Global Risk in Long-Term Sovereign Debt

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Abstract

In this paper we uncover a novel investment strategy on sovereign bonds issued by emerging countries and denominated in local currency. We show that by allocating bonds into portfolios with respect to their comovement with the *Carry* currency risk factor, investors obtain a large cross-section of dollar excess returns. We find that most of these returns represent compensation for aggregate global risk. A standard, no-arbitrage affine model of defaultable long-term bonds in local currency with global and country-specific shocks can replicate these findings if there is sufficient heterogeneity in exposure to global shocks, bond maturities are short enough, and the global component of default risk is sufficiently homogenous across countries.

Keywords: local currency sovereign bonds; currency risk; term premium; default risk
JEL Classification: F31, F34, G15

1 Introduction

In this paper we focus on bonds issued by emerging governments in their own, *local*, currency, henceforth LC-bonds. We take the perspective of foreign U.S. investors. The main risks of investing in LC-bonds are related to currency and credit risk, which depend in turn on global and local factors. In this paper, we show that risk and average excess returns on LC-bonds depend on countries' heterogenous exposure to global factors. In order to do so, we allocate sovereign LC-bonds in portfolios with respect to their exposure to the *Carry* currency factor from Lustig et al. (2011). This strategy produces a large and monotonically increasing cross-section of excess returns and Sharpe ratios. A standard CAPM model explains most of the variability of the returns on these portfolios. We show that a no-arbitrage model of defaultable long-term bonds, with country-specific and global shocks, can match the data if countries differ with respect to their exposure to the global risk factors, bond maturities are short enough, and the global component of default risk is sufficiently homogenous across countries.

Governments can issue debt in their own currency, or in a foreign currency, and they typically do both. By issuing bonds denominated in local currency, governments curb the exposure to exchange rate risk, typical of debt denominated in foreign currency. While governments in developed countries issue most of their debt in their own currency, those in emerging and developing countries have, for a long time, issued most of their debt in foreign currency, mostly the U.S. dollar. This is the so called "original sin" (Eichengreen et al., 2003). However, since at least the beginning of this century, governments in emerging countries increasingly issue bonds denominated in their local currency and the share of this market held by foreign investors has been progressively growing. Understanding returns to speculation in emerging government LC-bonds is important because they are a growing global asset class, as well as a primary form of financing for many emerging market sovereigns. For example, Du and Schreger (2016b) show that the mean share of local currency debt in total external sovereign debt held by nonresidents increased from 10 percent to around 60 percent for a sample of 14 countries over the period 2004–2012. According to data from EMTA (2017), trading volume in emerging markets debt stood at US$1.323 trillion in the third quarter of 2017 and local markets instruments's share of the total was 55 percent.

Our paper has close links with the most recent advances in research in currencies. Lustig et al. (2011) show that the cross-section of currency portfolios sorted by their forward discount can be explained by a "slope" currency risk factor labeled *Carry*, which captures relative exposure to global shocks. We uncover a profitable investment strategy by building portfolios of LC-bonds sorted on the basis of their time-varying exposure to the *Carry* currency risk factor. We take the perspective of a U.S. foreign investor buying LC-bonds without hedging her currency exposure. This investor, at time t, borrows U.S. dollars to purchase the local currency of the sovereign issuer to buy one unit of the LC-bond. At time $t+1$, the investor sells the LC-bond and converts back the local currency into U.S. dollars. This investor is exposed to several sources of risk: first, if the U.S. dollar appreciates against the local currency, then the value of the investment in dollars drops; second, shocks that increase future interest rates will cause the local currency price of long-term bonds to drop; third, the sovereign might default[1]. We consider a sample of 17 emerging countries included in the J.P. Morgan GBI-EM Broad indices of local currency sovereign bonds for the period 4/2002–10/2017 and build five portfolios by allocating countries with respect to their exposure to the *Carry* risk factor with a monthly rebalancing. This strategy produces a large and monotonically increasing cross-section of excess returns and Sharpe ratios. The spread in excess returns between the last and first portfolio is about 750 basis points *per annum* with a Sharpe ratio of 0.56, larger than the Sharpe ratio on the U.S. equity market. The last portfolio contains the bonds with the highest exposure to *Carry*, while the first portfolio those with the smallest exposure. We find that the cross-section of excess returns represents compensation for global risk. A standard one-factor capital asset pricing model (CAPM) explains more than 90 percent of the variability of the portfolios returns.

Building on our empirical findings, we build a no-arbitrage affine model of defaultable long-maturity bonds denominated in local currency. Heterogeneity in exposure to country-specific risk cannot explain the cross-section of bond returns, as investors' portfolio are well diversified, and any country-specific risk is averaged out. On the contrary, heterogeneity in exposure to common risk can explain the cross section of bond returns we observe in the data. First, if bonds are default risk-free and short-term, as in Lustig et al. (2011), bonds and currency returns are the same. If the precautionary effect of global volatility is strong, then countries with higher exposure to global shocks, relative to the U.S., have currencies that tend to depreciate with respect to the U.S. dollar after a positive global shock and appreciate after a negative global shock. Therefore, from the perspective of U.S. investors, LC-bonds from these countries are less risky because, on average, offer high dollar payoffs in bad times and low dollar payoffs in good times. Second, if bonds are default risk-free but have long maturity, then we uncover an interesting novel *trade-off*. We find that, if the precautionary effect of global volatility is strong, then the "term premium" in local currency,

[1] Investors in LC-bonds face also additional sources of risks: e.g., inflation risk; currency convertibility risk; changes in taxation and regulation; liquidity risk. Note that as the typical maturity of LC-bonds extends beyond time $t+1$, any shock at time $t+1$ affecting the final value of the bond at a later date $t' > t+1$ will be reflected in the market price at time $t+1$. For example, *ceteris paribus*, an unexpected increase in the perceived likelihood of a future default will immediately lower the market bond price.

i.e., the spread in returns between a long- and a short-term bond expressed in local currency, increases for all countries after a positive global shock, with the size of the change larger for countries that are more exposed to the global shock. Therefore, the payoffs in local currency are riskier for countries with a higher exposure to global shocks because they are relatively higher in good times and lower in bad times. Third, if bonds are also subject to default risk, we find that if countries with higher exposure to global shocks have also higher default probabilities conditional on the global shocks, then the local currency bond payoffs are risky because they are relatively higher in good times and lower in bad times. Therefore, when bonds are defaultable and long-term, these novel two effects counter currency risk which, in the data, prevails. Therefore, for the model to match the data, the bond maturity must be sufficiently short and the global component to default risk sufficiently homogenous across countries. We calibrate the model to match several empirical moments, including default probabilities and bond maturities, and show that it reproduces the cross-section of excess returns uncovered in the data.

This paper contributes to several strands of the literature. First, our paper contributes to the large literature on sovereign risk. Reinhart and Rogoff (2011a) look at sovereign defaults on domestic and international markets over the last two centuries. Most of the theoretical and empirical literature has been focused on foreign currency bonds and on a more recent sample (Aguiar et al., 2016). Borri and Verdelhan (2011) find that a large fraction of the excess returns on FC-bonds issued by emerging countries represents compensation for aggregate U.S. market risk. Longstaff et al. (2011) and Ang and Longstaff (2013) study the relative importance of global and local factors in sovereign risk for emerging and developed countries. A growing recent literature, motivated by the increasing size of the local currency debt market (Burger and Warnock, 2007; Burger et al., 2012), looks at local currency bonds. Du and Schreger (2016a) study credit risk on LC-bonds by creating a synthetic local currency risk-free rate using currency swaps in order to hedge currency risk. Even though sovereigns can always print more money, they show that credit risk spreads on LC-bonds are sizable but on average smaller than on bonds denominated in foreign currency, and less correlated across countries, and with global risk factors. In this paper, we focus instead on *unhedged* bond returns. This is relevant as a U.S. investor buying LC-bonds cannot perfectly hedge her currency exposure because the time $t+1$ value, in local currency, of her investment is unknown and the price volatility of LC-bonds tends to be large. In addition, forward contracts for some of the currencies of the countries in our sample might be expensive, not very liquid, and not available for the investor's desired maturity. Second, our paper contributes to the large literature on currency risk. Lustig et al. (2011) find that excess returns from carry trade strategy in the currency market are explained by one single "slope" risk factor, *Carry* related to global equity market volatility. Verdelhan (2014) shows that the *Carry* factor, together with a level factor, *Dollar*, accounts for a large share of the variation in bilateral exchange rates. Farhi et al. (2009) find that disaster risk accounts for more than a third of currency risk premia in advanced countries. Lettau et al. (2014) find that excess returns on currency, equity, commodities, and sovereign bond portfolios are explained by a conditional downside-risk CAPM. Finally, our empirical results are useful for the recent theoretical work on local currency sovereign risk, including Araujo et al. (2013), Corsetti and Dedola (2013), Da-Rocha et al. (2013), Aguiar et al. (2014).

The rest of the paper is organized as follows: section 2 begins by describing the data, the method used to build the bond portfolios, and the main characteristics of these portfolios. Section 3 shows that a simple CAPM model explains most of the cross-sectional variation in bond excess returns. Section 4 considers several extensions. In section 5, we use a no-arbitrage affine model of defaultable long-term bonds with global and local shocks to interpret these findings. Section 6 presents our conclusions.

2 Bond portfolios

We take the perspective of foreign investors buying government bonds issued by emerging countries and denominated in local currency (henceforth LC-bonds). We uncover a profitable investment strategy based on time-varying correlations with the *Carry* "slope" currency risk factor from Lustig et al. (2011) with Sharpe ratios comparable, if not higher, to the ones measured in equity markets in developed countries.

2.1 Building bond portfolios

Local currency bond portfolios We use s to denote the log of the spot exchange rate in units of local currency per U.S. dollar, and p for the log of the price of the local currency government bond price. An increase in s denotes an appreciation of the U.S. dollar. We take U.S. investors to be the representative investors and assume they can borrow one dollar today at the gross dollar risk-free rate R^f. We denote with rx^i_{t+1} the log excess returns of the following strategy: at time t, investors borrow U.S. dollar at the risk-free rate to buy one unit of the local currency bond; at time $t+1$, investors sell the local currency bond and convert its value back to the U.S. dollar. Formally, these dollar log returns are

$$rx^i_{t+1} = \Delta p^i_{t+1} - \Delta s^i_{t+1} - r^f_t, \tag{1}$$

where i denotes the sovereign issuing the bond, with $i = 1, ..., I$. Note that the excess returns rx^i_{t+1} are *unhedged*, in the sense that exchange rate risk is not hedged. Therefore, if the local currency depreciates with respect to the U.S. dollar at $t+1$, the investment value expressed in U.S. dollar decrease. Du and Schreger (2016a) show how to build a synthetic local currency risk-free asset and consider *hedged* excess returns. However, they observe that the hedge is not perfect, as investors cannot fully insure against exchange rate risk using cross-country currency swaps because they do not know with certainty the value of the bond price index at $t+1$.

Currency risk factors We consider the currency risk factors uncovered by Lustig et al. (2011); Verdelhan (2014); Lustig et al. (2014)[2]. In particular, we first express the excess returns for investing in the currency of country i as the returns on the following strategy: the U.S. investor buys currency i in the forward market and then sells it in the spot market after one month:

$$rx^{fx,i}_{t+1} = f^i_t - s^i_{t+1}$$

This excess return can also be stated as the log forward discount minus the change in the spot rate

$$rx^{fx,i}_{t+1} = f^i_t - s^i_t - \Delta s^i_{t+1}$$

In normal conditions, forward rates satisfy the covered interest parity condition and the forward discount is equal to the interest rate differential $f^i_t - s^i_t \approx r^i_t - r_t$, where r^i and r denote the country i and U.S. nominal risk-free interest rates over the maturity of the contract[3]. Lustig et al. (2011) show that the systematic components of currency excess returns are driven by two risk factors: *Carry* and *Dollar*. The *Carry* factor is the excess returns of a strategy that invests in high- and borrows in low-interest rate currencies

$$Carry_{t+1} = \frac{1}{N_H}\sum_{i\in H} rx^{fx,i}_{t+1} - \frac{1}{N_L}\sum_{i\in L} rx^{fx,i}_{t+1}$$

where N_H (N_L) denotes the number of high (low) interest rate currencies in the sample.

The *Dollar* risk factor is the average of all currencies excess returns defined in US dollars

$$Dollar_{t+1} = \frac{1}{N}\sum_{i} rx^{fx,i}_{t+1}$$

[2]Additional relevant work in this literature include Lustig and Verdelhan (2007), Menkhoff et al. (2012), Gabaix and Maggiori (2015).

[3]See Du et al. (2017) for an analysis of large deviations form the covered interest rate parity. Akram et al. (2008) argue that the covered interest rate parity holds at daily and lower frequencies.

where N denotes the number of currencies in the sample. In order to estimate the *Carry* and *Dollar* risk factors, we follow Lustig et al. (2011) and at the end of every month t we sort countries on the basis of their forward discount $f_t - s_t$. We then form six portfolios and compute the excess returns $rx_{t+1}^{fx,j}$ as the average of the excess returns in portfolio j. We estimate the risk factors in a large sample of advanced and developing countries[4]. *Dollar* is then constructed, for each month t, as the cross-sectional mean across the six portfolios, while *Carry* as the difference between the excess returns in the last and first portfolios.

Data First, we collect daily frequency total return indices of local currency denominated bonds issued by emerging governments from J.P. Morgan through Datastream. In particular, we use the J.P. Morgan GBI-EM Broad indices for local currency denominated debt. The JPM GBI-EM Broad indices track local currency bonds issued by emerging market governments and are based on local currency, and not U.S. dollar, values, and include individual bonds that meet specified criteria in terms of liquidity and reliability of market prices. 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 longest sample is 31/12/2002–31/10/2017, but the size of the cross-section progressively increases as more countries enter the indices. In particular, there are 7 countries at the beginning of the sample and 16 at the end. We build daily returns as log differences in the total return price indices. We drop Argentina from 1/6/2011 to 27/2/2017 because the price index is flat for the whole time period. J.P. Morgan also publishes two additional families of emerging market government bond indices. The classic EMBI indices, formed in the early 1990s after the issuance of the first Brady bonds, collect foreign currency denominated debt (mostly U.S. dollar denominated). The ELMI+ indices also collect local currency denominated debt, but collects money market instruments and therefore have a very short duration (on average, 0.15 years against the average maturity of 5 years at the end of 2015 for the bonds included in the J.P. Morgan GBI-EM Broad indices). In this paper, we focus exclusively on the J.P. Morgan GBI-EM Borad local currency denominated bond indices. We additionally collect spot and one month forward exchange rate data with respect to the U.S. dollar from Reuters and Barclays through Datastream (exchange rates are in units of

[4]In order to build *Carry* and *Dollar* we use the same sample of advanced and developed countries in Lustig et al. (2011) for the period 12/1983-10/2017. The countries in the sample are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Japan, Italy, Malaysia, Mexico, Netherlands. New Zealand, Norway, the Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom, Korea, and Kuwait. Starting with January, 1999 countries that adopted the Euro are dropped and replaced with the common currency. The appendix contains additional details on the construction of *Dollar* and *Carry*.

foreign currency per U.S. dollar) for a large set of advanced and developed countries. We use exchange rate data to build the *Carry* and *Dollar* factor uncovered by Lustig et al. (2011). Finally, we consider the return on the 3-month U.S. T-bill as our risk-free rate. In the separate appendix we provide details on the construction of these two factors.

Portfolios At the end of each period t, we allocate all bonds in the sample to five portfolios on the basis of their *Carry* betas (β^i_{Carry}), defined as the slope coefficient in a regression of local bond excess returns on the *Carry* currency factor:

$$rx^i_{t+1} = \alpha^i + \beta^i_{Carry} Carry_{t+1} + \epsilon_{t+1}$$

We compute the betas on a 24-month rolling window ending at period $t-1$ to obtain time-series of $\beta^i_{Carry,t}$. Note that in the estimation of $\beta^i_{Carry,t}$ we use only information available at time t. Portfolios are rebalanced at the end of every month. They are ranked from low to high *Carry* betas; portfolio 1 contains bonds with returns with the lowest comovement with *Carry* and portfolio 5 contains bonds with returns with the highest comovement with *Carry*. We compute the log bond excess returns rx^j_{t+1} for portfolio j by taking the average of the log bond excess returns in each portfolio j. The total number of bonds in our portfolios varies over time. We have a total of 7 countries at the beginning of the sample in 6/2003 and 16 at the end in 10/2017. The maximum number of bonds attained during the sample is 16[5].

2.2 Returns to Bond Speculation for a US investor

Figure 1 offers a quick snapshot of our five portfolios obtained by sorting countries on their *Carry*-betas. Excess returns increase monotonically across the five portfolios, from 180 basis point *per annum* to almost 940 basis points on the last portfolio. Even though the standard deviation of excess returns also increase across the portfolios, Sharpe ratios increase monotonically from 0.18 on the first portfolio to 0.61 on the last. Table 1 provides a detailed overview of the additional properties of the five bond portfolios from the perspective of a US investor. For each portfolio j, we report the average of the log dollar bond excess returns $rx^j_{t+1} = \Delta p^i_{t+1} - \Delta s^i_{t+1} - r^f_t$, the log changes in the spot rate Δs^j, the forward discount $f^j - s^j$, the log changes in the local currency bond price Δp^i_{t+1}, and the high-minus-low excess returns from a strategy that goes long portfolio $j = 2, \ldots, 5$ and short the first portfolio. All exchange rates and returns are reported in US dollars and the moments of returns are

[5] In case of missing values, we estimate *Carry* betas when we have a minimum of 14 observations in the rolling window. The sample of portfolio returns starts after 31/12/2002 because of the data required for the rolling window estimation.

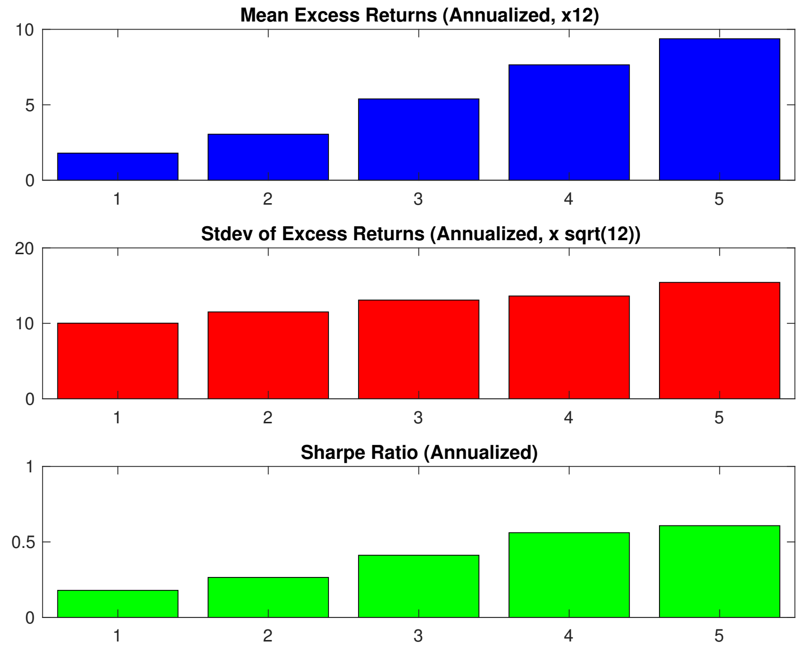
annualized: we multiply the mean of the monthly data by 12 and the standard deviation by $\sqrt{12}$. The Sharpe ratio is the ratio of the annualized mean to the annualized standard deviation. Finally, we report the averages for the pre-formation and post-formation β^j. We have already discussed the monotonic cross-section in excess returns and Sharpe ratios. We now discuss additional interesting moments of our baskets of bonds reported in the additional panels of table 1. First, sorting countries on their $Carry$-betas is not equivalent to sorting them on the basis of their forward discount, which is a proxy for the short-term interest rate differential. In fact, we do not observe any clear pattern for the average forward discount on the five portfolios. Second, for all five portfolios, the average log changes in the spot rate are positive denoting that, on average, U.S. foreign investors exchange back local currency bonds for a lower dollar value. This is not surprising because, in the sample of analysis, the U.S. dollar appreciated with respect to most of the emerging countries' currencies. Third, returns in local currency (Δp^j_{t+1}) are always positive and increase monotonically from approximately 400 basis points *per annum* for portfolio 1 to 1100 basis points *per annum* for portfolio 5. Fourth, the fifth panel shows the high-minus-low returns, i.e., the excess returns of going long portfolios $j = 2, \ldots, 5$ and short the first. Excess returns go from 125 basis to 750 basis points *per annum*, and Sharpe ratios from 0.11 to 0.56. Fifth, post-formation betas vary from 0.05 on the first portfolio to 0.71 on the last portfolio. Finally, the last panel reports the frequency of bond portfolio switches. We define the average frequency as the time-average of the following ratio: the number of portfolio switches divided by the total number of currencies in each date. The average frequency is 22 percent, and equal to 15 and 9 percent in the first and last portfolio respectively. In section B of the appendix we provide additional information on the five bond portfolios sorted on the basis of their $Carry$-betas. In particular, we show that portfolios have similar average credit ratings, include bonds with similar shares held by foreign investors, and include countries with similar debt-to-GDP ratios.

We have documented that a US investor with access to government bonds denominated in local currency can generate large returns with annualized Sharpe ratios that are comparable to those in the US stock market. In the next section we show that a single factor CAPM model explains a large fraction of the variation in these excess returns.

3 Common Factors in Local Currency Bond Returns

This section shows that the large bond excess returns described in the previous section are matched by covariances with a single risk factor: the excess returns on the U.S. stock market. A standard CAPM model explains most of the variation on bond excess returns.

Figure 1: Five Bond Portfolios



Notes: This figure presents means, standard deviations (in percentages), and Sharpe ratios of bond excess returns on five monthly rebalanced bond portfolios for a US investor. The data are monthly for the period 6/2003–10/2017 from Barclays, Reuters and J.P. Morgan through Datastream. These portfolios are constructed by sorting bonds into five groups at time t based on their OLS slope coefficients β^j. Each β^j is obtained by regressing bond i excess returns rx^i on $Carry$ on a 24-month period moving window that ends in period t-1. The first portfolio contains bonds with the lowest βs. The last portfolio contains bonds with the highest βs.

3.1 Methodology

Linear factor models predict that average returns on a cross-section of assets can be attributed to risk premia associated with their exposure to a small number of risk factors. In the arbitrage pricing theory (APT) of Ross (1976), these factors capture common variation in individual asset returns. A principal component analysis on our bond portfolios reveals that two factors explain more than 87 of the variation in returns on these five portfolios, and that the first principal component accounts for approximately 70 percent of the total variance. Table 2 reports the loadings of our bond portfolios on each of the principal components as well as the fraction of the total variance of portfolio returns attributed to each principal component. The loadings on the first principal component increase monotonically across the five portfolios. Therefore, we interpret the first principal component as a "slope" factor. Motivated by the principal component analysis, we construct a standard CAPM model with one risk factor: the excess returns on a broad U.S. market index (Mkt). In particular, we use the log total excess returns on the S&P500 Composite index. In section 4.1 we show that alternative risk factors, like the $Carry$ currency factor itself, are also able

Table 1: Bond portfolios: US investor

Portfolio	1	2	3	4	5
			Bond excess returns: rx^j_{t+1}		
Mean	1.80	3.05	5.39	7.65	9.38
Std	10.03	11.52	13.09	13.63	15.43
SR	0.18	0.26	0.41	0.56	0.61
			Spot change: Δs^j		
Mean	2.24	0.75	3.46	1.66	1.83
Std	10.03	11.52	10.15	10.64	10.48
			Forward discount: $f^j - s^j$		
Mean	6.99	8.09	6.24	6.99	5.69
Std	4.54	4.62	3.45	2.88	1.52
			Bond price change: Δp^j_{t+1}		
Mean	4.04	3.80	8.85	9.31	11.21
Std	4.64	4.57	5.11	4.90	6.80
			High minus low: $rx^j_{t+1} - rx^1_{t+1}$		
Mean		1.25	3.59	5.85	7.58
Std		12.00	12.24	12.28	13.62
SR		0.11	0.29	0.48	0.56
			Pre-formation: β^j		
Mean	-0.08	0.23	0.49	0.76	1.45
Std	0.27	0.36	0.04	0.44	0.04
			Post-formation: β^j		
Mean	0.05	0.22	0.37	0.31	0.71
s.e.	[0.09]	[0.10]	[0.10]	[0.10]	[0.10]
			Frequency		
Trades/bond	15.60	27.23	32.56	28.20	8.56

Notes: This table reports, for each portfolio j, the mean and standard deviation for the average log excess return rx^j, the average change in the log spot exchange rate Δs^j, the average forward discount $f^j - s^j$, the average change in the log bond price in local currency, and the average spread return between portfolios $j = 2, \ldots, 5$ and portfolio 1. All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting bonds into five groups at time t based on slope coefficients β^j. Each β^j is obtained by regressing bond i excess returns rx^i on *Carry* on a 24-month period moving window that ends in period t-1. The first portfolio contains bonds with the lowest βs. The last portfolio contains bonds with the highest βs. We report the average pre- and post-formation beta for each portfolio. Post-formation betas are obtained by regressing realized log excess returns on portfolio j on *Carry* and *Dollar*. We only report *Carry* betas. The standard errors are reported in brackets. The last panel reports the turnover, expressed as average number of trades per bond in each portfolio. Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 6/2003–10/2017.

to explain the cross section of excess returns. In addition, we show that a conditional CAPM could be also used to price the cross-section of excess returns. Specifically, we use the DR-CAPM model of Lettau et al. (2014), which extends the CAPM model to include a second risk-factor, which captures downside risk, or a concern for bad equity market returns. In the separate appendix, we also show results of a conditional estimation using managed portfolios as described in Cochrane (2009). However, our preferred specification is the standard single factor CAPM as the relatively short length of the sample means that it is hard to estimate downside risk.

3.2 Results

Table 2: Bond portfolios: Principal Components

Portfolio	1	2	3	4	5
1	0.27	-0.01	0.02	-0.95	-0.16
2	0.34	-0.81	-0.05	0.18	-0.44
3	0.46	0.10	-0.83	0.07	0.30
4	0.50	-0.18	0.50	0.04	0.68
5	0.59	0.55	0.24	0.24	-0.49
% Var.	67.19	10.04	8.45	7.90	6.42

Notes: This table reports the principal component coefficients of the bond portfolios presented in Table 1. The last row reports (in %) the share of the total variance explained by each common factor. Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 6/2003–10/2017.

Cross-sectional Asset Pricing We use Rx^j_{t+1} to denote the average excess return in levels on portfolio j in period $t+1$. All asset pricing tests are run on excess returns in levels, not log excess returns, to avoid having to assume joint log-normality of returns and the pricing kernel. In the absence of arbitrage opportunities, this excess return has a zero price and satisfies the following Euler equation

$$E_t\left[M_{t+1}Rx^j_{t+1}\right] = 0$$

We assume that the stochastic factor M is linear in the pricing factors Φ:

$$M_{t+1} = 1 - b\left(\Phi_{t+1} - \mu_\Phi\right),$$

where b is the vector of factor loadings and μ_Φ denotes the factor means. This linear factor model implies a beta pricing model: the expected excess return is equal to the factor price λ times the beta of each portfolio β^j

$$E\left[Rx^j\right] = \lambda'\beta^j$$

where

$$\lambda = \sum_{\Phi\Phi} b$$

and $\Sigma_{\Phi\Phi}$ is the variance-covariance matrix of the factor

$$\Sigma_{\Phi\Phi} = E\left(\Phi_t - \mu_\phi\right)\left(\Phi_t - \mu_\Phi\right)'$$

and β^j denotes the regression coefficients of the return Rx^j on the factors. To estimate the factor prices λ and the portfolio betas β, we use two different procedures: a Generalized Method of Moments estimation (GMM) applied to linear factor models, following Hansen (1982), and a two-state OLS estimation following Fama and MacBeth (1973), henceforth FMB. In the first step, we run a time series regression of returns on the factors. In the second step, we run a cross-sectional regression of average returns on the betas. We do not include a constant in the second step ($\lambda_0 = 0$) and therefore assume that assets with a beta equal to zero must offer zero excess returns.

3.3 Results

Table 3 reports the asset pricing results obtained using GMM and FMB on bond portfolios sorted on $Carry$-betas.

Cross-sectional regressions The top panel of the table reports estimates of the market prices of risk λ and the factor loadings b, the adjusted R^2, the square-root of mean-squared errors $RMSE$ and the p-value of χ^2 tests (in percentage points). The market price of risk of the U.S. stock market (Mkt) is 1294 basis points *per annum*. This means that an asset with a beta of one earns a risk premium of 12.94 percent *per annum*. Since the factors are returns, no arbitrage implies that the risk price of the factor should equal its average excess return. The average excess return of Mkt is 887 basis points, with a standard error of 399 basis points. Therefore, in our estimation, this no-arbitrage condition is satisfied even though our point estimate is well above the sample mean of the U.S. stock market excess returns. The GMM standard error is 687 basis points. The FMB standard error is 579 basis points. Therefore, the risk price is approximately two standard errors from zero and thus statistically significant. The loading b has a natural interpretation as the regression coefficient in a regression of the stochastic discount factor on the single factor. The t-stat on b_{Mkt} shows that the Mkt risk factor helps to explain the cross-section of bond returns in a statistically significant way. Overall, the pricing errors are small. The $RMSE$ is just 66 basis points and the adjusted R^2 is approximately 90 percent. The null that the pricing errors are zero cannot be rejected, regardless of the estimation procedure: all the p-values (reported in percentage points in the column labeled χ^2) exceed 5 percent.

Time Series Regressions The bottom panel of Table 3 reports the intercepts (denoted α^j) and the slope coefficients (denoted β^j) obtained by running time-series regressions of each portfolio's excess returns Rx^j on a constant and the Mkt risk factor. The returns and α's are in percentage points *per annum*. The first column reports α's estimates. The point estimates are small and never significant. The null that the αs are jointly zero cannot be rejected at standard significance levels. The second column of the same panel reports the estimated βs for the Mkt factor. These βs increase monotonically from 0.18 for the first portfolio to 0.66 for the last bond portfolio. Therefore, a natural interpretation of our results is that portfolios with higher comovement with Mkt are riskier exactly because, on average, have high returns in good times, when Mkt excess returns are large, and low returns in bad times, when Mkt excess returns are small. Figure 2 plots realized average portfolios excess returns on the vertical axis against predicted average excess returns on the horizontal axis together with the 45 degree line. The model is very successful at explaining the cross-section of portfolios excess returns as all portfolios line up very closely to the 45 degree line.

4 Robusteness

In this section, we consider several extensions. First, we use directly $Carry$ as single risk-factor. Second, we test the performance of the DR-CAPM model of Lettau et al. (2014) on our five portfolios.

4.1 Other factors

In this section we show that alternative risk factors are also able to explain the cross-section of excess returns on our five portfolios. In particular, we consider the excess returns from a currency carry-trade strategy, i.e., the $Carry$ currency risk factor.

Carry currency risk factor In the top panel of table 4, we present the estimates of the market price of risk and factor loading. The market price of $Carry$ is equal to 892 basis points and significant at standard confidence levels. We cannot reject the null that the estimate for λ_{Carry} is equal to the sample mean of the risk factor so that the no arbitrage condition is satisfied. The adjusted R-square is approximately 80 percent and the mean pricing error is 102 basis points. The null that all pricing errors are zero cannot be rejected.

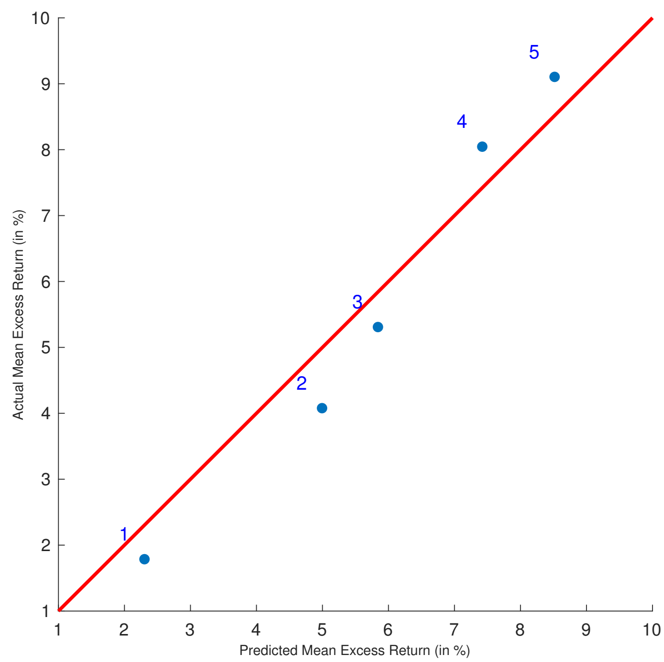
Table 3: Asset Pricing: US investor

	Panel I: Risk Prices				
	λ_{Mkt}	b_{Mkt}	R^2	$RMSE$	$\chi^2(\%)$
GMM_1	12.94	0.60	93.84	0.66	1.02
	[7.71]	[0.36]			97.20
GMM_2	14.73	0.68	83.38	1.08	
	[6.87]	[0.32]			97.84
FMB	12.94	0.59	92.38	0.66	
	[5.79]	[0.27]			97.87
	(5.92)	(0.27)			98.15
Mean	**8.87**				
s.e.	[3.99]				
	Panel II: Factor Betas				
Portfolio	α_0^j	β_{Mkt}^j	R^2	$\chi^2(\alpha)$	p-value (%)
1	0.02	0.18	5.76		
	[0.29]	[0.04]			
2	−0.03	0.38	20.11		
	[0.23]	[0.06]			
3	0.11	0.45	21.58		
	[0.28]	[0.09]			
4	0.21	0.57	31.97		
	[0.26]	[0.08]			
5	0.29	0.66	32.97		
	[0.28]	[0.09]			
All				1.83	87.18

Notes: Panel I reports results from GMM and Fama and MacBeth (1973) asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of the mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1986) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey and West (1986) variance-covariance matrix (1 lag) for the system of equations (see Cochrane (2009)). Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 6/2003–10/2017. The alphas are annualized and in percentage points.

The bottom panel of table 4 shows the pricing errors alphas are small and never significant. The estimates for the β^j_{Carry} provide the intuition for our results: the exposure of portfolios to $Carry$ increase monotonically. Therefore, the last (first) portfolio, on average, has low (high) returns when the excess returns of the currency carry-trade strategy are low. Figure 3 confirms that the model prices very accurately all portfolios with the exception of the fourth one.

Figure 2: Predicted vs. Realized Average Excess Returns



Notes: This figure plots realized average bond excess returns on the vertical axis against predicted average excess returns on the horizontal axis. We regress actual excess returns on a constant and the Mkt risk factor to obtain slope coefficients β^j. Mkt is the excess returns on the S&P 500 Total Return Index. Each predicted excess return is obtained using the OLS estimate β^j times the sample mean of the risk factor. Portfolios are built using $Carry$ betas. All returns are annualized. Data are monthly. The sample period is 6/2003–10/2017.

DR-CAPM Lettau et al. (2014) show that a downside risk capital asset pricing model (DR-CAPM) can price the cross-section of currency returns sorted on the forward discount, as well as the cross-section of equity, commodity and foreign currency sovereign bonds. The model is simply

$$E[Rx^j] = \beta_j \lambda + (\beta_j^- - \beta_j)\lambda^-$$

where

$$\beta_j = \frac{cov(Rx^j, Rx^m)}{var(Rx^m)}, \quad \beta_j^- = \frac{cov(Rx^j, Rx^m | Rx^m < \delta)}{var(Rx^m | Rx^m < \delta)}$$

and Rx^m denotes the stock market excess returns, Rx^j the excess returns on asset j, β_j and β_j^- the unconditional and downside beta defined by the exogenous threshold δ. This model reduces to the CAPM in the absence of differential pricing of downside risk from unconditional market risk ($\lambda^- = 0$), or if the downside beta equals the CAPM beta ($\beta_j^- = \beta_j$). We estimate the model with the two stage FMB procedure. In the first stage, for

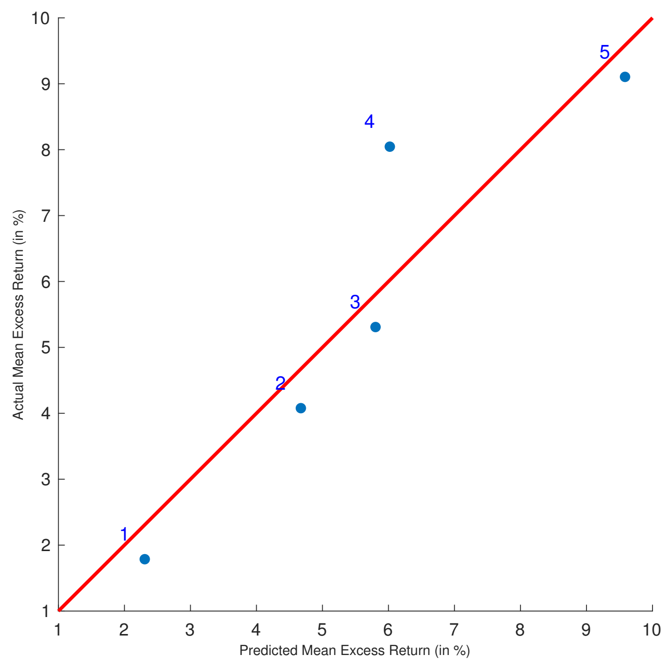
Table 4: Asset Pricing: US investor (Alternative Risk Factor)

	Panel I: Risk Prices				
	λ_{Carry}	b_{Carry}	R^2	$RMSE$	$\chi^2(\%)$
GMM_1	8.92	1.38	85.12	1.02	
	[5.81]	[0.90]			92.52
GMM_2	8.64	1.33	84.55	1.04	
	[4.84]	[0.75]			92.57
FMB	8.93	1.37	80.29	1.02	
	[4.00]	[0.61]			87.07
	(4.18)	(0.64)			89.28
Mean	**7.10**				
s.e.	[2.15]				
	Panel II: Factor Betas				
Portfolio	α_0^j	β_{Carry}^j	R^2	$\chi^2(\alpha)$	p-value (%)
1	−0.00	0.26	3.64		
	[0.28]	[0.10]			
2	−0.02	0.47	8.94		
	[0.26]	[0.14]			
3	0.07	0.65	13.46		
	[0.35]	[0.22]			
4	0.25	0.65	12.38		
	[0.31]	[0.17]			
5	0.14	1.08	26.68		
	[0.34]	[0.21]			
All				1.09	95.50

Notes: Panel I reports results from GMM and Fama and MacBeth (1973) asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of the mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1986) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey and West (1986) variance-covariance matrix (1 lag) for the system of equations (see Cochrane (2009)). Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 6/2003–10/2017. The alphas are annualized and in percentage points.

each portfolio, we run two separate time-series regressions to estimate β_j and β_j^-, by setting $\delta = E(Rx^m) - \sigma(Rx^m)$, where $E(Rx^m)$ and $\sigma(Rx^m)$ are, respectively, the sample mean and standard deviation of market excess returns. The left panel of figure 4 shows the increase in CAPM betas going from the low to high currency risk portfolio. Lettau et al. (2014) find, for different test assets, that while CAPM betas increase going to low to high risk portfolios, their cross-section is not wide enough to explain the cross-section of excess returns. On the contrary, on our test assets, we observe large differences in the CAPM

Figure 3: Predicted vs. Realized Average Excess Returns (Alternative Risk Factor)



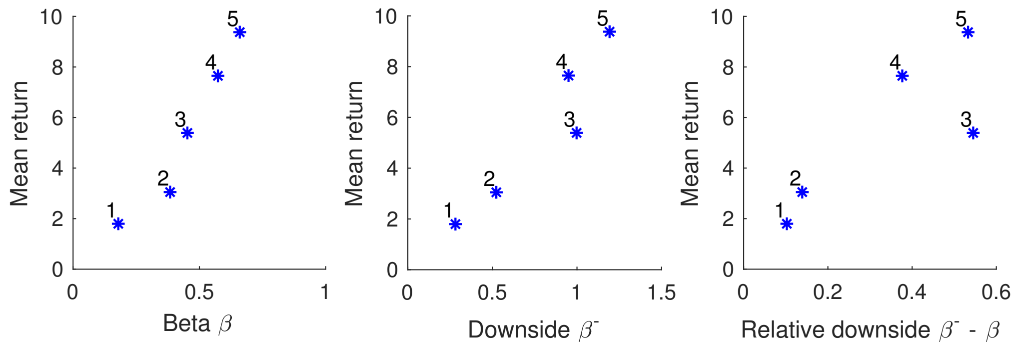
Notes: This figure plots realized average bond excess returns on the vertical axis against predicted average excess returns on the horizontal axis. We regress actual excess returns on a constant and the *Carry* currency risk factor to obtain slope coefficients β^j. Each predicted excess return is obtained using the OLS estimate β^j times the sample mean of the risk factor. Portfolios are built using *Carry* betas. All returns are annualized. Data are monthly. The sample period is 6/2003–10/2017.

betas. From the analysis of section 3, we know that a single factor CAPM model is able to explain the cross-section of portfolios returns. The middle panel shows that the average bond returns are also strongly related to downstate beta. The right panel shows that the relative downstate beta, the difference between downstate and unconditional beta, is also associated with contemporaneous returns, with the exception of portfolio 3. Therefore, it is likely that the true factor structure contains at least two factors: the aggregate market return and the downside risk factor. On average, portfolios that have higher downstate unconditional betas are riskier and earn higher excess returns[6].

In order to investigate the relevance of the second factor, we estimate the second step of the FMB procedure restricting the cross-sectional model so that the market return is exactly priced. Therefore, we set $\lambda = E(Rx^m)$, and add the stock market portfolio to the test assets. Figure 5 and illustrates the performance of the DR-CAPM model. The figure shows that the DR-CAPM explains the cross-section of bond excess returns. The market price of the downside risk is 470 basis point *per annum* and it is statistically significant. The adjusted

[6]Note that, give the short length of our sample, our estimate of downside risk is not very precise. In our sample, the share of downstates is approximately 11 percent and corresponds to 20 observations.

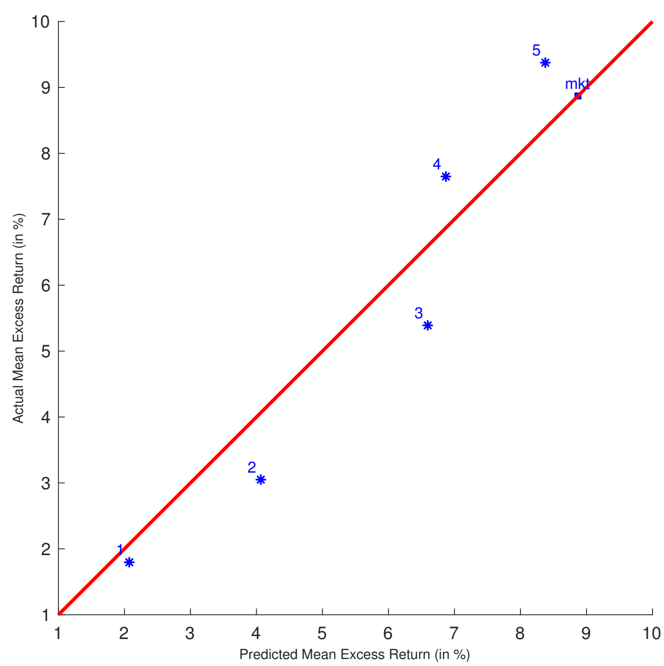
Figure 4: Risk-return relations



Notes: This figure plots risk-return relations for five local currency bond portfolios, monthly, re-sampled based on their time-varying *Carry*-betas. From left to right, the panels plot the realized mean excess return versus the capital asset pricing model betas (β), the downside betas (β^-), and the relative downside betas ($\beta^- - \beta$). All returns are annualized. Data are monthly. The sample period is 4/2002–10/2017.

R-square is equal to 89 percent and the average pricing error to 71 basis points.

Figure 5: DR-CAPM performance



Notes: This figure plots realized average bond excess returns on the vertical axis against predicted average excess returns on the horizontal axis. Predicted excess returns are obtained with the DR-CAPM model by restricting the model so that the market return is perfectly priced. We include the market excess return as a test asset. Portfolios are built using *Carry* betas. All returns are annualized. Data are monthly. The sample period is 4/2002–10/2017.

5 A No-Arbitrage Model of Bond Returns

We derive properties on the stochastic discount factors of foreign investors and emerging countries that need to be satisfied in order to reproduce the global risk premium that we have documented in the data. We impose minimal structure by considering a no-arbitrage model. Our model has an exponentially affine pricing kernel and therefore shares some features with other models in this class, such as those proposed by Frachot (1996); Brennan and Xia (2006) and Backus et al. (2001). Following recent applications by Lustig et al. (2011, 2014); Verdelhan (2014) and Brusa et al. (2014), we consider a world with N different countries, bonds, and currencies, where N is large. The key distinguishable novel feature of this model is the introduction of defaultable local currency denominated bonds with long maturity.

In each country i, the logarithm of the real SDF m^i follows

$$-m^i_{t+1} = \alpha^i + \chi^i z^i_t + \sqrt{\gamma^i z^i_t} u^i_{t+1} + \tau^i z^w_t + \sqrt{\delta^i z^w_t} u^w_{t+1} + \sqrt{\kappa^i z^i_t} u^g_{t+1}$$

There is a common global state variable z^w_t and a country-specific state variable z^i_t. The common state variable enters the pricing kernel of all investors in N different countries. The country-specific state variable z^i appears only in the SDF of country i. The country-specific innovations, u^i_{t+1}, and global innovations, u^w_{t+1} and u^g_{t+1}, are i.i.d, mean-zero, variance-one Gaussian shocks; u^w_{t+1} is a global shock, common across countries, that is priced similarly in each country up to scaling factor δ^i; u^g_{t+1} is a second global shock that is priced differently across countries even when κ^i are the same; while u^i_{t+1} is a local shock uncorrelated across countries. We refer to the volatilities of the SDF related to the two global shocks as the market prices of risk of these shocks (i.e., $\sqrt{\delta^i z^w_t}$, and $\sqrt{\kappa^i z^i_t}$). We assume that all countries share the same parameters $(\alpha, \chi, \tau, \gamma, \kappa)$, but not δ, i.e., the loading on the global component u^w. In particular, we assume that the US have the average δ loading on the global component and, in what follows, we omit the super-script i when we refer to the U.S.

We further assume that the same innovations that drive the pricing kernel variation will govern the dynamics of the country-specific and world volatility processes which we assume following a auto-regressive square root process

$$\begin{aligned} z^i_{t+1} &= (1-\phi)\theta + \phi z^i_t + \sigma\sqrt{z^i_t} u^i_{t+1} \\ z^w_{t+1} &= (1-\phi^w)\theta^w + \phi^w z^w_t + \sigma^w \sqrt{z^w_t} u^w_{t+1} \end{aligned}$$

We assume that financial markets are complete, but that some frictions in the goods markets prevent perfect risk-sharing across countries. Therefore, the change in the real exchange rate Δq^i between the home country and country i is

$$\begin{aligned}
\Delta q_{t+1}^i &= m_{t+1} - m_{t+1}^i \\
&= \chi \left(z_t^i - z_t \right) + \sqrt{\gamma z_t^i} u_{t+1}^i - \sqrt{\gamma z_t} u_{t+1} \\
&+ u_{t+1}^w \sqrt{z_t^w} \left(\sqrt{\delta^i} - \sqrt{\delta} \right) + u_{t+1}^g \sqrt{\kappa} \left(\sqrt{z_t^i} - \sqrt{z_t} \right)
\end{aligned}$$

where q^i is measured in units of country i goods per home country good. An increase in q^i denotes a depreciation of the local currency with respect to the currency of foreign investors (i.e., the US). The exchange rate between country i and the U.S. depends on the country-specific shocks (u_{t+1}, u_{t+1}^i), and on the two global shocks (u_{t+1}^g, u_{t+1}^w). Note that, *ceteris paribus*, the exchange rates with respect to the US responds differently to global shocks u^w depending on the relative exposure captured by δ^i. Specifically, the exchange rate of countries with the high (low) exposure to the global shock appreciates (depreciates) after a positive shock (i.e., in good times), and depreciates (appreciates) after a negative shock (i.e., in bad times).

Following Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012) we consider long-term debt contracts that mature probabilistically. Specifically, each unit of outstanding debt matures next period with probability λ. If the unit does not mature, which happens with complementary probability $1 - \lambda$, it gives out a coupon payment C. This way of modeling makes outstanding debt obligations memoryless so that we don't need to keep track of each bond date's of issuance because a unit of bond λ issued $k \geq 1$ periods in the past has exactly the same payoff structure as another unit issued $k' > k$ periods in the past. Note that we use the expression local currency to denote the national currency of the sovereign issuer. We further assume that every period, a share of the bonds defaults, and investors, in this case, recover a fraction $1 - H_t$. The gross return on the bond portfolio is then

$$R_{t+1}^i = \frac{(1 - H_{t+1}^i) \left[\lambda + (1 - \lambda) \left(P_{t+1}^i + C^i \right) \right]}{P_t^i},$$

where H_{t+1}^i is satisfying $0 \leq H_{t+1}^i < 1$ and the parameter $\lambda \geq 0$ controls maturity. If $\lambda = 1$ we have a one-period bond; while if $\lambda = 0$ we have a perpetual bond as in Greenwood et al. (2016).

We assume that the log recovery rate $h_t^i = \log(1 - H_t^i)$ follows an exponentially affine process:

$$h_{t+1}^i = \mu_h^i + \psi_h^i z_t^i + \psi_h^{w,i} z_t^w + \sigma_h^i \sqrt{z_t^i} u_{t+1}^i + \sigma_h^{w,i} \sqrt{z_t^w} u_{t+1}^w + \sigma_h^{g,i} \sqrt{z_t^i} u_{t+1}^g \tag{2}$$

The recovery rate for the bonds issued by country i depends on country-specific shocks (u_{t+1}^i), but also on the two global shocks (u_{t+1}^g, u_{t+1}^w). In order to focus on the differences between the SDFs, and not on differences in the recovery rates, we assume that all countries share the same parameters $\mu_h, \psi_h, \psi_h^w, \sigma_h, \sigma_h^w, \sigma_h^g$. We use Campbell and Shiller (1988)'s log-linear approximation of the price to coupon ratio to obtain that the logarithm of the return on the bond issued by country i is:

$$r_{t+1}^i \approx k_0^{b,i} + k_1^{b,i} p_{t+1}^i - p_t^i + h_{t+1}^i, \tag{3}$$

where $k_0^{b,i}, k_1^{b,i}$ are constants coming from the Taylor approximation around the mean log price-coupon ratio[7]. In this case, the process for the logarithm of the price of the long-term bond is affine.

$$p_t^i = A_b^i + B_b^i z_t^i + C_b^i z_t^w \tag{4}$$

where the coefficients A_b^i, B_b^i and C_b^i result from applying the equilibrium Euler equation to local currency bond returns (i.e., $E_t[M_{t+1}^i R_{t+1}^i] = 1$) and as solutions to the following systems of equations[8]

$$A_b^i = k_0^{b,i} + k_1^{b,i} \left(A_b^i + B_b^i (1-\phi)\theta + C_b^i (1-\phi^w)\theta^w \right) + \mu_h - \alpha \tag{5}$$

$$B_b^i = k_1^{b,i} B_b^i \phi + \psi_h - \chi + 0.5 \left(\sqrt{\gamma} - k_1^{b,i} B_b^i \sigma - \sigma_h \right)^2 + 0.5 \left(\sqrt{\kappa} - \sigma_h^g \right)^2 \tag{6}$$

$$C_b^i = k_1^{b,i} C_b^i \phi^w + \psi_h^w - \tau + 0.5 \left(\sqrt{\delta^i} - k_1^{b,i} C_b^i \sigma^w - \sigma_h^w \right)^2 \tag{7}$$

Finally, in order to replicate the asset pricing results of section 3, we need to define U.S. equity returns in order to build the single risk factor used to price the cross-section of bond excess returns. Specifically, we assume the following dividend growth process

$$\Delta d_{t+1} = \mu_D + \psi_d z_t + \psi_d^w z_t^w + \sigma_d \sqrt{z_t} u_{t+1} + \sigma_d^w \sqrt{z_t^w} u_{t+1}^w + \sigma_d^g \sqrt{z_t} u_t^g$$

where the innovations are the same as those in the SDFs. Therefore, U.S. dividend

[7] In particular, they are equal to $k_1^b = \frac{(1-\lambda)\exp\bar{p}}{\lambda + (1-\lambda)(\exp c + \exp\bar{p})}$ and $k_0^b = -\frac{(1-\lambda)\exp\bar{p}}{\lambda + (1-\lambda)(\exp c + \exp\bar{p})}\bar{p} + \log\left(\lambda + (1-\lambda)(\exp c + \exp\bar{p})\right)$, where lower case letters denote the logarithm of a variable. If $\lambda = 0$ they are equal to $k_1^b = 1/(1+\exp(c-\bar{p}))$ and $k_0^b = \exp(c-\bar{p})/(1+\exp(c-\bar{p}))\bar{p} + \log(1+\exp(c-\bar{p}))$ as in Greenwood et al. (2016).

[8] The system has three equations, with two independent quadratic equations that define B_b^i and C_b^i and one linear equation that defines A_b^i. Each of the two quadratic equations has two solutions. It is possible to show that one of the two solutions is explosive. For each quadratic equation, we select the non-explosive solution. See the appendix for more details.

growth rates respond to both U.S. country-specific and global shocks. In this model, also the log price-dividend ratio is affine in the state variables z_t and z_t^w

$$pd_t = A_{pd} + B_{pd} z_t + C_{pd} z_t^w$$

where the constants A_{pd}, B_{pd} and C_{pd} are defined as function of the SDF of foreign U.S. investors and dividend growth parameters. In particular, we first derive the log linear approximation for the log gross equity return on the aggregate dividend claim

$$r_{t+1}^e \approx k_0^e + k_1^e pd_{t+1} - pd_t + \Delta d_{t+1}$$

where k_0^e and k_1^e are defined by the Taylor approximation of the log price-dividend ratio pd_t around its mean. The Euler equation applied to the equity market return implies that the coefficients A_{pd}, B_{pd} and C_{pd} are the solutions to the following system (see appendix for details)

$$\begin{aligned}
A_{pd} &= k_0^e + k_1^e \left(A_{pd} + B_{pd}(1-\phi)\theta + C_{pd}(1-\phi^w)\theta^w\right) + \mu_d - \alpha \\
B_{pd} &= k_1^e B_{pd}\phi + \psi_d - \chi + 0.5\left(\sqrt{\gamma} - k_1^e B_{pd}\sigma - \sigma_d\right)^2 + 0.5\left(\sqrt{\kappa} - \sigma_d^g\right)^2 \\
C_{pd} &= k_1^e C_{pd}\phi^w + \psi_d^w - \tau + 0.5\left(\sqrt{\delta} - k_1^e C_{pd}\sigma^w - \sigma_d^w\right)^2
\end{aligned}$$

5.1 Restricted Model

In order to explore the role of heterogeneity in the exposure to global risk across different bonds, captured by δ^i, on the cross-section of expected bond excess returns, we first focus on a restricted version of the model in which local currency bonds are 1-period zero-coupon bonds with no default risk. Accordingly, we set $\lambda = 0$ and $h_t^i = 0$ for any t. Under these restrictions, our model is a version of Lustig et al. (2011) and excess returns on local currency bonds, from the perspective of U.S. investors, are simply currency excess returns[9]. This environment is particularly useful to extract the global risk factors and corresponds to the first step of our empirical analysis, where we used a large set of advanced and developing countries to estimate the *Carry* and *Dollar* factors. In the next section, we will explore the interaction of global and default risk on long-term government bonds denominated in local currency.

In each country i, the real risk-feee interest rate on the 1-period zero coupon bond (in logarithms) is

[9] The only difference between the restricted version of our model and Lustig et al. (2011) is in the specification of the SDF. While we assume two global shocks, they assume one global shock that affects countries differently depending on a scaling factor δ^i and the country specific state variable z^i.

$$r_t^i = \alpha + z_t^i \left(\chi - \frac{1}{2}(\gamma + \kappa)\right) + z_t^w \left(\tau - \frac{1}{2}\delta^i\right)$$

Countries with high exposure to the global shock (i.e., high δ^i) have, on average, lower interest rate because of the *precautionary saving effect*: in good times, investors want to save to create a buffer against future bad times. Our focus is on the cross-sectional variation in conditional expected excess returns for foreign investors purchasing local currency bonds issued by country i (i.e., $rx_{t+1}^i = r_t^i - r_t - \Delta q_{t+1}^i$). In our model, the log SDF m_{t+1} and the log excess returns rx_{t+1}^i are jointly normally distributed. The Euler equation applied to returns (i.e., $E[MR^i] = 1$) implies that the expected excess return corrected for the Jensen's term is the conditional covariance between the log pricing kernel and returns (Cochrane, 2009)

$$\begin{aligned} E_t\left[rx_{t+1}^i\right] + \frac{1}{2}Var_t\left[rx_{t+1}^i\right] &= -Cov_t\left[m_{t+1}, rx_{t+1}^i\right] \\ &= Var_t\left[m_{t+1}\right] - Cov_t\left[m_{t+1}^i, m_{t+1}\right] \\ &= \gamma z_t + \sqrt{z_t^w \delta}\left(\sqrt{z_t^w \delta} - \sqrt{z_t^w \delta^i}\right) \\ &+ \sqrt{z_t \kappa}\left(\sqrt{z_t \kappa} - \sqrt{z_t^i \kappa}\right) \end{aligned}$$

Therefore, the loading on the dollar shock (i.e., u_{t+1}) is equal to one for returns on any currency, and γz_t is the price of the dollar-specific risk. The risk price for the first global shock (i.e., u_{t+1}^w) demanded by foreign investors is δz_t^w and the quantity of global risk depends on the relative exposure of the two SDFs to the global shock; the risk price of the second global shock (i.e., u_{t+1}^g) is equal to κz_t and the quantity of global risk depends on the relative country-specific state z^i. *Ceteris paribus*, high (low) δ^i countries offer lower (higher) expected excess returns to foreign investors. This is because they are safer (riskier), as their exchange rate with respect to the U.S. dollar, on average, appreciates (depreciates), in bad times, after a low realization of the global shock. Note that countries with higher δ^i have also lower average interest rates. Therefore, the loading on the first global factor can be interpreted as a *Carry*-beta, where *Carry* is the investment strategy that goes long the bonds of countries with high interest rates and short the bonds of countries with low interest rates:

$$\beta_t^{Carry,i} = 1 - \sqrt{\frac{\delta^i}{\delta}}$$

The currency risk premium is independent on the country-specific state z_t^i only if $\kappa = 0$. In this case, as explained in Lustig et al. (2011), the time variation in the global component of the conditional price of risk depends only on the first global factor and we need asymmetric loadings on the common component to generate the currency risk premium across countries we observe in the data.

5.2 Building bond portfolios to extract factors

We sort sovereign short-term bonds from the restricted model into portfolios based on their interest rate differentials $(r_t^i - r_t)$, as we have done in the data. We use H_R to denote the set of countries in the last portfolio and L_R to denote the countries in the first portfolio. The *Carry* and *Dollar* risk factors are defined as

$$\begin{aligned} Dollar_{t+1} &= \frac{1}{N_R}\sum_i rx_{t+1}^i \\ Carry_{t+1} &= \frac{1}{N_{H_R}}\sum_i rx_{t+1}^i - \frac{1}{N_{L_R}}\sum_i rx_{t+1}^i \ , \end{aligned}$$

where $N_{H_R}(N_{L_R})$ is the number of high (low) interest rate countries and N_R is the total number of countries in the restricted version of the model.

We let $\overline{\sqrt{x_t}}$ denote the average of $\sqrt{x_t^j}$ across all bond returns in portfolio j. The portfolio composition changes over time. The carry trade and dollar risk factors have a natural interpretation. The first one measures the common innovation, while the second one measures the U.S. country-specific innovation. We assume that the number of bonds in each portfolio is large, and that country-specific shocks average out within each portfolio. We then derive the innovations to the two risk factors

$$\begin{aligned} Carry_{t+1} - E_t\left[Carry_{t+1}\right] &= \left(\overline{\sqrt{\delta^L}} - \overline{\sqrt{\delta^H}}\right)\sqrt{z_t^w}u_{t+1}^w \\ Dollar_{t+1} - E_t\left[Dollar_{t+1}\right] &= \sqrt{\gamma}\sqrt{z_t}u_{t+1} \end{aligned}$$

Therefore, if countries have different exposure to the common volatility factor, then the innovation to *Carry* measures the common innovation to the SDF. The *Carry* betas on portfolio j are

$$\beta_{Carry,t}^j = \frac{\sqrt{\delta} - \overline{\sqrt{\delta_t^j}}}{\overline{\sqrt{\delta_t^L}} - \overline{\sqrt{\delta_t^H}}}$$

On the contrary, the innovation to the *Dollar* factor measures U.S. country-specific innovation. The *Dollar* betas on portfolio j are

$$\beta^{j}_{Dollar,t} = 1$$

In the model, sorting countries on the interest rate differential produces a monotonic increasing cross-section in the *Carry* betas (i.e., a monotonic decreasing cross-section of δ^i) if

$$0 < \tau < \frac{1}{2}\delta^i; \quad 0 < \chi < \frac{1}{2}(\gamma + \kappa)$$

Under this condition, countries' interest rates (r^i) respond with the same sign to a change of world and domestic economic conditions (i.e., z^w_t and z^i_t respectively). Specifically, in good times, when z^w (z^i) is high, interest rates are low as the precautionary effect of global (domestic) volatility dominates. If the condition is not satisfied and, for example, it holds only for countries with a $\delta^i > \tilde{\delta}$, where $\tilde{\delta}$ is some given threshold, then in bad times, when z^w is low, low interest rate currencies would have low, rather than high, δ. On the contrary, when the condition is satisfied, in bad times the gap $\sqrt{\delta^L_t} - \sqrt{\delta^H_t}$ increases.

5.3 Full model

We have demonstrated that countries with high δ loadings will have low interest rates on average and earn low average excess returns, while the opposite holds for currencies with low δ. The full model incorporates the existence of defaultable bonds with maturity longer than one period.

We take the perspective of U.S. foreign investors buying long maturity bonds, in local currency, issued by country i and with risky return r^i. We assume that the U.S. issues 1-period default risk-free bond and that investors can borrow at this rate, which we denote r_t. The unhedged dollar excess returns are $rx^i_{t+1} = r^i_{t+1} - r_t - \Delta q^i_{t+1}$.

The local currency returns on the bonds issued by country i are now risky, as the issuer can partially default on its debt. In addition, unexpected changes in the time $t+1$ price of the bond will also affect local currency returns. The innovations to the log gross bond returns in local currency are

$$r^i_{t+1} - E_t[r^i_{t+1}] = \sqrt{z^i_t}\left(k^{b,i}_1 B^i_b \sigma + \sigma_h\right) u^i_{t+1} + \sqrt{z^w_t}\left(k^{b,i}_1 C^i_b \sigma^w + \sigma^w_h\right) u^w_{t+1} + \sqrt{z^i_t}\sigma^g_h u^g_{t+1}$$

Local currency bond returns at time $t+1$ depend on both domestic and global shocks, and the coefficients B^i_b, C^i_b depend on the parameters defining the SDF, the state variables

z^i and z^w, and the recovery process h^i. Only C_b^i depends on the exposure to the first global shock δ^i, and it is possible to show that, under our parametrization, it is always positive and larger for high δ^i countries (see the separate appendix for details). *Ceteris paribus*, after a positive (negative) global shock u^w, local currency returns on long-maturity bonds are higher (lower) for high δ^i countries, i.e., for countries that on average have low short-term interest rate.

In order to gain intuition, it is useful to decompose the excess returns for U.S. foreign investors $rx_{t+1}^i = r_{t+1}^i - r_t - \Delta q_{t+1}^i$ into three parts

$$rx_{t+1}^i = \left(r_{t+1}^i - r_{t+1}^{i,short}\right) + \left(r_{t+1}^{i,short} - r_t\right) - \Delta q_{t+1}^i$$

where $r_{t+1}^{i,short}$ is the return, in local currency, on a 1-period bond issued by country i. The first term denotes the local currency term premium; the second, the credit spread; and the third, the change in the real exchange rate. While the credit spread term does not depend on δ^i, both the term premium and the change in real exchange rate depend on countries' exposure to the first global shock. We find that when the precautionary effect of global volatility is strong, then countries' heterogenous exposure to the global shock has two conflicting effects. First, the "term premium" in local currency increases for all countries after a positive global shock, with the size of the change larger for countries that are more exposed to the global shock. This is because, after a positive global shock, investors want to save more not only today, but also tomorrow since the state is persistent, driving up bond prices. Second, countries with higher exposure to global shocks, relative to the U.S., have currencies that tend to depreciate with respect to the U.S. dollar after a positive global shock and appreciate after a negative global shock. Therefore, one hand payoffs in local currency are riskier for countries with a higher exposure to global shocks because they are relatively higher in good times and lower in bad times; on the other, from the perspective of U.S. investors, LC-bonds from these countries are less risky because, on average, offer high dollar payoffs in bad times and low dollar payoffs in good times. By sorting emerging countries' LC-bonds with respect to their exposure to the $Carry$ factor we have demostrated that In the data the second effect prevails (see appendix for additional details).

We sort countries, as we did for the data, on the basis of their $Carry$ betas, where $Carry$ is computed as described in the discussion of the restricted version of this model[10]. The individual countries $Carry$ betas are

[10] Note that even when $\kappa \neq 0$, $Carry$ does not change since if law of large number applies, the cross-sectional mean of z_t^i is constant and equal to θ.

$$\beta_t^{Carry,i} = \frac{\left(k_1^{b,i} C_b^i \sigma^w + \sigma_h^w\right) + \left(\sqrt{\delta} - \sqrt{\delta^i}\right)}{\sqrt{\delta_t^L} - \sqrt{\delta_t^H}}$$

where the first term in the numerator depends on the recovery rate and the maturity of the bond issued by country i. Recall that high δ countries have lower interest rates, on average, because they are more exposed to the global shock and we assume that the precautionary saving effect is strong. In the restricted model, when bonds are default risk-free and short maturity, the only risk for the U.S. investors is the exchange rate risk and the first term is equal to zero. In this case, the higher exposure to global shocks goes along a smaller exposure to exchange rate risk from the perspective of U.S. investors. On the contrary, in the unrestricted model, foreign investors are also exposed to default and interest rate risk as local currency bonds have longer maturity. As discussed before, these risks are larger for countries with high δ. Therefore, the first term in the expression for the $Carry$ betas is positive and mitigates the exposure of countries to the $Carry$ factor. In order for the sorting on $Carry$ to produce a monotonic increasing cross-section of excess returns, exchange rate risk must dominate the other risks.

After we build the portfolios, we show that they are related to both the $Carry$ factor and the Mkt factor

$$\begin{aligned}
\beta_{mkt,t}^j &= \frac{z_t \sqrt{\gamma}\left(k_1^e B_{pd} \sigma + \sigma_d\right)}{z_t \left(k_1^e B_{pd} \sigma + \sigma_d\right)^2 + z_t^w \left(k_1^e C_{pd} \sigma^w + \sigma_d^w\right)^2 + z_t (\sigma_d^g)^2} \\
&+ \frac{z_t^w \left[\left(k_1^e C_{pd} \sigma^w + \sigma_d^w\right)\left(\left(\overline{k_1^{b,j} C_b^j} \sigma^w + \sigma_h^w\right) + \left(\sqrt{\delta} - \overline{\sqrt{\delta^j}}\right)\right)\right]}{z_t \left(k_1^e B_{pd} \sigma + \sigma_d\right)^2 + z_t^w \left(k_1^e C_{pd} \sigma^w + \sigma_d^w\right)^2 + z_t (\sigma_d^g)^2} \\
&+ \frac{\sqrt{z_t} \sigma_d^g \left(\overline{\sqrt{z^j}} \sigma_h^g + \sqrt{\kappa}\left(\overline{\sqrt{z^j}} - \sqrt{z_t}\right)\right)}{z_t \left(k_1^e B_{pd} \sigma + \sigma_d\right)^2 + z_t^w \left(k_1^e C_{pd} \sigma^w + \sigma_d^w\right)^2 + z_t (\sigma_d^g)^2}
\end{aligned}$$

and

$$\beta_{carry,t}^j = \frac{\left(\overline{k_1^{b,j} C_b^j} \sigma^w + \sigma_h^w\right) + \left(\sqrt{\delta} - \overline{\sqrt{\delta^j}}\right)}{\overline{\sqrt{\delta^L}} - \overline{\sqrt{\delta^H}}}$$

where $j = 1, ...N_P$ is the index for portfolios. Note that the market betas capture exposure to all sources of risks, including U.S. domestic shocks and dividend volatility risk.

5.4 Inflation

Investors in LC-bonds are exposed to the risk that emerging countries' government might inflate away their debt. In this case, nominal exchange rate would depreciate with respect to the U.S. dollar to accommodate this event. To investigate this possibility, we specify a process for the nominal pricing kernel, in order to determine nominal variables, such as interest rates and exchange rates. The log of the nominal pricing kernel in country i is simply given by the real pricing kernel less the rate of inflation π^i:

$$m_{t+1}^{i,n} = m_{t+1}^{i} - \pi_{t+1}^{i}$$

and the change in the nominal exchange rate is equal to the difference between the nominal SDFs, which in turn is equal to the sum of the change in the real exchange and the difference in the inflation rate in country i with respect to the U.S.

$$\Delta s_{t+1}^{i} = m_{t+1}^{n} - m_{t+1}^{i,n} = \Delta q_{t+1}^{i} + (\pi_{t+1}^{i} - \pi_{t+1})$$

We assume that inflation is composed of a country-specific component and a global component

$$\pi_{t+1}^{i} = \pi_0^{i} + \eta^{i} z_t^{i} + \eta^{w,i} z_t^{w}$$

We further assume that all countries are equal with respect to the inflation process, so that the parameters $\pi_0^i, \eta^i, \eta^{w,i}$ are the same. Note that with this specification, π_{t+1} inherits the stochastic properties of the two state variables so that inflation unconditionally has positive mean and volatility, but conditionally on the time t realization of the states has zero variance and covariance with the country-specific and global shocks. Lustig et al. (2011) specify a similar inflation process, but also include inflation innovations orthogonal to all the other shocks. The only difference with respect to our specification is that in this case nominal variables can have higher volatilities than real variables.

If bonds are default risk-free and 1-period, then it is straightforward to derive the expression for the nominal short risk-free interest rate

$$r_t^{i,n} = \pi_0 + \alpha + z_t^{i}\left(\chi + \eta - \frac{1}{2}(\gamma + \kappa)\right) + z_t^{w}\left(\tau + \eta^{w} - \frac{1}{2}\delta^{i}\right)$$

Note that both the loading on the local and global state variables increase and short-term nominal rates are larger than for the corresponding real rates. In the appendix we show that if bonds are defaultable and long-term, nominal bond prices, and bond returns, are less sensitive to global shocks than real bond prices. Furthermore, we show that if the inflation process follows an autoregressive square root process similar to that of the recovery rate, then inflation risk and default risk have the same effect on bond returns.

5.5 Calibration

We show that a version of the model that is calibrated to match key moments of interest rates, default and exchange rates, and bond maturities can match the properties of excess returns on local currency bonds. Lustig et al. (2011) calibrate a similar model by targeting annualized moments of monthly data. We borrow the values they set for the parameters defining the SDF and the state variables; while we borrow from Brusa et al. (2014) the values of the parameters defining the dividend growth process. Table 5 reports all the parameters defining the SDFs, the state variables, the dividend growth rate and the recovery process, while table 6 reports the moments used in the calibration and their target values. Specifically, we assume that all state variables follows the same process. This assumption drastically reduces the number of parameters to be estimated to ϕ, θ and σ. Lustig et al. (2011) calibrate these three parameters to match three moments of the risk free rate in the US: the unconditional mean $E\left[r^{US}\right]$, the unconditional standard deviation $std\left[r^{US}\right]$ and the persistence $\rho(r^{US})$. We also assume that each country's SDF differs only in the exposure to the global shock δ^i and that $\tau = \chi$. These parameters are calibrated to match the average return of a US investor on currency markets $E\left[rx\right]$, the unconditional standard deviation of the exchange rate $std\left[\Delta q\right]$, the UIP slope coefficient, the Feller coefficient, the standard deviation of the log SDF $std\left[m\right]$, the average cross-country correlation of real interest rates. Following Brusa et al. (2014), we set $\psi_d = 0$ and $\sigma_d^w = 0$ in the dividend growth process. The remaining four parameters, μ_d, ψ_d, ψ_d^w, σ_d, σ_d^w, σ_d^g, are set to match four moments: the unconditional mean of the price dividend ratio $E\left[p-d\right]$ and dividend growth rate $E\left[\Delta d\right]$; the unconditional standard deviation of the price dividends $std\left[p-d\right]$ and the dividend growth rate $std\left[\Delta d\right]$. The constants from the Taylor approximation of the equity return, k_0^e and k_1^e, are pinned down by the unconditional mean of the price-dividend ratio which is equal to 30 in level. In order to calibrate the recovery process, we start by setting the values for k_0^b and k_1^b, i.e., the constants from the Taylor expansion of the long maturity bond price. These parameters are function of the coupon C, the long-run mean price $\bar{p}$, and the parameter that pins down the average duration λ. For the sake of simplicity, we assume that bonds are zero-coupons (i.e., $C = 0$) and set $\lambda = 1/60$ to match the average maturity of the local currency debt in our sample of 60 months. This number is similar to values used in existing literature (for example, see Chatterjee and Eyigungor (2012)). We further assume that the country-specific shock and the first of the two global shocks do not affect the volatility of the recovery rate (i.e. $\sigma_h = 0$ and $\sigma_h^w = 0$). The remaining four parameters, μ_h, ψ_h, ψ_h^w and σ_h^g, are set to match four moments of the recovery rate. Specifically, we use the unconditional mean $E[h]$, the unconditional standard deviation $std[h]$, the mean correlation between countries' recovery rates and their own GDP growth and world GDP growth using defaults data from Reinhart and Rogoff (2011c) and haircuts data from Cruces and Trebesch (2013). Finally, the parameters π_0, η and η^w are from Lustig et al. (2011). In the appendix, we provide more detailed on the calibration of the recovery process.

5.6 Simulation

In this section, we first show that sorting simulated bond returns on the *Carry* risk factor generates a cross-section of excess returns as in the data; second, we show that a single factor explains a large fraction of the variation in these excess returns. We use the parameters discussed in section 5.5, and first consider the restricted version of the model, with one period risk-free bonds. We generate simulated data for 31 countries that differ only in their exposure with respect to the global shoch δ^i. The US has the average exposure δ.

We sort bonds excess returns on the forward discount (i.e., the interest rate spread $r_t^i - r_t$) and then construct *Carry* as the difference between the excess returns on the last portfolio, which contains on average countries with low δ and high interest rates, and the first portfolio, which contains on average countries with high δ and low interest rates. Table 7 reports the characteristics of these portfolios. Forward discounts increase monotonically from -348 basis points to 340 basis points. The top panel reports the average bond excess returns on each portfolio, along their standard deviation and Sharpe ratios. Excess returns increase from -425 basis points for portfolio 1 to 405 basis points on portfolio 5; the standard deviation is similar across portfolios, and thereby Sharpe ratios increase monotonically from -0.35 to 0.31%. As explained in section 5.1, sorting countries on the forward discount allocates, on average, countries with the largest δ^i to the first portfolio; and countries with the lowest δ^i to the last portfolio. The *Carry* trade strategy goes long high-interest rate currencies and short low-interest rate currencies. In the bottom panel, we report the spread return of going long portfolios $2, ..., 5$ and short portfolio 1. We denote with *Carry* factor the spread return between portfolio 5 and portfolio 1. The *Carry* factor has an average excess return of 830 basis points and a Sharpe ratio of approximately 0.5.

Second, we consider a second set of 31 countries, characterized by different realizations of the country-specific shocks (u_{t+1}^i), but sharing the same global shocks of the set of countries we used to extract the *Carry* factor, which is only function of the global shock u^w. The

Table 5: Parameter Values

(a) Panel A: Stochastic discount factor

$$-m^i_{t+1} = \alpha^i + \chi^i z^i_t + \sqrt{\gamma^i z^i_t} u^i_{t+1} + \tau^i z^w_t + \sqrt{\delta^i z^w_t} u^w_{t+1} + \sqrt{\kappa^i z^i_t} u^g_{t+1}$$

SDF					Heterogeneity		
α (%)	χ	γ	κ	τ	δ	δ_L	δ_H
0.86	2.78	0.65	16.04	2.78	13.96	6.25	21.67

(b) Panel B: State variable dynamics

$$z^i_{t+1} = (1-\phi)\theta + \phi z^i_t + \sigma \sqrt{z^i_t} u^i_{t+1} \qquad z^w_{t+1} = (1-\phi^w)\theta^w + \phi^w z^w_t + \sigma^w \sqrt{z^w_t} u^w_{t+1}$$

ϕ	θ (%)	σ (%)	ϕ^w	θ^w (%)	σ^w (%)
0.92	7.81	0.25	0.92	7.81	0.25

(c) Panel C: Dividend growth rate

$$\Delta d_t = \mu_d + \psi_d z^i_t + \psi^w_d z^w_t + \sigma_d \sqrt{z_t} u_t + \sigma^w_d \sqrt{z^w_t} u^w_t + \sigma^g_d \sqrt{z_t} u^g_t$$

μ_d (%)	ψ_d	ψ^w_d	σ_d	σ^w_d	σ^g_d
2.5	0	-1	0.75	0.75	0.75

(d) Panel D: Recovery rate

$$h^i_t = \mu_h + \psi_h z^i_t + \psi^w_h z^w_t + \sigma_h \sqrt{z^i_t} u^i_t + \sigma^w_h \sqrt{z^w_t} u^w_t + \sigma^g_h \sqrt{z_t} u^g_t$$

μ_h (%)	ψ_h	ψ^w_h	σ_h (%)	σ^w_h (%)	σ^g_h (%)
-0.44	-1	1	0	0	3

(e) Panel E: Inflation rate

$$\pi^i_{t+1} = \pi_0 + \eta z^i_t + \eta^w z^w_t + \sigma_\pi \sqrt{z^i_t} u^i_{t+1} + \sigma^w_\pi \sqrt{z^w_t} u^w_{t+1} + \sigma^g_\pi \sqrt{z^i_t} u^g_{t+1}$$

π_0 (%)	η	η^w	σ_π (%)	σ^w_π (%)	σ^g_π (%)
-0.49	0	9.41	0	0	0

Notes: This table reports the parameter values for the calibrated version of the full model. All countries share the same parameter values except for δ^i. The average country is the U.S., with a value of δ which is the average between δ_L and δ_H. The parameters for the SDF and the state variables are from Lustig et al. (2011), with the exception of the range for δ which is wider; the parameters for the dividend growth rate are from Brusa et al. (2014). The parameters for the recovery rate are calibrated to match defaults and haircuts target data from Reinhart and Rogoff (2011c) and Cruces and Trebesch (2013). The parameters π_0, η and η^w is from Lustig et al. (2011). All parameters are chosen to match the moments reported in table 6.

Table 6: Calibrating the Model

	Moment	Target monthly	Target annual
β_{UIP}	$\frac{\chi}{\chi+\frac{1}{2}(\gamma+\kappa)}$	-0.5	-0.5
$E\left[r^{US}\right]$	$\alpha+\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)\theta+\left(\tau-\frac{1}{2}(\delta)\right)\theta^{w}$	0.11	1.37
$std\left[r^{US}\right]$	$\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^{2}\frac{(\sigma)^{2}\theta}{1-(\phi)^{2}}+\left(\tau-\frac{1}{2}(\delta)\right)^{2}\frac{(\sigma^{w})^{2}\theta^{w}}{1-(\phi^{w})^{2}}$	0.15	0.51
$\rho(r^{US})$	$\frac{\phi\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^{2}\frac{(\sigma)^{2}\theta}{1-(\phi)^{2}}+\phi^{w}\left(\tau-\frac{1}{2}(\delta)\right)^{2}\frac{(\sigma^{w})^{2}\theta^{w}}{1-(\phi^{w})^{2}}}{\left(\chi-\frac{1}{2}(\gamma+\kappa)\right)^{2}\frac{(\sigma)^{2}\theta}{1-(\phi)^{2}}+\left(\tau-\frac{1}{2}(\delta)\right)^{2}\frac{(\sigma^{w})^{2}\theta^{w}}{1-(\phi^{w})^{2}}}$	0.95	0.95
cross std Delta q		3.13	10.85
std m		14.43	50
corr rus r		0.19	0.19
rx		0.04	0.5
Feller		20	20
maturity	λ	60	5
$E_{cross}\left[h^{i}\right]$	$\mu_{h}+\psi_{h}\theta+\psi_{h}^{w}\theta^{w}$		-0.665
$std_{cross}\left[h^{i}\right]$	$\sqrt{\sigma_{h}^{2}\theta+\left(\sigma_{h}^{w}\right)^{2}\theta^{w}+\left(\psi_{h}\right)^{2}\frac{\sigma^{2}\theta}{1-\phi^{2}}+\left(\psi_{h}^{w}\right)^{2}\frac{(\sigma^{w})^{2}\theta^{w}}{1-(\phi^{w})^{2}}}$		0.765
$E\left[\Delta d\right]$	$\mu_{D}+\psi_{d}\theta+\psi_{d}^{w}\theta^{w}$		0.765
$std\left[\Delta d\right]$	$\sqrt{\sigma_{d}^{2}\theta+\left(\sigma_{d}^{w}\right)^{2}\theta^{w}+\left(\psi_{d}\right)^{2}\frac{\sigma^{2}\theta}{1-\phi^{2}}+\left(\psi_{d}^{w}\right)^{2}\frac{(\sigma^{w})^{2}\theta^{w}}{1-(\phi^{w})^{2}}}$		0.765

Notes: This table reports the moments used in the calibration. The first column defines each moment, the second column presents its closed form expression in our model, while the last two columns report the monthly and annual empirical values of each moment in our data. The target values for all moments, with the exception of the mean and standard deviation of h^{i}, are from Lustig et al. (2011) and Brusa et al. (2014). The target values for the recovery moments are from Reinhart and Rogoff (2011c) and Cruces and Trebesch (2013).

Table 7: Bond portfolios: Restricted Model

Portfolio	1	2	3	4	5
		Bond excess returns: rx^j_{t+1}			
Mean	-4.25	-1.55	-0.04	1.43	4.05
Std	12.30	10.57	9.83	10.74	13.08
SR	-0.35	-0.15	-0.00	0.13	0.31
		Real exchange rate change: Δq^j			
Mean	0.76	-0.03	0.02	0.12	-0.65
Std	12.27	10.54	9.80	10.72	13.06
		Forward discount: $f^j - s^j$			
Mean	-3.48	-1.58	-0.02	1.55	3.40
Std	0.43	0.40	0.38	0.39	0.42
		Exposure to global shock: $\overline{\delta^j}$			
Mean	19.45	17.15	14.01	10.88	8.35
Std	0.72	0.86	0.89	0.78	0.58
		High minus low: $rx^j_{t+1} - rx^1_{t+1}$			
Mean		2.69	4.21	5.67	8.30
Std		6.69	9.13	12.69	16.87
SR		0.25	0.46	0.45	0.49

Notes: This table reports, for each portfolio j, the average log excess return rx^j, the average change in the log real exchange rate Δq^j, the average forward discount $f^j - s^j$, the average exposure to the first global shock $\overline{\delta^j}$, and the average spread . All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting bonds into five groups at time t based on the forward discount $f^j - s^j \approx r^i_t - r_t$. The first portfolio contains bonds with the lowest interest rate spread with respect to the U.S., while the last portfolio contains bonds with the highest interest rate spread. Data are obtained simulating 31 countries for $T = 10000$ months and using the parameters presented in section 5.5. Country-specific shocks of the 31 countries of the restricted model are different from the country-specific shocks of the 31 countries of the unrestricted model.

second set of countries is described by the unrestricted version of our model, with long maturity defaultable bonds. For each country, we estimate time-varying *Carry* betas as slope coefficients of bond excess returns on a constant and the *Carry* risk factor over a rolling window of 100 months. We then sort countries on these betas. Note that we sort countries at t using only information available up to t. Table 8 reports the characteristics of these second set of portfolios. The first panel report excess returns from the perspective of U.S. investors that borrow at the short-term U.S. risk-free rate to buy long maturity risky bonds denominated in local currency. Excess returns increase monotonically from -236 basis points per annum to 331 basis points per annum. Also Sharpe ratios increase monotonically from -0.21 to 0.24. Sorting countries on their *Carry* betas implies a monotonic cross section also for the forward discount and the *Market* betas. The latter are slope coefficients of bond excess returns on a constant and the U.S. equity market excess return (Mkt) over a rolling window of 100 months. Also, sorting countries on their exposure to *Carry* allocates to the first portfolio countries with the highest δ^i and to the last portfolio countries with the lowest δ^i.

Table 8: Bond portfolios: Unrestricted Model

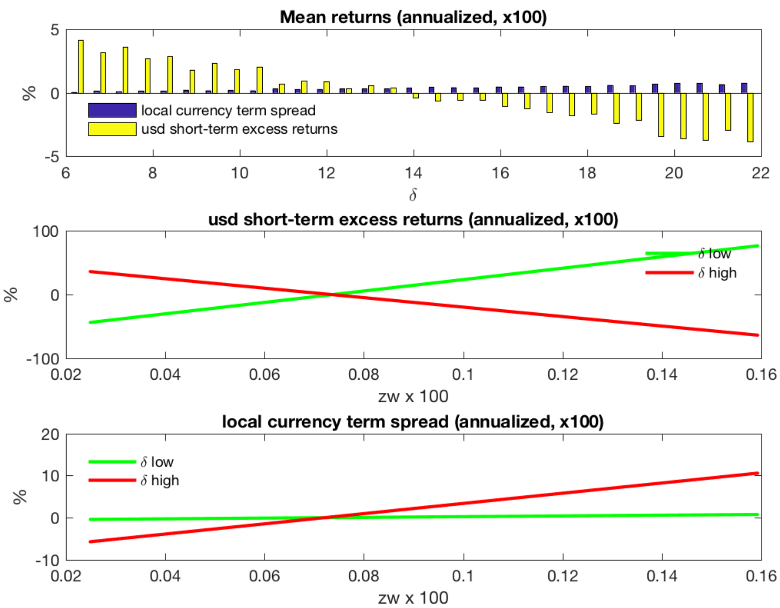
Portfolio	1	2	3	4	5
			Bond excess returns: rx^j_{t+1}		
Mean	-2.36	-0.93	0.48	1.87	3.31
Std	11.35	10.14	9.76	10.94	13.68
SR	-0.21	-0.09	0.05	0.17	0.24
			Real exchange rate change: Δq^j		
Mean	0.24	0.04	0.04	0.07	-0.03
Std	12.29	10.65	9.81	10.73	13.47
			Forward discount: $f^j - s^j$		
Mean	-2.12	-0.89	0.51	1.93	3.28
Std	1.66	1.42	1.16	0.92	0.75
			Carry betas: β^j_{Carry}		
Mean	-0.32	-0.14	0.05	0.27	0.53
Std	0.08	0.07	0.07	0.08	0.08
			Market betas: β^j_{Mkt}		
Mean	0.09	0.26	0.42	0.61	0.84
Std	0.17	0.14	0.13	0.11	0.11
			Exposure to global shock: $\overline{\delta^j}$		
Mean	20.12	17.38	14.01	10.67	7.67
Std	0.27	0.33	0.27	0.22	0.15
			High minus low: $rx^j_{t+1} - rx^1_{t+1}$		
Mean		1.43	2.84	4.23	5.68
Std		5.58	8.22	11.91	16.16
SR		0.14	0.35	0.36	0.35

Notes: This table reports, for each portfolio j, the average log excess return rx^j, the average change in the log real exchange rate Δq^j, the average forward discount $f^j - s^j$, the average *Carry* and *Market* betas, the average exposure to the first global shock $\overline{\delta^j}$, and the average spread . All moments, with the exception of the betas, are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting bonds into five groups at time t based on time-varying *Carry* betas estimated as slope coefficients on OLS regressions of country i bond excess returns on a constant and the *Carry* risk factor using a rolling window of 100 months. Data are obtained simulating 31 countries for $T = 10000$ months and using the parameters presented in section 5.5. Country-specific shocks of the 31 countries of the unrestricted model are different from the country-specific shocks of the 31 countries of the restricted model.

The spread in excess returns between the last and first portfolio in the unrestricted version of the model is smaller than in the restricted version of the model (i.e., 568 basis points and 830 basis points respectively). This is because, as explained in section 5.3, the local currency term spread component of bond excess returns goes up more, after a positive global shock u^w, in high δ^i countries so that, from this perspective, they are riskier. In order to focus on the role of bond maturity, in figure 6 we decompose dollar bond excess returns under the special case of long-maturity bond with no default risk. All the parameters are those for the unrestricted model, with the exception of $\log(1-H^i)=0$ for any i. The top panel reports for each country, identified by its exposure to the global shock δ^i, the average local currency term spread $(r^i_{t+1} - r^{i,short}_{t+1})$ and the average dollar short-term excess returns $(r^{i,short}_{t+1} - r_t - \Delta q^i_{t+1})$. The latter, correspond to the currency excess returns in Lustig et al. (2011) and are, on average, higher for low δ^i countries and lower for high δ^i countries. On the contrary, the local currency term spread are, on average, always positive and higher for high, not low, δ^i countries. This second effect tends to reduce the cross-section of bond excess returns. In order to gain intuition, in the second and third panel we report the fit of two sets of OLS regressions. In the first, reported in the second panel, we regress dollar short-term excess returns at time $t+1$ on the realization of the global state variable z^w also at $t+1$ for the countries with the lowest and highest value of δ^i. Dollar short-term excess returns for low δ^i countries are riskier because they are high in good times, when z^w is high, and low in bad times, when z^w is low. This is why these countries, on average, must offer higher dollar short-term excess returns. In the second set of regressions the dependent variables are the realized local currency term spreads at $t+1$ for the countries with the lowest and highest δ^i, and the independent variable is the realization of the global state variable z^w also at $t+1$. While for low δ^i countries the local currency term spread is small and similar in good and bad times, for high δ^i countries local currency term spreads are higher (lower) in good (bad) times. This second effect makes high δ^i countries relatively riskier, increasing the overall average dollar bond excess returns they must offer to investors.

Finally, in table 9 we report the results for the asset pricing exercise on the portfolios of dollar bond excess returns sorted on the $Carry$ factor constructed with the simulated data from the unrestricted model. We use two risk factors, Mkt and $Dollar$. The first, is the excess return on the U.S. equity market (i.e., for the country with the median δ); the second is the cross-sectional average excess return on the portfolios from the restricted model. As expected, only Mkt has a market price of risk significantly different from zero. However, it is important to add $Dollar$ to capture the level of average portfolio excess returns. Pricing errors are small and never significant. Note that Mkt captures, in part, also the effect of the $Dollar$ factor, this explains why the β^j_{Dollar} are not uniform and equal to 1. In the appendix we show results from a similar asset pricing exercise in which we use directly $Carry$ as a risk factor. In this case, β^j_{Dollar} are all equal to 1, as $Carry$ depends only on the U.S. country-specific shock.

Figure 6: Decomposing dollar bond excess returns



Notes: The top panel of this figure reports the sample averages of the local currency term spread and dollar short-term bond excess returns for each country, where each country is identified by its exposure to the first global shock δ^i. The second panel reports the fit of a OLS regression of dollar short-term excess returns realized at time $t+1$ on the realization of the global state variable z^w_{t+1} for low (green) and high (red) δ^i countries. Similarly, the third panel reports the fit of a OLS regression of local currency term spread realized at time $t+1$ on the realization of the global state variable z^w_{t+1} for low (green) and high (red) δ^i countries. All returns are annualized and multiplied by 100. The realization of the state variable is also multiplied by 100. Moments are computed in a version of the unrestricted model in which there is no default risk ($\log(1-H^i)=0$ for any i).

6 Conclusion

In this paper we uncover a novel investment strategy on sovereign bonds issued by emerging countries and denominated in local currency. We show that by allocating bonds with respect to their comovement with the *Carry* currency risk factor, investors obtain a large cross-section of dollar excess returns. We find that most of these returns represent compensation for aggregate global risk. Our empirical results are subject to some limitations. First, they are based on bond indices and do not account for transaction costs which would reduce portfolio returns. Second, for many of the countries in our sample, foreign investors hold a relatively small share of public debt denominated in local currency. We build a standard, no-arbitrage affine model of defaultable long-term bonds in local currency with global and country-specific shocks to investigate what are the conditions to replicate these findings. We find that a model calibrated to match several moments, including default probabilities and bond maturities, can replicate our empirical findings if there is sufficient heterogeneity in

Table 9: Asset Pricing: Simulated Data

Panel I: Risk Prices							
	λ_{Mkt}	λ_{Dollar}	b_{Mkt}	b_{Dollar}	R^2	$RMSE$	$\chi^2(\%)$
GMM_1	5.73	−0.07	0.43	−0.34	99.20	0.15	
	[0.62]	[0.34]	[0.04]	[0.05]			4.63
GMM_2	5.75	−0.06	0.43	−0.34	99.20	0.15	
	[0.62]	[0.34]	[0.04]	[0.05]			4.63
FMB	5.73	−0.07	0.43	−0.34	98.80	0.15	
	[0.62]	[0.33]	[0.04]	[0.05]			3.66
	(0.62)	(0.33)	(0.04)	(0.05)			4.02
Mean	**5.40**	**-0.11**					
s.e.	[0.45]	[0.34]					

Panel II: Factor Betas						
Portfolio	α_0^j	β_{Mkt}^j	β_{Dollar}^j	R^2	$\chi^2(\alpha)$	p-value (%)
1	−0.02	−0.36	1.23	70.81		
	[0.02]	[0.01]	[0.01]			
2	0.01	−0.17	1.08	79.18		
	[0.01]	[0.00]	[0.01]			
3	0.02	0.06	0.93	85.30		
	[0.01]	[0.00]	[0.01]			
4	0.02	0.32	0.74	79.54		
	[0.01]	[0.01]	[0.01]			
5	0.01	0.61	0.54	69.56		
	[0.02]	[0.01]	[0.01]			
All					9.63	8.66

Notes: This table reports asset pricing results on the portfolios of dollar bond excess returns constructed using simulated data from the unrestricted model. Panel I reports results from GMM and Fama and MacBeth (1973) asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of the mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1986) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey and West (1986) variance-covariance matrix (1 lag) for the system of equations (see Cochrane (2009)). Data are simulated generating $T = 10000$ draws for the country-specific shocks (31 countries), and two global shocks. Parameters are those for the unrestricted version of the model described in section 5.3. The alphas are annualized and in percentage points.

exposure to global shocks, bond maturities are short enough, and the global component of default risk is sufficiently homogenous.

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Appendix

A Data

A.I Local currency government bond return indices

In this section we provide additional descriptive statistics on the LC-bonds data. The first six columns of table A1 reports mean, standard deviation, skewness, kurtosis and first order autocorrelation for the LC-bond returns (r^i). Average monthly returns, expressed in local currency, are positive for all the countries in the sample and range from 0.24% for China to 1.40% for Argentina and tend to be negatively skewed and with large kurtosis. Columns 7–8 report mean and standard deviation for the monthly change in the exchange rate (Δs^i). In the sample considered, most of the emerging countries currencies depreciated against the U.S. dollar. Therefore, dollar returns on investing in LC-bonds are, on average, lower than returns expressed in local currency. Columns 9–10 report mean and standard deviation of the monthly dollar returns on LC-bonds ($r^i - \Delta s^i$). Despite the U.S. dollar average appreciation, dollar returns on LC-bonds are positive for all countries, with the exception of Chile. Note how dollar returns on LC-bonds are more volatile as their variability depends also on exchange rate volatility.

A.II Risk factors

Table A2 reports descriptive statistics on a set of candidate risk factors. $Carry$ is the return from a strategy that goes long high-interest rate currencies and short low-interest rate currencies and is constructed as discussed in Lustig et al. (2011) from portfolios of large advanced and developing countries sorted according on their forward discount with respect the U.S. dollar. $Dollar$ is the return from a strategy that goes long all currencies and is constructed from the same portfolios used to extract $Carry$. Mkt is the excess return on the aggregate U.S. stock market. The market return is from Kenneth French's data library and the risk-free rate is the 3-month T-bill return. Vix is the return on the CBOE Vix index. $Corp$ is the excess return on the Bank of America Merrill Lynch U.S. Corporate bond index. $Comm$ is the excess return on the Bloomberg commodity index. For each risk factor, the table reports the monthly mean in percentage (μ); the monthly standard deviation in percentage (σ); the skewness ($Skew$), kurtosis ($Kurt$) and correlation (ρ) with respect to U.S. stock market excess returns. With the exception of Vix, all factors have, on average, negatively skewed returns and all factors exhibit high kurtosis. $Dollar$ is, on average, highly correlated with the return on the U.S. stock market ($\rho = 0.60$), but also $Carry$, $Corp$ and $Comm$ have correlation coefficients close to 0.4. Vix is, instead, highly negatively correlated with the returns on the U.S. stock market.

Table A3 reports unconditional correlation coefficients between the first five principal components extracted from 5 portfolios of LC-bonds sorted with respect to their $Carry$ betas and the sanme set of candidate risk factors described in table A2. $Dollar$ is the risk factor with the highest correlation with the first principal component ($\rho = 0.83$), which explains approximately 67% of the total variation in bond excess returns. Despite the high correlation, $Dollar$ is not priced in the cross-section as all countries load similarly on it. On the contrary, $Carry$ and Mkt are also highly correlated with the first principal component (0.47 and 0.61 respectively), and are both able to price the cross-section of bond excess

Table A1: Descriptive statistics bond returns

	r^i						Δs^i		$r^i - \Delta s^i$	
Country	Mean	Std	Skewness	Kurtosis	AC(1)	N	Mean	Std	Mean	Std
Argentina	1.40	14.23	-2.52	18.19	0.07	54	0.77	2.31	0.62	15.51
Brazil	1.06	1.81	-0.45	9.51	-0.02	189	0.16	5.17	0.90	6.18
Chile	0.24	0.71	-0.09	4.11	0.02	83	0.30	2.98	-0.06	2.83
China	0.29	0.99	-0.74	8.49	0.21	165	-0.13	0.66	0.43	1.16
Colombia	0.83	1.79	-0.12	3.48	0.18	177	0.02	3.88	0.81	4.95
Hungary	0.65	2.01	-0.58	6.68	0.01	189	-0.03	4.29	0.67	5.72
India	0.64	1.77	0.97	11.66	0.08	189	0.15	2.24	0.49	2.94
Indonesia	0.99	3.75	-0.62	10.67	0.06	177	0.24	2.69	0.75	5.80
Malaysia	0.33	0.89	-0.68	7.88	0.12	189	0.06	2.03	0.27	2.42
Mexico	0.70	1.64	-0.30	4.59	-0.01	189	0.39	3.02	0.31	3.95
Peru	0.61	2.65	0.29	4.97	0.12	133	-0.00	1.71	0.61	3.71
Philippines	0.49	2.56	-0.82	4.66	-0.04	84	0.22	1.48	0.28	3.53
Poland	0.52	1.07	-0.10	3.94	0.05	189	-0.07	4.10	0.59	4.52
Romania	0.43	0.82	0.30	3.06	0.15	55	0.25	2.50	0.19	2.70
Russia	0.68	1.97	-1.83	18.02	0.11	152	0.49	4.58	0.19	5.96
South Africa	0.77	1.99	0.11	4.86	-0.09	189	0.11	4.77	0.65	5.98
Turkey	1.04	2.15	-0.14	4.42	0.09	162	0.61	3.84	0.43	5.41

Notes: This table reports descriptive statistics on the country level LC-bond returns. The first six columns report mean, standard deviation, skewness, kurtosis, first order autocorrelation, and number of monthly observations for the bond returns in local currency (r^i). The mean and the standard deviation are monthly and in percentage. Columns 7–8 report mean and standard deviation, in percentage, of monthly changes in the exchange rate between each country i and the U.S. dollar (Δs^i). Columns 9–10 report mean and standard deviation, in percentage, of monthly LC-bond returns converted in U.S. dollars ($r^i - \Delta s^i$). Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The maximum sample period is 4/2002–10/2017.

returns as we show in section 3.

A.III Defaults and Haircuts

Typically countries issue debt in different markets (i.e., local and foreign), and different currencies. Emerging countries issue most of the debt denominated in local currency in the local market, hence under domestic jurisdiction. On the contrary, most of the foreign currency debt is issued in foreign markets, under foreign jurisdiction. Reinhart and Rogoff (2011b) writes that: *"The overwhelming majority of external public debt, debt under the legal jurisdiction of foreign governments, has been denominated in foreign currency and held by foreign residents"*. We, therefore, assume that the default on debt issued under domestic law is a good proxy for default on debt denominated in local currency, while external debt is denominated in foreign currency. When a country defaults, bondholders enter a renegotiation process that, typically, ends with some form of restructuring of the outstanding debt that implies a *haircut*, or a reduction in the market value of debt with respect to its pre-default value. Table A4 reports data on defaults from Reinhart and Rogoff (2011c) (panel A), and

Table A2: Descriptive statistics risk factors

Factors	*Carry*	*Dollar*	*Mkt*	*Vix*	*Corp*	*Comm*
μ	0.59	0.11	0.74	-0.37	0.38	-0.08
σ	2.14	1.99	3.88	19.95	2.89	4.91
Skew	-0.79	-0.54	-1.08	0.63	-1.14	-0.89
Kurt	5.55	4.49	6.47	4.74	7.99	6.03
ρ	0.39	0.60	1.00	-0.69	0.37	0.48

Notes: This table reports descriptive statistics on a set of candidate risk factors. *Carry* is the return from a strategy that goes long high-interest rate currencies and short low-interest rate currencies and is constructed as discussed in Lustig et al. (2011) from portfolios of large advanced and developing countries sorted according on their forward discount with respect the U.S. dollar. *Dollar* is the return from a strategy that goes long all currencies and is constructed from the same portfolios used to extract *Carry*. *Mkt* is the excess return on the aggregate U.S. stock market. The market return is from Kenneth French's data library and the risk-free rate is the 3-month T-bill return. *Vix* is the return on the CBOE Vix index. *Corp* is the excess return on the Bank of America Merrill Lynch U.S. Corporate bond index. *Comm* is the excess return on the Bloomberg commodity index. For each risk factor, the table reports the monthly mean in percentage (μ); the monthly standard deviation in percentage (σ); the skewness (*Skew*), kurtosis (*Kurt*) and unconditional correlation (ρ) with respect to U.S. stock market excess returns. Data are monthly, from Datastream, Bloomberg and Kenneth French's data library. The sample period is 4/2002–10/2017.

Table A3: Correlation matrix: Risk factors vs. Principal Components

	Carry	*Dollar*	*Mkt*	*Vix*	*Corp*	*Comm*
$PC1$	0.47	0.83	0.61	-0.46	0.17	0.53
$PC2$	0.13	-0.04	-0.01	-0.04	0.10	-0.03
$PC3$	0.02	0.05	0.09	-0.07	-0.01	-0.01
$PC4$	0.16	-0.05	0.19	0.01	0.27	0.10
$PC5$	-0.14	-0.06	0.01	0.01	-0.04	0.02

Notes: This table reports unconditional correlation coefficients between the first five principal components extracted from 5 portfolios of LC-bonds sorted with respect to their *Carry* betas and a set of candidate risk factors. *Carry* is the return from a strategy that goes long high-interest rate currencies and short low-interest rate currencies and is constructed as discussed in Lustig et al. (2011) from portfolios of large advanced and developing countries sorted according on their forward discount with respect the U.S. dollar. *Dollar* is the return from a strategy that goes long all currencies and is constructed from the same portfolios used to extract *Carry*. *Mkt* is the excess return on the aggregate U.S. stock market. The market return is from Kenneth French's data library and the risk-free rate is the 3-month T-bill return. *Vix* is the return on the CBOE Vix index. *Corp* is the excess return on the Bank of America Merrill Lynch U.S. Corporate bond index. *Comm* is the excess return on the Bloomberg commodity index. Data are monthly, from Datastream, Bloomberg and Kenneth French's data library. The sample period is 4/2002–10/2017.

haircuts (panel B) from Cruces and Trebesch (2013). Reinhart and Rogoff (2011c) have documented and categorized all defaults in the past two centuries for domestic (i.e. debt issued domestically usually under domestic jurisdiction) and external (i.e debt issued on international financial markets usually under foreign jurisdiction) public debt. Their sample contains seventy countries for the period 1800-2009 covering Africa, Asia, Europe, Latin America, North America and Oceania. We start considering two shorter time periods: the first starting in 1950 and the second, to match our sample of local currency bond indices, in 2000. Both samples end in 2009. We measure default probability as the total number of defaults as a fraction of the total number of years. Defaults are rare events: in the longer sample, the default probability is 2.17% for external and just 0.60% for domestic debt; in the shorter sample, default probabilities are similar (1.51% and 0.78% respectively). Historically, countries have defaulted on local currency debt also by printing money. Reinhart and Rogoff (2011c) define hyperinflation as inflation crisis episodes using a threshold of 20% per annum. In the longer sample, the frequency of these hyperinflation episodes is 3.68%, while only 1.01% in the shorter sample. If we take a longer view encompassing all countries who have ever defaulted in the last two centuries at least twice, one on domestic and one on external debt, we find that the default probability is 2.50% for external debt, 1.43% for domestic debt, and 4.46% when we include hyperinflation episodes. Looking at the total number of episodes, in the recent postwar period, governments have defaulted on foreign debt 176 times, while on domestic debt only 48 times. However, in the same periods, we observe 158 hyperinflation episodes which constitute a *de facto* partial default on debt denominated in local currency. Interestingly, data indicate that governments default selectively (see also the classic paper by Duffie et al. (2003) on the recent Russian default). Specifically, only 13 times did countries defaulted both on domestic and external debt in the same year. Therefore, less than 30% of domestic defaults coincide with external default. Panel B of table A4 presents data on haircuts and recovery conditional on a default. Data are from Cruces and Trebesch (2013) that use the definition of haircut developed by Sturzenegger and Zettelmeyer (2008)

$$H_t^i = 1 - \frac{\text{PV new debt } (r_t^i)}{\text{PV old debt } (r_t^i)}$$

where the numerator and denominator are the present values of new and old debt computed using the same discount rate r_t^i equal to the interest rate at the exit from default. We define the recovery rate, as in our model, as $h = \log(1 - H)$. The sample contains 187 default episodes from 1970 to 2010. The average haircut is equal to approximately 37% on external debt, and 30% for domestic debt. However, in Cruces and Trebesch (2013) sample, most of the default episodes refer to external defaults. Finally, we report the correlation between the size of the haircut and U.S. demeaned GDP growth and also domestic demeaned GDP growth. Interestingly, it appears that the size of the haircuts is related to global and domestic conditions. Specifically, we find that haircuts tend to be larger in bad economic times for the U.S., and smaller in bad times for the domestic economy. We use this evidence to justify our assumption that the recovery process h_t loads positively on the global shock $\psi_h^w > 0$ and negatively on the country specific shock $\psi_h < 0$.

B Bond portfolios

In this section we report additional information on the bond portfolios sorted on *Carry* betas, as well as alternative portfolios constructed by sorting countries with respect to their stock market betas.

B.I Characteristics of Portfolios sorted on *Carry* betas

Table A5 reports additional information on the bond portfolio built by sorting countries with respect to their *Carry* betas. On average, portfolio 1 contains countries with low *Carry* betas

Table A4: Default and Recovery

(a) Panel A: Defaults

	Mean %			Std %			Total		
	Dom	Ext	Hyper	Dom	Ext	Hyper	Dom	Ext	Hyper
all countries 1950–	0.60	2.17	3.68	3.68	7.69	14.56	48	176	158
all countries 2000–	0.78	1.51	1.01	8.81	12.18	10.00	13	26	10
ever defaulter	1.43	2.50	4.46	11.86	15.63	20.64	44	78	84
our sample	0.00	0.47	0.88				0	1	2

(b) Panel B: Haircuts and Recovery Rate

	Mean %		Std %		Total		Correlation (ρ)	
	Dom	Ext	Dom	Ext	Dom	Ext	US GDP	Dom GDP
Haircut (H)	31.40	37.66	19.99	27.94	6	181	-0.25	0.30
							[-3.5]	[4.28]
$h = \log(1-H)$	-41.13	-66.64	28.61	76.49	6	181		

Notes: This table reports mean, standard deviation, and total number of default episodes (panel A) and size of haircuts (H) and recovery rates ($h = \log(1-H)$. Data on defaults is from Reinhart and Rogoff (2011c) who collect data on 70 countries for the last two centuries. Data on haircut are from Cruces and Trebesch (2013) and include 187 debt restructuring episodes in the period 1970–2010. The first two rows of panel A consider all countries in Reinhart and Rogoff (2011c) in two sample starting, respectively, in 1950 and 2000. The third row considers a sample including all countries who, in the last two centuries, have defaulted at least twice, one on domestic and one on external debt. The fourth row considers the same sample used in our empirical analysis, both in terms of countries and time period. Haircut is measured as in Sturzenegger and Zettelmeyer (2008) as the ratio between the present value of new debt to old debt computed using the same discount rate equal to the interest rate at the exit from default. The t-stats for the correlation coefficients (ρ) are in brackets and computed as $t = \rho\sqrt{(N-2)/(1-\rho^2)}$.

while portfolio 5 contains countries with high *Carry* betas. *Carry* is the return from an investment strategy that goes long high-interest rate currencies and short low-interest rate currencies. *Carry* is constructed as described in Lustig et al. (2011) on a large sample of advanced and developing countries. The first panel shows, for each portfolio, the average share of local currency bonds held by foreign investors using data from Arslanalp and Tsuda (2014). Borri (2017) shows that countries with larger shares of local currency debt held by foreign investors are more exposed to aggregate tail risk. However, in our portfolios, these shares are not significantly different and are approximately equal to 15% for the first four portfolios, and 25% for the last portfolio. The second panel reports, for each portfolio, the average credit ratings using S&P credit ratings for local currency sovereign debt. We convert letter ratings in a numerical index, with a higher number denoting a lower credit rating. The table shows that there are no significant differences in terms of default probabilities across the five portfolios. The third panel reports, for each portfolio, the average total debt-to-GDP ratio. Also in this case, we find no significant differences across the portfolios with similar ratios of approximately 40%.

Table A5: Characteristrics of the Bond portfolios

Portfolio	1	2	3	4	5
			Share foreign investors		
Mean	14.60	16.78	15.50	17.01	25.75
Std	10.71	7.49	7.55	9.83	7.50
			S&P credit rating		
Mean	8.43	7.73	8.41	8.76	9.19
Std	1.71	1.87	2.10	1.56	1.54
			Debt-to-GDP		
Mean	40.12	43.34	42.00	44.81	43.27
Std	12.27	10.51	13.67	14.24	6.82
	Non-resident tax rate on government bond interest in 2015				
Mean	1.3%	6.7%	7.9%	10.0%	0.0%

Notes: This table reports, for each portfolio j, the average and standard deviations for the share of local currency debt held by foreign investors, the S&P credit rating on local currency denominated government debt, the total debt-to-GDP ratio. Letter credit ratings are converted to a numerical index with a higher number denoting a lower credit rating. Data are monthly, from Barclays, Reuters, J.P. Morgan, S&P through Datastream and Arslanalp and Tsuda (2014). The sample period is 4/2002–10/2017.

B.II Alternative sorts

In section 2 we show that sorting countries with respect to their *Carry* betas produces a monotonic cross-section of bond excess returns in U.S. dollars. In section 3 we show that a single factor, the excess return on the U.S. stock market, explains a large fraction of the variation of these excess returns. In this section, we show the properties of portfolios constructed according to alternative sorting. First, we show the portfolios constructed by sorting countries on time-varying stock market betas ($\beta_t^{i,mkt}$). Second, we show the portfolios constructed by sorting countries on the one-month forward discount.

Table A6 presents results of the portfolios sorted according to the stock market betas. We estimate the market betas as slope coefficients of OLS regressions of bond excess returns on the excess return on the U.S. stock market over a rolling window of 24 months. Portfolio 1 contains, on average, bonds with returns that have the smallest correlation with the U.S. stock market, while portfolio 5 contains, on average, bonds with returns with the highest correlation with the U.S. stock market. The first panel of the table reports the average excess return for each portfolio. When sorting on market betas, we do not get a monotonic increasing cross-section of excess returns, even though portfolios 1, 2 and 3 have all significantly lower returns than portfolio 5. A strategy that goes long portfolio 5 and short portfolio 1 generates, on average, 468 basis points *per annum* with a Sharpe ratio of 34%. The fourth panel shows that sorting LC-bonds on stock market betas produces a monotonically increasing cross-section of returns in local currency (Δp_{t+1}^j). However, since the changes in the spot rates show no clear pattern across the five portfolios, we do not observe the same monotonic increasing cross-section of bond excess returns we uncovered in section 2.

Table A7 presents the properties of portfolios constructed by sorting countries with respect to the one-month forward discount which is approximately equal to the short-term interest rate differential. At time t we sort bonds based on the one-month forward discount at the end of period t-1. The first portfolio contains bonds of countries with the lowest short-term interest rates. The last portfolio contains bonds of countries with the highest short-term interest rates. In this case, we do not obtain any cross-section of bond excess returns. In fact, the high-minus-low strategy that goes long bonds of countries with high short-term interest rates and short bonds of countries with low short-term interest rates has, on average, a negative returns.

B.III Taxes

In this section we present stylized data on tax rates that foreign investors have to pay to purchase local currency bonds of the countries in our sample. The second column of table A8 reports the average portfolio in which each country is allocated over the whole sample. The remaining columns reports the tax rates on corporate bonds, government bonds, dividends, and capital gains. Tax data are for the fiscal year 2015 and for a representative foreign investor from Luxembourg. Different countries can have different tax treaties with each of the countries in our sample. We observe that for most countries, the tax rate on local currency government bonds is zero, with the exception of India, Indonesia, the Philippines, Poland and Russia that have tax rate of approximately 20 percent.

C Conditional Global Risk

In section 4 we showed that a conditional CAPM model, like the DR-CAPM of Lettau et al. (2014), is able to explain the cross-section of portfolio excess returns. In this section, we present results from an alternative strategy commonly used to estimate time-varying risk premia and that is based on the construction of managed portfolios.

Table A6: Bond portfolios sorted on U.S. market betas

Portfolio	1	2	3	4	5
			Bond excess returns: rx^j_{t+1}		
Mean	4.66	2.78	3.10	8.32	9.34
Std	7.99	11.51	14.19	14.12	15.43
SR	0.58	0.24	0.22	0.59	0.61
			Spot change: Δs^j		
Mean	-0.05	2.46	4.01	0.47	2.23
Std	7.99	11.51	10.67	11.36	11.08
			Forward discount: $f^j - s^j$		
Mean	8.13	7.42	5.03	6.51	6.64
Std	5.77	4.31	2.06	2.35	1.46
			Bond price change: Δp^j_{t+1}		
Mean	4.61	5.24	7.11	8.80	11.56
Std	4.67	4.65	5.60	5.09	6.22
			High minus low: $rx^j_{t+1} - rx^1_{t+1}$		
Mean		-1.88	-1.56	3.66	4.68
Std		11.56	13.01	12.16	13.60
SR		-0.16	-0.12	0.30	0.34
			U.S. market betas: $\beta^{mkt,j}$		
Mean	0.06	0.26	0.41	0.55	0.88
Std	0.09	0.16	0.04	0.25	0.04
			Frequency		
Trades/bond	13.37	25.00	32.17	34.88	10.48

Notes: This table reports, for each portfolio j, the average log excess return rx^j, the average change in the log spot exchange rate Δs^j, the average forward discount $f^j - s^j$, the average change in the log bond price in local currency, and the average spread . All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting bonds into five groups at time t based on slope coefficients $\beta^{mkt,i}$. Each $\beta^{mkt,i}$ is obtained by regressing bond i excess returns rx^i on the returns on the U.S. stock market on a 24-month period moving window that ends in period t-1. The first portfolio contains bonds with the lowest βs. The last portfolio contains bonds with the highest βs. The last panel reports the turnover, expressed as average number of trades per bond in each portfolio. Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 4/2002–10/2017.

C.I Managed portfolios

In order to analyze conditional risk premia we report results with managed portfolios. Investors can adjust their position in a given LC-bond based on the state of economic conditions, proxied by the level of the CBOE VIX index at the start of each period t. We assume that such managed investment strategies capture the cross-section of conditional expected excess returns in addition to the raw bond excess returns (Cochrane, 2009). To construct the managed portfolios, we multiply each portfolio excess returns by the beginning-of-month value of the VIX index, normalized by subtracting its unconditional mean and dividing it by the normalized standard deviation. We use the same estimation technique and risk factor presented in section 3 on the augmented set of test assets. Table xx reports the results. The

Table A7: Bond portfolios sorted on one-month forward discount

Portfolio	1	2	3	4	5
			Bond excess returns: rx^j_{t+1}		
Mean	8.47	8.41	6.80	5.89	7.15
Std	10.30	9.48	12.70	14.22	15.62
SR	0.82	0.89	0.54	0.41	0.46
			Spot change: Δs^j		
Mean	-1.90	-2.20	0.76	3.26	3.81
Std	10.30	9.48	9.06	10.79	10.98
			Forward discount: $f^j - s^j$		
Mean	-3.52	1.57	3.52	5.88	20.73
Std	1.78	0.62	0.65	0.89	5.72
			Bond price change: Δp^j_{t+1}		
Mean	6.57	6.22	7.56	9.16	10.96
Std	5.63	4.29	5.86	5.86	6.86
			High minus low: $rx^j_{t+1} - rx^1_{t+1}$		
Mean		-0.05	-1.67	-2.58	-1.32
Std		10.32	10.53	11.75	12.38
SR		-0.01	-0.16	-0.22	-0.11
			Frequency		
Trades/bond	43.62	56.56	61.35	62.50	31.55

Notes: This table reports, for each portfolio j, the average log excess return rx^j, the average change in the log spot exchange rate Δs^j, the average forward discount $f^j - s^j$, the average change in the log bond price in local currency, and the average spread . All moments are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting bonds into five groups at time t based on the one-month forward discount (i.e, short-term nominal interest rate differential) at the end of period t-1. The first portfolio contains bonds of countries with the lowest short-term interest rates. The last portfolio contains bonds of countries with the highest short-term interest rates. The last panel reports the turnover, expressed as average number of trades per bond in each portfolio. Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 4/2002–10/2017.

market price of risk of the U.S. stock market return (λ_{Mkt}) is positive and significant and in line with the value obtained on the unconditional returns. Therefore, our standard CAPM model accounts for a large share of the cross-sectional differences in bond excess returns in both samples.

C.II Kernel smoothed conditional correlation

The kernel smoothed conditional correlation presented in section 4 is computed as follows

$$f(x) = E[(x - \mu_x)(y - \mu_y)|Z = z]$$

Compute

Table A8: Taxes

country	portfolio	Corporate bonds	Government bonds	Dividends	Capital gains
Argentina	4	0.35	0	0.1	0.135
Brazil	3	0.15	0	0	0
Chile	1	0.04	0.04	0.35	0.35
China	1	0.1	0	0.1	0.1
Colombia	3	0.15	0	0.05	0.1
Hungary	3	0	0	0	0
India	2	0.2	0.2	0	0.2
Indonesia	4	0.2	0.2	0.2	0.2
Malaysia	2	0.15	0	0	0.03
Mexico	3	0.049	0	0.1	0.1
Peru	2	0.04	0	0.068	0.3
Philippines	3	0.2	0.2	0.15	0.3
Poland	3	0.2	0.2	0.19	0.19
Romania	1	0.16	0	0.16	0.16
Russia	3	0.2	0.15	0.15	0
South Africa	5	0.15	0	0.15	0.075
Turkey	5	0	0	0.15	0

Notes: This table reports, for each of the countries in our sample, the average portfolio in which they are allocated and the tax rates for foreign investors on different financial instruments. Tax data are for the fiscal year 2015 and are from KPMG and the foreign investors are from Luxembourg.

$$\hat{f}(z) = \sum_{i=1}^{T} W_t(z)(x_t - \bar{x})(y_t - \bar{y})$$

where $W_i(z) = K((z_t - z)/h)/\sum_{t=1}^{T} K((z_t - z)/h)$ and $K(u) = exp(-u^2/2)$ is the normal kernel. The averages are conditional

$$\bar{x} = \sum_{t=1}^{T} W_t(z)x_t \quad \bar{y} = \sum_{t=1}^{T} W_t(z)y_t$$

D Model

D.I Approximating returns

In the model, we approximate returns on defaultable long-term bonds using the Campbell and Shiller (1988)'s log-linear approximation of the price to coupon ratio

$$r^i_{t+1} \approx k^{b,i}_0 + k^{b,i}_1 p^i_{t+1} - p^i_t + h^i_{t+1}, \tag{A1}$$

where $k^{b,i}_0, k^{b,i}_1$ are constants coming from the Taylor approximation around the mean log price-coupon ratio. In this case, the process for the logarithm of the price of the long-term bond is affine.

$$p_t^i = A_b^i + B_b^i z_t^i + C_b^i z_t^w \tag{A2}$$

where the coefficients A_b^i, B_b^i and C_b^i result from applying the equilibrium Euler equation to local currency bond returns (i.e., $E_t[M_{t+1}^i R_{t+1}^i] = 1$) and as solutions to the following systems of equations

$$A_b^i = k_0^{b,i} + k_1^{b,i}\left(A_b^i + B_b^i(1-\phi)\theta + C_b^i(1-\phi^w)\theta^w\right) + \mu_h - \alpha \tag{A3}$$

$$B_b^i = k_1^{b,i} B_b^i \phi + \psi_h - \chi + 0.5\left(\sqrt{\gamma} - k_1^{b,i} B_b^i \sigma - \sigma_h\right)^2 + 0.5\left(\sqrt{\kappa} - \sigma_h^g\right)^2 \tag{A4}$$

$$C_b^i = k_1^{b,i} C_b^i \phi^w + \psi_h^w - \tau + 0.5\left(\sqrt{\delta^i} - k_1^{b,i} C_b^i \sigma^w - \sigma_h^w\right)^2 \tag{A5}$$

The system has three equations, with two independent quadratic equations that define B_b^i and C_b^i and one linear equation that defines A_b^i. Each of the two quadratic equations has two solutions. The quadratic equation on C_b^i has two roots: one is explosive in the limit of $\sigma^w \to 0$, while in fact it should converge to

$$\frac{\psi_h^w - \tau + 0.5\left(\sqrt{\delta^i} - \sigma_h^w\right)^2}{1 - k_1^{b,i}\phi^w}$$

Following a similar reasoning, we exclude the explosive solution for B_b^i, which we identify by taking the limit of $\sigma \to 0$. We approximate the return on U.S. equity market (i.e., the return on the aggregate dividend claim) in a similar way. The structure of the equation for $C_p d$ is identical to C_b^i. By taking the same limit of $\sigma^w \to 0$, we can eliminate the explosive root and keep the one, which converges to

$$\frac{\psi_d^w - \tau + 0.5\left(\sqrt{\delta} - \sigma_d^w\right)^2}{1 - k_1^e \phi^w}$$

D.II Decomposing Excess Returns on Long-Term Bonds

We are interested in decomposing the total expected excess return on defaultable long-term bonds for foreign investors into three component:

$$\begin{aligned} E_t\left[rx_{t+1}^i\right] &+ \frac{1}{2}Var_t\left[rx_{t+1}^i\right] = -Cov_t\left[m_{t+1}, rx_{t+1}^i\right] \\ &= -k_1^{b,i} Cov_t\left[p_{t+1}^i, m_{t+1}\right] - Cov_t\left[h_{t+1}^i, m_{t+1}\right] \\ &+ Cov_t\left[m_{t+1}, \Delta q_{t+1}^i\right] \end{aligned}$$

The first term represents the local currency term premium: i.e., the covariance between the future price and the U.S. investor SDF. The second term represents the credit risk: the covariance between the recovery rate and the U.S. investor SDF. The last term represents the exchange rate risk premium. The exchange rate risk premium is the same of the restricted model. We focus here on the first two terms:

$$\begin{aligned}
-k_1^{b,i} Cov_t\left[p_{t+1}^i, m_{t+1}\right] &= k_1^{b,i}\left(C_b^i \sigma^w \sqrt{z_t^w}\sqrt{z_t^w \delta} + B_b^i \sigma \sqrt{z_t^i}\sqrt{z_t \gamma}\right) \\
-Cov_t\left[h_{t+1}^i, m_{t+1}\right] &= \sigma_h^w \sqrt{z_t^w}\sqrt{z_t^w \delta} + \sigma_h \sqrt{z_t^i}\sqrt{z_t \gamma} + \sigma_h^g \sqrt{z_t^i}\sqrt{z_t \kappa} \\
Cov_t\left[m_{t+1}, \Delta q_{t+1}^i\right] &= \gamma z_t + \sqrt{z_t^w \delta}\left(\sqrt{z_t^w \delta} - \sqrt{z_t^w \delta^i}\right) + \sqrt{z_t \kappa}\left(\sqrt{z_t \kappa} - \sqrt{z_t^i \kappa}\right)
\end{aligned}$$

If $h_t^i = 0$ for any t, then the second term is zero. If the bond is short term, $k_1^{b,i} = 0$ and also the first term is equal to zero. In this case, we are back to the restricted model discussed in section 5.1. In order to understand if there is cross section with respect to sorting on δ^i, we take the derivative of each term with respect to δ^i

$$\begin{aligned}
-k_1^{b,i}\frac{\partial Cov_t\left[p_{t+1}^i, m_{t+1}\right]}{\partial \delta^i} &= k_1^{b,i}\sigma^w z_t^w \sqrt{\delta}\frac{\sqrt{\delta^i}\left(1 - k_1^{b,i}\phi^w + k_1^{b,i}\sigma^w\left(\sqrt{\delta^i} - k_1^{b,i} C_b^i \sigma^w - \sigma_h^w\right)\right)}{0.5\left(\sqrt{\delta^i} - k_1^{b,i} C_b^i \sigma^w - \sigma_h^w\right)} \\
\frac{\partial Cov_t\left[m_{t+1}, \Delta q_{t+1}^i\right]}{\partial \delta^i} &= -\sqrt{\delta} z_t^w \frac{1}{2\sqrt{\delta^i}}
\end{aligned}$$

For empirically plausible set of parameters, $\frac{\partial C_b^i}{\partial \delta^i}$ is positive. Hence, the whole term premium increases with δ^i. Interestingly, it also increases with maturity, which is controlled by the parameter $k_1^{b,i} \in [0,1]$. On the contrary, the exchange rate risk premium exhibits a the negative cross section with respect to δ^i. In the limited case of one period bond $k_1^{b,i} = 0$, the derivative of term premium is equal zero. If the bond is very long-term, then the effect of term premium might dominate the effect of the exchange rate.

D.III Inflation

We assume that inflation is time varying, specifically it follows the auto-regressive square root process similar to the one for the SDF or the recovery rate.

$$\pi_{t+1}^i = \pi_0 + \eta z_t^i + \eta^w z_t^w + \sigma_\pi \sqrt{z_t^i} u_{t+1}^i + \sigma_\pi^w \sqrt{z_t^w} u_{t+1}^w + \sigma_\pi^g \sqrt{z_t^i} u_{t+1}^g$$

In section 5.4, for simplicity we assume that $\sigma_\pi = \sigma_\pi^w = \sigma_\pi^g = 0$, so that π_{t+1} simply inherits the stochastic properties of the country-specific and global state variables. If bonds are defaultable and long-maturity, then the the nominal returns have a very similar form to real returns

$$r_{t+1}^{n,i} \approx k_0^{b,n,i} + k_1^{b,n,i} p_{t+1}^{n,i} - p_t^{n,i} + h_{t+1}^i,$$

where $k_0^{b,n,i}, k_1^{b,n,i}$ are constants coming from the Taylor approximation around the mean log price-coupon ratio. In this case, the process for the logarithm of the nominal price of the long-term bond is affine.

$$p_t^{n,i} = A_b^{n,i} + B_b^{n,i} z_t^i + C_b^{n,i} z_t^w$$

where the coefficients $A_b^{n,i}$, $B_b^{i,n}$ and $C_b^{i,n}$ result from applying the equilibrium Euler equation to nominal local currency bond returns (i.e., $E_t[M_{t+1}^{n,i} R_{t+1}^{n,i}] = 1$) and as solutions to the following systems of equations

$$\begin{aligned}
A_b^{n,i} &= k_0^{b,i} + k_1^{b,i}\left(A_b^{n,i} + B_b^{i,n}(1-\phi)\theta + C_b^{i,n}(1-\phi^w)\theta^w\right) + \mu_h - \alpha - \pi_0 \\
B_b^{i,n} &= k_1^{b,i} B_b^{i,n}\phi + \psi_h - (\chi + \eta) + 0.5\left(\sqrt{\gamma} + \sigma_\pi - k_1^{b,i} B_b^{i,n}\sigma - \sigma_h\right)^2 + 0.5\left(\sqrt{\kappa} + \sigma_\pi^g - \sigma_h^g\right)^2 \\
C_b^{i,n} &= k_1^{b,i} C_b^{i,n}\phi^w + \psi_h^w - (\tau + \eta^w) + 0.5\left(\sqrt{\delta^i} + \sigma_\pi^w - k_1^{b,i} C_b^{i,n}\sigma^w - \sigma_h^w\right)^2
\end{aligned}$$

If $\sigma_\pi = \sigma_\pi^w = \sigma_\pi^g = 0$, then inflation influences nominal bond prices only through the conditional mean effect captured by the parameters η and η^w. When the conditional volatilities of the shocks to the inflation process are different from zero, then inflation influences nominal bond prices also through the precautionary saving effect. In table A11

D.IV Simulated Moments

In this section, we first presents simulated moments of the unrestricted model. Second, we present the properties of the portfolios of nominal bond excess return sorted on the *Carry* risk factor extracted by the restricted version of our model with inflation.

Table 7 presents the simulation results. We list the moments for the nominal and real bond returns, exchange rates, and inflation in the simulated data. Panel I reports moments for the U.S. (i.e., the country with the median δ^i in the model). The average U.S. nominal risk-free rate is approximately 4% per annum, the average U.S. nominal equity return is approximately 12% per annum, and inflation approximately 3%. Panel II reports the moments for the cross-section of countries. The simulated defaultable long-maturity bond returns are lower than in the data, and not as volatile.

In table A11 we presents portfolios of nominal bond excess returns. All the parameters are those discussed in section 5.5, while the parameters defining the inflation process are $\pi_0 = -0.49\%$, $\eta = 0$, and $\eta^w = 9.41$. The properties of the portfolios are similar to those obtained using real returns from the unrestricted model.

D.V Asset Pricing: using *Carry* as Risk Factor

In table A12 we report results of the asset pricing exercise where we replace the *Mkt* factor with *Carry*. Results are mostly similar to those produced by using *Mkt*.

Table A9: Conditional Asset Pricing (Managed Portfolios)

	Panel I: Risk Prices				
	λ_{Mkt}	b_{Mkt}	R^2	$RMSE$	$\chi^2(\%)$
GMM_1	9.66	0.45	88.63	2.35	
	[6.58]	[0.30]			53.92
GMM_2	12.68	0.58	58.36	4.50	
	[5.00]	[0.23]			57.64
FMB	9.66	0.44	87.54	2.35	
	[5.42]	[0.25]			49.73
	(5.49)	(0.25)			53.14
Mean	**8.88**				
s.e.	[3.99]				
	Panel II: Factor Betas				
Portfolio	α_0^j	β_{Mkt}^j	R^2	$\chi^2(\alpha)$	p-value (%)
1	0.02	0.18	5.76		
	[0.29]	[0.04]			
2	−0.03	0.38	20.11		
	[0.23]	[0.06]			
3	0.11	0.45	21.58		
	[0.28]	[0.09]			
4	0.21	0.57	31.97		
	[0.26]	[0.08]			
5	0.29	0.66	32.97		
	[0.28]	[0.09]			
6	0.19	0.56	8.13		
	[0.63]	[0.17]			
7	−0.44	1.41	31.75		
	[0.70]	[0.31]			
8	−0.14	1.68	28.04		
	[0.89]	[0.44]			
9	0.02	2.13	36.60		
	[0.87]	[0.39]			
10	0.48	2.30	35.11		
	[1.00]	[0.44]			

Notes: Panel I reports results from GMM and Fama and MacBeth (1973) asset pricing procedures applied to an augmented set of test assets that included managed portfolios constructed by multiplying each portfolio excess returns by the beginning-of-month value of the VIX index, normalized by subtracting its unconditional mean and dividing it by the normalized standard deviation. Market prices of risk λ, the adjusted R^2, the square-root of the mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1986) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey and West (1986) variance-covariance matrix (1 lag) for the system of equations (see Cochrane (2009)). Data are monthly, from Barclays, Reuters and J.P. Morgan through Datastream. The sample period is 4/2002–10/2017. The alphas are annualized and in percentage points.

Table A10: Simulated moments

Moment	*Nominal Values*	*Real Values*
	Panel I: Time Series Moments – U.S.	
	Bond Returns (short-maturity & risk-free)	
$E[r]$	4.09	1.11
$\sigma[r]$	0.46	0.43
$\rho[r]$	0.92	0.92
	Equity market	
$E[r^e]$	12.21	6.62
$\sigma[r^e]$	12.18	12.78
$\rho[r^e]$	0.03	0.00
	Inflation	
$E[\pi]$	2.98	
$\sigma[\pi]$	0.58	
$\rho[\pi]$	0.92	
	Panel II: Cross-Sectional Moments – All countries	
	Bond returns (long-maturity & risky)	
$E_{cross}(E[r^i])$	4.04	1.72
$E_{cross}(\sigma[r^i])$	0.46	0.43
$E_{cross}(\rho[r^i])$	-0.02	-0.03
$E_{cross}(\rho[r, r^i])$	-0.13	0.10
	Exchange Rates	
$E_{cross}(\sigma[\Delta s^i])$	13.66	13.66
	Stochastic Discount Factor	
$E_{cross}(\sigma[m^i_{t+1}])$	53.48	53.48
$E_{cross}(\rho[m_{t+1}, m^i_{t+1}])$	0.97	0.97

Notes: This table reports the annualized means and standard deviations (in percentages) of nominal and real variables for the unrestricted version of the model. The autocorrelations ($\rho(x)$) and the correlations ($\rho(x_1, x_2)$) are reported monthly. In the first section of Panel I, the table presents the mean, standard deviation, and autocorrelation of the short-term (i.e., 1-period) default risk-free rate in the U.S. In the second section of Panel I, the table reports mean, standard deviation and autocorrelation of the equity market return in the U.S. In the third section of Panel I, the table presents the mean, standard deviation and autocorrelation of the inflation rate in the U.S. In the first section of Panel II, the table reports the cross-sectional average of the mean, standard deviation, autocorrelation, and cross-country correlation with the U.S. of returns on defaultable long-maturity bonds. In the second section of Panel II, the table reports the cross-sectional average of exchange rates' volatilities. In the third section of Panel II, the table reports the cross-sectional average of the SDFs' volatilities and of the cross-country correlation of all SDFs with the U.S. SDF. Data are simulated using the unrestricted model and the parameters discussed in section 5.5.

Table A11: Bond portfolios: Unrestricted Model with Nominal Variables

Portfolio	1	2	3	4	5
	Nominal bond excess returns: rx^j_{t+1}				
Mean	-3.15	-1.68	-0.21	1.27	2.78
Std	12.34	10.77	9.77	10.23	12.48
SR	-0.26	-0.16	-0.02	0.12	0.22
	Nominal exchange rate change: Δs^j				
Mean	0.24	0.04	0.05	0.06	-0.03
Std	12.28	10.65	9.81	10.73	13.47
	Forward discount: $f^j - s^j$				
Mean	-2.91	-1.64	-0.17	1.33	2.75
Std	0.68	0.78	0.99	1.27	1.54
	Carry betas: β^j_{Carry}				
Mean	-0.41	-0.23	-0.04	0.18	0.43
Std	0.08	0.08	0.07	0.07	0.08
	Market betas: β^j_{Mkt}				
Mean	0.08	0.24	0.38	0.56	0.77
Std	0.19	0.16	0.15	0.12	0.12
	Exposure to global shock: $\overline{\delta^j}$				
Mean	20.12	17.38	14.01	10.67	7.67
Std	0.27	0.33	0.27	0.22	0.15
	High minus low: $rx^j_{t+1} - rx^1_{t+1}$				
Mean		1.47	2.93	4.41	5.93
Std		5.57	8.20	11.87	16.10
SR		0.14	0.36	0.37	0.37

Notes: This table reports, for each portfolio j, the average log excess return rx^j, the average change in the log real exchange rate Δq^j, the average forward discount $f^j - s^j$, the average *Carry* and *Market* betas, the average exposure to the first global shock $\overline{\delta^j}$, and the average spread. All variables are nominal. All moments, with the exception of the betas, are annualized and reported in percentage points. For excess returns, the table also reports Sharpe ratios, computed as ratios of annualized means to annualized standard deviations. Portfolios are constructed by sorting bonds into five groups at time t based on time-varying *Carry* betas estimated as slope coefficients on OLS regressions of country i bond excess returns on a constant and the *Carry* risk factor using a rolling window of 100 months. Data are obtained simulating 31 countries for $T = 10000$ months and using the parameters presented in section 5.5 and setting the parameters defining the inflation process to $\pi_0 = -0.49\%$, $\eta = 0$, and $\eta^w = 9.41$. Country-specific shocks of the 31 countries of the unrestricted model are different from the country-specific shocks of the 31 countries of the restricted model.

Table A12: Asset Pricing: Simulated Data

Panel I: Risk Prices							
	λ_{Carry}	λ_{Dollar}	b_{Carry}	b_{Dollar}	R^2	$RMSE$	$\chi^2(\%)$
GMM_1	6.85	0.08	0.20	−0.01	99.19	0.16	
	[0.68]	[0.35]	[0.02]	[0.03]			4.68
GMM_2	6.86	0.08	0.20	−0.01	99.19	0.16	
	[0.68]	[0.35]	[0.02]	[0.03]			4.68
FMB	6.85	0.08	0.20	−0.01	98.79	0.16	
	[0.68]	[0.33]	[0.02]	[0.03]			3.42
	(0.68)	(0.33)	(0.02)	(0.03)			3.61
Mean	**8.30**	**-0.11**					
s.e.	[0.58]	[0.34]					

Panel II: Factor Betas						
Portfolio	α_0^j	β_{Carry}^j	β_{Dollar}^j	R^2	$\chi^2(\alpha)$	p-value (%)
1	0.04	−0.32	0.97	82.51		
	[0.01]	[0.00]	[0.01]			
2	0.04	−0.16	0.97	83.68		
	[0.01]	[0.00]	[0.01]			
3	0.03	0.03	0.97	85.17		
	[0.01]	[0.00]	[0.00]			
4	−0.01	0.25	0.97	84.90		
	[0.01]	[0.00]	[0.01]			
5	−0.06	0.49	0.98	83.92		
	[0.02]	[0.00]	[0.01]			
All					28.75	0.00

Notes: This table reports asset pricing results on the portfolios of dollar bond excess returns constructed using simulated data from the unrestricted model. Panel I reports results from GMM and Fama and MacBeth (1973) asset pricing procedures. Market prices of risk λ, the adjusted R^2, the square-root of the mean-squared errors $RMSE$ and the p-values of χ^2 tests on pricing errors are reported in percentage points. b denotes the vector of factor loadings. All excess returns are multiplied by 12 (annualized). Shanken (1992)-corrected standard errors are reported in parentheses. We do not include a constant in the second step of the FMB procedure. Panel II reports OLS estimates of the factor betas. R^2s and p-values are reported in percentage points. The standard errors in brackets are Newey and West (1986) standard errors computed with the optimal number of lags according to Andrews (1991). The χ^2 test statistic $\alpha' V_\alpha^{-1} \alpha$ tests the null that all intercepts are jointly zero. This statistic is constructed from the Newey and West (1986) variance-covariance matrix (1 lag) for the system of equations (see Cochrane (2009)). Data are simulated generating $T = 10000$ draws for the country-specific shocks (31 countries), and two global shocks. Parameters are those for the unrestricted version of the model described in section 5.3. The alphas are annualized and in percentage points.