HARVARD | BUSINESS | SCHOOL

Sovereign Risk, Currency Risk, and Corporate Balance Sheets

Wenxin Du
Jesse Schreger

Working Paper 17-024

Sovereign Risk, Currency Risk, and Corporate Balance Sheets

Wenxin Du
Federal Reserve Board

Jesse Schreger
Harvard Business School

Working Paper 17-024

Copyright © 2016 by Wenxin Du and Jesse Schreger

Working papers are in draft form. This working paper is distributed for purposes of comment and discussion only. It may not be reproduced without permission of the copyright holder. Copies of working papers are available from the author.

Sovereign Risk, Currency Risk, and Corporate Balance Sheets*

Wenxin Du
Federal Reserve Board

Jesse Schreger †
Harvard Business School
and NBER

September 2016

Abstract

We construct a new dataset of 14 emerging markets and show that sovereigns increasingly borrow from foreigners in local currency but the private sector continues to borrow in foreign currency. We show that a higher reliance on foreign currency corporate financing is associated with more sovereign default risk. We introduce local currency sovereign debt and private currency mismatch into a standard sovereign debt model to examine how the currency composition of corporate borrowing affects the sovereign's incentive to inflate or default. A calibration of the model generates the empirical patterns of currency and sovereign credit risk over the last decade.

*We are especially grateful to Gita Gopinath, Ken Rogoff, John Campbell, Jeff Frieden, and Jeff Frankel for their invaluable advice and guidance. We thank Laura Alfaro, Serkan Arslanalp, David Baqaee, Carol Bertaut, Laura Blattner, Max Eber, Emmanuel Farhi, Herman Kamil, Ricardo Hausmann, Illenin Kondo, Marcio Garcia, Matteo Maggiori, Andrea Raffo, Romain Raniciere, Carmen Reinhart, John Rogers, Felipe Saffie, Jeremy Stein, Alexandra Tabova, Adrien Verdelhan, Vivian Yue, and various seminar and conference participants for helpful comments. We are particularly grateful to our discussants Luigi Bocola and Galina Hale for very useful feedback. We thank Lina Beatriz Gómez Castillo, Joao Henrique Freitas, Emmanuel Kohlscheen, and Renzo Jiménez Sotelo for assistance in acquiring and interpreting various data sources. Conor Howells and Christine Rivera provided excellent research assistance. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or any other person associated with the Federal Reserve System. All errors are our own.

†Schreger (Corresponding author): Harvard Business School, Morgan Hall, Boston, MA 02163. Email: jschreger@hbs.edu. Du: Federal Reserve Board, 20th and C Streets NW, Washington, D.C. 20551. Email: wenxin.du@frb.gov.

1 Introduction

During the 1980s, 1990s, and early 2000s, a number of sovereign debt crises engulfed emerging markets. While the details of each sovereign debt crisis were different, the broader story remained the same: the government borrowed from foreign investors in foreign currency (FC) during good times only to later default on their external debt as economic conditions deteriorated. Following these crises, emerging market governments curtailed their FC borrowing and moved toward borrowing in their local currency (LC). Using a newly constructed comprehensive dataset on the currency composition of sovereign and corporate external debt, we find that over the last decade major emerging market sovereigns went from having around 85% of their external debt in FC to having more than half of their external sovereign debt in their own currency. By contrast, even as governments were dramatically changing the way they finance themselves, the private sector continued to borrow from foreigners almost entirely in FC.

Despite their shift toward LC debt, emerging market (EM) sovereigns continue to be charged a positive credit spread when they borrow in their own currency. The outright default risk on LC debt might at first seem puzzling. In his Presidential Address to the American Economic Association, Chris Sims (Sims, 2013) writes "Nominal sovereign debt promises only future payments of government paper, which is always available... Obviously outright default on nominal debt is much less likely than default on real debt... Nominal debt is (almost) non-defaultable." In our previous work (Du and Schreger, 2016), we calculate a measure of the default-free LC interest rate using cross-currency swaps and show that emerging market sovereigns borrow at a significant credit spread above the risk-free rate in their own currency. These positive LC credit spreads suggest that nominal LC sovereign bonds are not default-free. Furthermore, LC credit spreads remain positive even for countries where the sovereign external liabilities are almost exclusively denominated in LC, such as Thailand, Malaysia, and South Korea. This raises the question of why a sovereign would default on debt denominated in its own currency when it could instead inflate the debt away. The simplest answer is that it would default if the sovereign finds it less painful to do so than to experience inflation high enough to restore fiscal solvency.

In this paper, we argue that the private sector's continuing reliance on external FC debt raises the cost of inflating away sovereign debt and explains why sovereign default risk remains even though governments increasingly borrow in their own currency. If the private sector earns revenues in LC but has borrowed extensively in FC, a depreciation could adversely affect firm net worth, which in turn could reduce aggregate output in the presence of firm financial constraints. The idea that corporate balance sheet mismatch could make depreciations contractionary was studied extensively following the Asian Financial Crisis.[1] The theoretical contribution of this paper is to demonstrate how these contractionary effects working through corporate balance sheets can be a source of default risk on LC sovereign debt.

[1] See, for instance, Krugman (1999), Céspedes et al. (2004), Gertler et al. (2007), and Aghion et al. (2000, 2001, 2004). Korinek (2010) explores the effects of the private sector borrowing in foreign currency.

We begin by documenting the dramatic contrast between the currency denomination of sovereign and corporate external portfolios in 14 major emerging markets. We find that sovereigns are increasingly borrowing in LC from foreign investors, while corporate external liabilities still remain largely in FC. Since 2003, we find that the average fraction of external sovereign debt in LC increased from around 15% to almost 60%. However, during this same period, the share of external private sector debt in LC only increased from 7% to 10%. Figure 1 documents the sharp rise of foreign participation in LC sovereign debt markets and shows that foreign holdings now account for approximately one-third of all outstanding LC sovereign debt.

[Figure 1 here]

The composition of corporate balance sheets has significant implications for sovereign credit risk. We use our aggregate cross-country dataset on the currency composition of external liabilities to show that a higher reliance on external FC corporate financing is associated with a higher default risk on sovereign debt. In a panel regression, conditional on the variables the literature has shown to explain sovereign credit spreads, we find that an increase in the ratio of private FC debt-to-GDP of 10% is associated with a nearly 60 basis point increase in the sovereign LC credit spread. We then present evidence that the FC liabilities of emerging market firms are unlikely to be fully hedged by FC revenues or foreign exchange (FX) derivatives. We find that firms in non-tradable sectors, as well as firms in sectors with low levels of exports, borrow significant amounts in foreign currency. In addition, we show that the outstanding amounts of FC liabilities are generally much larger than the notional outstanding of cross-currency swaps for most sample countries.

Motivated by the dramatic changes in emerging market borrowing and the empirical evidence on the importance of private FC debt for sovereign risk, we introduce LC sovereign debt and a corporate sector with FC external liabilities and LC revenues into the canonical Eaton and Gersovitz (1981) sovereign default model, as formulated in a quantitative framework by Aguiar and Gopinath (2006) and Arellano (2008). The model demonstrates that the borrowing patterns of the private sector can have large effects on the nature of sovereign risk. When the private sector is highly mismatched, meaning private debt is overwhelmingly in FC but revenues are in LC, the sovereign is reluctant to allow an exchange rate depreciation to reduce the real value of its debt, generating a "fear of floating" as in Calvo and Reinhart (2002). In this case, when the government considers whether to default or use inflation to reduce the fiscal burden of sovereign debt repayments, it is relatively more inclined to explicitly default than to inflate away the debt because of the effect of depreciation on the private sector.

A calibration of the dynamic model to the average share of corporate debt in our panel of emerging markets produces simulated moments of currency and credit risk very similar to the cross-country mean empirical moments documented in our previous work (Du and Schreger 2016). The model suggests that relatively small reductions in the share of private external borrowing in FC could significantly reduce the probability of a sovereign default. The model's prediction on the rate at which sovereign credit risk declines with the share of LC corporate debt finds strong support in the data.

This paper makes two primary contributions. First, we provide a comprehensive account of the currency composition of external liabilities by sector in emerging markets. This contributes to the work on "original sin," beginning with Eichengreen and Hausmann (1999), and the evolution of the currency composition of external liabilities documented in Lane and Shambaugh (2010) and Bénétrix et al. (2015). Several recent papers document the rapid growth in foreign participation in domestic LC sovereign debt markets, for example, Burger and Warnock (2007), Burger et al. (2012), Burger et al. (2014), and Arslanalp and Tsuda (2014). We combine data on foreign participation in domestic sovereign debt markets with data on international debt securities and cross-border loans and demonstrate how including foreign ownership of domestic debt in calculations of external debt significantly changes the aggregate currency composition of sovereign external liabilities. Vulnerabilities in the emerging market corporate sector coming from external foreign currency borrowing have recently been highlighted by Avdjiev et al. (2014), Chui et al. (2014), and Acharya et al. (2015). We argue that these vulnerabilities in the corporate sector are a source of sovereign risk. Bruno and Shin (2015) and Caballero et al. (2015) present evidence that emerging market non-financial corporates are essentially running a carry trade by borrowing in foreign currency and investing in higher-yielding local currency assets.

The second major contribution of the paper is that we offer a new explanation for why nominal sovereign debt may not be default-free. The history of sovereign default on domestic debt is addressed in detail in Reinhart and Rogoff (2008, 2011). We contribute to the large literature on the determinants of sovereign credit risk by demonstrating how the borrowing patterns of the private sector affect sovereign risk.[2] The theoretical section contributes to the international finance literature on sovereign default by introducing LC sovereign debt and a mismatched corporate sector into the Aguiar and Gopinath (2006) and Arellano (2008) formulation of the Eaton and Gersovitz (1981) model. We build on recent papers that introduce long-term bonds into this framework, such as Hatchondo and Martinez (2009), Arellano and Ramanarayanan (2012), and Chatterjee and Eyigungor (2012). Our modeling of the balance sheet mismatch in the corporate sector builds on Céspedes et al. (2004) and Gertler et al. (2007), who study a Bernanke et al. (1999) financial accelerator in the open economy when firms potentially borrow in foreign currency. Our contribution is to integrate a simplified version of this channel into a sovereign default framework to examine how the cost of depreciation arising from this balance sheet channel can affect sovereign risk. We contribute to a growing literature on the default risk on nominal debt, including recent work by Aguiar et al. (2013, 2015), Corsetti and Dedola (2013), Araujo et al. (2013) and Sunder-Plassmann (2013), by exploring a channel through which differences in private borrowing behavior explain why the risk of sovereign default on nominal debt varies across countries. While we focus on why borrowing in local currency is insufficient to eliminate sovereign default risk, we do not examine why the currency composition of debt varies across countries or time. That issue is examined in Du et al. (2016b), Ottonello and Perez (2016), and Engel and Park (2016).

[2]See, for instance, Edwards (1984), Eichengreen and Mody (1998), Hilscher and Nosbusch (2010), Longstaff et al. (2011), and Uribe and Yue (2006).

Our paper is organized as follows. In Section 2, we review the evidence of credit risk on LC-denominated debt documented in our earlier work (Du and Schreger, 2016). Section 3 constructs measures of the currency composition of external sovereign and corporate portfolios and examines the contrasting behavior of sovereign and corporate external borrowing. Section 4 provides empirical evidence on the relationship between private FC debt and sovereign default risk and evidence that FC liabilities of emerging market firms are not fully hedged by FC revenue or FX derivatives. Sections 5 and 6 present a new sovereign default model featuring LC sovereign debt and FC corporate financing. Section 7 concludes.

2 Measuring Credit Risk on LC Sovereign Debt

The first challenge in examining the default risk on LC sovereign debt is to measure it separately from currency risk. When a country borrows in a foreign currency, for instance the US dollar, the credit spread is measured as the difference between the yield a borrowing government pays and the yield on a US Treasury bond of the same duration. However, when a government borrows in its own currency, the difference in the yield it pays versus what the US government pays to borrow in dollars might be compensating investors for the risk that the local currency depreciates ("currency risk") as well as the risk that the sovereign explicitly defaults on the debt ("credit risk"). In our previous work (Du and Schreger, 2016), we develop a methodology to measure the credit risk on LC sovereign debt in emerging markets that separates the credit risk from the currency risk. We define the LC credit spread (s_t^{LCCS}) as the gap between an emerging market sovereign bond yield (y_t^{LC}) and the LC risk-free rate implied by the US Treasury bond yield (y_t^*) and the fixed-for-fixed LC/USD cross-currency swap rate (ρ_t),

$$s_t^{LCCS} = y_t^{LC} - (y_t^* + \rho_t), \tag{1}$$

The way to understand the LC risk-free rate ($y_t^* + \rho_t$) is to think of it as the nominal interest rate that the US government (assumed to be default-free) would pay if it issued a bond in an emerging market currency. The fixed-for-fixed LC/USD cross-currency swap rate (ρ_t) is the interest rate differential an investor receives when converting fixed dollar cash flows into fixed LC cash flows. When dealing with zero-coupon bonds, ρ_t is simply the long-horizon forward premium. By using cross-currency swaps to convert the fixed dollar cash flows from a US Treasury into fixed LC cash flows, we construct a synthetic LC instrument that is free from sovereign default risk. The LC credit spread measures how much an emerging market sovereign pays to borrow relative to this default-free benchmark in its own currency. In other words, the LC credit spread measures the deviation from long-term covered interest rate parity between a nominal sovereign bond and a US Treasury bond.

If emerging market sovereign debt were free from credit risk, the LC credit spread should equal zero in the absence of arbitrage. However, when we look at emerging markets, we see that they borrow at a significant credit spread even in their own currency. From 2005 to 2012, for 13 emerging

markets,[3] the mean LC credit spread is 148 basis points for five-year zero-coupon bonds. This is in stark contrast to a developed economy like the United Kingdom, where the mean LC credit spread is under 10 basis points on average over the same time period.[4]

Throughout the paper, we refer to s^{LCCS} as the credit risk of an LC bond and ρ as the currency risk component of the bond. Using the LC credit spread definition given in Equation 1, we can decompose the nominal yield differential between an emerging market sovereign LC bond and a US Treasury ($s^{LC/US}$) into a credit and a currency risk component:

$$s_t^{LC/US} = s_t^{LCCS} + \rho_t. \tag{2}$$

In Figure 2, we plot the cross-country average of the nominal spread $s^{LC/US}$, credit risk s^{LCCS}, and currency risk ρ on nominal LC sovereign debt. This broad pattern, with around 75% of the nominal spread composed of currency risk and the remaining 25% composed of credit risk, will be a key moment of interest in the dynamic model. In Appendix Table A.1, we report summary statistics for currency and credit risk in each of our sample countries.

[Figure 2 here]

In this paper, we do not consider selective defaults across LC and FC sovereign debt and we abstract from the effects of various capital market frictions on sovereign credit spread measures.[5] We show in Du and Schreger (2016) that LC and FC credit spreads are strongly correlated, and have even recently converged to the same level on average. Because LC credit spreads measure default risk on LC debt and credit default swap (CDS) spreads measure default risk on FC debt, the convergence of the credit spreads on the two type of debt suggests a market expectation for simultaneous default and restructuring. Jeanneret and Souissi (2014) document 31 defaults on LC debt and 27 defaults on FC debt between 1996 and 2012, with 15 of these instances being simultaneous default on both types of debt.

3 The Changing Composition of External Portfolios

In this section, we combine various national and international data sources to construct measures of the currency composition of the external liabilities of the sovereign and corporate sectors in 14 major emerging markets. We document that emerging market sovereigns have shifted away from borrowing externally in foreign currency to borrowing primarily in LC. However, we show that the external liabilities of the corporate sector remain largely denominated in FC.

[3] The included countries are Brazil, Colombia, Hungary, Indonesia, Israel, Malaysia, Mexico, Peru, Poland, South Africa, South Korea, Thailand, and Turkey. Russia is excluded, as the local currency debt market was not investable for foreigners during much of the period. See Du and Schreger (2016) for details on the segmentation of Russia's domestic debt market.

[4] For an analysis of the failure of covered interest parity, see Du et al. (2016a).

[5] We address the effects of factors such as capital controls, liquidity in the currency swap market, counterparty risk, and incomplete integration between domestic and external debt markets in detail in Du and Schreger (2016).

3.1 Dataset Construction and Definitions

The goal of this section is to construct a measure of the currency composition of emerging market external debt issued by the government and corporate sector. We define "external debt" as any public or private debt issued by emerging market entities and owed to nonresidents, regardless of the market of issuance. We can then classify external debt along three dimensions: currency, market of issuance, and sector. First, in terms of the currency classification, "LC debt" refers to debt for which the principal and coupons are denominated in the currency of the country of issuance and "FC debt" is debt for which the principal and coupons are denominated in another country's currency. Second, in terms of the market of issuance classification, "international debt" is defined as debt issued under foreign law in international markets and "domestic debt" is debt issued in domestic markets under domestic law. Finally, in terms of the sector classification, "government debt" is debt issued by central and local governments and social security funds, and corporate debt is debt issued by the private sector of the economy.

In the rest of this subsection, we discuss the construction of different components of external debt by currency and sector for debt securities and cross-border loans and deposits. We restrict our analysis to private lending to emerging markets, excluding official loans made by bilateral and multilateral organizations.

3.1.1 Debt Securities

In this section, we discuss the construction of the amount of external debt securities outstanding by currency. We start with international debt securities. We assume that all international debt securities are held by nonresidents and thus count toward external debt. We obtain the amount of international debt securities outstanding for the sovereign and corporate sectors from the Bank for International Settlements (BIS) debt securities statistics. The BIS does not report the currency composition of international debt securities at the country level. We address this data gap as follows. Only a few countries (Brazil, Colombia, Mexico, Peru, and Russia) have ever issued LC-denominated sovereign bonds in the international market. We construct amounts outstanding for these individual LC sovereign issuances and treat the rest of BIS sovereign international debt securities as FC. We obtain currency shares of corporate international debt securities by aggregating the entire universe of individual corporate bonds recorded in the Thomson One bond database for our sample countries.

The Thomson One bond database provides comprehensive primary market issuance data for international debt securities starting in the 1980s. The dataset includes all major characteristics of a bond deal, including issuance and maturity dates, currency of denomination, and the market of issuance. For each sample country, we aggregate net issuance of corporate bonds by currency (LC and FC) and by market (domestic and international) to estimate outstanding amounts in each category, assuming that the full principal of the bond matures at the maturity date. The currency conversion is done by marking all outstanding bonds using the spot dollar exchange rates at the end of each period. Since firms may issue additional amounts of a previously issued bond or buy back a bond before it matures, our estimated outstanding amounts based on Thomson One issuance data

may not be exact. On the other hand, the BIS debt securities statistics take into account these adjustments and use a few other commercial databases in addition to Thomson One, and hence provide more accurate data on international corporate bonds outstanding.[6] Therefore, we combine total outstanding amounts from the BIS and the share of LC debt in total bonds outstanding from Thomson One to arrive at our estimated amounts of international corporate bonds by currency.

Second, in terms of nonresident holdings of domestic debt by currency, we assume that nonresident holdings of FC domestic debt are equal to zero. This assumption is reasonable because the outstanding amount of FC domestic debt is negligible.[7] The dataset of nonresident holdings of domestic LC sovereign debt for our 14 emerging markets comes from individual central banks, finance ministries, and the Asian Development Bank. The detailed data sources are given in the appendix. In simultaneous work, Arslanalp and Tsuda (2014) compiled a dataset of foreign holdings of domestic debt from similar sources, focusing on how this change affected emerging market vulnerability to funding shocks.

There are no comparable national data available on foreign holdings of domestic corporate debt. Our estimation is based on our data on nonresident holdings of domestic LC sovereign debt and the US Treasury International Capital (TIC) data. TIC data publishes US portfolio holdings of foreign securities by country, sector of issuance, and currency denomination. To approximate foreign holdings of domestic LC corporate debt, we make the assumption that US investors compose an equal share of foreign investors in domestic corporate and domestic sovereign debt. For example, if US investors account for 25% of total nonresident holdings of domestic LC sovereign debt for a given country, and hold $250 million of LC corporate debt, we estimate that total foreign holdings of domestic LC corporate debt are equal to $1 billion.[8]

More specifically, given the total nonresident holdings of LC government securities A^G_{TOTAL} and the US holdings of LC government securities in TIC A^G_{US}, we can estimate the share of the US holdings in total nonresident holdings of government securities as

$$S^G_{US/TOTAL} = A^G_{US}/A^G_{TOTAL}.$$

We estimate a time-invariant $S^G_{US/TOTAL}$ using the full 10-year sample.[9] To estimate the US holdings of LC corporate debt securities, we assume that the share of the US holdings in total nonresident holdings of emerging market corporate debt securities ($S^C_{US/TOTAL}$) is the same as the share of the US holdings in total nonresident holdings of emerging market sovereign debt securities ($S^G_{US/TOTAL}$).

[6] In Appendix Figure A.1, we compare our estimated amounts of international corporate bonds outstanding based on Thomson One and the BIS reported outstanding amount for our sample countries. The two series follow very similar trends, despite a noticeable gap between them.

[7] For the countries with data available, we see that nonresident holdings of indexed and FC domestic debt are very small relative to nonresident holdings of LC domestic debt.

[8] We use the updated Table 13 in the TIC data recently compiled by Carol Bertaut and Alexandra Tabova at the Federal Reserve Board. The updated dataset extended Table 13 back to 2003 and corrected a few errors in the public data published on the Treasury website at http://www.treasury.gov/resource-center/data-chart-center/tic/Pages/windex.aspx.

[9] Alternatively, we can also use a time-varying share each year, which yields similar final results for the currency composition of corporate external portfolios.

Given the level of US holdings of corporate LC debt securities A^C_{US}, we estimate total nonresident holdings of LC EM corporate securities as

$$\hat{A}^{LC}_{TOTAL} = \frac{A^C_{US}}{S^C_{US/TOTAL}} = \frac{A^C_{US}}{(A^G_{US}/A^G_{TOTAL})}.$$

3.1.2 External Loans and Deposits

In addition to debt securities, we also consider cross-border loans and deposits as part of external debt. The data on total external loans and deposits come from the BIS locational banking statistics (LBS). The BIS LBS provides quarterly data on cross-border financial claims and liabilities of banks resident in the BIS reporting countries. There are currently 22 BIS reporting countries for LBS, including most large developed and developing countries and offshore financial centers, such as Bermuda and the Cayman Islands. The level of external loans for country i is given by the total claims of all BIS reporting countries against counterparty country i. Since most developed, large developing countries, and offshore financial centers are BIS reporting countries, the aggregate lending of BIS reporting countries to country i represents the majority of private sector cross-border loans from the rest of the world to country i. These portions of the data are publicly available.[10]

To estimate the currency composition of these external loans, we use the restricted version of the BIS LBS available to central banks, which classifies the currency of cross-border loans and deposits into reporting countries' home currencies, dollar, euro, yen, British pound, Swiss franc, and residual currencies. From an emerging market country i's perspective, the amount of loans and deposits denominated in the residual currencies of the reporting countries gives a very good proxy of the level of loans and deposits denominated in the LC of country i.

In terms of the sectoral breakdown of cross-border loans, the BIS LBS gives the financial and non-financial breakdown, but not the sovereign and corporate sectoral breakdown. To estimate the cross-border loans by the sovereign and corporate sector, we use loan data from Thomson One. Similar to the Thomson One bond data, Thomson One loan data provide issuance data for bank loans (mostly syndicated) worldwide since the 1980s. We define a loan deal as cross-border if at least one bookrunner of the deal is a foreign bank. Again, we assume the full principal amount of the loan is held to maturity and aggregate the entire universe of cross-border loans outstanding in the Thomson loan database by sector and by currency.[11] Similar to the construction for amounts outstanding of debt securities by sector and currency, we combine total outstanding amounts of cross-border loans from the BIS and the sectoral and currency shares based on Thomson One to arrive at our estimated amounts of cross-border loans by sector and currency.

[10] The level of cross-border loans and deposits vis-à-vis individual emerging markets is available in Table 7A published on the BIS website: http://www.bis.org/statistics/bankstats.htm.

[11] In Appendix Figure A.1, we compare the total and LC cross-border loan outstanding reported by the BIS and estimated from Thomson One for our sample countries. The BIS and Thomson cross-border loan series follow similar trends. The level difference is very small for LC cross-border loans, but differs by more for total cross-border loans.

3.2 Comparison between Sovereign and Corporate Currency Portfolios

By combining these various sources, we find that the share of external sovereign debt in LC increased from 15% to 60% over the past decade. Figure 3 plots the cross-country mean of the share of sovereign, corporate, and total debt in LC from 2003 to 2012. However, EM sovereigns are not issuing debt in their own currency in international markets. Instead, foreign investors are buying sovereign debt issued under domestic law. While the share of debt in FC is shrinking dramatically for sovereign external liabilities, external emerging market corporate debt remains primarily in FC. The shares of corporate debt and private external bank loans in LC have increased at a much slower pace, reaching about 10% in 2012. These aggregate numbers mask a substantial degree of cross-country heterogeneity, as can be seen in Table 1 and Appendix Figure A.2. For instance, by 2012, over 90% of Thailand's external sovereign debt to private creditors was in LC, but less than 15% of Colombia's external sovereign debt was in LC. Despite this cross-country heterogeneity, in all of our sample countries, the sovereign borrows more in LC as a share of total external debt than does the private sector.

In Figure 4, we plot the cross-country mean LC/GDP and FC/GDP ratios by year. While we see in the right panel that the FC/GDP ratios are stable across time, the LC/GDP ratio has nearly quintupled for sovereigns over the last decade. However, even as the growth of sovereign external LC borrowing has dramatically increased, corporate external LC borrowing has stayed very low. At the end of 2012 for our 14 sample countries, of the roughly $1 trillion of EM external sovereign debt outstanding, 60% is in LC and 40% is in FC. Foreign holdings of domestic LC sovereign debt account for 95% of sovereign external LC liabilities. Of the roughly $1.9 trillion in external EM corporate debt outstanding, approximately 90% is denominated in FC.

[Table 1 here]

[Figures 3 and 4 here]

4 Corporate Liabilities and Sovereign Risk

Having documented the changing external borrowing patterns in emerging markets, we now provide evidence that this currency composition matters. We first provide evidence on the linkage between corporate balance sheets and sovereign credit risk. We show in a panel regression framework that an increase in the corporate FC debt/GDP ratio is associated with an increase in the sovereign credit spread. We then present evidence that FC liabilities of emerging market firms are unlikely to be fully hedged by FC revenues or FX derivatives.

4.1 Sovereign Risk and Corporate Balance Sheets

We now turn to the question of whether more FC corporate debt at the country level is associated with a higher level of sovereign default risk. To do so, we examine the relationship between sovereign

LC credit spreads and the country's debt composition. At the country level we find evidence that a higher reliance on external FC corporate debt is associated with a higher risk of sovereign default.

In Table 2, we estimate the following regression at the quarterly and frequency:

$$Spread_{i,t} = \alpha + \beta_1 \left(\frac{FC\ Private}{GDP}\right)_{t-1} + \beta_2 \left(\frac{FC\ Gov}{GDP}\right)_{t-1} + \beta_3 \left(\frac{LC\ Gov}{GDP}\right)_{t-1} + \gamma X_{i,t} + \delta_i + \epsilon_{i,t},$$

where δ_i is a country fixed effect and $X_{i,t}$ is a vector of time-varying country level or global variables. As an alternative to global variables, we also introduce quarter fixed effects. We also consider specifications omitting country fixed effects to allow for a between-country comparison. For global variables, we follow Hilscher and Nosbusch (2010) in including four time series to proxy for factors such as global risk aversion, world interest rates, and liquidity. Those variables are the VIX index, the BBB-Treasury Spread, the 10-Year Treasury Yield, the TED Spread, and the US Federal Funds Rate.[12] Standard errors are calculated following Driscoll and Kraay (1998) with four-quarter lags to account for within-country serial correlation and clustering by quarter to correct for spatial correlation across countries.[13]

In all columns, we run the regression at a quarterly frequency with the dependent variable the sovereign LC credit spread in basis points,[14] where column 1 includes quarter fixed effects and column 2 instead controls directly for global factors. Columns 1 and 2 include country fixed effects, and columns 3 and 4 do not. We find that increases in the amount of corporate FC debt are associated with higher sovereign credits spreads. We find that a 1% increase in the FC corporate debt/GDP ratio is associated with a 3.1-5.9 basis point increase in the LC credit spread. [15]

[Table 2 here]

4.2 Are Firms Hedging Their Currency Risk?

The corporate sector's external FC liabilities pose a particular concern if they are not matched by FC revenues or FX derivative hedging. Firms may have FC revenues and hence issue FC debt to hedge the currency risk of their revenues. In addition to operational hedging, firms can enter into FX derivative contracts to directly hedge their FC liabilities. In this subsection, we argue that FC revenue streams and FX derivatives do not fully hedge FC liabilities of emerging market firms. This evidence provides support for the idea FC borrowing leaves many emerging market corporates vulnerable to balance sheet effects from depreciation.

[12] All global variables are from Federal Reserve Economic Data (FRED), from the Federal Reserve Bank of St. Louis.

[13] When time fixed effects are included, we follow Vogelsang (2012).

[14] Only annual data (Q4) is available for South Africa. Following Datta and Du (2012), we include South Africa in the quarterly regression and treat the missing data as serially uncorrelated. This leads to South Africa being underweighted in the regression. Results are very similar if South Africa is excluded.

[15] In Appendix Table A.5, we include additional country-specific variables found to price sovereign risk in the previous literature and show that the main results are largely unchanged. In Appendix Table A.4, we include a version of Table 2 where we also include the ratio of LC corporate debt to GDP. The coefficient on the FC corporate debt/GDP ratio is qualitatively unchanged. The coefficient on the LC corporate debt/GDP ratio is imprecisely estimated and varies a great deal between specifications. In the appendix tables, we also include annual specifications.

The question of whether FC borrowing by emerging market firms leaves them vulnerable to depreciation has been receiving a renewed focus. Bruno and Shin (2015) and Caballero et al. (2015) present evidence that emerging market non-financial corporates are essentially running a carry trade by borrowing in FC and investing higher-yielding LC assets. Importantly for our study, these papers present compelling evidence that the decision to borrow in dollars is not driven primarily by a hedging motive and likely leaves firms vulnerable to a currency depreciation. Acharya et al. (2015) point to the recent growth in FC debt in the non-financial corporate sector as a potential vulnerability, presenting additional evidence that recent FC borrowing is not driven by hedging motives. The potential macroeconomic dangers raised by FC corporate borrowing are the focus of a chapter in the IMF's October 2015 *Global Financial Stability Report*, titled "Corporate Leverage in Emerging Markets—A Concern?"

These recent contributions build on an earlier literature examining the major devaluations of the 1990s. Aguiar (2005), Gilchrist and Sim (2007), Kim et al. (2015), and papers surveyed in Galindo et al. (2003) and Frankel (2005, 2010) find evidence of a balance sheet channel. However, some papers, such as Bleakley and Cowan (2008), do not find evidence for such a channel. While the firm-level data we analyze do not directly measure balance sheet effects, they provide evidence against the possibility that firms borrowing in FC are doing so to hedge their revenues. The data on aggregate derivatives usage provide evidence against the possibility that firms are using financial instruments to hedge their FC liabilities. Together, this bolsters the argument that significant FC borrowing by EM corporates leaves firm balance sheets vulnerable to depreciation.

4.2.1 Operating Hedge

Using the firm-level S&P Capital IQ Debt Capital Structure database, we show that many firms in the non-tradable and non-exporting sectors borrow significant amounts using FC debt. The fact that not only exporters with FC revenues borrow in FC suggest that the operating hedge motive (borrowing in dollars to hedge expected dollar earnings) cannot fully explain FC corporate borrowing.

The primary advantage of using Capital IQ Debt Capital Structure rather than alternative data sources such as Thomson One or Dealogic is that it focuses on the entire debt outstanding of firms, rather than primary market issuance of international debt securities and large syndicated loans. For example, direct non-syndicated bank lending is captured by Capital IQ but is often missing from Thomson One and Dealogic. Capital IQ collects data on corporate debt from several sources, including Dow Jones, Lexis Nexis, company websites, stock exchanges, and government regulatory agencies.[16]

We downloaded the annual balance sheet data for every available firm in Capital IQ for our sample countries from the Wharton Research Data Service, with a total of 1,808 emerging market

[16] All of this publicly available debt data is classified by Capital IQ according to many attributes of the debt, such as issued currency, security type, secured level, interest rate, maturity date, interest type, interest rate, benchmark, secured flag, interest rate comment, convertible type, convertibility information, non-recourse flag, and benchmark spread. However, we do not observe the market of issuance and so we cannot restrict ourselves to external debt.

firms.[17] For each firm, we then classify all outstanding debt at the end of 2012 by whether it is in FC or in the LC of the country. We measure the total debt level of the firm by summing the total principal outstanding and do not attempt to adjust for the value of promised coupon payments or any other intermediate payments. The FC debt share is the sum of all FC debt as a share of total firm debt.

In Figure 5, we present kernel density plots of the distribution of the share of FC debt in total corporate debt in 2012 in the S&P Capital IQ Debt Capital Structure database for firms in the tradable and non-tradable sector. We follow Aguiar and Gopinath (2005) and others and classify firms as being in the tradable sector if their primary SIC code is in 2000–3999 and exclude financial firms from the analysis. The left panel plots the full distribution, and the right panel only includes firms that have at least 1% of their debt in FC. While there are slightly more firms in the non-tradable sector with very little FC debt, we also see a significant share of firms in the non-tradable sector with a large share of their debt denominated in FC. Because firms in the non-tradable sector are likely to earn the bulk of their revenues in the LC, large shares of FC borrowing cannot be justified by the operating hedge motive.

In Figure 6, we present the equivalent picture but divide the sample into "low export" and "high export" groups. Because firm-level export data for emerging market firms are incomplete, we classify firms as high or low export depending on whether their primary industry exports more or less than the median industry of all firms in the sample. We calculate industry export intensities as the share of industry output that is exported according to the OECD-STAN Input-Output Tables.[18] Similarly, as when we split by tradability, we see that there are significant number of firms with very little export revenue but significant amounts of FC debt.

We see these two sets of figures as further bolstering the results of Bruno and Shin (2015) and Caballero et al. (2015) that emerging market corporate FC borrowing is not only driven by a hedging motive, which leaves the firm balance sheets vulnerable to depreciation. These figures provide support for our key assumption in the model in Section 5 that firms that borrow in FC earn a large share of their revenues in LC.

[Figures 5 and 6 here]

4.2.2 FX Derivative Hedging

Comprehensive data on corporate FX derivative usage rarely exist, even for developed countries. It is even more challenging to estimate the degree of FX derivative hedging used by emerging market firms. Instead, we examine aggregate statistics on FX derivative use from the Depository Trust and Clearing Corporation (DTCC) and FC debt outstanding at the country level. We find that these currency derivative markets are currently much smaller than the amount of FC debt outstanding

[17] The number of firms for each sample country is given in Appendix Section A.3.

[18] By using imputed export shares rather than tradability, we are limited to data from Brazil, Hungary, Indonesia, Israel, Mexico, Poland, Russia, South Africa, South Korea, and Turkey.

in most of emerging markets, making it very unlikely the FC liabilities are fully hedged with FX derivatives.

Cross-currency swaps (CCS) provide a direct way for firms to hedge against FC fixed income liabilities.[19] The DTCC recently started publishing global CCS derivative outstanding amounts by currency for the top 20 currencies. Table 3 compares the total amount of CCS outstanding reported by the DTCC with the amount of FC debt outstanding based on our estimation for 2012. Among 14 sample countries, 7 currencies are ranked as top 20 currencies in terms of CCS outstanding, so exact amounts are reported. The remaining 7 currencies by definition have a lower amount outstanding than the top 20 currencies, and so we can infer that they have less than $25 billion in CCS outstanding, the lowest reporting amount for the 20th-ranked currency. We compare CCS outstanding amounts with FC liabilities by country. With the exception of Turkey and South Africa, all the other 12 sample countries have total FC debt outstanding greater than total CCS outstanding.

[Table 3 here]

Furthermore, we know that not all the CCS outstanding is used for corporate FX derivative hedging. According to the BIS Semiannual OTC Derivative Survey, about half of the currency swaps outstanding is inter-dealer in nature.[20] This inter-dealer exposure likely represents market making and proprietary trading related activities in LC rates markets. In addition, portfolio investors also use CCS to hedge their long-term currency exposure on LC-denominated assets. Therefore, it is highly likely that total CCS outstanding amounts vastly overestimate the actual amount of FX hedging of FC corporate debt.

Together, the evidence on borrowing at the firm level and FX derivative use at the aggregate level provides strong support for the idea that emerging market corporate FC debt has left the private sector vulnerable to the balance sheet effects of currency depreciation.

5 A Model of Sovereign Risk and Corporate Balance Sheets

Motivated by these empirical findings, we now formally examine the interplay between sovereign risk and corporate balance sheets. Our main empirical motivations for the model are as follows. First, sovereigns are increasingly borrowing in LC and firms borrow overwhelmingly in FC. However, positive credit spreads on LC sovereign debt indicate that significant sovereign default risk remains. Second, emerging market firms do not fully hedge their FC liabilities with FC revenues and FX derivatives, leaving the firms vulnerable to LC depreciation. Third, higher levels of FC corporate debt are associated with a higher risk of default on LC sovereign debt. We argue that a mismatched corporate sector is one reason why a sovereign would choose to explicitly default on LC sovereign debt rather than inflating it away. In this section, we introduce LC sovereign debt and a mismatched

[19] Firms can also hedge their FC debt using short-term FX forwards and swaps. However, due to the mismatch between the duration of debt and derivative instruments, these hedges are imperfect.

[20] BIS surveys do not report FX derivative outstanding for individual emerging market currencies.

corporate sector into the standard model of sovereign debt, and demonstrate how corporate currency mismatch generates sovereign default risk.

5.1 Framework

A large literature following Arellano (2008) and Aguiar and Gopinath (2006) has examined sovereign default on FC debt in a quantitative Eaton and Gersovitz (1981) framework. As is standard in this class of models, we assume that the government borrows from risk-neutral foreign investors in order to smooth and/or front-load household consumption. The key friction in the model is that the government cannot commit, and instead decides each period whether or not to repay and how much to borrow. We will make two main changes relative to the existing literature. First, we introduce LC sovereign debt and give the sovereign another policy tool, the inflation rate, with which to reduce real repayments on the debt. Second, rather than working with an endowment economy, we introduce a production economy and treat aggregate productivity as the exogenous state variable. We will begin by discussing how we introduce these two new features. We will then discuss our microfoundation of the production economy that causes currency depreciation to reduce output.

5.1.1 Setup

As in the existing literature examining FC debt, we assume that the sovereign's objective is to maximize the discounted utility stream of consumption for the representative agent:

$$\max_{b',\zeta,D} E\left[\sum_{t=0}^{\infty}\beta^t u\left(C_t\right)\right].$$

The sovereign maximizes this objective function by choosing how much to borrow (b'), whether to default on the outstanding debt (D), and, now, how much of the existing debt to inflate away ζ. In order to tractably introduce LC sovereign debt, we assume that the sovereign borrows with exponentially decaying nominal LC perpetuities with promised LC cash flows:

$$P_t\kappa\left[1,\ \delta,\ \delta^2,...\right].$$

In this expression, P_t indicates today's price level and $\delta \leq 1$ controls the speed with which promised coupon payments decline, and thereby the duration of the bond. If $\delta = 0$, this is equivalent to one-period debt. We use the modeling device of Lorenzoni and Werning (2013) and normalize the coupon payments by $\kappa = 1 + r^* - \delta$, where r^* is the risk-free rate. Multiplying the coupon payments by κ guarantees that one unit of risk-free debt sells for a price of 1, regardless of the bond's duration. Because purchasing power parity will hold in our model, a foreign lender values this stream of coupons by dividing through by the LC price level at the time the coupons are paid to calculate their value in FC. Defining $\frac{P_{t+1}}{P_t} = 1 + \pi_{t+1}$, with π being the net inflation rate, we can define the inflation tax as $\zeta_{t+1} = \frac{\pi_{t+1}}{1+\pi_{t+1}} \in [0,1]$. Working with the inflation tax rather than the inflation rate is simply a matter of convenience. The real (FC) value of the coupons can then be

written compactly as

$$\kappa \left[(1-\zeta_{t+1}),\ \delta \prod_{s=1}^{2} (1-\zeta_{t+s}),\ \delta^2 \prod_{s=1}^{3} (1-\zeta_{t+s}), ... \right]. \tag{3}$$

The bond price is equal to the discounted expected value of all future cash flows. The decaying perpetuity structure allows us to write the bond price schedule as a function of today's exogenous state A and amount of debt issued:[21]

$$q\left(A, b'\right) = \frac{E\left[\left(1 - D\left(A', b'\right)\right)\left(1 - \zeta\left(A', b'\right)\right)\left(\kappa + \delta q\left(A', b''\left(A', b'\right)\right)\right) \mid A, b'\right]}{1 + r^*} \tag{4}$$

This expectation is taken after the state A and borrowing b' have been realized, but tomorrow's state A' and tomorrow's borrowing level b'' are not yet known. $D\left(A', b'\right)$ is an indicator variable for default that depends on aggregate productivity and the amount of debt outstanding. In the event of default, $D = 1$, and the holder of the bond receives nothing. In repayment states, $D = 0$, and the expectation is taken over losses from inflation (ζ), which are a function of tomorrow's state A' and the debt level b'. If the bonds were only one period $(\delta = 0)$, then this would be sufficient. However, because these are long-term bonds, lenders must account for future inflation and default risk reducing the value of future repayments. The recursive pricing structure makes this calculation feasible, because rather than calculating expected future inflation and default over all future periods, investors only need to form an expectation over inflation, default, and the price of the bond tomorrow. The bond price next period is dependent not just on the aggregate state A', but also on the level of debt the sovereign will issue next period. If we were to restrict inflation to be zero, this bond pricing equation would be equivalent to that presented for FC debt in Hatchondo and Martinez (2009).

The second change we make is that we introduce a production economy where output is a Cobb-Douglas function of intermediate goods (X) and labor (L), and we note that aggregate intermediate good provision X is a function of the inflation rate ζ :

$$y = AX\left(\zeta\right)^{\gamma} L^{1-\gamma}.$$

The output costs of inflation and depreciation will come through reduced intermediate good provision and will be discussed in detail in the next subsection. For now, we simply write X as a function of ζ. Consumption in repayment is given by:

$$C^R = \underbrace{A_t X\left(\zeta\right)^{\gamma} L^{1-\gamma}}_{\text{Output}} - \underbrace{\left(1-\zeta\right)\kappa b}_{\text{Coupon payments}} + \underbrace{q\left(A, b'\right)\left[b' - \left(1-\zeta\right)\delta b\right]}_{\text{Net revenue from bond issuance}}. \tag{5}$$

The term $\left(1-\zeta\right)\kappa b$ gives the real value of coupon payments this period. Therefore, the real amount paid (measured in tradables) is the coupon per bond κ, scaled by the number of bonds outstanding b, times the real value of the local currency, which is $\left(1-\zeta\right)$. The next term, $q\left(A, b'\right)\left[b' - \left(1-\zeta\right)\delta b\right]$,

[21] The details of this bond pricing can be found in Appendix Section B.1.

is the net revenue raised from bond issuance. Net issuances are just the gross issuance b' minus the equivalent number of today's bonds from the previous period, $(1-\zeta)\,\delta b$. $(1-\zeta)$ denotes the measure of existing bonds not inflated away, δ the speed with which coupon payments decay, and b is the number of these perpetuities the government issued last period. If $b' - (1-\zeta)\,\delta b > 0$, then the sovereign has positive net issuance, and if $b' - (1-\zeta)\,\delta b < 0$, then the sovereign is repaying the outstanding debt.

If the sovereign chooses to default, then rather than aggregate productivity is reduced to:

$$A_D = A - \phi(A),$$

where $\phi(A) \geq 0$ denotes how much aggregate productivity is reduced by a sovereign default. In the quantitative analysis, we will follow Aguiar and Gopinath (2006), Arellano (2008), and Chatterjee and Eyigungor (2012) and calibrate the costs of default in reduced form.[22] While we will follow the existing literature in modeling default as a reduced form cost, the cost of inflation will depend on how output is affected by inflation. This will be determined by our microfoundation for the equilibrium intermediate good production as a function of inflation, $X(\zeta)$, the focus of the next subsection.

5.1.2 Entrepreneurs' Problem

We assume there is a continuum of identical households and, similar to the microfoundation of Gertler and Karadi (2011), we assume that within each household there are two types of agents. While Gertler and Karadi (2011) assume the household is made up of workers and bankers, we assume that a fraction $1-\gamma$ of household members are "workers" and γ are "entrepreneurs."

At the beginning of the period entrepreneurs have access to projects that require a fixed investment to return a fixed amount ω of the tradable good. To finance the investment in the project, entrepreneurs borrow intra-period from foreign lenders. The key assumption is that conditional on producing, entrepreneurs are committed to sell a share of their output at a fixed LC per-unit price. Because they have set their prices in LC but have to repay a real amount, inflation (depreciation) reduces the real value of their profits. Therefore, we are assuming that goods prices are sticky for a longer period than it takes entrepreneurs to borrow and invest. While the entrepreneurs are constrained to sell a fraction of their output in fixed LC prices, the single consumption good is also traded internationally with flexible prices. This implies that purchasing power parity holds, and changes in the domestic price level are equal to changes in the nominal exchange rate. This will allow us to talk about inflation and depreciation interchangeably. Entrepreneurs' profits from the

[22] The literature provides a number of potential micro-foundations of the costs of default, including Mendoza and Yue (2012), who generate a reduction in measured aggregate productivity from default in a framework where default leaves firms unable to import intermediate goods for production, forcing them to switch to less efficient domestic substitutes and reducing their efficiency. Bocola (2016) and Perez (2014) generate micro-founded output costs from sovereign default by modeling how a default on sovereign debt harms the domestic financial system. Hebert and Schreger (2016) exploit the timing of legal rulings for and against the government of Argentina in the case of *Republic of Argentina vs. NML Capital* to identify a large reduction in the value of firms caused by an increase in sovereign default risk.

sale of the tradable good in the first stage of the period constitute their net worth when they want to invest in intermediate good production in the second stage. We assume that no external finance can be used for the production of intermediate goods, and so changes in net worth will determine the amount of intermediate goods entrepreneurs can produce. This in turn will determine aggregate production.[23]

At the beginning of the period, entrepreneurs borrow a fixed amount from foreign lenders with a share α in LC. Entrepreneurs borrow significantly less than they will produce ω, so we do not consider them defaulting on their debt.[24] However, their profit Π is a function of the inflation rate. The amount produced per project is denoted by ω, and the face value of promised repayments is given by Z. A share α of the face value of the debt is denominated in LC, and $(1-\alpha)$ is denominated in FC. We assume that entrepreneurs are committed to sell a share μ of their output at a fixed LC price P_{t-1} and may set the price of the remaining $(1-\mu)$ optimally. Using our earlier definition of the inflation tax ζ, we can write the real value of entrepreneurial profits as:

$$\Pi = \gamma\left(\left(1-\zeta\right)\left(\mu\omega - \alpha Z\right) + \left(1-\mu\right)\omega - \left(1-\alpha\right)Z\right).$$

Because the tradable good is the numeraire, the profit per entrepreneur represents the entrepreneurs' net worth measured in tradable goods. We assume that entrepreneurs have access to a linear production technology that allows them to invest to produce intermediate goods $X = \xi I$, where ξ is the productivity of the intermediate good production technology and I denotes the units of tradable goods invested. The key financial friction is that we assume entrepreneurs cannot access external finance to invest in intermediate good provision, so we must have that investment is less than net worth:

$$I \leq \Pi. \tag{6}$$

We will consider the case where this constraint binds in every state, and so entrepreneurs will invest the maximum amount possible and we have $I = \Pi$. We can therefore write the amount of intermediates produced in equilibrium as:

$$X\left(\zeta\right) = \xi\gamma\left(\left(1-\zeta\right)\left(\mu\omega - \alpha Z\right) + \left(1-\mu\right)\omega - \left(1-\alpha\right)Z\right). \tag{7}$$

[23]The closest paper in the literature to our entrepreneurial sector is Céspedes et al. (2004), who study a Bernanke et al. (1999) financial accelerator in an open economy environment. Céspedes et al. (2004) demonstrate that depreciations are less expansionary, and potentially contractionary, when entrepreneurs are indebted in FC but earn revenues in sticky LC prices. In their model, informational frictions create an external finance premium that is falling in net worth. A lower net worth that leads to a higher premium on external borrowing thereby reduces aggregate investment. While we are after a similar channel, we make a starker assumption. In particular, we assume that entrepreneur net worth comes only from their profits from the sale of their output in the first stage, net of external debt repayment. We then assume that only this net worth can be used to finance intermediate good production, and no external financing can be used in the second stage when they invest in intermediate good production. By making these simplifications, we can solve the entrepreneurs' subproblem in closed form, avoiding the need for local approximation methods. This facilitates the introduction of the mismatched entrepreneurial sector into the nonlinear sovereign default problem.

[24]When we turn to the sovereign's problem, we will see that an optimizing sovereign would not choose a level of inflation in equilibrium that leaves entrepreneurs unable to repay their debt.

In default states, inflation $\zeta = 0$, and so if we have $X_D = \xi I_D$ and $I_D \leq \Pi_D$, equilibrium intermediate good provision in default states will be given by:

$$X_D = \xi\gamma\left(\omega - Z\right). \tag{8}$$

5.1.3 Introducing Entrepreneurs into the Model

Having presented the relationship between the sovereign choice of inflation and intermediate good provision $X\left(\zeta\right)$, we can introduce the production economy into the model. After entrepreneurs produce the intermediate goods, they rejoin their household. Each household has access to a Cobb-Douglas production technology that combines intermediate goods from the entrepreneurs and inelastically-supplied labor from the workers to produce a final good. This delivers consumption in repayment states given by Equation 5, where $X\left(\zeta\right)$ is given by equation 7. Before we can determine when the sovereign finds it optimal to default, we first need to calculate the best the sovereign can do by repaying and choosing the optimal inflation rate. This problem is kept tractable because our microfoundation of the entrepreneurs' problem delivers a simple closed-form expression for the inflation policy function, conditional on any choice of borrowing tomorrow and the bond price schedule. Conditional on the choice of borrowing being b', the sovereign chooses inflation to maximize static consumption (Equation 5). Taking the first-order condition of consumption in repayment states with respect to inflation delivers an inflation policy function:

$$\zeta\left(A, b, b'\right) = \max\left[\frac{\omega - Z - \left(\gamma^{1+\gamma}\xi^{\gamma}\left(\mu\omega - \alpha Z\right)\left(\frac{A}{b\left(\kappa + \delta q\left(A, b'\right)\right)}\right)\right)^{1/(1-\gamma)}}{\left(\mu\omega - \alpha Z\right)}, 0\right]. \tag{9}$$

This captures the trade-offs the sovereign faces in choosing the optimal inflation rate. First, inflation is countercyclical, as a lower aggregate productivity makes it more tempting to inflate away the debt. Second, the larger today's debt service, κb, the higher the optimal inflation rate. Third, the term $\delta b q\left(A, b'\right)$ captures the present value of outstanding long-term debt that can be inflated away. Because the expression for inflation is for a fixed amount of debt to be issued, b', net revenue raised, $q\left(A, b'\right)\left(b' - \left(1 - \zeta\right)\delta b\right)$, is increasing with the amount of debt inflated away. Therefore, the higher the price a sovereign will receive for new bond issuances, the more tempting it is to inflate away the existing debt. Of course, this temptation will be captured by the bond price schedule in equilibrium.

While the inflation choice can thus be reduced to a static optimization problem, the choice of the debt level is inherently dynamic, as this debt level is the endogenous state variable in the next period. Before turning to this problem, we need to briefly discuss how the economy operates during a sovereign default, as the optimal amount to borrow depends critically on how costly default is.

Consumption in default is simply output in default, and from the entrepreneurs' problem, we have

$$C_D = (A - \phi(A)) X_D^{\gamma} L^{1-\gamma}, \tag{10}$$

where X_D is given by Equation 8 and $\phi(A)$ is a non-negative function capturing how much aggregate productivity drops in default. Following Aguiar and Gopinath (2006) and Arellano (2008), we assume that once the government defaults, there is a constant probability λ each period that the government is redeemed, productivity losses cease, and the government can re-enter sovereign debt markets with zero outstanding debt. However, with probability $(1-\lambda)$ the government remains locked out of sovereign debt markets for another period. With this setup, we can write the government's problem recursively as:

$$\begin{aligned} V^R(A,b) &= \max_{b'} u\left(C_R\left(A,b,b'\right)\right) + \beta EV\left(A',b'\right) \\ V^D(A) &= u\left(C_D(A)\right) + \beta\left(\lambda EV^R\left(A',0\right) + (1-\lambda) EV^D\left(A'\right)\right) \\ V(A,b) &= \max_{D\in\{0,1\}} (1-D) V^R(A,b) + DV^D(A), \end{aligned} \tag{11}$$

where the inflation policy is given by Equation 9, consumption in repayment and default by Equations 5 and 10, intermediate good provision in repayment and default by Equations 7 and 8, and the bond price by Equation 4. The value function in repayment states V^R is today's flow utility and the expectation of tomorrow's value function. In the event a country defaults or remains in bad credit history, there are no choices to be made and the country's period utility is just $u\left(C_D(A)\right)$. Finally, the value function today is the upper envelope of the two: the sovereign remains in V^R if it prefers to repay the debt rather than explicitly default, and if it prefers to default, the relevant value function is V^D. In addition, it captures the fact that, conditional on a choice of b', the optimal inflation policy function is pinned down analytically, conditional on the equilibrium bond price schedule $q\left(A,b'\right)$.

One of the primary benefits of the way in which we introduce LC debt and the entrepreneurial sector into the canonical model is that our model is a generalization of the benchmark model used for modeling FC debt. If we were to restrict inflation to always be zero, then this setup collapses exactly to a model with FC debt, particularly the version with long-term debt studied by Hatchondo and Martinez (2009). If we also restricted the sovereign to borrowing with one-period debt ($\delta = 0$), then this would be equivalent to the model studied by Arellano (2008) and Aguiar and Gopinath (2006).[25] Because of this, we will be able follow the existing literature in our numerical solution of the model.

[25] With no inflation, we would have $X = \xi\gamma(\omega - Z)$ every period, and so output would be equivalent to an endowment economy, with changes in the endowment proportional to changes in productivity A.

5.1.4 Equilibrium Definition

We study the Recursive Markov Equilibrium for this economy, where all decision rules are functions only of the state variables A and b. An equilibrium is a set of policy functions for consumption $\tilde{c}(A,b)$, debt issuance $\tilde{b}(A,b)$, default $\tilde{D}(A,b)$, and inflation $\tilde{\zeta}(A,b)$, and a price function for debt $q(A,b')$ such that (1) taking as given the government policy functions, household consumption satisfies the resource constraint; (2) taking the bond price function $q(A,b')$ as given, the government's policy functions satisfy the sovereign's optimization problem; (3) the bond price function satisfies the risk-neutral foreign lenders' zero-profit condition. The government's lack of commitment is captured by the fact that equilibrium policy functions are restricted to be functions of today's state variables A and b, and cannot be history dependent. Instead, the government policy functions must satisfy the government's optimization problem period by period.

5.2 Bond Pricing, Currency Risk, and Credit Risk

Just as in Section 2 we were able to measure the currency and credit risk on LC sovereign debt in the data by pricing a synthetic default-free LC bond, in the model our decomposition of currency and credit risk will rely on pricing an instrument in zero net supply. Even though the only debt actually issued by the government is a defaultable LC bond, we can still price a default-free LC bond. This will be the theoretical counterpart to our empirical version of combining a US Treasury with a cross-currency swap to approximate the interest rate at which a risk-free entity would borrow if it issued a single unit of debt in an EM currency. To do so, we simply have to calculate what price global investors would pay for the *default-free* sequence of LC cash flows in Equation 3. The price is the discounted risk-neutral expected value of the cash flows, conditional on the time t information set,

$$\begin{aligned} q_t^{*LC} &= E_t\left[\frac{\kappa\cdot(1-\zeta_{t+1})}{1+r^*}+\frac{\delta\kappa\cdot(1-\zeta_{t+1})(1-\zeta_{t+2})}{(1+r^*)^2}+\ldots\right] \\ &= \frac{E_t\left[(1-\zeta_{t+1})\left(\kappa+\delta q_{t+1}^{*LC}\right)\right]}{1+r^*}, \end{aligned} \tag{12}$$

and so once again the bond price has a simple recursive representation. Just as is the case for the defaultable LC bond price q_t, the default-free LC bond price is a function of today's exogenous productivity level A and the amount of defaultable debt issued b'. It is important to note that the payoff on this bond is a function of the sovereign's inflation choice, and therefore its payoffs are a function of government policy just like the defaultable debt. The key difference is that this default-free debt is not issued by the sovereign and therefore cannot be defaulted on.[26]

In order to connect the bond prices to the empirical currency and credit spread decomposition discussed in Section 2, we need to convert these bond prices to yields. To do so, we can define the

[26] Additional details can be found in Appendix Section B.1. In particular, we address the need to price the default-free LC debt during states when the sovereign is in default.

yield to maturity (YTM) of bond type j at time t as r_t^j, as the internal rate of return that equates the present value of the bond's promised cash flows to its price:

$$q_t^j = \sum_{s=1}^{N} \frac{CF_{t+s}}{\left(1 + r_t^j\right)^s},$$

where CF_{t+s} is the promised cash flow of the bond at time $t+s$. Because the bonds we are looking at have an exponentially declining coupon structure, this calculation is particularly simple and becomes:

$$r_t^j = \frac{\kappa}{q_t^j} - (1 - \delta). \tag{13}$$

This allows us to calculate the credit risk (LC credit spread, Equation 1), to calculate the currency risk (cross-currency swap rate), and to decompose the nominal yield into currency and credit risk:

$$\begin{aligned} \rho_t &= r_t^{*LC} - r^* \\ s_t^{LCCS} &= r_t^{LC} - r_t^{*LC} \\ s_t^{LC/US} &= r_t^{LC} - r^* \\ &= s_t^{LCCS} + \rho_t, \end{aligned}$$

where r_t^{LC} is the YTM on a defaultable LC sovereign bond, r_t^{*LC} is the YTM on the (zero net supply) default-free LC bond, and r^* is the FC risk-free rate, which we assume to be constant. By calculating these three spreads in the model, we will be able to compare the model-implied moments to their empirical counterparts.

5.3 Discussion of Assumptions and Extensions

Throughout the model, we maintain a few simplifying assumptions for tractability. Before turning to the quantitative results, we will briefly discuss these assumptions and how they might be relaxed. First, the model assumes zero recovery upon default. In the model, since the only reason to inflate is to reduce the real value of debt repayments, the model has the counterfactual prediction of no inflation upon default. Na et al. (2014), building on the findings of Reinhart (2002), find that default is accompanied by large depreciations and high inflation; they provide an explanation of this phenomenon by introducing downward nominal wages into a quantitative sovereign debt model. In Du and Schreger (2016), we document a similar empirical relationship between depreciation and default. In Appendix Section B.2, we study one potential resolution of this issue: partial default. If the government only repudiates a fraction of its debt upon default, as in a bargaining framework such as Yue (2010) or Pitchford and Wright (2011), then the government may still want to reduce its real repayments through inflation even after it explicitly defaults.

Second, the model assumes that sticky price goods are sold to foreign investors, whereas in reality many goods priced in the local currency would likely be sold domestically. In Appendix Section B.2, we allow for domestic sales of the sticky price goods. In particular, we assume that

domestic intermediaries, owned by the household, purchase the good, resell it, and distribute the profits evenly. Partial default reduces the benefits of default, and domestic sales reduce the costs of inflation. In the appendix, we show that we can obtain results quantitatively similar to the baseline case with either partial default or domestic sales by introducing these features into the model while reducing the costs of default from our benchmark calibration.

Third, the model treats the currency composition of sovereign and corporate debt as exogenous parameters. While it is an interesting research question why the sovereign borrows more in local currency while the firms borrow more in foreign currency, for our purpose of explaining sovereign default risk, we do not believe it is necessary to take a stand on one particular channel.[27] One natural explanation would be risk-based. If lenders required a risk premium on LC borrowing, then any reason why the sovereign would be willing to pay the risk premium but the corporate sector would not could help explain this pattern. Du et al. (2016b) explore the question of sovereign portfolio choice with risk-averse lenders. Why might corporates be unwilling to pay a risk premium to borrow in their own currency when the government would choose to pay such a premium? One potential explanation for the difference in sovereign and corporate borrowing patterns is bailout guarantees, as in Schneider and Tornell (2004), such that firms don't bear the full cost of borrowing in their own currency. Another would be incentives that lead non-financial corporates to run a carry trade by receiving revenues in high-yielding local currencies and borrowing in US dollars, as argued in Bruno and Shin (2015). For our purposes, however, the important part is that this FC borrowing leaves firms vulnerable to depreciation, as argued in Section 4.

6 Quantitative Results

6.1 Calibration and Numerical Solution

In this section, we will outline the functional form assumptions, parameter calibrations, and solution method used to solve the model numerically. We assume a CRRA utility function with a coefficient of relative risk aversion σ, and we assume that log productivity follows an AR(1) process:

$$u(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}$$
$$\ln A_t = \mu_z (1-\rho_z) + \rho_z \ln A_{t-1} + \epsilon_t,\ 0 < \rho_z < 1 \ and \ \epsilon_t \sim N\left(0, \sigma_\epsilon^2\right).$$

We follow Chatterjee and Eyigungor (2012) and use the flexible form for default costs:

$$\phi(A) = \max\left\{0, d_0 A + d_1 A^2\right\},\ d_1 \geq 0.$$

[27] In the current framework, we do not impose a breakeven condition on corporate debt; therefore, firms would (weakly) prefer to borrow in LC and set α to 1 if they could choose. This is because we define α as the share of the face value of payments to be repaid. Imposing a breakeven condition on LC corporate borrowing is feasible but computationally challenging, as it would involve adding another state variable (expected inflation).

If $d_1 = 0$ and $d_0 > 1$, this is simply the proportional default costs used in Aguiar and Gopinath (2006). If $d_1 \geq 0$ and $d_0 < 0$, then the default costs become closer to the Arellano (2008) costs because when $A \leq -\frac{d_0}{d_1}$, the default costs are zero but when A is above that threshold the default costs are convex in A. However, because here we have A_D increasing with A rather than staying constant, the default costs are less kinked than in Arellano (2008).

[Table 5 here]

We calibrate the model to a quarterly frequency. The parameter values are documented in Table 5. We set the intermediate good share γ to 1/3 so that the labor share is 2/3. We set the amount of FC external corporate financing Z to 0.51, so that in the absence of inflation the mean debt/output ratio is equal to 17%, the mean private external debt/GDP ratio documented in Section 3. We calibrate mean entrepreneur output and the efficiency of the intermediate good production technology ξ so that in the absence of inflation, $X = 1$ and the model collapses to the endowment economy with FC sovereign debt. This requires $\xi = 1/\gamma\left(\omega - Z\right)$, meaning that the choice of ξ and ω only involves setting one parameter. We set ξ and ω to match the average inflation differential between the 13 EMs and the United States from 2000 to 2012. This delivers $\xi = 3.025$ and $\omega = 1.5017$. We set the default costs to match the historical average credit spread on FC debt (from CDS) over the last decade of 2% when we solve a version of the model with only FC debt. The implied default costs correspond to an aggregate productivity loss of 3% in the worst state and 3.75% in the best state. This is within the range used in the literature, as in Aguiar and Gopinath (2006) the proportional cost is equal to 3%, in Hatchondo and Martinez (2009) it is equal to 10%, and in Arellano (2008) it is 0% in the low-productivity states and it can exceed 20% in high productivity states. Our benchmark calibration sets α to 10% to match the mean share of LC corporate debt in total external corporate debt in the data. In the simulations, we will also consider a calibration with $\alpha = 50\%$. This is the counterfactual case where the corporate sector is significantly less mismatched. We set the quarterly discount factor $\beta = 0.95$, a standard value in this literature with long-term debt ((Hatchondo and Martinez, 2009)). In order to generate default in equilibrium, the sovereign has to be less patient than international investors. This leads the sovereign to try to front-load consumption, generating default risk in equilibrium. This low discount factor can be understood as capturing a government that is more impatient than individuals for political economy reasons.[28]

To calibrate the productivity process, we follow Aguiar and Gopinath (2006), setting the autocorrelation $\rho_z = 0.9$ and $\sigma_z = 0.034$. We follow Tauchen (1986) to discretize the productivity process. We let $\delta = 0.9595$ to set the risk-free duration of the LC bonds to 5 years when the quarterly risk-free rate is 1%.[29] This duration is close to the cross-country average calculated in

[28] See Cuadra and Sapriza (2008) for a model that explicitly models political economy frictions in an Eaton and Gersovitz (1981) sovereign debt model.

[29] The risk-free Macaulay duration of bond is given by $D = \sum_{n=1}^{\infty} n \frac{C_n \left(1 + r^*\right)^{-n}}{q}$, where C_n is the coupon payment due in period n. In our framework with exponentially declining coupons, $D = \frac{1 + r^*}{1 + r^* - \delta}$.

Appendix Table A.3. For the probability of re-entry into credit markets, we follow Aguiar and Gopinath (2006) and set the probability of re-entry λ to 10%.[30] The share of sticky price goods μ is set to 0.75, a common calibration parameter for Calvo pricing.

To solve the model, we use value function iteration over a discretized state space. Because our recursive representation is identical to the model studied in Hatchondo and Martinez (2009), Chatterjee and Eyigungor (2012), and a one-bond version of Arellano and Ramanarayanan (2012), with one additional constraint on the policymaker (Equation 9), we can simply follow the solution methods used in the FC sovereign debt literature. The state space for productivity shocks is discretized to a 41-state grid. The state space for bonds is discretized into 501 grid points. A finer grid is used for the endogenous state variable to keep the discretization from impacting the sovereign's choices. Following the recommendations in Hatchondo et al. (2010), we iterate backward from the solution of the final period of the finite-horizon model so that we select the equilibrium bond price of the finite-horizon model. To improve the convergence properties of the solution, we follow Chatterjee and Eyigungor (2012) and introduce a small i.i.d. component to the productivity process. Chatterjee and Eyigungor (2012) show that in sovereign debt models with long-term bonds, large changes in the bond issuance policy function can achieve roughly the same welfare level, so that small changes in the bond price can lead the bond issuance policy function to change significantly. These discontinuities arise from the non-convexity of the budget set. The introduction of a small i.i.d. component to the productivity process acts to convexify the budget set and improve convergence without significantly affecting the business cycle properties of the model. In the event of default, we set this i.i.d. component to its lowest value, slightly raising the cost of default.[31]

After solving for the equilibrium policy functions and the defaultable LC bond price, we price the synthetic default-free LC bond as in Section 5.2. With our policy functions and bond price schedules in hand, we can calculate the model-implied moments by simulating the model 20 times for 3,000 quarters per simulation. We discard the first 500 periods of each simulation.

6.2 Quantitative Results and Key Mechanisms

6.2.1 Quantitative Results

In Table 4, we report the key moments for eight different calibrations of α. In the first row, we report the sample average LC credit spread $\left(s^{LCCS}\right)$, the nominal spread $\left(s^{LC/US}\right)$, and the share of credit risk in the nominal spread $\left(s^{LCCS}/s^{LC/US}\right)$. These are the average of currency and credit spreads for 13 countries from 2005 to 2012[32] calculated following the methodology discussed in Section 2. Each country receives equal weight in computing the sample average. The final column, external sovereign debt/GDP, is again just the simple cross-country average, with the external debt/GDP

[30] This implies that on average sovereigns are excluded from financial markets for 2.5 years.

[31] As in Chatterjee and Eyigungor (2012), we set a bounded support of this i.i.d. shock at .006 and find it is sufficient to achieve faster convergence for our calibration. Rather than using the continuous formulation of this i.i.d. shock, we model it as a discrete uniform distribution with an 11-point grid. This method corresponds to column IV in Table C1 of their appendix.

[32] Russia is excluded because its LC debt was not investable for much of the period.

ratio calculated using our data discussed in Section 3. The remaining rows of the table report the simulated moments for the five alternative calibrations of the model, with the baseline calibration with α set to its sample average of 10%. In our baseline calibration, we come quite close to matching the average cross-country empirical moments, with an average local currency credit spread of 1.11 percentage points as compared to 1.48 percentage points in the data, and a nominal spread of 3.30 percentage points as compared to a mean of 4.66 percentage points in the data. In addition, in the baseline calibration we generate a ratio of external sovereign debt to annual GDP of 8.7%, very close to the 9% found in the data. By changing α from 10% to 50%, we see that credit risk disappears completely for the reasons discussed in the previous section. One key finding of the quantitative model, is that there is a fairly narrow region of the parameter space where both inflation and default are observed in equilibrium. Therefore relatively small changes to the corporate debt composition may have large effects on the risk of sovereign default. In this calibration, we find that the nominal spread on LC sovereign debt does not dramatically increase with the share of LC corporate debt. The mechanisms behind these results are the focus of the next subsection.

[Table 4 here]

6.2.2 Equilibrium Policy Functions and Bond Prices

In order to better understand the mechanisms at work in the model, we will begin by looking at the sovereign's policy functions for two different levels of currency mismatch, $\alpha = 10\%$ (baseline) and $\alpha = 50\%$ (low mismatch). In Figure 7, we plot the sovereign's equilibrium default and inflation policy functions for different levels of debt outstanding and aggregate productivity. The legend on the right side of each figure indicates the level of inflation, where warmer colors mean higher inflation and white indicates explicit default. In the left panel, we plot the baseline case, where 10% of corporate debt is in LC, and we see that there is only a small range of low positive inflation before the sovereign chooses to explicitly default on its debt. This is in sharp contrast to the right panel of Figure 7, where half of corporate debt is in LC. Here, we see a wider range of positive inflation before the sovereign actually chooses to default on the debt.

[Figure 7 here]

Because lenders recognize the incentives facing the sovereign, these policy functions are embodied in the bond price schedules ensuring that foreign lenders break even in expectation. In Figure 8, we plot the bond price schedule the sovereign faces for two levels of corporate mismatch. The blue line plots the case where 10% of private sector debt is in LC, and the dashed red line plots the case where 50% of private sector debt is in LC. With only 10% of debt in LC, the narrow band of positive inflation from the policy function is reflected in the bond price schedule as the government borrows at a relatively high price (low spread) at lower levels of debt before the bond price sharply declines. This reflects the fact that the default threshold is very steep in the amount of debt outstanding. Therefore, there is only a small region of the bond price schedule where the sovereign significantly

compensates the lender for currency risk and, as the amount of debt issued increases, the bond price sharply declines as the sovereign approaches the default threshold. By contrast, when half of corporate debt is in LC, we initially see a more gradual decline in the bond price as the sovereign compensates the lender for the increasing currency risk, and then a sharper decline as default risk becomes more prevalent.

[Figure 8 here]

Figure 7 shows that even when there is a relatively low level of corporate currency mismatch ($\alpha = 0.5$), for every productivity level there is still a level of debt above which the sovereign prefers to default. As seen in Table 4, however, at higher levels of α, there is no default risk in equilibrium. These two facts are reconciled through the sovereign's equilibrium bond issuance policy function. The sovereign's inability to commit not to inflate or default generates a debt Laffer curve, where the market value of outstanding sovereign debt initially increases with the face value of debt before reaching the peak of the curve. In equilibrium, the sovereign generally borrows on the good side of the debt Laffer curve, where revenue is increasing with the face value of the debt. If the temptation to inflate away the debt occurs at lower borrowing levels than the temptation to default, then a government that internalizes the effect of the amount it borrows on the interest rate it is charged will not borrow enough to put itself at risk of default. This is the case when the corporate sector is not overly reliant on FC external financing, meaning that sovereign debt is free from default risk in equilibrium when there are low enough levels of corporate currency mismatch. In Appendix Section B.1.1, we explore the debt Laffer curve in more detail.

6.3 Theory and Data

The results in Table 4 show that the model predicts that sovereign credit risk declines very sharply with the share of private LC debt. In order to assess the empirical relevance of this theoretical prediction, we need to examine the relationship between the share of external corporate debt in LC and sovereign default risk on nominal debt. To do so, we regress the LC credit spread on the empirical counterpart of α, the share of external corporate debt in LC, the share of external sovereign debt in LC (which we denote α_G), and the external sovereign and corporate debt/GDP ratios. In addition, while we have assumed risk-neutral pricing in the theory, a number of papers, such as Longstaff et al. (2011) and Hilscher and Nosbusch (2010), demonstrate the importance of global factors in determining sovereign spreads. Therefore, we alternately control for the global covariates discussed in Section 4 or use time fixed effects.

In Table 6, we estimate a panel regression of the form:

$$y_{i,t} = \beta_0 + \beta_1 \cdot \alpha + \beta_2 \cdot \alpha_G + \beta_3 \left(\frac{Ext.\,Sov.\,Debt}{GDP} \right) + \beta_4 \left(\frac{Ext.\,Corp.\,Debt}{GDP} \right) + \delta X_t + \epsilon_{i,t},$$

where X_t is a vector of time-varying global variables. We estimate the regression at an annual frequency. In columns 1 and 2, $y_{i,t}$ is the LC credit spread, where we use global controls in column

1 and time fixed effects in column 2. Conditional on the controls, we see that a 1% reduction in the share of corporate debt in LC is associated with a 6.3-6.4 basis point reduction in the local currency credit spread. Because Brazil's LC credit spread is significantly higher than other countries', and as discussed in Du and Schreger (2016) it may be driven by capital control risk, in columns 3 and 4 we consider a version of the regression excluding Brazil. Here, we see that a 1% reduction in the share of corporate debt in LC is associated with a roughly 3 basis point decline in the LC credit spread. In Figure 9a, we plot two binned scatterplots of the LC credit spread against the share of corporate debt in LC, after orthogonalizing the LC credit spread on the covariates used in column 1 of Table 6. We can then regress the residuals on α and plot the estimated LC credit spread, averaged across 13 quantiles. These data points are in red, as is the dashed linear fit connecting them. We also the plot the mean model-implied LC credit spread against each level of α, with the model-implied moments in blue along with a linear fit. Here, we restrict α to be less than the maximum observed country average, which is 30% for South Africa.

[Table 6 here]

[Figure 9 here]

While the model fits the empirical credit spreads remarkably well, the fit is not quite as strong for inflation and currency risk. In columns 5 and 6 of Table 6, we replace the LC credit spread in the regression with the annual realized inflation rate. We estimate that every 1% increase in the share of corporate debt in LC is associated with a 5.5 basis point higher inflation rate. The model also predicts a strong positive relationship between α and inflation, a predicted relationship that is somewhat sharper than in the data. This can be seen in the left panel of Figure 9b. The model-implied slope is larger, and the R^2 is higher much higher, than we see in the data. In columns 7 and 8, we run the same regression with ρ, the cross-currency swap rate, as the left-hand-side variable and find a positive but statistically insignificant relationship between the share of corporate debt in local currency and the average cross-currency swap rate.[33]

7 Conclusion

This paper examines why a country would default on its sovereign debt when the government could instead inflate it away. We argue that a government is more inclined to default than inflate when the currency mismatch of the corporate sector implies large adverse balance sheet effects from a currency depreciation. In making this argument, we construct a new dataset on the currency composition of emerging market external borrowing and show that the corporate sector remains reliant on external FC debt even as sovereigns have swiftly moved toward borrowing in their own currency. We show that a higher level of external FC corporate debt is associated with more sovereign credit risk. In addition, we provide evidence that corporate FC debt is unlikely to be hedged with revenues or directly using FX derivatives.

[33] In Appendix Figure A.9, we report a version of Figure 9 for the cross-currency swap rate.

Motivated by these empirical findings, we provide an explanation for why there continues to be sovereign default risk on LC debt by presenting a model where mismatched corporate balance sheets increase the cost of inflating away sovereign debt and make default relatively more appealing. We embed a corporate balance sheet channel in the canonical Eaton and Gersovitz (1981) sovereign debt model and demonstrate how higher shares of LC private debt can reduce the default risk on LC sovereign debt in equilibrium by affecting the cost of inflation relative to default and the sovereign's endogenous issuance decision. A calibration of the model matches the patterns credit risk on LC sovereign debt in the data. The model implies that reductions in the share of FC external debt would significantly reduce sovereign default risk on LC debt.

References

Acharya, Viral, Stephen Cecchetti, Jose De Gregorio, Sebnem Kalemli-Ozcan, Philip Lane, and Ugo Panizza, "Corporate Debt in Emerging Economies: A Threat to Financial Stability?," *Brookings Institution*, 2015.

Aghion, Philippe, Philippe Bacchetta, and Abhijit Banerjee, "A Simple Model of Monetary Policy and Currency Crises," *European Economic Review*, 2000, *44* (4), 728–738.

_ , _ , and _ , "Currency Crises and Monetary Policy in an Economy with Credit Constraints," *European Economic Review*, 2001, *45* (7), 1121–1150.

_ , _ , and _ , "A Corporate Balance-Sheet Approach to Currency Crises," *Journal of Economic Theory*, 2004, *119* (1), 6–30.

Aguiar, Mark, "Investment, Devaluation, and Foreign Currency Exposure: The Case of Mexico," *Journal of Development Economics*, 2005, *78* (1), 95–113.

_ and Gita Gopinath, "Fire-Sale Foreign Direct Investment and Liquidity Crises," *Review of Economics and Statistics*, 2005, *87* (3), 439–452.

_ and _ , "Defaultable Debt, Interest Rates and the Current Account," *Journal of International Economics*, 2006, *69* (1), 64–83.

_ , Manuel Amador, Emmanuel Farhi, and Gita Gopinath, "Crisis and Commitment: Inflation Credibility and the Vulnerability to Sovereign Debt Crises," *Working Paper*, July 2013.

_ , _ , _ , and _ , "Coordination and Crisis in Monetary Unions," *The Quarterly Journal of Economics*, 2015.

Araujo, Aloisio, Marcia Leon, and Rafael Santos, "Welfare Analysis of Currency Regimes with Defaultable Debts," *Journal of International Economics*, 2013, *89*, 143–153.

Arellano, Cristina, "Default Risk and Income Fluctuations in Emerging Economies," *American Economic Review*, 2008, *98* (3), 690–712.

_ and Ananth Ramanarayanan, "Default and the Maturity Structure in Sovereign Bonds," *Journal of Political Economy*, April 2012, *120* (2), 187–232.

Arslanalp, Serkan and Takahiro Tsuda, "Tracking Global Demand for Emerging Market Sovereign Debt," *IMF Working Paper*, March 2014, (14/39).

Avdjiev, Stefan, Michael KF Chui, and Hyun Song Shin, "Non-Financial Corporations from Emerging Market Economies and Capital Flows," *BIS Quarterly Review December*, 2014.

Bénétrix, Agustín S, Philip R Lane, and Jay C Shambaugh, "International Currency Exposures, Valuation Effects and the Global Financial Crisis," *Journal of International Economics*, 2015, *96*, S98–S109.

Bernanke, Ben S, Mark Gertler, and Simon Gilchrist, "The Financial Accelerator in a Quantitative Business Cycle Framework," *Handbook of Macroeconomics*, 1999, pp. 1341–1393.

Bleakley, Hoyt and Kevin Cowan, "Corporate Dollar Debt and Depreciations: Much ado about Nothing?," *Review of Economics and Statistics*, 2008, *90* (4), 612–626.

Bocola, Luigi, "The Pass-Through of Sovereign Risk," *Journal of Political Economy*, August 2016, *124* (4), 879–926.

Bruno, Valentina and Hyun Song Shin, "Global Dollar Credit and Carry Trades: a Firm-Level Analysis," *Available at SSRN 2614074*, 2015.

Burger, John D. and Francis E. Warnock, "Foreign Participation in Local Currency Bond Markets," *Review of Financial Economics*, 2007, *16* (3), 291–304.

_ , _ , and Veronica Cacdac Warnock, "Emerging Local Currency Bond Markets," *Financial Analysts Journal*, 2012, *68* (5).

Burger, John D, Rajeswari Sengupta, Francis E Warnock, and Veronica Cacdac Warnock, "US Investment in Global Bonds: As the Fed Pushes, some EMEs Pull," *National Bureau of Economic Research*, 2014.

Caballero, Julian, Ugo Panizza, and Andrew Powell, "The Second Wave of Global Liquidity: Why are Firms Acting like Financial Intermediaries?," *Working Paper, Inter-American Development Bank*, 2015.

Calvo, Guillermo A and Carmen M Reinhart, "Fear of Floating," *The Quarterly Journal of Economics*, 2002, *117* (2), 379–408.

Céspedes, Luis Felipe, Roberto Chang, and Andrés Velasco, "Balance Sheets and Exchange Rate Policy," *American Economic Review*, 2004, *94* (4), 1183–1193.

Chatterjee, Satyajit and Burcu Eyigungor, "Maturity, Indebtedness, and Default Risk," *American Economic Review*, 2012, *102* (6), 2674–2699.

Chui, Michael KF, Ingo Fender, and Vladyslav Sushko, "Risks Related to EME Corporate Balance Sheets: The Role of Leverage and Currency Mismatch," *BIS Quarterly Review September*, 2014.

Corsetti, Giancarlo and Luca Dedola, "The Mystery of the Printing Press: Self-fulfilling Debt Crises and Monetary Sovereignty," *Working Paper*, April 2013.

Cuadra, Gabriel and Horacio Sapriza, "Sovereign Default, Interest Rates and Political Uncertainty in Emerging Markets," *Journal of International Economics*, 2008, *76* (1), 78–88.

Datta, Deepa Dhume and Wenxin Du, "Nonparametric HAC Estimation for Time Series Data with Missing Observations," *International Finance Discussion Paper No.1060, Federal Reserve Board*, 2012.

Driscoll, John C. and Aart Kraay, "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data," *Review of Economics and Statistics*, 1998, *80* (4), 549–560.

Du, Wenxin, Alexander Tepper, and Adrien Verdelhan, "Deviations from Covered Interest Rate Parity," *Working Paper*, 2016.

_ **and Jesse Schreger**, "Local Currency Sovereign Risk," *Journal of Finance*, 2016, *71* (3), 1027–1070.

_ **, Carolin E. Pflueger, and Jesse Schreger**, "Sovereign Debt Portfolios, Bond Risks, and the Credibility of Monetary Policy," *NBER Working Paper Series No. 22592*, 2016.

Eaton, Jonathan and Mark Gersovitz, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Studies*, 1981, *48* (2), 289–309.

Edwards, Sebastian, "LDC Foreign Borrowing and Default Risk: An Empirical Investigation, 1976-80," *The American Economic Review*, 1984, pp. 726–734.

Eichengreen, Barry and Ashoka Mody, "What Explains Changing Spreads on Emerging-Market Debt: Fundamentals or Market Sentiment?," 1998.

_ **and Ricardo Hausmann**, "Exchange Rates and Financial Fragility," in "New Challenges for Monetary Policy," Federal Reserve Bank of Kansas City, 1999, pp. 329–68.

Engel, Charles and JungJae Park, "Debauchery and Original Sin: The Currency Composition of Sovereign Debt," *Working Paper*, 2016.

Frankel, Jeffrey A., "Contractionary Currency Crashes in Developing Countries," *National Bureau of Economic Research*, 2005.

Frankel, Jeffrey A, "Monetary Policy in Emerging Markets: A Survey," in Benjamin Friedman and Michael Woodford, eds., *Handbook of Monetary Economics*, Vol. 3B 2010, pp. 14–39.

Galindo, Arturo, Ugo Panizza, and Fabio Schiantarelli, "Debt Composition and Balance Sheet Effects of Currency Depreciation: A Summary of the Micro Evidence," *Emerging Markets Review*, 2003, *4* (4), 330–339.

Gertler, Mark and Peter Karadi, "A Model of Unconventional Monetary Policy," *Journal of Monetary Economics*, 2011, *58* (1), 17–34.

_ , Simon Gilchrist, and Fabio M. Natalucci, "External Constraints on Monetary Policy and the Financial Accelerator," *Journal of Money, Credit and Banking*, 2007, *39* (2-3), 295–330.

Gilchrist, Simon and Jae W Sim, "Investment During the Korean Financial Crisis: A Structural Econometric Analysis," *National Bureau of Economic Research*, 2007.

Hatchondo, Juan Carlos and Leonardo Martinez, "Long-Duration Bonds and Sovereign Defaults," *Journal of International Economics*, 2009, *79* (1), 117–125.

_ , _ , and Horacio Sapriza, "Quantitative Properties of Sovereign Default Models: Solution Methods Matter," *Review of Economic Dynamics*, 2010, *13* (4), 919–933.

Hebert, Benjamin and Jesse Schreger, "The Costs of Sovereign Default: Evidence from Argentina," *NBER Working Paper*, 2016, (22270).

Hilscher, Jens and Yves Nosbusch, "Determinants of Sovereign Risk: Macroeconomic Fundamentals and the Pricing of Sovereign Debt," *Review of Finance*, 2010, pp. 235–262.

Jeanneret, Alexandre and Slim Souissi, "Sovereign Defaults by Currency Denomination," *Working Paper*, May 2014.

Kim, Yun Jung, Linda Tesar, and Jing Zhang, "The Impact of Foreign Liabilities on Small Firms: Firm-Level Evidence from the Korean Crisis," *Journal of International Economics*, 2015, *97* (2), 209–230.

Korinek, Anton, "Excessive Dollar Borrowing in Emerging Markets: Balance Sheet Effects and Macroeconomic Externalities," *Working Paper*, 2010.

Krugman, Paul, "Balance Sheets, the Transfer Problem, and Financial Crises," *International Tax and Public Finance*, 1999, *6*, 459–472.

Lane, Philip R and Jay C Shambaugh, "Financial Exchange Rates and International Currency Exposures," *The American Economic Review*, 2010, pp. 518–540.

Longstaff, Francis A., Jun Pan, Lasse H. Pedersen, and Kenneth J. Singleton, "How Sovereign is Sovieregn Credit Risk?," *American Economic Journal: Macroeconomics*, April 2011, *3*, 75–103.

Lorenzoni, Guido and Ivan Werning, "Slow Moving Debt Crises," *NBER Working Paper*, July 2013, (19228).

Mendoza, Enrique G and Vivian Z Yue, "A General Equilibrium Model of Sovereign Default and Business Cycles," *The Quarterly Journal of Economics*, 2012, *127* (2), 889–946.

Na, Seunghoon, Stephanie Schmitt-Grohé, Martin Uribe, and Vivian Z Yue, "A Model of the Twin Ds: Optimal Default and Devaluation," *National Bureau of Economic Research*, 2014.

Ottonello, Pablo and Diego Perez, "The Currency Composition of Sovereign Debt," *Working Paper*, 2016.

Perez, Diego J, "Sovereign Debt, Domestic Banks and the Provision Of Public Liquidity," *Manuscript, Stanford University*, 2014.

Pitchford, Rohan and Mark LJ Wright, "Holdouts in Sovereign Debt Restructuring: A Theory of Negotiation in a Weak Contractual Environment," *The Review of Economic Studies*, 2011.

Reinhart, Carmen M, "Default, Currency Crises, and Sovereign Credit Ratings," *The World Bank Economic Review*, 2002, *16* (2), 151–170.

Reinhart, Carmen M. and Kenneth S. Rogoff, *This Time is Different: Eight Centuries of Financial Folly*, Princeton University Press, 2008.

_ **and** _ , "The Forgotten History of Domestic Debt," *The Economic Journal*, May 2011, *121*, 319–350.

Schneider, Martin and Aaron Tornell, "Balance sheet effects, bailout guarantees and financial crises," *The Review of Economic Studies*, 2004, *71* (3), 883–913.

Sims, Christopher A, "Paper money," *The American Economic Review*, 2013, *103* (2), 563–584.

Sunder-Plassmann, Laura, "Inflation, Default, and the Denomination of Sovereign Debt," *Working Paper*, 2013.

Tauchen, George, "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions," *Economics Letters*, 1986, *20* (2), 177–181.

Uribe, Martin and Vivian Z Yue, "Country Spreads and Emerging Countries: Who Drives Whom?," *Journal of International Economics*, 2006, *69* (1), 6–36.

Vogelsang, Timothy J, "Heteroskedasticity, Autocorrelation, and Spatial Correlation Robust Inference in Linear Panel Models with Fixed-Effects," *Journal of Econometrics*, 2012, *166* (2), 303–319.

Yue, Vivian Z, "Sovereign Default and Debt Renegotiation," *Journal of International Economics*, 2010, *80* (2), 176–187.

Tables

Table 1: Share of External Borrowing in Local Currency

	Sovereign		Corporate	
	2004 (%)	2012 (%)	2004 (%)	2012 (%)
Brazil^^	32.9	65.4	4.2	4.7
Colombia^	7.0	16.6	5.5	7.2
Hungary	49.0	48.3	6.9	10.6
Indonesia	25.0	46.2	5.4	8.3
Israel	6.1	37.9	1.3	6.3
Malaysia	20.9	91.4	4.8	9.1
Mexico	13.0	72.1	4.6	11.3
Peru	0.0	46.4	0.3	7.0
Poland	53.0	46.4	19.5	19.4
Russia	0.1	37.9	0.8	11.5
South Africa^^	42.8	77.0	27.3	29.9
South Korea	6.3	77.9	3.2	4.2
Thailand	16.8	97.9	6.1	9.0
Turkey^	40.2	51.6	8.3	11.6

Notes: ^ indicates that 2006 data are used for the 2004 column, and ^^ indicates that 2007 data are used for the 2004 column because that is the first year of data availability. Each value represents the percentage of external borrowing for the sovereign or corporate sector that is in LC at the end of each year.

Table 2: Sovereign Credit Spreads and External Debt, 2005—2012

VARIABLES	(1) LCCS	(2) LCCS	(3) LCCS	(4) LCCS
$\frac{FC\,Private}{GDP}$	5.873	5.343	3.403	3.189
	(1.184)	(1.133)	(0.803)	(0.846)
$\frac{FC\,Gov}{GDP}$	9.980	9.530	3.946	3.818
	(4.598)	(5.083)	(1.669)	(1.810)
$\frac{LC\,Gov}{GDP}$	5.916	6.782	-5.496	-4.451
	(1.996)	(1.957)	(2.121)	(2.144)
VIX		0.913		1.036
		(0.464)		(0.408)
Fed Funds Rate		-0.166		-3.780
		(5.090)		(6.210)
BBB-Treasury Spread		13.94		6.249
		(5.224)		(5.540)
10-Year Treasury Yield		-13.23		-33.04
		(12.74)		(12.05)
Ted Spread		37.07		49.42
		(15.70)		(15.13)
Constant	209.2	214.2	15.49	138.3
	(25.83)	(56.21)	(13.94)	(42.70)
Observations	355	355	355	355
R-squared	0.735	0.690	0.354	0.304
Countries	13	13	13	13
Country FE	Yes	Yes	No	No
Time FE	Yes	No	Yes	No

Notes: The table reports panel regression results of the level of the LC credit spread on country-level and global variables. All specifications contain country fixed effects. Heteroskedasticity autocorrelation spatial correlation robust Driscoll and Kraay (1998) standard errors with a four-quarter lag. Standard errors follow Vogelsang (2012) when time fixed effects are used. $\left(\frac{FC\,Gov}{GDP}\right)$, $\left(\frac{LC\,Gov}{GDP}\right)$, and $\left(\frac{FC\,Private}{GDP}\right)$ are the FC sovereign debt/GDP ratio, the LC sovereign debt/GDP ratio, and the FC private debt/GDP ratio. These variables are constructed in Section 3, with the data sources and methods described there and in Appendix Section A.2. The VIX, Fed Funds Rate, BBB-Treasury Spread, 10-Year Treasury Spread, and Ted Spread are all from FRED of the Federal Reserve Bank of St. Louis. VIX is the 30-day implied volatility of the S&P, the Fed Funds Rate is the effective overnight Federal Funds Rate, the BBB-Treasury Spread is the option-adjusted spread of the Bank of America Merrill Lynch US Corporate BBB Index over US Treasuries, the 10-Year Treasury Spread is the 10-Year Treasury Constant Maturity Rate, and the Ted Spread is the spread between 3-month dollar Libor and the 3-month Treasury Bill. Standard errors are reported in parentheses.

Table 3: CCS and FC Debt Outstanding in 2012

Country	Currency	(1) CCS Notional ($ Billions)	(2) FC Corporate ($ Billions)	(3) FC Government ($ Billions)
		Reporting Currencies		
Turkey	TRY	320	141	53
Russia	RUB	83	287	41
South Korea	KRW	76	268	15
South Africa	ZAR	67	53	11
Mexico	MXN	67	164	48
Hungary	HUF	53	45	24
Poland	PLN	53	65	70
		Non-Reporting Currencies		
Brazil	BRL	<25	369	62
Colombia	COP	<25	28	20
Indonesia	IDR	<25	80	33
Israel	ILS	<25	34	12
Malaysia	MYR	<25	80	4
Peru	PEN	<25	36	12
Thailand	THB	<25	57	0.3

Notes: CCS notional outstanding from Table 3 in the DTCC Trade Information Warehouse: Link. "FC Corporate" refers to notional outstanding of FC external corporate debt, and "FC Government" refers to notional outstanding of FC external government debt. Corporate FC and Government FC data are from the dataset constructed in Section 3.

Table 4: Key Moments

	Share LC Debt α (%)	Mean LCCS s^{LCCS} (%)	Mean Nom. Spread $s^{LC/US}$ (%)	Credit Share $s^{LC/US}/s^{LCCS}$ (%)	Sov. Debt/GDP B/Y (%)
Data	10	1.48	4.66	31.8	9
Model	0	1.75	2.63	66.5	8.9
Model	5	1.41	2.94	47.9	8.8
Model	10	1.11	3.30	33.7	8.7
Model	15	0.63	3.68	17.0	8.6
Model	20	0.27	4.03	6.7	8.4
Model	25	0.05	4.28	1.3	8.2
Model	30	0.00	4.32	0.0	8.0
Model	50	0.00	4.27	0.0	7.1

Notes: This table reports the empirical and model-generated moments of currency and credit risk. The first row, Data, reports the mean LC credit spread s^{LCCS}, nominal spread $s^{LC/US}$, share of credit risk in the nominal spread $s^{LC/US}/s^{LCCS}$, and external debt/GDP ratio B/Y for the 13 countries in our dataset for 2005–2012. The subsequent eight rows report the mean model-generated parameters for different calibrations, with the share of corporate debt in LC α given by the first column. Our baseline results refer to the case when $\alpha = 10\%$.

Table 5: Calibration (Quarterly)

Parameter	Value	Description	Target or Source
γ	1/3	Intermediate Share	Labor share of 2/3
Z	.51	Firm-level indebtedness	External Corp/GDP of 17%, data
ω	1.5017	Entrepreneur output	$X = 1$ if $\zeta = 0$, inflation differential at 2000-2012 mean
ξ	3.025	Intermediate good production productivity	$X = 1$ if $\zeta = 0$, inflation differential at 2000-2012 mean
α	.1	Share of corporate debt in LC	Data for 2012
δ	.9595	Bond coupon decay parameter	Risk-Free Sovereign Duration of 5 years, Data
β	.95	Discount Factor	Hatchondo and Martinez (2009)
d_0, d_1	[0.0174,0.0160]	Default costs parameters with C&E functional form	3% output cost in bad state, 3.75% in best state
ρ	.9	AR(1) productivity persistence	Aguiar and Gopinath (2006)
σ_z	.034	S.D. of Log of Aggregate Productivity	Aguiar and Gopinath (2006)
λ	10%	Probability of redemption after default	Aguiar and Gopinath (2006)
r^*	1%	Risk-free rate	Literature standard
σ	2	Coefficient of relative risk aversion	Literature standard
μ	.75	Share of fixed prices	Literature standard

Notes: C&E refers to Chatterjee and Eyigungor (2012).

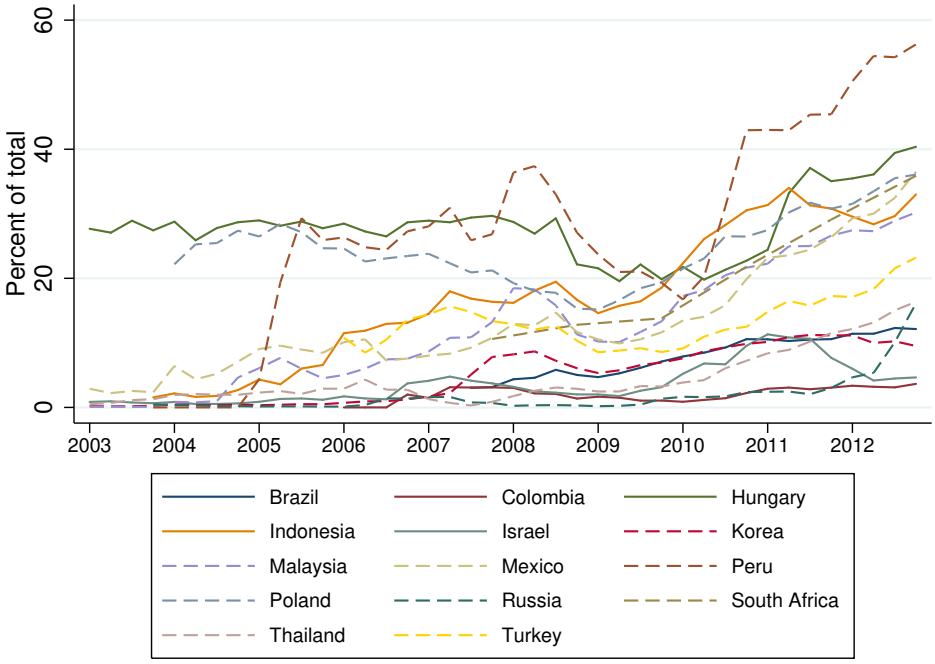
Table 6: Panel Regression: Share of External LC Corporate Borrowing and Sovereign Default Risk

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All	All	Ex. BRL	Ex. BRL	All	All	All	All
	LCCS	LCCS	LCCS	LCCS	Inflation	Inflation	ρ	ρ
α Share of External Corporate Debt in LC	-6.274	-6.373	-3.092	-3.138	5.492	5.366	1.002	0.803
	(0.982)	(0.869)	(0.552)	(0.498)	(1.457)	(1.335)	(3.394)	(3.004)
Share of External Sovereign Debt in LC	0.287	0.122	-0.402	-0.468	-0.520	0.220	-2.094	-1.721
	(0.455)	(0.354)	(0.385)	(0.314)	(1.158)	(1.263)	(1.423)	(1.304)
External Sovereign Debt/GDP	3.961	3.352	2.574	2.125	-1.437	0.333	5.190	5.717
	(1.369)	(1.116)	(0.935)	(0.766)	(3.411)	(3.714)	(3.955)	(3.181)
External Corporate Debt/GDP	0.876	1.201	2.509	2.751	2.140	1.078	-5.506	-5.960
	(0.864)	(0.847)	(0.884)	(0.869)	(1.530)	(1.921)	(2.076)	(1.793)
Constant	45.06	87.41	77.28	69.03	358.2	246.3	375.0	502.1
	(167.2)	(10.26)	(160.1)	(11.68)	(187.7)	(74.31)	(117.4)	(15.58)
Observations	98	102	92	96	107	115	98	102
R-squared	0.408	0.439	0.473	0.505	0.106	0.135	0.100	0.100
Countries	13	13	12	12	13	13	13	13
Global Controls	Yes	No	Yes	No	Yes	No	Yes	No
Time FE	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The table reports panel regression results of the level of the LC credit spread, inflation, and the average CCS rate (ρ) on country-level and global variables. Heteroskedasticity autocorrelation spatial correlation robust Driscoll and Kraay (1998) standard errors with a 4 quarter lag are computed following Vogelsang (2012). The share of external corporate and sovereign debt in LC and the Sovereign and Corporate debt/GDP ratios are constructed in Section 3, with the data sources and methods described there and in Appendix Section A.2. Columns 3 and 4 exclude Brazil. The LHS variables in columns 1–4 is the LC credit spread, in columns 5–6 it is in the inflation rate, and in columns 7–8 it is the cross-currency swap rate. "Global Controls" refers to the VIX, Fed Funds Rate, BBB-Treasury Spread, 10-Year Treasury Spread, and Ted Spread. All global controls are from FRED of the Federal Reserve Bank of St. Louis. VIX is the 30 day implied volatility of the S&P, the Fed Funds Rate is the effective overnight Federal Funds Rate, the BBB-Treasury Spread is the option-adjusted spread of the Bank of America Merrill Lynch US Corporate BBB Index over US Treasuries, the 10-Year Treasury Spread is the 10-Year Treasury Constant Maturity Rate, and the Ted Spread is the spread between 3-month dollar Libor and the 3-Month Treasury Bill. Standard errors on global controls omitted for space. Standard errors are reported in parentheses.

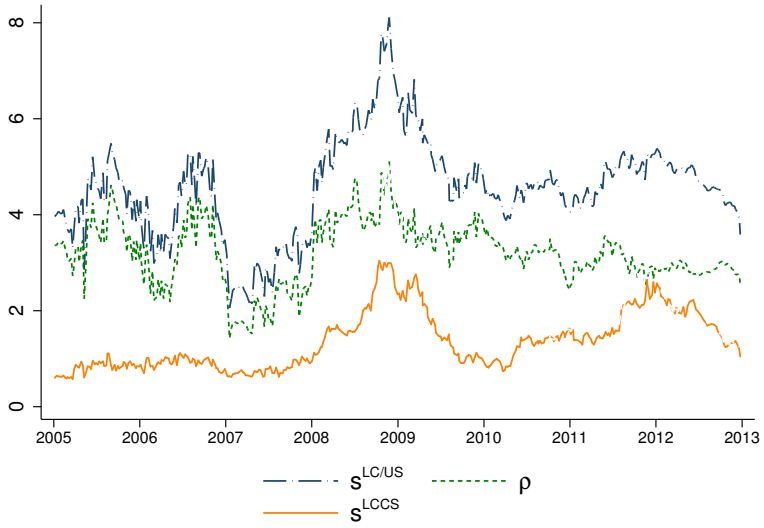
Figures

Figure 1: Share of Foreign Ownership of Outstanding Domestic LC Sovereign Debt Securities



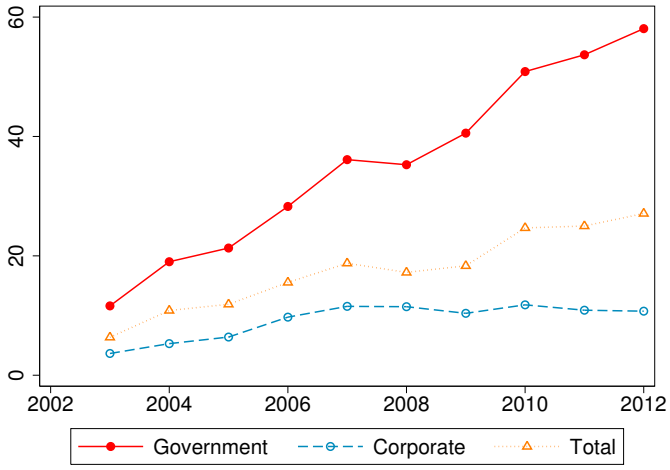
Notes: Share of foreign ownership of domestic sovereign debt in 14 emerging markets. Data are from national sources or the Asian Development Bank, with details in the appendix.

Figure 2: Currency Risk, Credit Risk, and the Nominal Spread on LC Sovereign Debt: Cross-Country Average



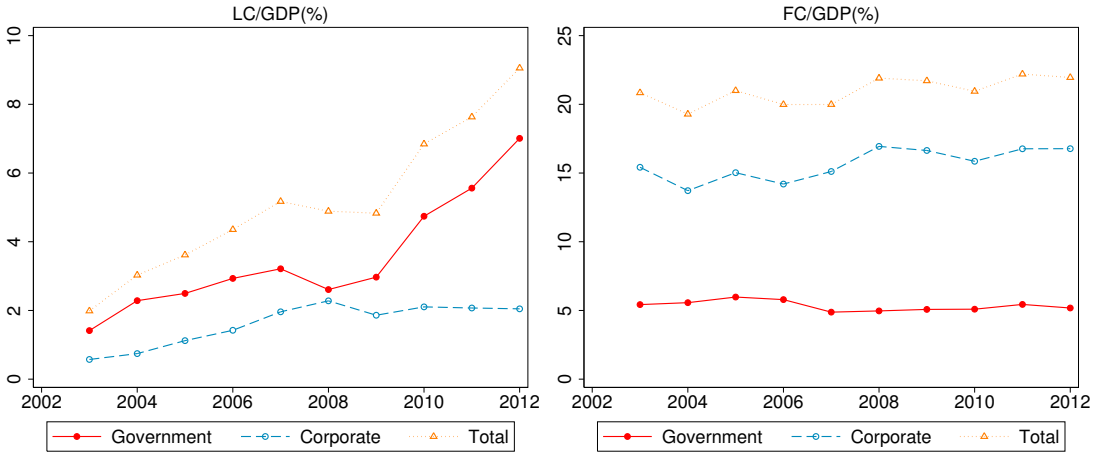
Notes: $s^{LC/US}$ is the nominal spread between a 5-year LC sovereign bond a 5-year US Treasury. ρ is the fixed-for-fixed 5-year zero-coupon cross-country swap rate. s^{LCCS} is the local currency credit spread, the difference between $s^{LC/US}$ and ρ. The countries included are Brazil, Colombia, Hungary, Israel, Mexico, Malaysia, Peru, Poland, South Africa, South Korea, Thailand, and Turkey. All data are from Bloomberg.

Figure 3: Share of External Debt in LC (Mean of 14 sample countries)



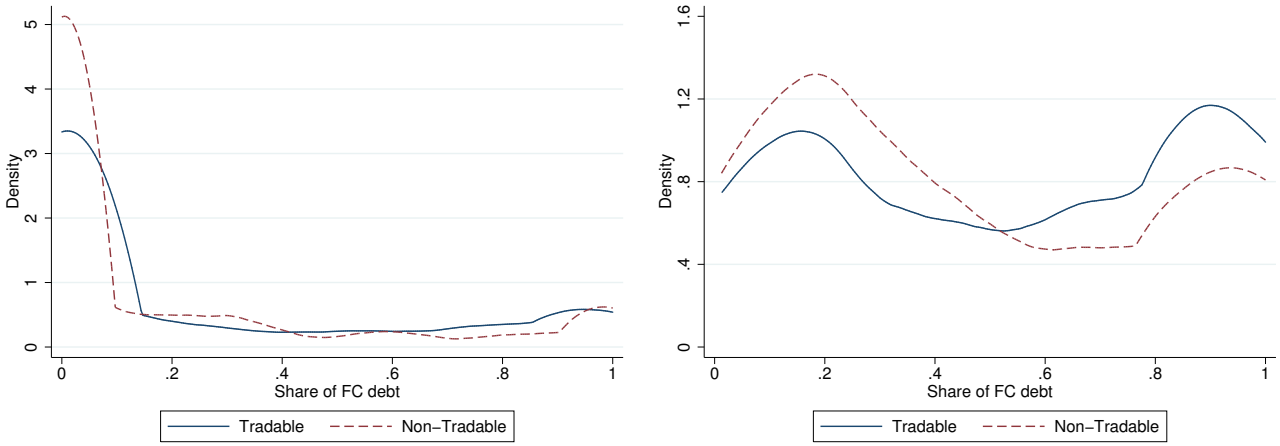
Notes: This figure plots the cross-country mean of the share of external debt by sector in LC. The cross-country mean gives each country in the sample an equal weight. Within each country, the share of total debt in LC is the weighted average of the share of sovereign and corporate debt in LC, weighted by the amount of each type of debt outstanding. The countries included in the sample are Brazil, Colombia, Hungary, Indonesia, Israel, Malaysia, Mexico, Peru, Poland, Russia, South Korea, South Africa, Thailand and Turkey.

Figure 4: External Debt/GDP by Currency and Sector



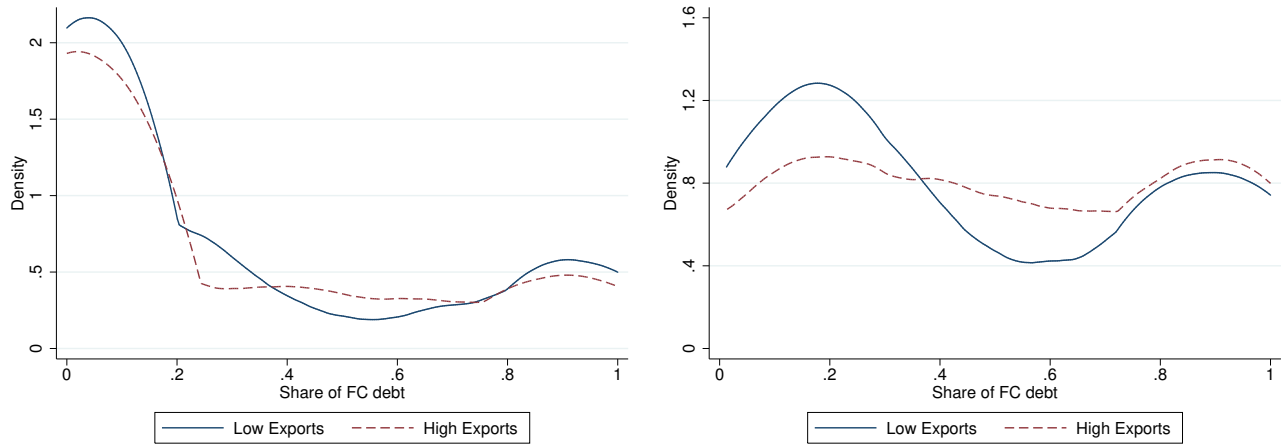
Notes: The left panel plots the cross-country mean of the amount of external LC debt outstanding, as a share of GDP, for the government, private sector, and the sum of the two. The right panel plots the cross-country mean of the amount of external FC debt outstanding for the same three categories. The cross-country mean equally weights all countries in the sample. The countries in the sample are Brazil, Colombia, Hungary, Indonesia, Israel, Malaysia, Mexico, Peru, Poland, Russia, South Africa, South Korea, Thailand, and Turkey.

Figure 5: Share of FC Debt by Tradability, 2012



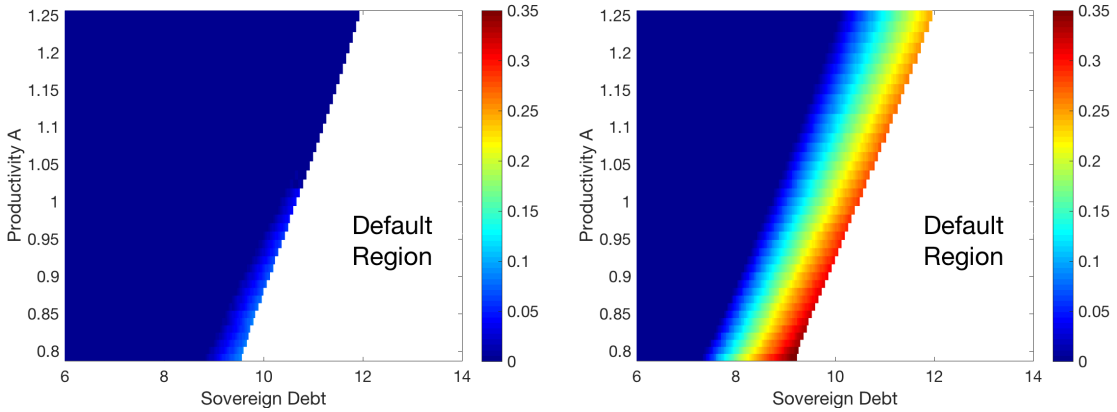
Notes: This figure is a kernel density plot of the density of firms by the share of their total debt that is denominated in foreign currency. Firms are split into two categories: tradable and non-tradable by their primary SIC industry. Tradable firms are those with an SIC code between 2000 and 3999 (manufacturing), and non-tradable firms are all others excluding finance. The left panel includes all firms, and the right panel conditions on having at least 1% of total debt in foreign currency.

Figure 6: Share of FC Debt by Export Intensity



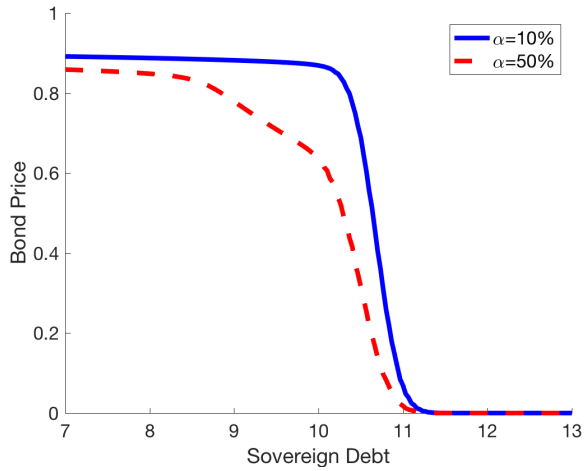
Notes: This figure is a kernel density plot of the density of firms by the share of their total debt that is denominated in foreign currency. Firms are split into either Low Export or High Export bins. Low Export firms are those whose primary industry exports a smaller share of production than the median industry, and High Export firms are those whose primary industry exports a larger share than the median. Industry export intensity is calculated using OECD-STAN Input-Output Tables. Input-Output tables are available for Brazil, Hungary, Indonesia, Israel, Mexico, Poland, Russia, South Africa, South Korea, and Turkey. The left panel includes all firms, and the right panel conditions on having at least 1% of total debt in foreign currency.

Figure 7: Inflation Policy Function and Default Region: $\alpha = 10\%$ (Left), $\alpha = 50\%$ (Right)



Notes: This figure plots the inflation policy function and the default set for two calibrations of the dynamic model. The left panel sets the share of LC private debt $\alpha = 10\%$, and the right panel sets $\alpha = 50\%$. The coloring of the figure indicates the equilibrium inflation rate the sovereign chooses for a given amount of inherited debt and productivity level. The white region in the lower right-hand corner denotes the region where the sovereign explicitly defaults and the dark blue in the upper left-hand corner denotes repayment and zero inflation. In between, as the colors get warmer, the inflation rate is rising. The inflation rate corresponding to each color is given by the bar to the right of each figure.

Figure 8: Bond Price Schedule

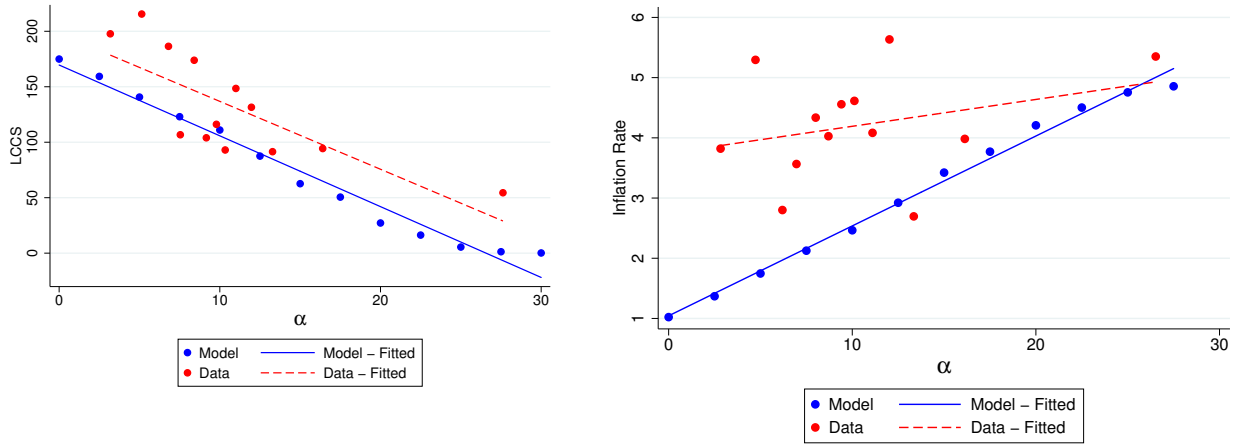


Notes: This figure plots the bond price schedule $q(A, b')$ for two calibrations of the model. The x-axis denotes the amount of sovereign bonds a government can issue b' and the y-axis the bond price q. The solid blue line refers to the baseline calibration of the model when the share of corporate debt in LC $\alpha = 10\%$, and the dashed red line refers to the calibration of the model when $\alpha = 50\%$.

Figure 9: LC Credit Spread, Inflation, and the Share of Private Debt in LC

(a) LC Credit Spread

(b) Inflation



Notes: The left panel plots the empirical and model generated relationship between the LC credit spread and the share of corporate debt in LC, α. The right panel plots the empirical and model generated relationship between the inflation rate and the share of corporate debt in LC, α. The empirical plots (dashed red line, and red dots) are derived by orthogonalizing the LC credit spread on the variables in column 1 in Table 6 and then plotting them as a binned scatterplot. The model observations (solid blue line, and blue dots) are generated by solving the model for different values of α and calculating the simulated mean LC credit spread, as in Table 4.

Appendix (For Online Publication)

A Empirical Appendix

A.1 LC Sovereign Risk

Table A.1: Credit and Currency Risk in LC Sovereign Debt, 5-Year Bonds, 2005-2012

Country	Start	$s^{LC/US}$	s^{LCCS}	ρ
Brazil	Jul 2006	10.10	3.67	6.43
Colombia	Jun 2005	5.93	1.72	4.21
Hungary	Jan 2005	5.28	2.44	2.83
Indonesia	Jan 2005	6.73	1.25	5.49
Israel	Feb 2006	1.75	0.82	0.93
Korea	Jan 2005	1.86	1.87	-0.01
Malaysia	Dec 2006	1.31	1.18	0.13
Mexico	Jan 2005	4.46	0.65	3.81
Peru	Nov 2006	3.08	0.89	2.19
Poland	Mar 2005	3.28	1.54	1.73
South Africa	Jan 2005	5.22	0.37	4.85
Thailand	Nov 2006	1.28	0.88	0.40
Turkey	May 2005	10.23	2.00	8.23
Average		4.66	1.48	3.17

Notes: This table reports the country average nominal spread, $s^{LC/US}$, LC credit spread s^{LCCS}, and cross-currency swap rate ρ for 13 emerging markets form 2005-2012. Start indicates the first month for which we were able to estimate a local currency sovereign yield curve and data on cross-currency swaps were available. Yield curve and cross-currency swap data from Bloomberg. "Average" is the equal weighted mean of the 13 country means.

A.2 Currency Composition of External Portfolios

A.2.1 International Debt Securities

We obtain country-level data on international sovereign debt outstanding from the BIS debt securities statistics. The BIS defines international debt as debt issued outside the market where the borrower resides (Table 11) or the nationality of the borrower (Table 12). For sovereigns, there is no difference between the residence and nationality definitions. Source: BIS. As discussed in the text, we collect data on international LC sovereign bonds from Bloomberg and international LC bonds from Thomson.

A.2.2 Domestic Sovereign Debt

In this section, we describe the data sources for foreign ownership of domestic sovereign debt.

- **Brazil:** Source: Brazilian Central Bank (direct contact). Ownership data are available at the security type level. Data on domestic debt outstanding by instruments are available. Includes foreign ownership of LFT (Financial Treasury Bills), LTN (National Treasury Bills), NTN (National Treasury Notes)
- **Colombia**: Source: Colombia Ministry of Finance (in Spanish). Only contains data only on Treasury Bonds. Ownership data are available at the security type level (i.e. fixed rate

local currency and inflation-indexed). Data on domestic debt outstanding by instruments are available. Link to raw data: Source: Colombian Ministry of Finance (in Spanish) (last access: March 3, 2014).

- **Hungary:** Source: AKK – Hungarian Government Debt Management Agency. Quarterly data distinguishes between Treasury Bonds and Treasury Bills but the daily nonresident ownership data does not. Ownership data by interest rate types (i.e. fixed, floating, indexed) are not available. Links: to raw data: Data on domestic debt outstanding by instrument (last access: March 3, 2014). nonresident ownership data (last access: March 3, 2014).

- **Indonesia:** Source: Asian Development Bank and Indonesian Central Bank. Treasury bills are not included. Ownership data by interest rate types are not available. Links to raw data: Ownership data source: Asian Development Bank Asian Bond Online (last access: March 3, 2014). Domestic debt outstanding by interest rate type from Bank of Indonesia (last access: March 3, 2014).

- **Israel**: Ownership data: Bank of Israel. Data prior to 2011 are obtained directly from central bank officials. Treasury bills are included. Ownership data by interest rate type are not available. Link to data after 2011: Bank of Israel (last access: March 3, 2014). Link to domestic debt outstanding by coupon type (excel files): 2007 data,2008 data,2009 data,2010 data,2011 data,2012 data,2013 data

- **Korea:** Source: Asian Development Bank. Treasury bills are not included. Domestic debt is close to 100 percent fixed coupon nominal debt but ownership data by interest rate types are not available. Link to raw data: Ownership data source: Asian Development Bank Asian Bond Online (last access: March 3, 2014).

- **Malaysia:** Source: Asian Development Bank. Treasury bills are not included. Only 3-20 year Malaysian bonds are included. Domestic debt is close to 100 percent fixed coupon nominal debt but ownership data by interest rate types are not available. Link to raw data: Ownership data source: Asian Development Bank Asian Bond Online (last access: March 3, 2014).

- **Mexico:** Source: Central Bank of Mexico. Treasury bills are included. Ownership data by interest rate types are available. Link to raw data: Central Bank of Mexico (last access: March 3, 2014).

- **Peru:** Source: Peruvian Ministry of Finance. Treasury Bonds only. Ownership data at the level of individual bond are available. Dataset created by digitizing the pie charts in the PDFs in link "Tenencia de Bonos Soberanos" (in Spanish)

- **Poland:** Source: Polish Ministry of Finance. Includes both Treasury Bonds and Treasury Bills, and foreign ownership data of bonds by interest rate type . Link to raw data: Polish Ministry of Finance(last access: March 3, 2014).

- **Russia:** Source: Russian Central Bank and Ministry of Finance. Treasury bills are included. Ownership data by interest rate types are not available. Debt outstanding by interest rate type are not available. Links to raw data: External debt of Russian Federation and Government debt outstanding from the Ministry of Finance (last access: March 3, 2014).

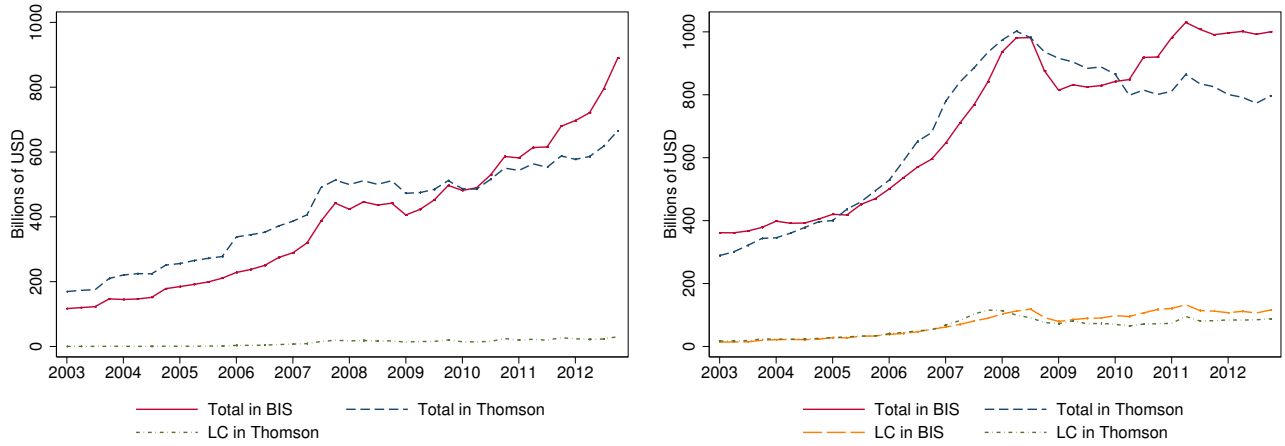
- **South Africa:** Source: South African Central Bank. The annual data are directly obtained from central bank officials. Ownership data by interest rate type are not available. Debt outstanding data by interest rate type are not available.

- **Thailand:** Source: Asian Development Bank. Treasury bills are included. Domestic debt is close to 100 percent fixed coupon nominal debt but ownership data by interest rate types are not available. Link to raw data: Ownership data source: Asian Development Bank Asian Bond Online (last access: March 3, 2014).

- **Turkey:** Source: Ministry of Finance. Treasury bills are included. Link to raw data: Ownership data and debt outstanding by interest rate types (last access: March 3, 2014).

A.2.3 Comparison between BIS and Thomson One Data

Figure A.1: International Corporate Bonds (Left) and Cross-Border Loans (Right)



Notes: In Figure (a), the "Total in BIS" line plots the total amount of international corporate bonds outstanding for our sample countries based on the BIS Debt Securities Statistics. The "Total in Thomson" line plots the estimated total amount of international corporate bonds outstanding based on the individual bond issuance data from Thomson One. The "LC in Thomson" line plots the amount of LC international corporate bonds outstanding based on Thomson One. LC bond amounts outstanding are not published by the BIS. In Figure (b), the "Total in BIS" line plots the total amount of cross-border loans outstanding for our sample countries based on the BIS LBS. The "Total in Thomson" line plots the estimated total amount of cross-border loans outstanding based on the individual loan issuance data from Thomson One. The "LC in BIS" line plots the estimated amount outstanding of LC cross-border loans based on the BIS LBS. The "LC in Thomson" line plots the estimated amount of LC cross-border loans outstanding based on Thomson One.

A.2.4 Country-Level Currency Composition of External Debt

Figure A.2: Currency Compositions of External Debt by Country, percentage

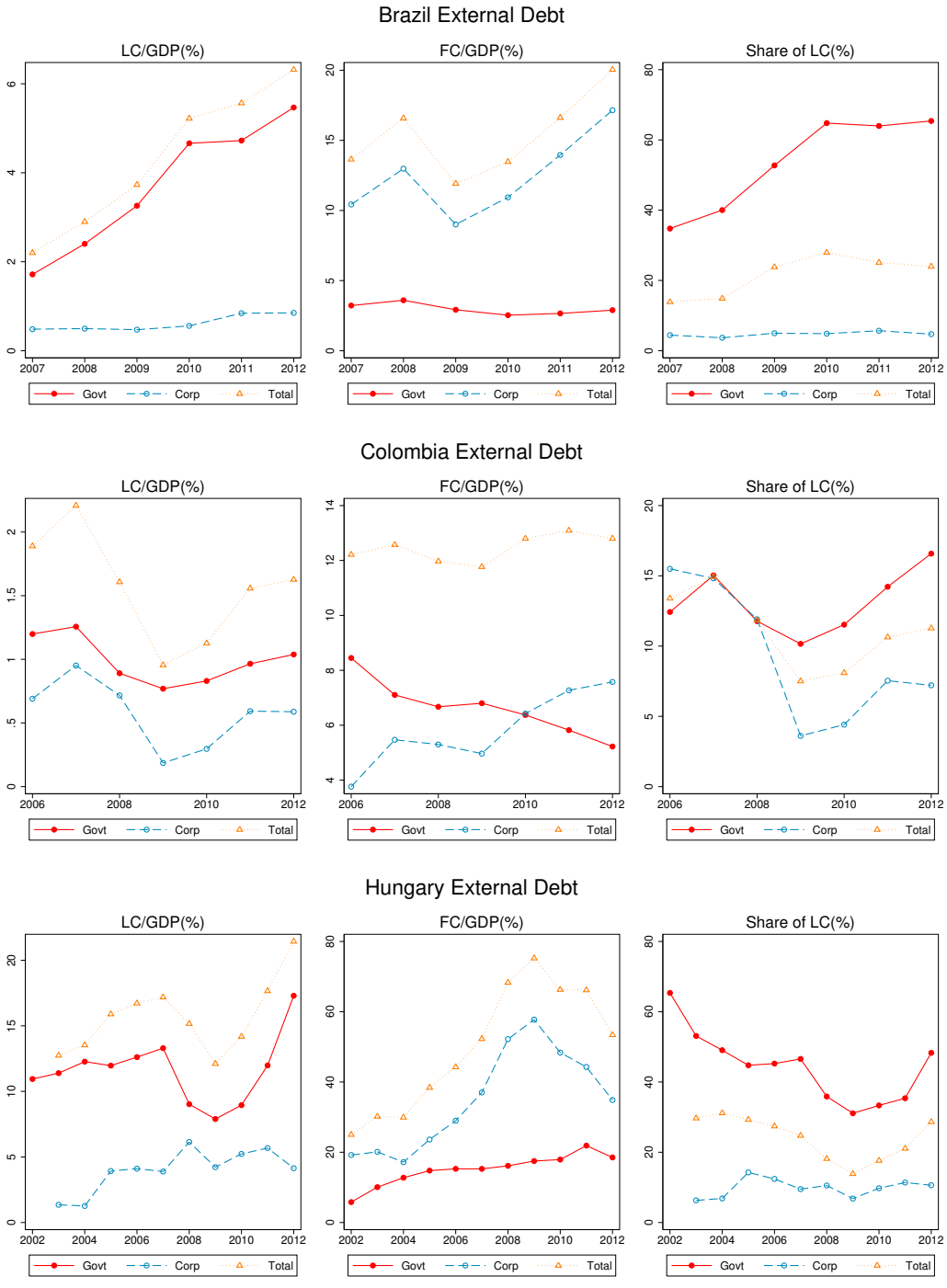


Figure A.2: Sovereign debt structure by Country, percentage (continued)

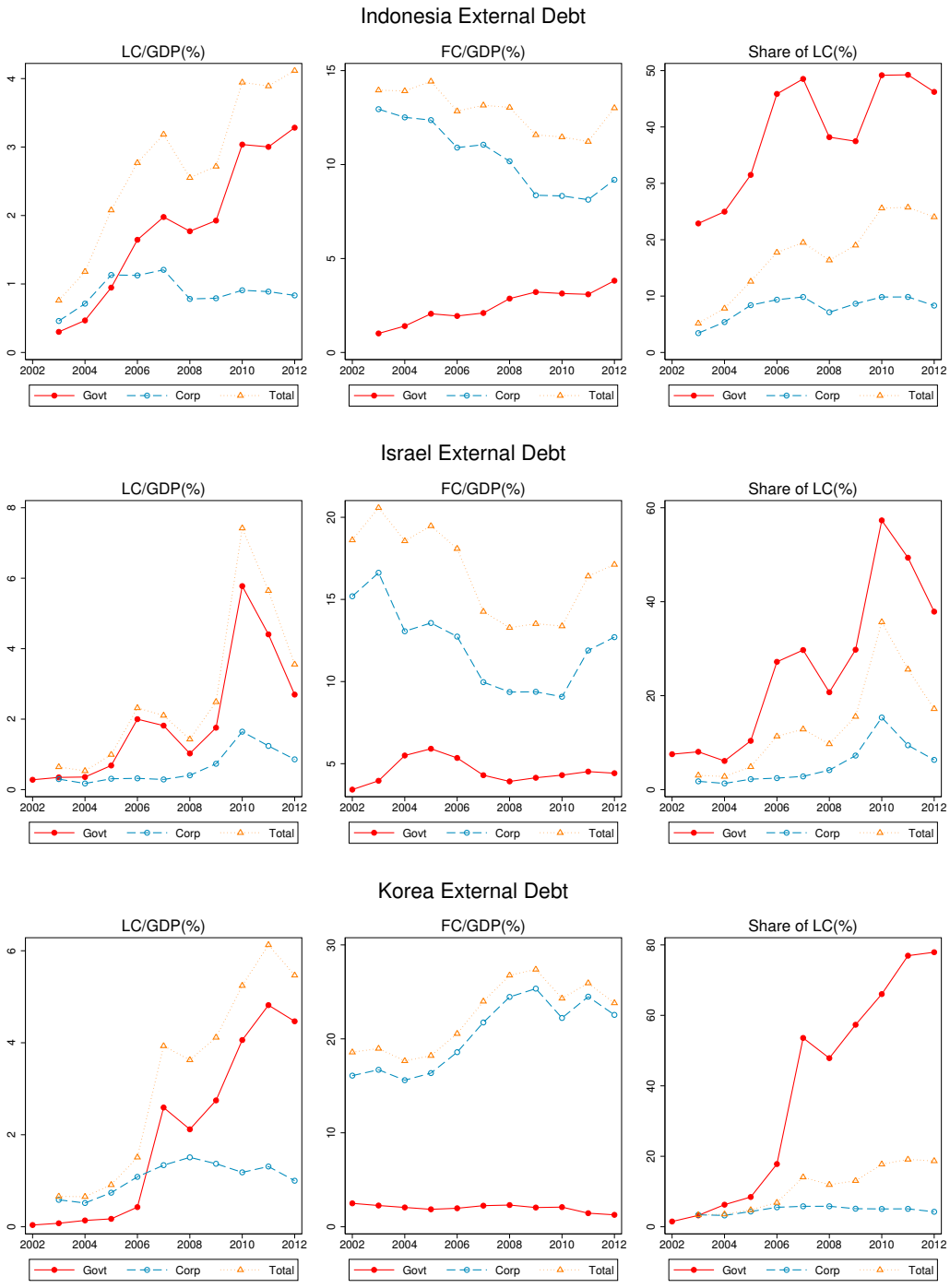


Figure A.2: Sovereign debt structure by Country, percentage (continued)

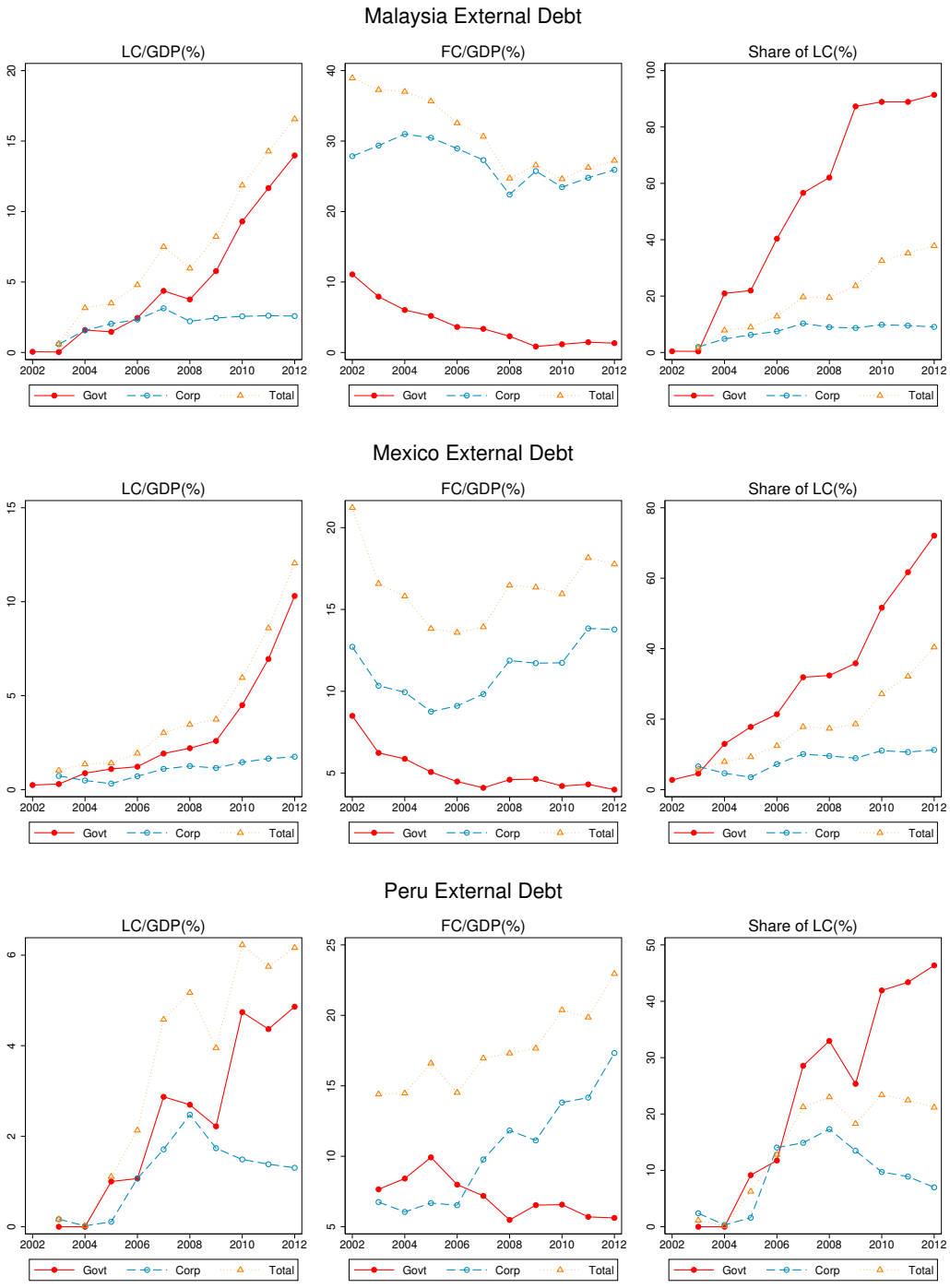


Figure A.2: Sovereign debt structure by Country, percentage (continued)

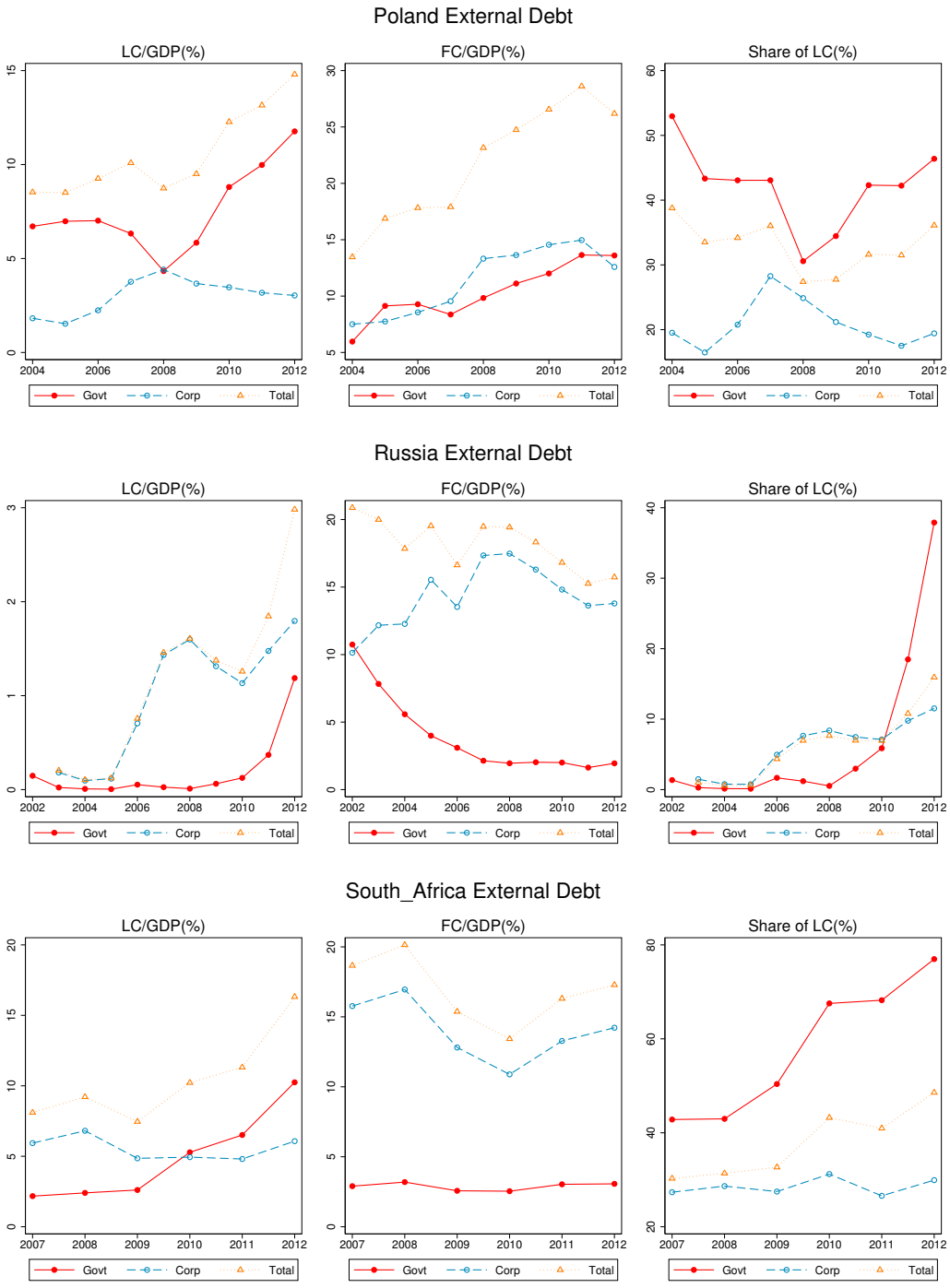
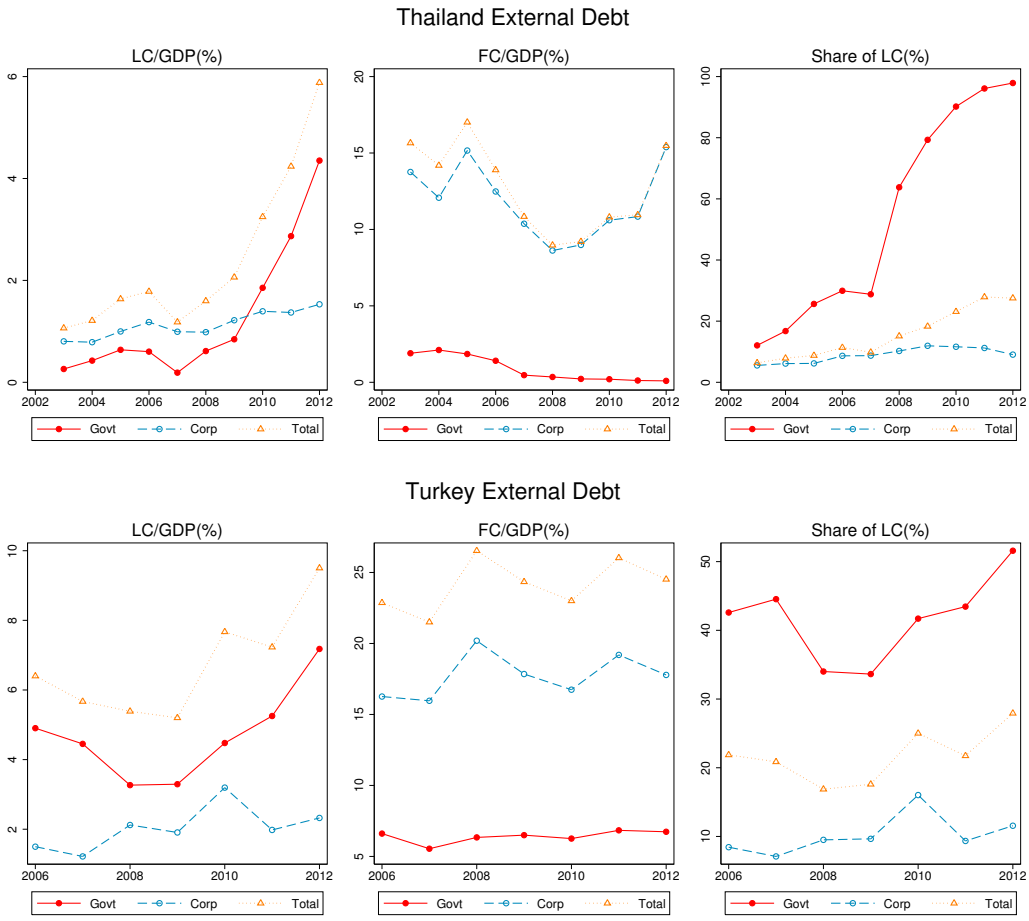


Figure A.2: Sovereign debt structure by Country, percentage (continued)



Notes: The first panel plots the amount of LC external debt held by non-official lenders. The middle panel, FC/GDP (%) is defined equivalently. The dotted orange line (Total) is the sum of corporate (Corp) and government (Govt) debt/GDP. Finally, the third panel is the share of each type of debt that is in LC. The dotted orange line (Total) is the average of the share of corporate (Corp) and government (Govt) external debt in LC, weighted by the amount of each type of debt outstanding.

A.3 Country-Level Coverage in Capital IQ Debt Capital Structure

Table A.2: Firms per country with currency composition data in Capital IQ Debt Capital Structure, 2012

Country	Number of Firms	Country	Number of Firms
Brazil	195	Mexico	79
Colombia	26	Peru	68
Hungary	10	Poland	140
Indonesia	168	Russia	56
Israel	32	South Africa	124
Korea	117	Thailand	271
Malaysia	397	Turkey	125

Notes: This table reports the number of firms available in the Capital IQ Debt Capital Structure database in 2012 that are used in constructing Figures 5 and 6.

A.4 Debt Duration

Table A.3: LC Debt Duration

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Brazil	1.95	2.17	2.01	2.02	2.23	2.69	2.80	2.85	2.85	2.96	3.13
Colombia		3.42	3.47	3.25	3.25	3.54	3.63	4.41	4.44	4.49	4.60
Hungary	3.25	3.53	3.65	3.69	3.62	3.61	3.19	2.42	2.54	3.06	2.88
Indonesia		5.03	5.85	4.95	5.35	5.86	5.59	5.45	6.25	7.11	7.56
Malaysia	3.79	4.58	4.59	4.62	4.78	4.89	4.90	4.83	4.15	4.75	5.04
Mexico	2.15	2.27	2.50	2.97	3.75	4.53	5.13	5.11	5.82	5.99	6.14
Peru					7.87	10.41	9.78	10.78	10.14	9.81	9.46
Poland	2.49	2.46	2.97	3.29	3.49	3.85	3.83	3.75	3.89	3.89	4.03
Russia				5.96	6.60	6.82	6.46	5.74	4.66	5.07	5.26
South Africa	6.24	6.11	6.31	6.38	6.33	6.19	7.46	7.06	7.30	7.74	8.19
Thailand		5.43	5.15	4.84	4.72	5.03	5.33	5.16	5.29	5.94	6.81
Turkey			1.37	1.57	1.51	1.05	1.54	1.70	2.27	2.22	2.38
Median	3.25	4.05	3.65	4.15	4.72	4.96	5.02	5.14	4.98	5.51	5.69

Approximation of Macaulay duration of outstanding debt. Average maturity of the debt from BIS Securities Statistics and maturity weighted yield from JP Morgan EMBI. Assumption that coupons are paid annually.

A.5 Panel Regression

Table A.4: LC Sovereign Credit Spreads and External Debt, 2005-2012

VARIABLES	(1) Quarter	(2) Quarter	(3) Quarter	(4) Quarter	(5) Annual	(6) Annual	(7) Annual	(8) Annual
$\frac{FC\,Gov}{GDP}$	8.123	7.377	6.108	5.868	5.791	2.677	4.192	4.242
	(4.370)	(4.853)	(1.986)	(2.054)	(3.502)	(5.504)	(1.607)	(1.845)
$\frac{LC\,Gov}{GDP}$	6.123	6.265	-0.617	0.201	1.528	-3.738	3.133	3.270
	(1.849)	(1.866)	(2.541)	(2.723)	(3.484)	(5.392)	(3.519)	(3.344)
$\frac{FC\,Private}{GDP}$	4.992	4.295	4.593	4.389	4.376	3.788	4.403	4.357
	(1.038)	(1.116)	(0.802)	(0.822)	(1.911)	(2.443)	(0.795)	(0.813)
$\frac{LC\,Private}{GDP}$	25.55	24.16	-29.95	-29.15	-10.21	-18.07	-29.84	-30.76
	(6.187)	(6.864)	(4.531)	(4.175)	(17.98)	(19.11)	(5.757)	(5.962)
Constant	247.4	225.2	5.717	113.5	304.8	310.8	16.06	-3.725
	(27.08)	(58.65)	(13.41)	(42.51)	(28.27)	(213.7)	(12.53)	(193.5)
Observations	355	355	355	355	90	90	90	90
R-squared	0.742	0.697	0.392	0.343	0.744	0.710	0.427	0.395
Countries	13	13	13	13	13	13	13	13
Country FE	Yes	Yes	No	No	Yes	Yes	No	No
Global Controls	No	Yes	No	Yes	No	Yes	No	Yes
Time FE	Yes	No	Yes	No	Yes	No	Yes	No

Notes: The table reports panel regression results of the level of the LC credit spread on country level and global variables. All specifications contain country fixed effects. Heteroskedasticity autocorrelation spatial correlation robust Driscoll and Kraay (1998) standard errors with a 4 quarter lag. Standard errors follow Vogelsang (2012) when time fixed effects are used. $\left(\frac{FC\,Gov}{GDP}\right)$, $\left(\frac{LC\,Gov}{GDP}\right)$, $\left(\frac{FC\,Private}{GDP}\right)$, and $\left(\frac{LC\,Private}{GDP}\right)$ are the FC sovereign debt/GDP ratio, the LC sovereign debt/GDP ratio, the FC private debt/GDP ratio and the LC private debt/GDP. These variables are constructed in Section 3, with the data sources and methods described there and in Appendix A.2. "Global Controls" refers to the VIX, Fed Funds Rate, BBB-Treasury Spread, 10-Year Treasury Spread, and Ted Spread. All global controls are from FRED of the Federal Reserve Bank of St. Louis. VIX is the 30-day implied volatility of the S&P, the Fed Funds Rate is the effective overnight Federal Funds Rate, the BBB-Treasury Spread is the option-adjusted spread of the Bank of America Merrill Lynch US Corporate BBB Index over US Treasuries, the 10-Year Treasury Spread is the 10-Year Treasury Constant Maturity Rate, and the Ted Spread is the spread between 3-month dollar Libor and the 3-Month Treasury Bill. Coefficients on the global controls omitted for space. Standard errors are reported in parentheses.

Table A.5: LC Sovereign Credit Spreads and External Debt, 2005-2012

	(1) Quarter	(2) Quarter	(3) Quarter	(4) Quarter	(5) Annual	(6) Annual	(7) Annual	(8) Annual
$\frac{FC\,Gov}{GDP}$	11.08	9.587	3.004	3.330	5.126	2.014	2.693	2.637
	(3.737)	(4.464)	(1.867)	(1.960)	(4.510)	(5.975)	(1.631)	(1.887)
$\frac{LC\,Gov}{GDP}$	5.521	5.706	-4.837	-4.283	2.243	-2.694	-1.959	-1.935
	(2.157)	(2.121)	(2.345)	(2.541)	(3.900)	(6.221)	(2.713)	(2.931)
$\frac{FC\,Private}{GDP}$	6.006	5.338	3.990	3.563	3.929	2.891	3.013	2.924
	(1.175)	(1.150)	(1.006)	(0.976)	(2.283)	(2.790)	(0.783)	(0.848)
$\Delta Reserves$	11.71	-87.23	-32.33	-138.0	-13.79	-12.42	-23.96	-23.47
	(56.41)	(53.10)	(68.33)	(57.22)	(49.71)	(69.62)	(53.90)	(71.62)
ΔToT	136.1	226.6	141.4	233.4	142.0	167.1	159.5	185.3
	(56.75)	(74.41)	(185.1)	(185.3)	(43.92)	(40.02)	(117.9)	(124.7)
$Vol\,(ToT)$	466.7	316.3	718.1	490.7	2.022	1.426	1.470	0.796
	(88.66)	(78.82)	(374.7)	(191.0)	(1.203)	(1.671)	(1.107)	(1.402)
Constant	189.4	218.5	-1.564	130.4	310.4	265.2	32.70	6.551
	(26.57)	(58.92)	(18.48)	(42.76)	(26.30)	(198.0)	(11.01)	(193.9)
Observations	355	355	355	355	90	90	90	90
R-squared	0.745	0.704	0.381	0.336	0.765	0.734	0.392	0.362
Countries	13	13	13	13	13	13	13	13
Country FE	Yes	Yes	No	No	Yes	Yes	No	No
Time FE	Yes	No	Yes	No	Yes	No	Yes	No
Global Controls	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The table reports panel regression results of the level of the LC credit spread on country level and global variables. All specifications contain country fixed effects. Heteroskedasticity autocorrelation spatial correlation robust Driscoll and Kraay (1998) standard errors with a 4 quarter lag. Standard errors follow Vogelsang (2012) when time fixed effects are used. $\left(\frac{FC\,Gov}{GDP}\right)$, $\left(\frac{LC\,Gov}{GDP}\right)$ and $\left(\frac{FC\,Private}{GDP}\right)$ are the FC sovereign debt/GDP ratio, the LC sovereign debt/GDP ratio, and the FC private debt/GDP ratio. $\Delta Reserves$ in the log change in foreign exchange reserves, ΔToT is the log change in the terms of trade, and $Vol\,(ToT)$ is the volatility of the terms of trade over the previous 12 months. "Global Controls" refers to the VIX, Fed Funds Rate, BBB-Treasury Spread, 10-Year Treasury Spread, and Ted Spread. These variables are all from FRED of the Federal Reserve Bank of St. Louis. VIX is the 30-day implied volatility of the S&P, the Fed Funds Rate is the effective overnight Federal Funds Rate, the BBB-Treasury Spread is the option-adjusted spread of the Bank of America Merrill Lynch US Corporate BBB Index over US Treasuries, the 10-Year Treasury Spread is the 10-Year Treasury Constant Maturity Rate, and the Ted Spread is the spread between 3-month dollar Libor and the 3-Month Treasury Bill. Global controls coefficients omitted for space. Standard errors are reported in parentheses.

B Theory Appendix

B.1 Bond Pricing

In this section, we present the steps to price defaultable LC debt as in section 5.1 and default-free LC debt as in section 5.2. As discussed in the text, the bond promises LC cash flows of

$$P_t\kappa\left[1,\ \delta,\ \delta^2,...\right]$$

A foreign investor values these LC cash flows in FC by dividing through by the price level

$$\kappa\left[\frac{P_t}{P_{t+1}},\ \delta\frac{P_t}{P_{t+2}},\ \delta^2\frac{P_t}{P_{t+3}},...\right].$$

To price the bond, the investors again calculates present value of the expectation of the cash flows

$$\begin{aligned}
q_t &= E_t\left[\frac{\kappa\cdot\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)}{1+r^*}+\frac{\delta\kappa\cdot\left(1-D_{t+1}\right)\left(1-D_{t+2}\right)\left(1-\zeta_{t+1}\right)\left(1-\zeta_{t+2}\right)}{\left(1+r^*\right)^2}+\ldots\right]\\
&= E_t\left[\frac{\kappa\cdot\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)}{1+r^*}+\frac{\delta\kappa\cdot\prod_{j=1}^{2}\left(1-D_{t+j}\right)\left(1-\zeta_{t+j}\right)}{\left(1+r^*\right)^2}+\frac{\delta^2\kappa\cdot\prod_{j=1}^{3}\left(1-D_{t+j}\right)\left(1-\zeta_{t+j}\right)}{\left(1+r^*\right)^3}\cdots\right]\\
&= E_t\left[\sum_{s=0}^{\infty}\left(\prod_{j=1}^{s+1}\left(1-D_{t+j}\right)\left(1-\zeta_{t+j}\right)\right)\frac{\kappa\delta^s}{\left(1+r^*\right)^{1+s}}\right]\\
&= E_t\left[\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)\frac{\kappa}{1+r^*}+\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)\sum_{s=1}^{\infty}\left(\prod_{j=2}^{s+1}\left(1-D_{t+j}\right)\left(1-\zeta_{t+j}\right)\right)\frac{\kappa\delta^s}{\left(1+r^*\right)^{1+s}}\right]\\
&= E_t\left[\frac{\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)}{1+r}\left(\kappa+\delta\left(\sum_{s=0}^{\infty}\left(\prod_{j=1}^{s+1}\left(1-D_{t+1+j}\right)\left(1-\zeta_{t+1+j}\right)\right)\frac{\kappa\delta^s}{\left(1+r^*\right)^{1+s}}\right)\right)\right]\\
&= \frac{E_t\left[\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)\left(\kappa+\delta q_{t+1}\right)\right]}{1+r^*}
\end{aligned}$$

where once again the last step uses the initial definition of q_t^{LC}. When we have $\delta = 0$, and so we have one period debt, this becomes $q_t = \kappa\frac{E_t\left[\left(1-D_{t+1}\right)\left(1-\zeta_{t+1}\right)\right]}{1+r^*}$.

Finally, we turn to pricing a default-free LC bond. While this bond has the same promised cash flows as the defaultable LC bond, the lender continues to receive the coupon payments in the event of a sovereign default. To price the bond, the lender calculates the discounted present value of the debt:

$$
\begin{aligned}
q_t^{*LC} &= E_t\left[\frac{\kappa\cdot(1-\zeta_{t+1})}{1+r^*}+\frac{\delta\kappa\cdot(1-\zeta_{t+1})(1-\zeta_{t+2})}{(1+r^*)^2}+\dots\right]\\
q_t^{*LC} &= E_t\left[\frac{\kappa\cdot(1-\zeta_{t+1})}{1+r^*}+\frac{\delta\kappa\cdot\prod_{j=1}^{2}(1-\zeta_{t+j})}{(1+r^*)^2}+\frac{\delta^2\kappa\cdot\prod_{j=1}^{3}(1-\zeta_{t+j})}{(1+r^*)^3}\dots\right]\\
q_t^{*LC} &= E_t\left[\sum_{s=0}^{\infty}\left(\prod_{j=1}^{s+1}(1-\zeta_{t+j})\right)\frac{\kappa\delta^s}{(1+r^*)^{1+s}}\right]\\
q_t^{*LC} &= E_t\left[(1-\zeta_{t+1})\frac{\kappa}{1+r^*}+(1-\zeta_{t+1})\sum_{s=1}^{\infty}\left(\prod_{j=2}^{s+1}(1-\zeta_{t+j})\right)\frac{\kappa\delta^s}{(1+r^*)^{1+s}}\right]\\
q_t^{*LC} &= E_t\left[(1-\zeta_{t+1})\frac{\kappa}{1+r^*}+\frac{\delta}{1+r}(1-\zeta_{t+1})\left(\sum_{s=0}^{\infty}\left(\prod_{j=1}^{s+1}(1-\zeta_{t+1+j})\right)\frac{\kappa\delta^s}{(1+r^*)^{1+s}}\right)\right]\\
q_t^{*LC} &= E_t\left[\frac{(1-\zeta_{t+1})}{1+r}\left(\kappa+\delta\left(\sum_{s=0}^{\infty}\left(\prod_{j=1}^{s+1}(1-\zeta_{t+1+j})\right)\frac{\kappa\delta^s}{(1+r^*)^{1+s}}\right)\right)\right]\\
q_t^{*LC} &= \frac{E_t\left[(1-\zeta_{t+1})\left(\kappa+\delta q_{t+1}^{*LC}\right)\right]}{1+r^*}
\end{aligned}
$$

where once again the last step uses the initial definition of q_t^{*LC}. It is important to note that this bond price schedule does not affect the sovereign's decision in equilibrium and so, unlike the defaultable bond price schedule q^{LC}, this fixed point problem can be solved after the policy functions have been solved for. As discussed in the text, to calculate this expectation we need to price the default-free LC debt in states in which the sovereign has defaulted, accounting for stochastic re-entry into credit markets. Using the subscript D to indicate default and R to indicate repayment, we can write the expression for equation 12.

$$
\begin{aligned}
q_R^{*LC}(A,b') &= \frac{E\left[(1-\zeta(\cdot))\left(\kappa+\delta\left((1-D(A',b'))\left(q_R^{*LC}(A',b''(A',b'))\right)+D(A',b')\,q_D^{*LC}(A')\right)\right)\mid A,b'\right]}{1+r^*}\\
q_D^{*LC}(A) &= \frac{\kappa+\delta E\left[\lambda q_R^{*LC}(A',0)+(1-\lambda)\,q_D^{*LC}(A')\mid A,b'\right]}{1+r^*}
\end{aligned}
$$

This makes clear that the default-free bond price does still depend on the government's default policy function through its effect on the government's incentive to inflate in the future. In other words, the expectation of next period's bond price differs depending on whether the country is currently in good or bad financial standing:

$$
\begin{aligned}
E_t\left(q_{t+1}^{*LC}\mid D_t=0\right) &= E_t\left[(1-D(A',b'))\,q_R^{*LC}(A',b''(A',b'))+D(A',b')\,q_D^{*LC}(A')\right]\\
E_t\left(q_{t+1}^{*LC}\mid D_t=1\right) &= E_t\left[\lambda q_R^{*LC}(A',0)+(1-\lambda)\,q_D^{*LC}(A')\right]
\end{aligned}
$$

where $D=0$ means the country is in good standing and $D=1$ means the country is in bad standing. While the price of default-free LC debt during periods of sovereign default is an important element in pricing the debt, we will focus on comparing the default-free LC bond price to the defaultable LC bond price in non-default states, as the defaultable bond price is not defined when the sovereign is locked out of international debt markets.

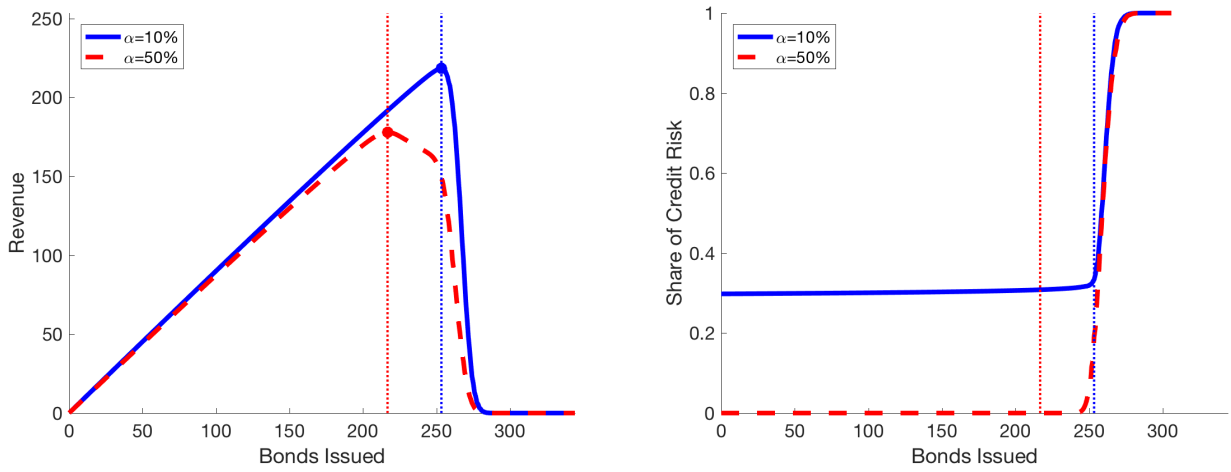
B.1.1 Laffer Curves

In this section, we expand on the Laffer curve intuition provided in Section 6.2.2. While these policy functions and bond price schedules are useful for seeing the options facing the sovereign, to understand the difference in equilibrium currency and credit risk in these two economies it is helpful to examine how the sovereign actually borrows when facing these different incentives. In particular, we have to look at the equilibrium bond issuance policy function $\tilde{b}(A, b)$. We will find it particularly useful to focus on the amount of debt the sovereign chooses to issue relative to the amount of debt that would maximize the market value of the debt. In order to do so, we define the gross revenue curve (the market value of the debt), as the quantity of debt times its price $q(A, b') \cdot b'$.[34]

In the left panel of Figure A.3, we plot the gross revenue curve for $\alpha = 10\%$ and $\alpha = 50\%$ when aggregate productivity A is at its mean. We see that in both cases the sovereign faces a debt Laffer curve: revenue initially increases with the quantity of debt and then declines as the bond price sharply falls with amount of debt issued. The dotted vertical lines indicate the peak of the debt Laffer curves for the two parameterizations. Because the cost of default is assumed to be independent of the stock of debt, as the face value of debt increases, the sovereign chooses to default in more states. Eventually the bond price goes to zero, as the debt level is high enough that the sovereign will default in the next period regardless of how productive the economy is. As the bond price goes to zero, the market value of outstanding debt $q \cdot b'$, also goes to zero. In the right panel of Figure A.3, we plot the share of credit risk in the nominal spread for the two parameterizations for each level of borrowing b'. Using the notation from Section 2, we define the credit share as $\left(s^{LCCS}/s^{LC/US}\right)$, the LC credit spread divided by the nominal spread. This credit share tells us what fraction of the spread a government pays over the risk-free rate is compensation for the risk that it may default on its debt. The vertical dotted lines are plotted at the peak of the debt Laffer curve, as in the left panel. This plot shows that when $\alpha = 10\%$, the credit share is positive for all levels of borrowing, increasing slightly as the government approaches the peak of the debt Laffer curve, and then going to 100% at borrowing levels slightly above the peak. By contrast, when $\alpha = 50\%$, the credit share is 0 for all borrowing levels below the peak of the debt Laffer curve, and it only becomes positive at debt levels well above the peak of the debt Laffer curve. In other words, debt issued when $\alpha = 10\%$ always contains credit risk, but when $\alpha = 50\%$, the debt is free from default risk unless the sovereign borrows far onto the declining side of the debt Laffer curve. However, if in equilibrium the sovereign issued past the peak of the debt Laffer curve in the region with positive credit risk, then there would be credit risk on debt issued below the peak of the debt Laffer curve. This is because with long-term debt, the bond price today reflects the probability of default in all future periods.

[34] The net revenue raised is only the amount raised from net issuances, $q(b', A) \cdot (b' - (1 - \zeta)\delta b)$. Of course, in the case of one period debt, $\delta = 0$ and so gross and net revenue from total bond issuance b' coincide.

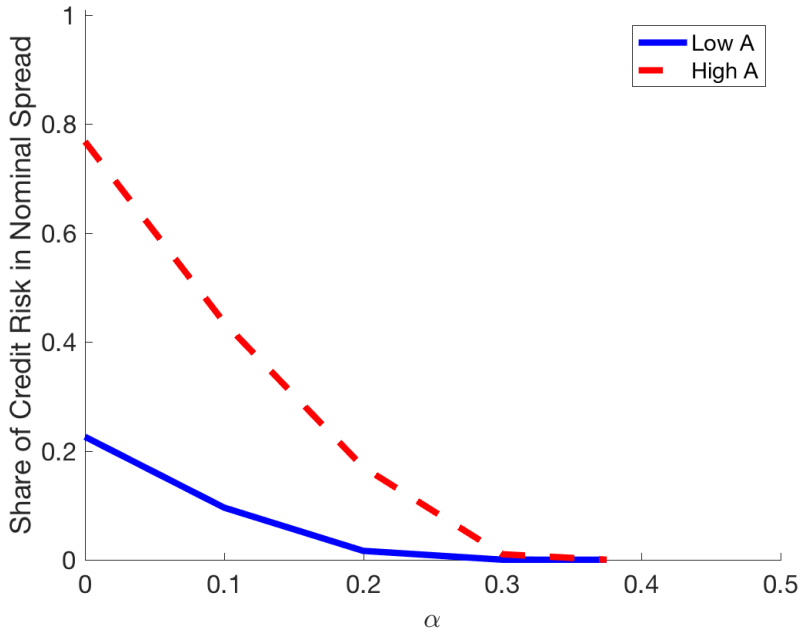
Figure A.3: The Debt Laffer Curve (Left) and the Share of Credit Risk (Right)



Notes: The left panel of the figure plots the Revenue curve ($q \cdot b'$) against the bond issuance curve (b') for the case when $\alpha = 0.1$ and $\alpha = 0.5$. The solid blue curve plots the case where $\alpha = 0.1$ and the dashed red curve plots the case where $\alpha = 0.5$. All figures are plotted for when $A = \bar{A}$. The vertical dashed lines are plotted at the peak of the two debt Laffer curves. In the right panel, the two curves plot the share of credit risk in the nominal spread $\frac{s^{LCCS}}{s^{LC/US}}$ for each level of borrowing b'. The vertical lines are the same as in the left panel, denoting the peak of the debt Laffer curve. The credit share plot is plotted in dashed lines after the peak of the debt Laffer curve.

In Figure A.4, we plot the share of credit risk in the nominal spread at the peak of the Laffer curve for different levels of α. We see that the credit share gradually falls with the fraction of private debt in LC. We plot the credit share for two levels of aggregate productivity, the highest realization and the lowest realization. We see that for each level of productivity, there is a higher share of credit risk when all private debt is in FC than when more private debt is LC. As the share of debt in LC increases, the share of credit risk in the nominal sovereign spread converges to zero for all productivity levels, meaning that the debt Laffer curve peaks because of currency risk alone. In other words, the total amount of resources that can be raised from lenders is not at all constrained by the risk of a sovereign default and is solely constrained by the temptation to inflate away the debt. In parameterizations of the model that do not generate credit risk at the peak of the debt Laffer curve, we observe no default risk in equilibrium.

Figure A.4: Share of Credit Risk at Peak of Laffer Curve

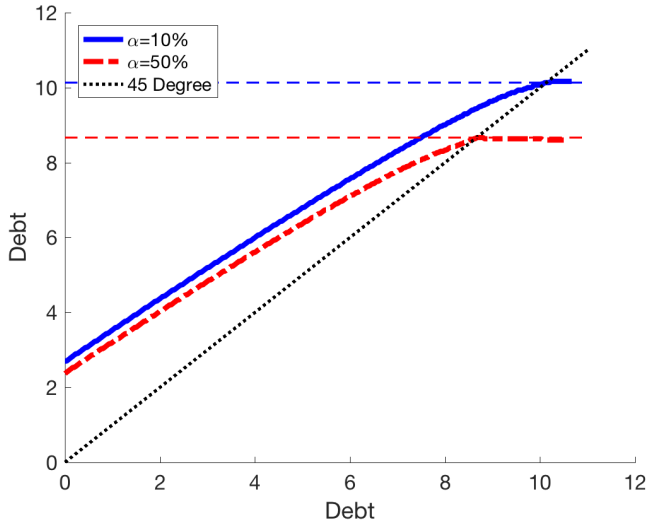


Notes: This figure plots the share of credit risk in the nominal spread $\left(s^{LCCS}/s^{LCUS}\right)$ at the peak of the debt Laffer curve for different levels of α, the share of corporate debt in LC. The dashed red line plots the case when aggregate productivity A is at its peak and the blue line plots the case when aggregate productivity A is at its trough.

In theory, the sovereign may actually choose to borrow past the peak of the debt Laffer curve. This is because if the sovereign borrows using long-term debt, it may be able to raise additional net revenue by borrowing on the declining side of the debt Laffer curve. Despite this possibility, we will show this rarely happens in our calibrated model. It is more convenient to discuss this issue using the terminology of Lorenzoni and Werning (2013), and define our debt Laffer curve as the "stock Laffer curve" and define another object called the "issuance Laffer curve." The stock Laffer curve, $q\left(A,b'\right)\cdot b'$, is the total market value of outstanding debt as a function of gross issuance b' ("stock" because it refers to the total stock of outstanding debt). The issuance Laffer curve $q\left(A,b'\right)\cdot\left(b'-\left(1-\zeta\right)\delta b\right)$ captures the change in new revenue the sovereign raises with new net issuance. Because existing creditors bear the debt dilution losses (the change in the value of outstanding debt $\delta q\left(A,b'\right)b$ as the sovereign increases b'), the issuance Laffer curve can still be increasing even after the sovereign has issued debt past the peak of the stock Laffer curve. This difference between the two Laffer curves could theoretically lead the sovereign to borrow on the declining side of the stock Laffer curve. This is more likely to happen the larger is the sovereign's inherited debt stock b and the smaller the slope of the bond price schedule with respect to b'. In Figure A.5, however, we plot the equilibrium bond issuance functions, $\tilde{b}\left(\bar{A},b\right)$ for $\alpha=10\%$ and $\alpha=50\%$. The dashed lines are the bond issuance levels denoting the peak of the stock Laffer curves for each parameterization of the model. In both cases, as long as the sovereign began the period on the increasing side of the stock Laffer curve, it will not find it optimal to issue on the declining side of the curve. This explains why when there is no credit risk at the peak of the stock Laffer curve, we observe no sovereign default in equilibrium.

While the sovereign could potentially find it optimal to issue debt past the peak of the stock Laffer curve and up the peak of the issuance Laffer curve, this is the not the case for the policy

Figure A.5: Debt Laffer Curve and Debt Issuance Policy



Notes: This figure plots the bond issuance policy function $\tilde{b}\left(\bar{A}, b\right)$ for average productivity $\bar{A}$ when $\alpha = 10\%$ (thick solid blue) and 50% (thin dashed red). Last period's debt issuance b is on the x-axis and this period's issuance b' is on the y-axis. The thin dashed red and blue lines are plotted at the level at which the debt Laffer curve $q\left(\bar{A}, b'\right) b'$ is maximized for $\alpha = 10\%$ and 50%, respectively. The dotted black line is the 45 degree line, so that when the bond issuance policy functions are above the dotted black line $\tilde{b}\left(\bar{A}, b\right) > b$.

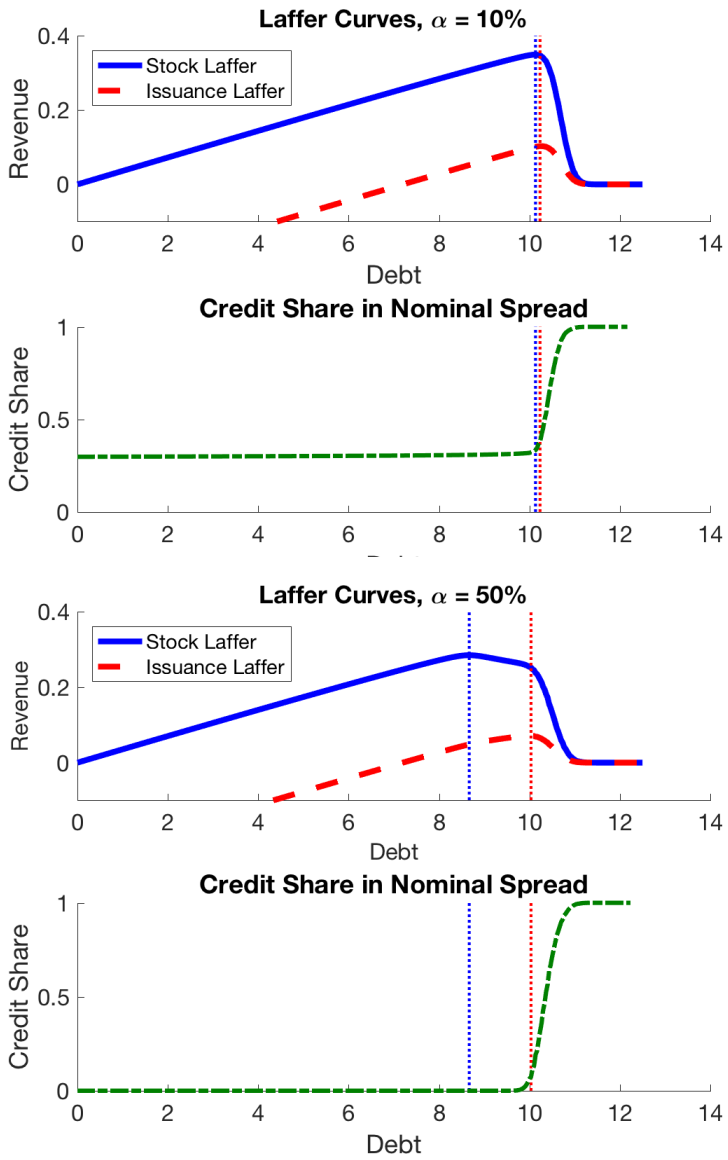
functions from our calibration. In Figure A.6, we plot the stock and issuance Laffer curves for the case that the sovereign issued 7.5% of debt-to-average-GDP last period, and productivity is at its mean level. Of course, the stock Laffer curve is independent of the amount of inherited debt. For the case when $\alpha = 10\%$ (first figure, top panel), we see the peak of the stock and issuance Laffer curves are very close together. This is because the bond price schedule is sufficiently steep that additional bond issuance at the peak of the stock Laffer curve fails to raise additional revenue. In the second figure of the first panel, we see that the credit share at the peak of the issuance Laffer curve is slightly higher than at the peak of the stock Laffer curve.

In the second set of figures, where $\alpha = 50\%$, we see in the top figure that there is now a fairly significant difference between the peak of the stock and issuance Laffer curves, with the issuance Laffer curve peaking after nearly 1.5% of GDP of additional borrowing. This is because the bond price schedule is less steep when the primary risk is inflation rather than default, and so there is a wide region where the debt dilution effects overwhelm the price fall. In the second figure, we can even see there is a small amount of credit risk at the peak of the issuance Laffer curve that is not present in the share Laffer curve. While the difference between these two curves makes it is potentially important to look at the issuance Laffer curve, in Figure A.7, we see this is not the case for our calibration.

The first two panels of this figure plot debt issuance at the debt level that would cause the stock and issuance debt Laffer curves to peak, along with the equilibrium bond issuance policy function $\tilde{b}\left(\bar{A}, b\right)$ for average productivity. The 45 degree line is plotted to indicate when $\tilde{b}\left(\bar{A}, b\right) > b$. The left panel in the top row plots the case when $\alpha = 10\%$ and the right panel plots the case when $\alpha = 50\%$. The bond issuance that causes the stock Laffer curve to peak is the same regardless of b and is therefore a horizontal line. The key result from the figure is that the sovereign does not choose to borrow past the peak of the *stock* Laffer curve when it begins on the increasing side of the stock Laffer curve. When we look at the right panel with $\alpha = 50\%$, we see that in equilibrium, the

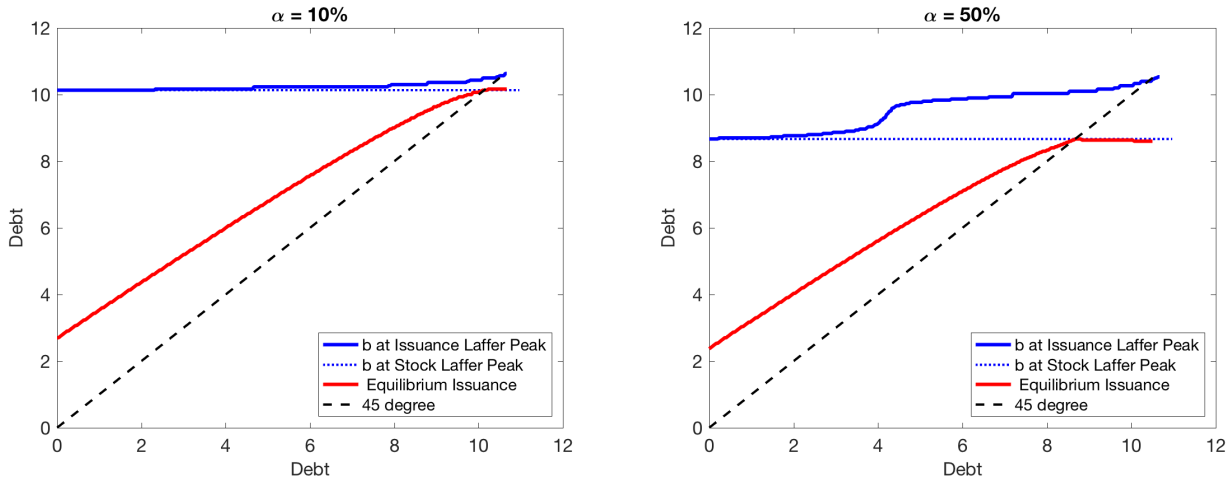
government's optimal policy keeps it below the peak of the stock Laffer curve and never comes close to approaching the peak of the issuance Laffer curve. In other words, the steepness of the bond price schedule as the sovereign approaches the peak of the stock Laffer curve makes the sovereign find it optimal to curtail its borrowing.

Figure A.6: Stock and Issuance Laffer Curves, $b = 7.5\%/\bar{Y}$



Notes: In both sets of plots, we consider the case when $A = \bar{A}$ and the sovereign issued 7.5% debt/GDP last period. The first pair of charts are for the case when $\alpha = 10\%$ and the second when $\alpha = 50\%$. The top figure in each of the two sets plots the stock and issuance Laffer curve, with the dashed vertical lines indicating the borrowing level at the peak of the two debt Laffer curves. The bottom figure in each set plots the credit share $s^{LCCS}/s^{LC/US}$ for each set level of debt issuance, with the vertical lines denoting the borrowing level at the peak of both types of debt Laffer curve.

Figure A.7: Debt Levels and Credit Shares at Peak of Laffer Curve



Notes: This figure plots debt issuance at the debt level that would cause the stock and issuance debt Laffer curves to peak, along with the equilibrium bond issuance policy function $\tilde{b}\left(\bar{A}, b\right)$ for average productivity. The 45 degree is plotted to indicate when $\tilde{b}\left(\bar{A}, b\right) > b$. The left panel in the top row plots the case when $\alpha = 10\%$ and the right panel plots the case when $\alpha = 50\%$. The bond issuance that causes the stock Laffer curve to peak is the same regardless of b and is therefore a horizontal line.

B.2 Extensions

In this section, we consider how we can relax two assumptions of the benchmark model by introducing partial default and domestic sales of the sticky price good. First, for partial default, in the event of default, instead of fully repudiating the debt, suppose that some fraction of the face value ψ needs to be repaid immediately. For simplicity, we assume that ψ is constant and exogenous. Yue (2010) solves for the endogenous recovery rate through Nash bargaining between the government and lenders, generating variation in the debt recovery rate as a function of indebtedness and the output level. Here, we will simply treat it as a parameter.

Second, we allow some of the sticky price good to be sold domestically. In order to tractably allow redistribution of profits from entrepreneurs to households, we assume there exists a continuum of domestic intermediaries that buy from the entrepreneurs and resell these goods abroad for a price of 1. Because the international price of the good is always 1, but they are sold domestically for a real price of $(1-\zeta)$, intermediaries earn a real profit of ζ on every unit they purchase. We will denote the fraction of sticky price goods sold domestically as ν. Given that there are measure γ entrepreneurs producing ω units of the good, with a share μ with sticky prices, we can denote the aggregate profits of the intermediary sector as $\zeta\omega_{LC}$, where

$$\omega_{LC} \equiv \gamma\nu\mu\omega$$

We assume profits are remitted lump-sum to the households, and therefore these profits will be added directly to consumption. With partial default and domestic sales, we can rewrite Equations 5 and 10 as

$$C_R = AX\left(\zeta\right)^{\gamma} - \kappa b\left(1-\zeta\right) + q\left(A, b'\right)\left(b' - \left(1-\zeta\right)\delta b\right) + \zeta\omega_{LC}$$
$$C_D = A_D\left(A\right)X\left(\zeta\right)^{\gamma} - \psi\left(1-\zeta\right)b + \zeta\omega_{LC}$$

We can then solve for the inflation rate that maximizes period consumption by taking the FOC (with the inflation rate bounded between 0 and 1):

$$\zeta_i = \frac{\omega - Z - \left(\gamma^{1+\gamma}\xi^{\gamma}\left(\mu\omega - \alpha Z\right)\left(\frac{A_i}{\Theta_i}\right)\right)^{1/(1-\gamma)}}{\left(\mu\omega - \alpha Z\right)}, \; i \in [R, D]$$

where $A_R = A$, $A_D = A - \phi(A)$ and

$$\Theta_R = b\left(\kappa + \delta q\left(A, b'\right)\right) + \omega_{LC}$$
$$\Theta_D = \psi b + \omega_{LC}$$

Under these circumstances, inflation will be positive if

$$\Theta_i > A_i \frac{\gamma^{1+\gamma}\xi^{\gamma}\left(\mu\omega - \alpha Z\right)}{\left(\omega - Z\right)^{1-\gamma}}$$

We also must account for the recovery rate of the debt in the bond pricing function:

$$q\left(A, b'\right) = \frac{E\left[\left(1 - D\left(A', b'\right)\right)\left(1 - \zeta\left(A', b'\right)\right)\left(\kappa + \delta q\left(A', b''\left(A', b'\right)\right)\right) + \psi D\left(A', b'\right)\right]}{1 + r^*} \tag{A.14}$$

In the baseline case where $\psi = \omega_{LC} = 0$, Θ_D was 0 and there was no role for inflation upon default. In order to calibrate ω_{LC}, we hold γ, μ and ω at their values in the benchmark calibration and vary the share of sticky price goods sold at home and abroad. In Table A.6, we consider calibrations of the model with $\omega_{LC} = 0.04,\ 0.08$, and 0.10. This is equivalent to assuming 10.7%, 21.3%, or 26.6% of the sticky price goods are sold domestically ($\gamma\mu\omega = 0.3754$).

The challenge in calibrating recovery upon default is that, using long-term bonds, only a small fraction of the bonds' present value is actually scheduled to be repaid during any given period (a quarter). In the benchmark calibration, the coupon payment κ is equal to slightly more than 5% of the face value of the bond. As such, $\psi > \kappa$ would actually involve a government making a larger immediate payment that in repayment. However, given that output is persistent and the government defaults in bad states, we can have $\psi \geq \kappa$ and still have a government choose to default in equilibrium. With the coupon payment $\kappa = 0.0505$, our calibration of recovery rates in Table A.6 of $\psi = 0.04$, 0.08 and 0.10 is equivalent to recovering a bit less than one coupon payment up to two coupon payments.

Because partial default reduces the benefits of default and domestic sales of the sticky price good reduces the costs of inflation, we will reduce the cost of sovereign default for these calibrations. Denoting θ as the scaling factor, the two parameters pinning down the cost of default will be changed to $\hat{d}_0 = \theta d_0$ and $\hat{d}_1 = \theta d_1$. We will consider several different values of θ.

In Figure A.8, we compare the inflation and default policy functions for the benchmark calibration to Alternate #3 and #4 in Table A.6. The top panel has $\alpha = 0.1$ and the bottom panel has $\alpha = 0.5$. As can be seen in the figures, by changing the relative cost of inflation and default, there are differences between the slope of the inflation policy function as well as the default threshold. However, qualitatively, the same forces are at play as in the baseline case, with the sovereign choosing only a narrow band of moderately low inflation before reaching the default threshold when the corporate sector is mismatched ($\alpha = 0.1$), and much higher inflation occurring before the default threshold when the corporate sector is less mismatched ($\alpha = 0.5$). While the quantitative results

of these model extensions are only meant to be suggestive, this section demonstrates that our key mechanism remains even when we relax some of our simplifying assumptions.

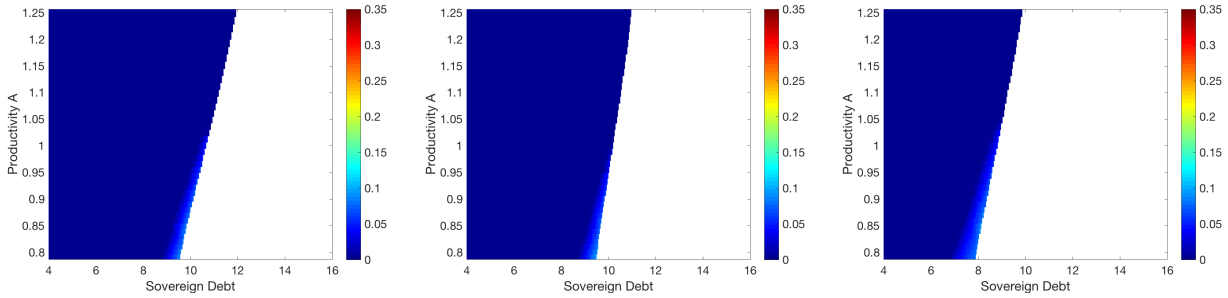
Table A.6: Key Moments

Specification	θ	ψ	ω_L	Mean LCCS s^{LCCS} (%)	Mean Nom. Spread $s^{LC/US}$ (%)	Credit Share $s^{LC/US}/s^{LCCS}$ (%)	Sov. Debt/GDP B/Y (%)
Benchmark	1.0	0.00	0.00	1.11	3.30	33.7	8.7
Alternate #1	0.9	0.00	0.04	1.01	3.85	26.2	7.8
Alternate #2	0.9	0.04	0.00	1.06	3.01	35.3	8.7
Alternate #3	0.8	0.00	0.08	0.84	4.62	18.3	6.8
Alternate #4	0.8	0.08	0.00	0.97	2.70	35.9	8.7
Alternate #5	0.7	0.00	0.10	1.43	4.02	35.6	6.2
Alternate #6	0.7	0.10	0.00	1.10	1.72	64.0	8.4

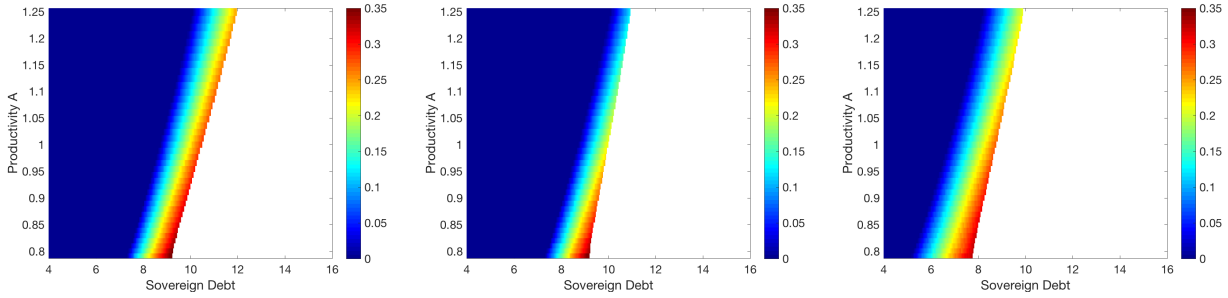
Notes: This table reports model generated moments of currency and credit risk. The first row, Baseline, repeats from our benchmark calibration discussed in Section 6. The next 6 rows report the moments from 6 alternative calibration. θ indicates the scaling of the default costs, ψ the amount of face value of debt repaid in the event of default, and ω_{LC} measures the potential profits earned by domestic intermediaries from domestic sales from inflation. In all result, we set $\alpha = 10\%$.

Figure A.8: Policy Functions: Benchmark, Partial Default, and Domestic Sales

(a) Baseline, $\alpha = 0.1$ (b) Partial Default, $\alpha = 0.1$ (c) Domestic Sales, $\alpha = 0.1$



(d) Baseline, $\alpha = 0.5$ (e) Partial Default, $\alpha = 0.5$ (f) Domestic Sales, $\alpha = 0.5$

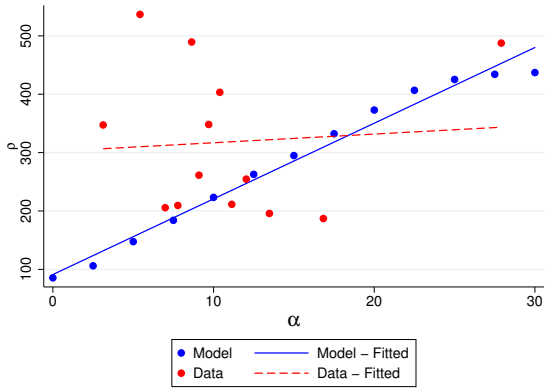


Notes: This figure plots the inflation policy function and the default set for six calibrations of the dynamic model. The top panel sets the share of LC private debt $\alpha = 10\%$ and the bottom panel sets $\alpha = 50\%$. The left column replicates Figure 7. The middle panel plots the policy functions for the case of partial default, setting $\theta = 0.8$ and $\psi = 0.08$. The right panel plots the policy functions for domestic sales of the sticky price good, setting $\theta = 0.8$ and $\omega_{LC} = 0.08$. The coloring of the figure indicates the equilibrium inflation rate the sovereign chooses for a given amount of inherited debt and productivity level. The white region in the lower right hand corner denotes the region where the sovereign explicitly defaults and the dark blue in the upper left hand corner denotes repayment and zero inflation. In between, as the colors get warmer, the inflation rate is rising. The inflation rate corresponding to each color is given by the bar to the right of each figure.

B.2.1 Currency Risk

In Figure A.9, we produce the equivalent of Figure 9 using the cross-currency swap rate.

Figure A.9: Currency Risk and the Share of Private Debt in LC



Notes: This figure plots the empirical and model generated relationship between the cross-currency swap rate and the share of corporate debt in LC, α.The empirical plots (dashed red, and red dots) are derived by orthogonalizing the inflation rate and cross-currency swap rate on the variables in column 1 in Table 6 and then plotting them as a binned scatterplot. The model observations (solid blue, and blue dots) are generated by solving the model for different values of α and calculating the simulated mean LC credit spread, as in Table 4.