
$$

4.8 Solving the equilibrium

Solving the model involves finding a solution to a system of 24 polynomial equations (12 market-clearing conditions and the expressions from the solution of the optimization problem of generalist investors) in 24 unknowns (5 states and 1 constant times 2 yields and the 2 corresponding demands from generalists). The coefficients $\delta_{C0}, \boldsymbol{\delta}_{C1}, \alpha_{C0}, \boldsymbol{\alpha}_{C1}$ are then derived by additional restrictions. TO BE COMPLETED. NOTE: WE HAVE MULTIPLE SOLUTIONS AS IN GREENWOOD.

4.9 Special case: exogenous and constant supplies

In the special case in which the supplies of asset A and B are exogenous and equal to $\bar{q}_A$ and $\bar{q}_B$, we can compute the coefficients $\boldsymbol{\alpha}_{A1}$ and $\boldsymbol{\alpha}_{B1}$ in closed form by iterating forward the expressions for the yields in equations (40)–(42) and noting that the variances of 1-period excess returns are pinned down by these coefficients. In this case, the expressions for the coefficients are

$$
\begin{aligned}
\alpha_{Ar} &= \frac{1-\theta_A}{1-\rho_{r^\star}\theta_A} && (65)\\
\alpha_{Az} &= \frac{1-\theta_A}{1-\rho_z\theta_A}\rho_z && (66)\\
\alpha_{A\Delta s} &= -\frac{1-\theta_A}{1-\rho_{\Delta s}\theta_A}\rho_{\Delta s} && (67)\\
\alpha_{Br} &= \frac{1-\theta_B^\star}{1-\rho_{r^\star}\theta_B^\star} && (68)\\
\alpha_{Bz} &= \frac{1-\theta_B^\star}{1-\rho_z\theta_B^\star}\rho_z && (69)\\
\alpha_{B\Delta s} &= 0 && (70)\\
\alpha_{Cr} &= \frac{1-\theta_A}{1-\rho_{r^\star}\theta_A} && (71)\\
\alpha_{Cz} &= \frac{1-\theta_A}{1-\rho_z\theta_A}\rho_z && (72)\\
\alpha_{C\Delta s} &= \frac{1-\theta_A}{1-\rho_{\Delta s}\theta_A}\rho_{\Delta s}. && (73)
\end{aligned}
$$

In order to close the mode, we further need to determine the values of the constant terms α_{B0} and α_{C0}. Recall that restriction (43) implies that $\alpha_{A0} = \alpha_{C0} - 2\Delta\bar{s}$. To determine the remaining coefficients we use market- clearing conditions (63)-(64). Contrary to the more general case of time-varying bonds' supplies, when the supplies are constant the the market-clearing conditions collapse to a system of two linear equations with respect to α_{C0} and α_{B0}

$$
\begin{aligned}
\frac{\tau n_A}{\tilde{V}_A}\left(\alpha_{C0} - \bar{r}^\star - \bar{z} - \Delta\bar{s}\right) + (1-n_A-n_B)\delta_{A,0} &= \bar{q}_A && (74)\\
\frac{\tau n_B}{V_B}\left(\alpha_{B0} - \bar{r}^\star - \bar{z}\right) + (1-n_A-n_B)\delta_{B,0} &= \bar{q}_B, && (75)
\end{aligned}
$$

where $\delta_{A,0}$ and $\delta_{B,0}$ are linear functions of α_{C0} and α_{B0}, given by conditions (59)-(60); the variances $\tilde{V}_A = Var_t[rx_{A,t+1}]$, V_A and V_B, as well as the covariance $C_{A,B}$, are predetermined (i.e., in expressions (46), (56), (51) and (58) set $\sigma^2_{q_A} = \sigma^2_{q_A B} \equiv 0$). Therefore, in the special case of constant bond's supplies, we only need to solve a linear system of two equations and two unknowns.

We start our analysis by computing impulse responses to unanticipated shocks to the three relevant state variables. We set the parameters of the model following the assumptions in Greenwood et al. (2016) when possible. Therefore, we choose a large value for the risk tolerance parameter τ and set it equal to 50. Also, in the baseline case we set the shares of specialists $n_A = n_B = 0.45$. The parameters $\theta, \theta^\star$, which are inversely related to the coupon from the long-term perpetuities A and B, to the same value equal to 0.8. All the parameters describing the stochastic process for $r^\star$ and z are the same as in Greenwood et al. (2016). In particular, the short-term risk-free rate is on average equal to 4% per period, and moves slowly over time. The mean default realization is equal to 2%. For the exchange rate growth we set the mean to 0 and pick a low value for the autoregressive coefficient $\rho_e = 0.1$), as influential papers have argued that exchange rates follow a random walk (for example, Meese and Rogoff (1983)). We set the innovation to exchange rate growth to 6.8%, which is the average standard deviation in a large sample of emerging countries. We summarize all the parameters we use to build our impulse responses in table 5.

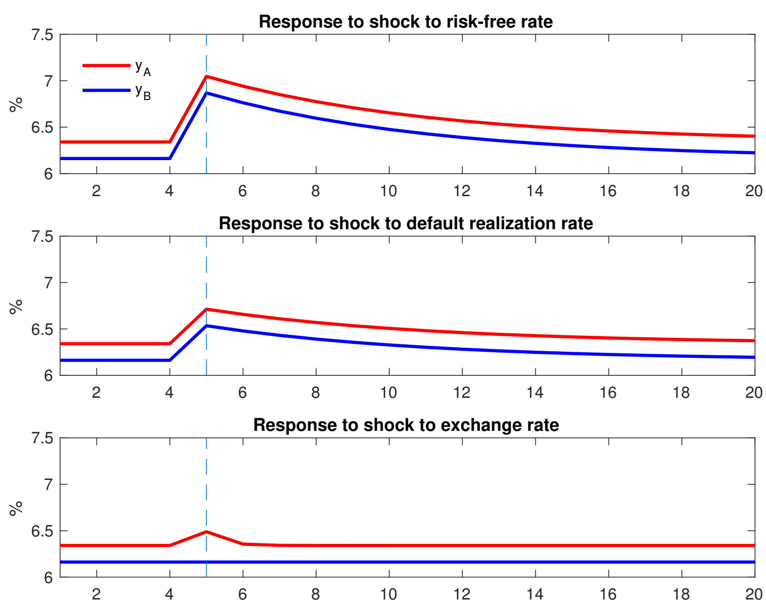
Table 5: Model parameters

Parameter	Value	Source
τ	50	Greenwood et al. 2016
n_A	0.45	Greenwood et al. 2016
n_B	0.45	Greenwood et al. 2016
θ_A	0.80	Greenwood et al. 2016
$\theta^\star_B$	0.80	Greenwood et al. 2016
$\bar{r}^\star$	0.04	Greenwood et al. 2016
$\rho_{r^\star}$	0.85	Greenwood et al. 2016
$\sigma_{r^\star}$	0.01	Greenwood et al. 2016
$\bar{q}_A$	30	
ρ_{q_A}	0.99	Greenwood et al. 2016
σ_{q_A}	0.60	Greenwood et al. 2016
$\bar{q}_B$	30	
ρ_{q_B}	0.99	Greenwood et al. 2016
σ_{q_B}	0.60	Greenwood et al. 2016
$\bar{z}$	0.02	Greenwood et al. 2016
ρ_z	0.85	Greenwood et al. 2016
σ_z	0.01	Greenwood et al. 2016
$\Delta\bar{s}$	0.00	Emerging countries sample
$\rho_{\Delta s}$	0.10	Emerging countries sample
$\sigma_{\Delta s}$	0.07	Emerging countries sample

Notes: This table reports the values of the parameters used in the simulation of the model.

In figure 2 we plot the impulse responses of an unanticipated shock to the risk-free rate (top panel); the default realization (middle panel); and the exchange rate growth (bottom panel). The shock is equal to 1 standard deviation and occurs in period 5. The red (blue) line correspond to the yield on bond A converted in foreign currency (on bond B). The parameters are from table 5, under the special case of constant bond supplies (i.e., $\sigma_{q_A} = \sigma_{q_B} \equiv 0$). The response of asset A and B to shocks to the risk-free rate and the default realization rate is similar: as these unanticipated shocks push bond prices down, yields increase and then slowly revert to their steady state values. On the contrary, shocks to the exchange rate growth affect only the yield on asset A. The intuition is that an unexpected increase in the exchange rate, by reducing the value of the local currency, pushes down the price in foreign currency of the local currency denominated bond and, therefore, increase its yield. Since the persistence of the growth in the exchange rate is small, the effect of the shock on the yield of bond A is short-lived.

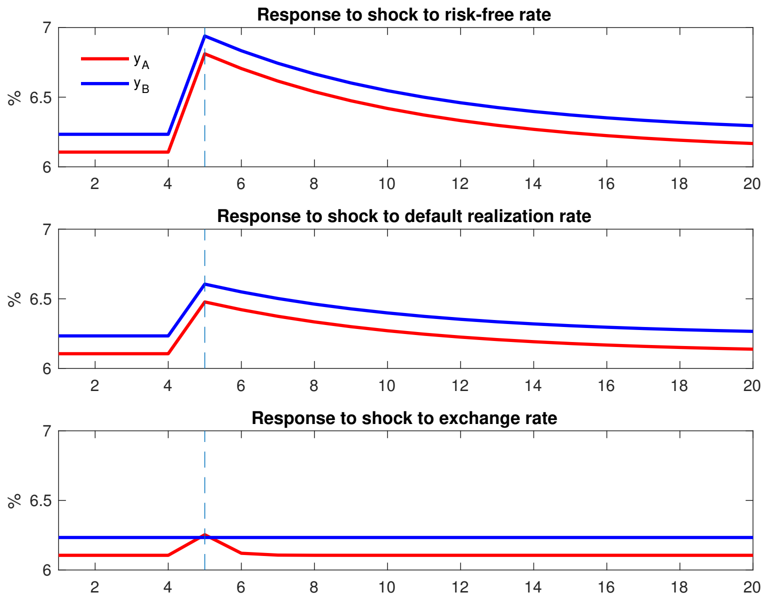
Figure 2: Impulse responses: constant bond supplies



Notes: This figure plots the impulse responses of an unanticipated shock to the risk-free rate (top panel); the default realization (middle panel); and the exchange rate growth (bottom panel). The shock is equal to 1 standard deviation and occurs in period 5. The red (blue) line correspond to the yield on bond A converted in foreign currency (on bond B). The parameters are from table 5, under the special case of constant bond supplies (i.e., $\sigma_{q_A} = \sigma_{q_B} \equiv 0$).

In figure 3 we present results of a simple exercise in which we increase the exogenous share of investors' types. In particular, we reduce the number of specialists in the two markets, and increase the share of generalists. The impulse responses, for the three shocks, show the same patterns discussed for figure 2. However, the steady-state yield values for asset B are now larger than those for asset A. The explanation is related to the fact that, when the share of generalist investor increases, asset B has a higher expected returns. Therefore, the price of B decreases and, correspondingly, its yield increases.

Figure 3: Impulse responses: constant bond supplies (large share of generalists)



Notes: This figure plots the impulse responses of an unanticipated shock to the risk-free rate (top panel); the default realization (middle panel); and the exchange rate growth (bottom panel) when a large share of generalists populates the market. The shock is equal to 1 standard deviation and occurs in period 5. The red (blue) line correspond to the yield on bond A converted in foreign currency (on bond B). The parameters are from table 5, under the special case of constant bond supplies (i.e., $\sigma_{q_A} = \sigma_{q_B} \equiv 0$) and with $n_A = n_B \equiv 0.3$.

4.10 Extensions to the baseline model

- Estimation of the parameters describing the risk-factors.
- Introducing risk-free rate in local currency.
- Endogenize the shares of investors' types, for example introducing different transaction costs or restriction to capital flows.

5 Conclusions

In this paper we show that deviations from the covered interest rate parity conditions between local and foreign currency denominated debt are related to partially segmented markets. The demand for local currency debt from foreign investors is persistent and increases after an improvement in the relative credit rating vis-a-vis foreign currency denominated debt. We propose a simple model of partially segmented markets that replicates the observed empirical regularities.

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Appendix

A Data

In this section of the appendix we present additional information of the data used in this paper. In figure A1, we present several characteristics of the JPM EMBI Global Diversified, JPM CEMBI Broad Diversified, JPM GBI-EM Global Diversified, and JPM ELMI+ indices. With the exception of the CEMBI index, which includes corporate bonds issued by emerging market companies, all the other indices refer to government bonds issued by emerging market sovereigns with different currency of denomination and maturity.

Exhibit 5
Characteristics of the Most Widely Used EMD Indices

	JPM EMBI Global Diversified	JPM CEMBI Broad Diversified	JPM GBI-EM Global Diversified	JPM ELMI+
Asset Class	Hard Currency Sovereign	Hard Currency Corporate	Local Currency Sovereign	Local Currency T-bills
Duration (Years)	7.16	4.84	4.96	0.15
YTM (%)	5.57	5.20	6.34	4.58
Spread (bps)	369	360	N/A	N/A
IG Yield (%)	4.20	4.06	N/A	N/A
IG Spread (%)	218	234	N/A	N/A
HY Yield (%)	8.10	7.88	N/A	N/A
HY Spread (%)	639	648	N/A	N/A
# of Countries	63	49	16	22
# of Issuers	127	549	16	N/A
# of Instruments	470	1166	197	N/A
Market Cap (USD Billions)	675.8	808.7	915.9	N/A
2015 YTD Performance (%)	2.01	2.36	-3.96	-2.41
2014 Performance (%)	7.43	4.96	-5.72	-7.03
Credit Quality (Average)	BBB-	BBB	BBB+	N/A
IG	59.9	65.4	93.4	N/A
HY	40.1	34.6	6.6	N/A
A and above	22.4	27.3	37.9	N/A
BBB	37.5	38.1	55.5	N/A
BB	19.4	16.3	4.9	N/A
B	14.8	9.1	1.7	N/A
CCC and below	2.8	2.8	0.0	N/A
Non Rated	3.1	6.4	0.0	N/A

As of 31 March 2015
Source: Bloomberg, Lazard

Figure A1: In this table, we report several characteristics of the JPM EMBI Global Diversified, JPM CEMBI Broad Diversified, JPM GBI-EM Global Diversified, and JPM ELMI+ indices. The sources are Bloomberg, and Lazard.

In figure A2, we plot the unconditional correlation coefficients, for each country, between monthly returns on the local and foreign currency denominated bond indices. The correlation coefficients are computed, for each country, over the longest common sample available. Therefore, the longest possible sample is for the period 1/2000 – 12/2016. The average correlation of monthly returns, across all the countries and over the whole sample, is approximately 0.5. There exist large differences across countries, with correlation coefficients that go from low values of less than 0.1 for China, to large values of approximately 0.8 for Indonesia and Turkey.

In figure A3 we plot the spread between the yields on the local currency denominated

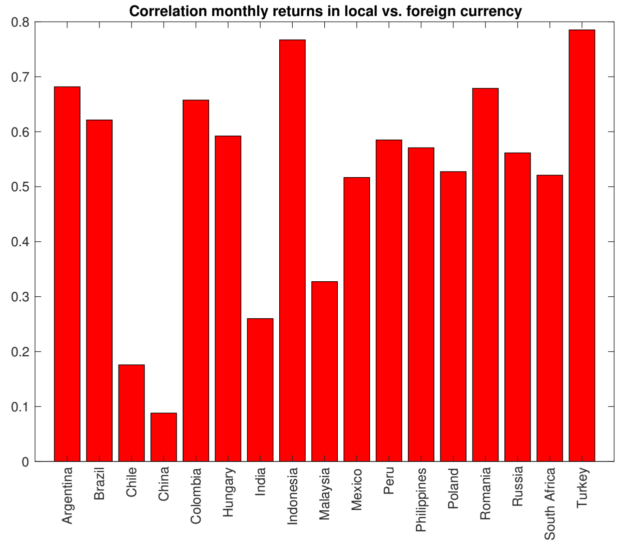


Figure A2: This figure plots, for each country in our sample, the correlation coefficients between monthly returns in local and foreign currency. Data are from J.P. Morgan GBI-Broad for local currency returns, and from J.P. Morgan EMBI for foreign currency returns. The correlation coefficients are estimated on the longest possible available sample for the period 1/2000 – 12/2016.

bond index and the yields on the foreign currency denominated bond index. The shaded areas delimit NBER recession dates. Note how during the Great Recession, the yields spreads, for most countries, dropped after an initial increase. Argentina is a bit of an exception, with the yield on the local currency debt shooting up to almost 50 percent.

B Robusteness checks

In this section, we presents results of the estimation of the panel discussed in section 3 using different level of the shares of local currency debt held by foreigners in the construction of our dummy variable. In particular, table 6 consider a threshold of 5% and table 7 of 20%.

Table 6: Log difference of Total Return vs dummy of SF (5 %)

	(1)	(2)	(3)	(4)	(5)	(6)
	CE	CE & YQE	CE	CE	CE & YQE	CE & YQE
α^r	0.607***	0.713***	0.629***	0.624***	0.277***	0.275***
	(0.0223)	(0.0270)	(0.0236)	(0.0243)	(0.0558)	(0.0560)
α^{fs}	0.162***	0.160***	0.173***	0.161***	0.0529	0.0703
	(0.0320)	(0.0317)	(0.0340)	(0.0365)	(0.0362)	(0.0372)
α^y				-0.265*	-0.352*	-0.315
				(0.115)	(0.139)	(0.181)
SF				0.000260	-0.00876	-0.00520
				(0.00701)	(0.00679)	(0.00994)
OfficialDebt			0.000205	0.0000578	0.000210	
			(0.000520)	(0.000535)	(0.000469)	
MarketDebt			-0.000442	-0.000599	-0.000695	
			(0.000579)	(0.000627)	(0.000564)	
MarketDebt LC			0.000328	0.000398	0.00115	
			(0.000646)	(0.000701)	(0.000629)	
α^{rf}					0.546***	0.545***
					(0.0587)	(0.0590)
SF*fs					0.397**	0.360*
					(0.142)	(0.140)
SF*GDP						-0.0873
						(0.202)
N	730	730	665	625	625	625
r2_o	0.514	0.598	0.516	0.507	0.650	0.671
r2	0.517	0.602	0.533	0.538	0.683	0.681
F_f	1.107	1.133	0.765	1.040	0.957	0.872

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Log difference of Total Return vs dummy of SF (20 %)

	(1) CE	(2) CE & YQE	(3) CE	(4) CE	(5) CE & YQE	(6) CE & YQE
α^r	0.598***	0.710***	0.616***	0.620***	0.739***	0.737***
	(0.0224)	(0.0292)	(0.0238)	(0.0244)	(0.0323)	(0.0321)
α^{fs}	0.204***	0.208***	0.212***	0.204***	0.193***	0.198***
	(0.0323)	(0.0328)	(0.0347)	(0.0353)	(0.0370)	(0.0358)
α^y				-0.341**	-0.418*	-0.399*
				(0.127)	(0.173)	(0.177)
SF				0.00131	0.00129	0.00663
				(0.00518)	(0.00709)	(0.00934)
OfficialDebt			0.000134	-0.0000918	0.000115	
			(0.000578)	(0.000592)	(0.000586)	
MarketDebt			-0.000254	-0.000315	-0.000557	
			(0.000639)	(0.000689)	(0.000693)	
MarketDebt LC			0.000120	-0.0000258	0.000695	
			(0.000713)	(0.000796)	(0.000805)	
α^{rf}					0.0118	0.0118
					(0.0676)	(0.0674)
SF*fs					0.108	0.0747
					(0.273)	(0.265)
SF*GDP						-0.188
						(0.303)
N	731	731	665	623	623	623
r2_o	0.511	0.574	0.515	0.518	0.566	0.578
r2	0.516	0.579	0.528	0.545	0.604	0.604
F_f	1.156	1.097	0.662	0.953	1.060	1.297

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

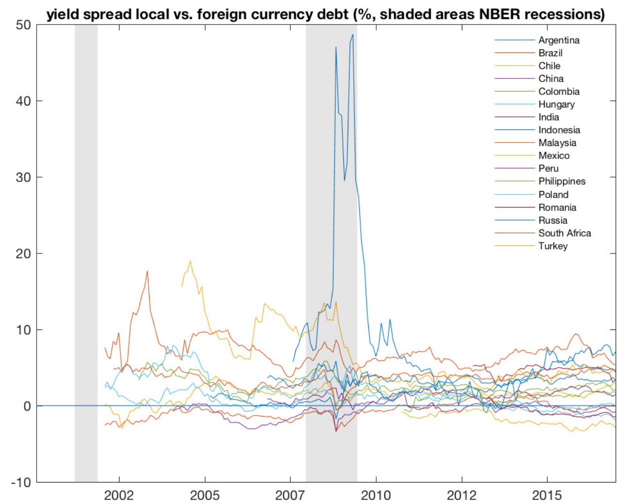
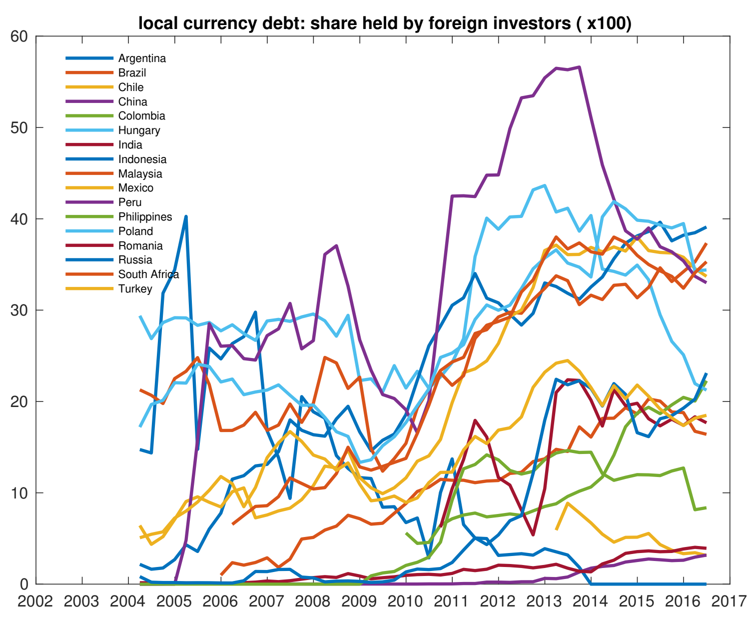


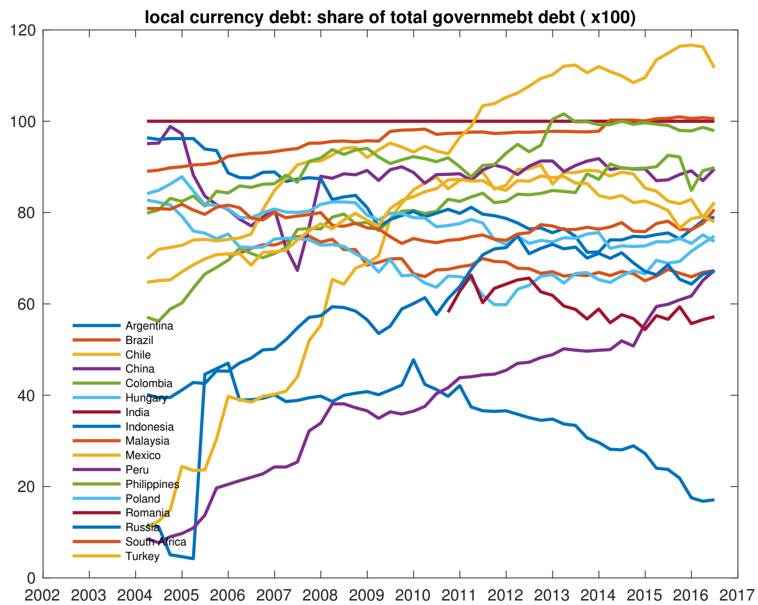
Figure A3: This figure plots the yield spreads between sovereign debt in local vs. foreign currency. Data are from J.P. Morgan GBI-Broad for local currency yields, and from J.P. Morgan EMBI for foreign currency yields. For each country, we use the longest available sample. The longest available sample is for the period 1/2000 – 12/2016.

Figure A4: Share of local currency government debt held by foreigners



Notes: This figure plots the share of local currency government debt held by foreign investors for the following countries: Argentina, Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Perù, Philippines, Poland, Romania, Russia, South Africa, and Turkey. Data are quarterly from Arslanalp and Tsuda (2014) for the period 2002:Q1 – 2016:Q2.

Figure A5: Local currency government debt as a share of total debt



Notes: This figure plots the local currency government debt as a share of total debt for the following countries: Argentina, Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Perù, Philippines, Poland, Romania, Russia, South Africa, and Turkey. Data are quarterly from Arslanalp and Tsuda (2014) for the period 2002:Q1 – 2016:Q2.