Sovereign Debt Portfolios, Bond Risks, and the Credibility of Monetary Policy

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Abstract

We document that governments whose local currency debt provides them with greater hedging benefits actually borrow more in foreign currency. We introduce two features into a government's debt portfolio choice problem to explain this finding: risk-averse lenders and lack of monetary policy commitment. A government without commitment chooses excessively counter-cyclical inflation ex post, which leads risk-averse lenders to require a risk premium ex ante. This makes local currency debt too expensive from the government's perspective and thereby discourages the government from borrowing in its own currency.

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1 Introduction

How should governments finance their deficits? A long-standing literature argues that governments should borrow using state-contingent debt to smooth fluctuations in domestic consumption or tax rates (for instance, Barro (1979); Bohn (1990a,b); Calvo and Guidotti (1993); Barro (2003); Lustig et al. (2008)). Debt that is denominated in a country's own currency is thought to help achieve this desired state-contingency, because the government can vary inflation to reduce the real debt burden in bad times.

In this paper, we demonstrate empirically that governments whose local currency (LC) debt provides them with greater hedging benefits actually borrow relatively more in foreign currency (FC). This relationship is puzzling from the perspective of the theory of optimal government debt issuance. We explain it by adding two features to an otherwise standard debt portfolio choice model: risk-averse lenders and lack of inflation commitment. If international lenders are risk-averse and global and domestic output are correlated, lenders will require a risk premium for holding debt that pays off poorly in domestic downturns. In our model, a government that cannot commit to an inflation policy rule ex ante will use counter-cyclical inflation ex post to smooth domestic consumption more than is optimal. As a result, lenders charge governments without commitment a risk premium on their LC debt, and these governments face a strong incentive to borrow in FC debt instead in order to lower their expected borrowing costs.

We start by investigating empirically whether governments that borrow in LC debt actually use that debt to smooth domestic consumption. Our sample is determined by the availability of long-term LC bond return data and comprises 11 developed markets and 17 emerging markets over the period 2005-2014. We measure the hedging properties of LC debt for the domestic borrower with the regression beta of LC bond excess returns on local stock market excess returns.[2] We refer to this measure as the LC bond-stock beta. We estimate a significant degree of cross-country heterogeneity in LC bond-stock betas. If LC bonds tend to fall in value at the same time as the local stock market, then the LC bond-stock beta will be positive. In that case, LC debt loses value exactly when a reduction in debt is most valuable to the borrowing government, thereby insuring the borrower against economic downturns. Therefore, if governments borrow with LC debt to take advantage of the domes-

[2]Here, the domestic stock market serves as a proxy for domestic consumers' stochastic discount factor. If there is a benevolent government and a representative consumer, as in our model, the government's and consumer's stochastic discount factor will coincide.

tic smoothing benefits traditionally emphasized in the literature, we should find a positive relationship between a country's bond-stock beta and its LC debt share. By contrast, we find a strong negative relationship between the LC share in government debt and a country's bond-stock beta. This pattern holds for the currency composition of total sovereign debt, as well as three measures of the currency composition of external sovereign debt held by international investors. It also holds when measuring the hedging properties of LC bonds relative to those of FC bonds.

We next provide evidence that the cyclicality of LC bond returns is driven by macroeconomic dynamics and, in particular, the cyclicality of inflation expectations. If the real burden of LC debt is indeed state-contingent due to inflation variability, LC bond returns should move inversely with inflation expectations. This logic suggests that countries with the lowest bond-stock betas should have the highest betas of inflation expectations with respect to the business cycle. We confirm this prediction in the data, measuring the cyclicality of inflation expectations using the beta of long-term inflation forecasts with respect to long-term output growth forecasts from Consensus Economics. This finding is robust to using the beta of realized inflation with respect to realized industrial production instead of survey expectations for inflation and output.

Two pieces of evidence demonstrate that the LC bonds with the best hedging value for the borrowing government are also the riskiest for international lenders. First, the bonds with the highest beta with respect to the local stock market also have the highest beta with respect to the US stock market. Second, international lenders expect to be compensated for bearing this risk, as captured by higher LC bond risk premia. In addition, we show that cross-country differences in LC bond risks are correlated with the governments' inflation credibility, based on a text-based measure from newspaper word counts. These links provide the empirical motivation for our model, where the ability to commit to an inflation policy function drives both the cyclicality of inflation and the LC bond risk premium, and therefore the equilibrium choice of the currency composition of debt.

We present a two-period model to explain the relationship between the choice of borrowing currency and the hedging properties of LC debt documented in the data. We consider two types of governments – one that can commit to a future inflation policy and one that cannot. The ability to commit is an exogenous characteristic of the government. Both the currency composition of government debt and the hedging value of LC debt are endogenous and chosen optimally by the government. Crucially, debt is priced by risk-averse lenders, whose stochastic discount factor (SDF) is assumed to be correlated with domestic output. A government with commitment sets its inflation policy as a function of domestic output, before domestic output is realized, and before its debt is priced and sold to international lenders. Such a government balances its desire to smooth domestic consumption against the risk premium lenders will charge it for inflating more in bad times. By contrast, a government that lacks commitment and operates under discretion chooses inflation after the debt has been priced and sold and after observing the state of the domestic economy.

The model has two key results. First, governments without commitment choose more counter-cyclical inflation than governments with commitment for a given LC debt share. This is because governments without commitment do not internalize the effect of their counter-cyclical inflation policy on the LC bond risk premium. To show this, we characterize the inflation policy functions of the two types of governments analytically by log-linearizing their first-order conditions in a simplified special case. Second, governments without commitment tilt their borrowing towards FC debt. They do so in order to reduce their expected borrowing costs arising from the LC bond risk premium. FC debt also acts as a commitment device to limit the government's own incentive to generate counter-cyclical inflation in the future, thereby lowering the LC bond risk premium ex ante.[3]

We then demonstrate that this mechanism can quantitatively explain the empirical patterns. We calibrate the model twice, once for a government with commitment ("Developed Markets") and once for governments without commitment ("Emerging Markets"). These differences in credibility can generate the empirically observed cross-country relationship between bond cyclicality and the currency composition of sovereign debt. With risk-neutral lenders, however, the model cannot generate the negative relationship between LC bond-stock betas and LC debt shares that we see in the data. This is because when international lenders do not charge a risk premium for insuring domestic consumption risk, the ability to commit affects only the average level but not the cyclicality of inflation. The qualitative relationship between LC bond-stock betas and LC debt shares is not sensitive to the value of the international risk aversion parameter, provided that it is greater than zero. Quantitatively, a relatively high degree of international risk aversion is required to match the level of the LC bond risk premium and the LC debt share in DMs and EMs.

This paper contributes to the extensive literature on optimal government debt management by showing that bond risk premia are a powerful driver of LC debt issuance across countries. The standard result in this long-standing literature prescribes that governments borrow with state-contingent debt that lowers debt repayments in recessions (Barro, 1979; Lucas and Stokey, 1983; Bohn, 1988, 1990b), in contrast to the patterns we document in the data.[4] The prior theoretical literature linking debt levels and inflation argues that a lack of

[3]Separately from the implications for inflation cyclicality, a lack of commitment also leads to higher inflation on average in our model.

[4]The existing literature that features risk-averse lenders does not tackle the problem of the currency composition of debt portfolios. For example, Lustig et al. (2008) study nominal debt issuance with perfect

commitment leads to inflation that is too high on average (Bohn, 1988; Calvo and Guidotti, 1990; Missale and Blanchard, 1994; Barro, 2003; Alfaro and Kanczuk, 2010; Díaz-Giménez et al., 2008). The distinction between our model and this prior literature arises, because we emphasize the cyclicality of inflation as opposed to the level of inflation arising from a lack of commitment. A model where a lack of commitment affects only the average inflation level and not its cyclicality cannot explain why the hedging properties of LC debt vary across countries as we see in the data. We emphasize the cyclicality of inflation, because this drives LC bond risk premia and hence raises the real cost of borrowing in LC. We explain the prevalance of "original sin" (Eichengreen and Hausmann 1999, 2005) in emerging markets through a channel whereby emerging market governments are unwilling to pay the (endogenously) high real interest rates required by lenders to lend in the country's local currency. In our calibrated model, this risk premium channel is quantitatively important compared to the standard incentive to borrow with FC debt to avoid a high level of inflation.

This paper also contributes to the literature on sovereign debt without commitment. Relative to this large literature, our primary contribution is to examine how lender risk-aversion affects the government's portfolio choice problem. While much of the literature includes a risk-averse lender, because there is generally only one type of debt, there is no role for examining how the friction of limited commitment interacts with lender risk-aversion to change the optimal composition of sovereign debt. Most of the quantitative sovereign debt literature, beginning with Arellano (2008) and Aguiar and Gopinath (2006), focuses on defaultable foreign currency debt in real models, abstracting from portfolio choice. Some more recent papers examine the implications of inflation and potentially nominal debt in this framework. Du and Schreger (2016b), Sunder-Plassmann (2013), and Aguiar et al. (2013) examine the decision of whether to inflate or default on nominal debt. Arellano et al. (2019) and Bianchi and Mondragon (2018) examine how monetary policy affects the ability to repay foreign currency debt. Ottonello and Perez (2019) and Engel and Park (2018) consider the optimal denomination of defaultable sovereign debt when borrowing from risk-neutral lenders. Finally, within this class of sovereign debt models, Lizarazo (2013) and Borri and Verdelhan (2011) among others consider the effect of risk-averse lenders on credit spreads. While we abstract from default in this paper, a promising avenue for future research would be to extend of the present framework to allow for strategic default.[5]

We also contribute to the international asset pricing literature. A growing literature has argued that international bond and currency risk premia depend on the comovement of

commitment in the domestic context, Debortoli et al. (2017) examine the optimal maturity structure of real government debt, and Broner et al. (2013) study the maturity choice of FC debt issuance.

[5] Hur et al. (2018) consider the effect of exogenous inflation cyclicality on real interest rates in a model with endogenous sovereign default risk.

returns with a priced factor, and, in particular, international lenders' consumption stream (Harvey, 1991; Colacito and Croce, 2011, 2013; Karolyi and Stulz, 2003; Lustig and Verdelhan, 2007; Lewis, 2011; Borri and Verdelhan, 2011; Lustig et al., 2011; David et al., 2016; Della Corte et al., 2016; Xu, 2019). We show that these risk premia have real effects on government fiscal policy. Similarly to Hassan (2013) and Hassan et al. (2016), we argue that government bond yields reflect the insurance value for lenders, even though the source of comovement that we focus on – monetary policy credibility – is different.

Finally, we contribute to a recent literature that seeks to understand the risks of bonds, as reflected in bond-stock return betas, in developed markets (Baele et al. (2010); David and Veronesi (2013); Campbell et al. (2017); Ermolov (2018); Duffee (2018); Campbell et al. (2019)). Unlike this prior literature, we do not study the time-variation in bond risks. However, to the best of our knowledge, we are the first ones to study the cross-sectional patterns in bond-stock betas in a broader cross-section of countries that includes both developed and emerging markets.

The structure of the paper is as follows: In Section 2, we present new stylized facts on the relationship between the hedging properties of LC bonds and shares of LC debt in sovereign portfolios. In Sections 3 and 4, we lay out the model, provide analytical intuition for the key mechanisms, and calibrate the model to demonstrate that it can replicate the observed patterns of the currency composition of sovereign debt and LC bond risks. Section 5 concludes.

2 Empirical Relation Between Local Currency Bond Risks and Local Currency Debt Shares

We first investigate empirically whether countries with a higher share of LC debt are countries where LC debt offers greater hedging benefits for the domestic borrower, as prescribed by standard theory of optimal government debt. In contrast to this intuition, we present robust empirical evidence that countries with the lowest LC debt shares also have the most procyclical LC bond returns. In other words, the countries who rely on LC debt the least actually have the LC bonds that offer the best consumption-smoothing benefits to the borrower.

2.1 LC Bond-Stock Beta

We examine a cross-section of countries as permitted by the availability of long-term LC debt data. We include 11 developed markets (Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, the United States, and the United Kingdom) and

17 emerging markets (Brazil, Chile, Colombia, the Czech Republic, Hungary, Indonesia, Israel, Malaysia, Mexico, Peru, Philippines, Poland, Singapore, South Africa, South Korea, Thailand, and Turkey).[6] We exclude developed markets in the euro area, except for Germany, due to the lack of independent monetary policy. We exclude China, India and Russia due to restrictions on foreign holdings of LC government debt for a large part of our sample. Because for most emerging markets in our sample LC government bond curves are available starting in the mid-2000s, our sample covers the period 2005—2014 to maintain a balanced panel.[7]

Since our cross-country sample is constrained by the availability of long-term LC bond markets, we naturally have a limited number of sample countries that constrains our cross-country analysis. However, our cross-country sample represents an improvement over much of the existing literature on sovereign debt, which has focused on a subset of our sample countries and examined emerging and developed markets separately. The larger cross-country sample allows us to provide the first systematic treatment of cross-country differences in LC bonds' hedging properties.

In this section, we measure the hedging value of LC bonds from the perspective of the domestic borrower using betas of LC bond returns with respect to the domestic stock market. Here, the domestic stock market serves as a proxy for domestic consumers' stochastic discount factor (SDF). Under the assumptions of a benevolent government and a representative domestic consumer, as we assume in the model, the SDF of the government and that of the domestic consumer coincide. Intuitively, a positive LC bond beta indicates that the real expected value of debt repayments declines when the domestic marginal utility of consumption is high, and therefore borrowing with LC debt reduces the domestic consumption volatility. Our benchmark cyclicality measure is based on asset returns, because bond and stock returns are available at higher frequency than macroeconomic data, thereby leading to more precise estimates in a short time series.

We use excess returns of LC bonds and equities over the LC T-bill rate in local currency. We denote the log annualized yield on a nominal LC n-quarter bond in country i at quarter

[6]We provide a list of local currency names and three-letter currency codes for our sample countries in Appendix A.1.

[7]For LC bond yields, we primarily use Bloomberg fair value (BFV) curves. We use the five-year tenor, which has the most consistent data availability across a wide range of countries. BFV curves are estimated using individual LC sovereign bond prices traded in secondary markets. Since sufficient numbers of bonds spanning different maturities are needed for yield curve estimation, the availability of the BFV curve is a good indicator for the overall development of the LC nominal bond market. Countries such as Argentina, Uruguay, and Venezuela have only a handful of fixed-rate bonds and hence do not have a BFV curve.

t by $y^{LC}_{i,n,t}$. The quarterly log holding period return on the bond is given by:

$$r^{LC}_{i,n,t+1} \approx \tau_{i,n,t} y^{LC}_{i,n,t} - (\tau_{i,n,t} - 1/4) y^{LC}_{i,n-1,t+1}, \tag{1}$$

where $\tau_{i,n,t}$ is the duration of the LC bond in years.[8] We let $y^{LC}_{i,1,t}$ denote the log annualized 3-month local T-bill yield that can be earned by holding the T-bill from time t to time $t+1$. Then the log quarterly excess return on LC bonds over the short rate is given by:

$$xr^{LC}_{i,n,t+1} = r^{LC}_{i,n,t+1} - y^{LC}_{i,1,t}/4. \tag{2}$$

From the perspective of the local government, the LC bond excess return over the T-bill rate captures the real excess burden of LC bonds over the government's short-term funding rate. Therefore, the cyclicality of these excess returns with respect to local equity excess returns captures the hedging benefit of LC bonds for the domestic borrower. Returns on LC bonds are the appropriate measure to capture changes in the real debt burden of a sovereign borrower, even if the LC bonds are long-term and governments do not roll over their debt every period. This is because re-issuance and buy-backs happen regularly and make LC bond returns a useful measure of the marginal cost for the government to changing its debt stock. Furthermore, even if the government does not buy back or re-issue its long-term LC debt for a given period, a decline in the LC bond price coincides with a fall in the present discounted value of the required fiscal surpluses to service the debt.[9]

From the perspective of an international lender, these LC excess returns are approximately equal to an excess return measured in US dollars (USD). Movements in the LC/USD exchange rate have the same first-order effect on the long position in the bond and the short position in the T-bill. Therefore, the holding period excess return measured in LC is approximately equal to the excess return on the LC bond measured in USD.[10] By focusing on the LC bond excess returns over the LC T-bill rate, we are able to largely abstract from currency risk and focus on the duration risk of long-term bonds, which is arguably more closely related to the credibility of domestic monetary policy. This connects our work to the literature on the macroeconomic determinants of bond duration risks in a domestic setting,

[8] In practice, we approximate $y^{LC}_{i,n-1,t+1}$ by $y^{LC}_{i,n,t+1}$ for the quarterly holding period. We also make the approximation $\tau_{i,n,t} \approx 5$ for the five-year par yield.

[9] See Cochrane (2019) and Jiang et al. (2019) for detailed analyses of this point.

[10] Since the price of the LC bond may increase or decrease at the end of the holding period, the international lender's dollar returns on the LC bond would be slightly different. We show in Appendix A.4.4 that LC bond-stock betas are nearly identical if instead we use excess returns on LC bonds in excess of a local currency 3-month T-bill, where the returns on both LC bonds and the T-bill are measured in US Dollars, thereby capturing the excess return earned by an international investor who takes a long position in the LC bond and a short position in the LC T-bill. Intuitively, currency fluctuations cancel out of this long-short position, leaving returns nearly unchanged.

typically done for the US or a small number of developed countries (for example, Baele et al. (2010); Campbell et al. (2009); David and Veronesi (2013); Duffee (2018); Campbell et al. (2019)).

We define the local equity log excess return as the log quarterly return on local benchmark equity over the log LC T-bill:

$$xr^{m}_{i,t+1} = (p^{m}_{i,t+1} - p^{m}_{i,t}) - y^{LC}_{i,1,t}/4,$$

where $p^{m}_{i,t}$ denotes the log benchmark equity return index in country i at time t. We obtain data on the benchmark equity return index from Bloomberg.

We then compute the local bond-stock beta, $\beta(bond_i, stock_i)$, by regressing LC bond log excess returns on local equity log excess returns:

$$xr^{LC}_{i,n,t} = a_i + \beta(bond_i, stock_i) \times xr^{m}_{i,t} + \epsilon_{i,t}. \tag{3}$$

To improve the precision of our beta estimates, we use data that is more finely sampled than the return period, following a long literature starting with Hansen and Hodrick (1980). In particular, we estimate Eqn. (3) using daily observations on overlapping one-quarter holding period excess returns. We use a tenor of $n = 20$ quarters. We use $\beta(bond_i, stock_i)$ as the key measure for the hedging properties of LC bonds for the domestic borrower. The LC bond is a good hedge for the borrower if $\beta(bond_i, stock_i) > 0$ and a risky instrument for the borrower if $\beta(bond_i, stock_i) < 0$.

2.2 Local Currency Debt Shares

In this section, we discuss how we measure the LC debt share. We measure the LC debt share in several different ways and show that our empirical findings are robust whether we use the LC share in debt held by all investors or the LC share in debt held by external (i.e. non-domestic) investors. The advantage of considering the LC debt share of total debt is that in practice governments have direct control over the LC debt share in total debt outstanding, suggesting that it might be a good measure of optimal debt policy. Moreover, empirical proxies for the LC debt share in all debt are more precise than those for the LC debt share held by external investors. On the other hand, it is important to consider the external LC debt share, because inflating away LC debt is only an aggregate transfer of resources to the domestic economy when the debt is owned by international lenders. Under the assumptions of lump-sum taxes and a representative domestic consumer, government debt held by domestic lenders does not affect the optimal inflation policy.[11]

2.2.1 LC Share in Total Government Debt

For developed countries, we construct the share of LC debt based on the OECD Central Government Debt Statistics and supplement this data with hand-collected statistics from individual central banks.[12]

For emerging markets, we measure the share of LC debt in total government debt using the Debt Securities Statistics from the Bank for International Settlements (BIS), supplemented with statistics from individual central banks. Table 16C of the BIS Debt Securities Statistics reports the instrument composition for outstanding domestic bonds and notes issued by the central government (D_t^{dom}) starting in 1995. Table 12E of the BIS Debt Securities Statistics reports total international debt securities outstanding issued by the general government (D_t^{int}). For emerging markets, D_t^{int} offers a good proxy for central government FC debt outstanding because the vast majority of sovereign debt issued in international markets is denominated in foreign currency, and local governments rarely tap international debt markets. The share of LC debt is computed as the ratio of the fixed-coupon domestic sovereign debt outstanding ($D_t^{dom,fix}$) over the sum of domestic and international government debt:

$$s_t = \frac{D_t^{dom,fix}}{D_t^{dom} + D_t^{int}}.$$

Inflation-linked debt, floating-coupon debt, and FC debt are all treated as real liabilities.

2.2.2 LC Share in External Government Debt

We estimate the share of LC in government debt held by international investors from three independent and complementary data sources. First, we calculate the share of LC debt in government debt owned by US domiciled investors. US investors report their security-level holdings as part of the Treasury International Capital (TIC) data. We calculate the LC debt share by dividing the total value of government debt in the borrowing country's currency by the total amount of that country's sovereign debt owned by US investors. The advantage of this data, and the reason we use it as our benchmark external debt share, is that it is available over the full sample over which we measure the bond-stock beta. The primary drawback is that it is limited to US investors.

[11] We formalize this argument in Appendix B.3.

[12] The OECD Central Bank Debt Statistics database was discontinued in 2010. We collected the statistics between 2010 and 2014 from individual central banks.

The second proxy of the LC debt share in externally held debt is the share among global mutual funds based on Morningstar data from Maggiori et al. (2019). The advantage of this data is that it includes not only US mutual funds, but also those from the euro area, Great Britain, Canada, and several other developed countries. The Morningstar data complements the US TIC data by demonstrating that our results hold for global investors. Its drawback is that mutual funds are only one part of global portfolio flows. However, Maggiori et al. (2019) demonstrate that mutual fund investors are largely representative of aggregate portfolio investment.

Third, we make use of the enhanced BIS locational banking statistics (LBS) available to central banks. Starting in 2013Q4, the enhanced BIS LBS reports holdings of government securities of BIS reporting banks by currency.[13] In terms of the currency breakdown, the BIS LBS reports debt outstanding denominated in US dollars, euros, British pounds, Japanese yen, Swiss francs, and all other currencies as an aggregate. We treat the "all other currencies" field as the local currency of the sample country, except for countries where the local currency is a direct reporting currency (i.e., the United States, Germany, the United Kingdom, Japan, and Switzerland). We average the BIS LC debt share over 2014Q1 to 2017Q2.[14]

2.3 Summary Statistics

Table 1 reports summary statistics across countries. Emerging market realized inflation is 2.2 percentage points higher than in developed markets (Column 1), and survey-based expected inflation is 1.8 percentage points higher in emerging markets than in developed markets (Column 2). For LC bonds, five-year LC yields are 3.4 percentage points higher in emerging markets than in developed markets (Column 3). The hedging properties of LC bonds are significantly different between emerging and developed markets. LC bond returns are more pro-cyclical in emerging markets than in developed countries (Column 4). The cross-country average LC bond-stock beta is -0.1 for developed markets and 0.07 for emerging markets. There is a wide dispersion in the bond-stock betas across countries with the minimum equal to -0.19 (Australia) and maximum equal to 0.32 (Turkey). This table shows standard deviations of the point estimates across countries, thereby showing the variation in each measure across

[13] Prior to the data enhancement, the earlier BIS LBS did not contain a sectoral breakdown between governments and non-financial corporates. We note that the coverage of the BIS LBS data on cross-border holdings of government debt securities is incomplete among BIS reporting countries. Our estimates are only based on the reporting countries that provide data on banks' holdings of government debt securities.

[14] In contrast to our baseline LC debt share measures, the BIS and MNS LC debt shares are computed over shorter sample periods because of data availability. We relate all LC debt share measures, including the BIS and MNS measures, to bond-stock betas estimated over the sample period 2005-2014, because a decade of data is needed to estimate these betas precisely. We believe this choice is justified because of the strong persistence in bond-stock betas, documented in Appendix A.4.6.

countries. The standard errors shown in Table 1 are uninformative about the precision with which bond-stock betas are estimated. We present the bond-stock beta estimate for each country and precision about these estimates in Appendix A.3.

Columns (5) through (8) of Table 1 report summary statistics for our four LC debt share measures, i.e. the LC share in total debt, and the LC share in external debt based on US TIC Data, global mutual fund holdings from Maggiori et al. (2019), and the BIS LBS, respectively. We see that developed market governments borrow almost completely in LC, but emerging markets' LC debt shares are only 61% of total debt and 55% of external debt according to TIC data. Unsurprisingly, total debt is always weighted more towards LC debt than external debt. Some differences across the three external debt measures are due to the fact that the data are available over different time periods. In Appendix Figure A.1, we show that LC currency debt shares based on TIC and Maggiori et al. (2019) are nearly identical if we restrict both samples to 2015.

Table 1: Summary Statistics for Developed and Emerging Markets (2005-2014)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	π	π^{Survey}	y^{LC}	$\beta(bond_i, stock_i)$	s^{TOT}	s^{TIC}	s^{MNS}	s^{BIS}
(A) Developed Markets ($N = 11$)								
Mean	1.73	1.83	2.71	-0.10	89.16	89.73	87.85	69.58
S.d.	0.83	0.64	1.26	0.04	11.33	14.04	12.59	35.48
Max	2.71	2.68	4.96	-0.03	100.00	100.00	99.75	99.89
Min	0.21	0.32	0.63	-0.19	65.91	55.92	65.79	8.79
(B) Emerging Markets ($N = 17$)								
Mean	3.92	3.65	6.15	0.07	61.17	54.56	63.96	45.42
S.d.	1.72	1.40	2.98	0.13	25.52	28.81	26.83	30.34
Max	8.00	6.82	12.33	0.32	100.00	100.00	99.40	99.85
Min	2.13	2.06	1.67	-0.07	11.97	7.57	20.32	8.26
(C) Full Sample ($N = 28$)								
Mean	3.06	2.93	4.80	0.00	72.16	68.37	73.35	54.91
S.d.	1.79	1.46	2.96	0.13	25.04	29.51	25.03	34.00
Max	8.00	6.82	12.33	0.32	100.00	100.00	99.75	99.89
Min	0.21	0.32	0.63	-0.19	11.97	7.57	20.32	8.26
(D) Mean Difference between Emerging and Developed Markets								
Mean Diff.	-2.20***	-1.82***	-3.44***	-0.17***	28.00***	35.17***	23.89***	24.16*
	(0.49)	(0.39)	(0.82)	(0.03)	(7.09)	(8.19)	(7.55)	(12.92)

Note: This table reports summary statistics for eight variables for developed and emerging market groups. The variables include (1) π, realized inflation (%), (2) π^{Survey}, survey inflation (%), (3) y^{LC}, five-year LC bond yield (%), (4) $\beta(bond_i, stock_i)$, LC bond-stock beta, (5) s^{TOT}, percentage share of LC debt in total sovereign debt portfolios for the period 2005-2014, (6) s^{TIC}, percentage share of LC debt in US holdings of sovereign debt, 2007-2014, (7) s^{MNS}, percentage share of LC debt in foreign mutual fund holdings of sovereign debt in 2015 from Maggiori et al. (2019), (8) s^{BIS}, percentage share of LC debt in holdings of government securities of BIS reporting banks from the enhanced BIS locational banking statistics (LBS) for the period 2014Q1-2017Q2. Panel (A) reports results for developed markets. Panel (B) reports results for emerging markets. Panel (C) reports results for the pooled sample. Panel (D) tests the mean difference between developed and emerging markets. Robust standard errors are reported in parentheses. Significance levels are denoted by *** p<0.01, ** p<0.05, * p<0.1.

2.4 LC Debt Shares and LC Bond Risks

Figure 1 summarizes our key empirical finding. Panel (A) shows a clearly downward-sloping relationship between LC bond-stock betas and the LC debt share of total government debt. Panel (B) shows a similar relationship with the LC debt share in externally-held debt from TIC. This result is puzzling from the perspective of standard optimal government debt theory, because a positive LC bond-stock beta indicates that LC debt helps the borrower hedge the volatility of domestic consumption.

Table 2 examines this relationship more formally and presents cross-sectional regressions of LC bond-stock betas on LC debt share measures. The first column shows that a 28% increase in the LC debt share, corresponding to the average difference between emerging and developed markets, is associated with a reduction in the LC bond-stock beta of 0.08 and this relation is statistically significant at the 1% level based on ordinary least squares (OLS) standard errors. Because asymptotic standard errors are likely to be inappropriate for a regression that is constrained to 28 observations, we use Monte Carlo simulations to explore a variety of distributional assumptions for the regression residuals. Appendix Table A.3 shows that this result is robustly statistically significant for a range of different distributional assumptions.

Column (2) controls for the beta of the local stock market on the US stock market in order to ensure that the results are not driven by differences in whether a country's equity market is risky for international lenders. Column (3) shows that the baseline relation is robust to controlling for the exchange rate regime and the share of commodities in total exports.[15] In Column (4) of Table 2, when we additionally control for mean per capita income, the relationship between the LC bond-stock beta and LC debt share remains negative and economically meaningful and statistically significant at the 10% level. It is however somewhat attenuated. This attenuation reflects the fact that higher-income countries tend to have lower LC bond-stock betas and higher LC debt shares. As we will discuss later in the model, we view both the LC debt share and the LC bond-stock beta as endogenous outcomes of monetary policy credibility. Since income per capita is likely to be highly correlated with a country's institutions, it is not surprising that it would partially explain the endogenous relationship between LC bond-stock betas and LC debt shares, if that relationship is fundamentally driven by monetary policy credibility.

In Table 3, we perform the same exercise for our three measures of the currency composition of external sovereign debt. We find that the slope coefficient for the LC debt share

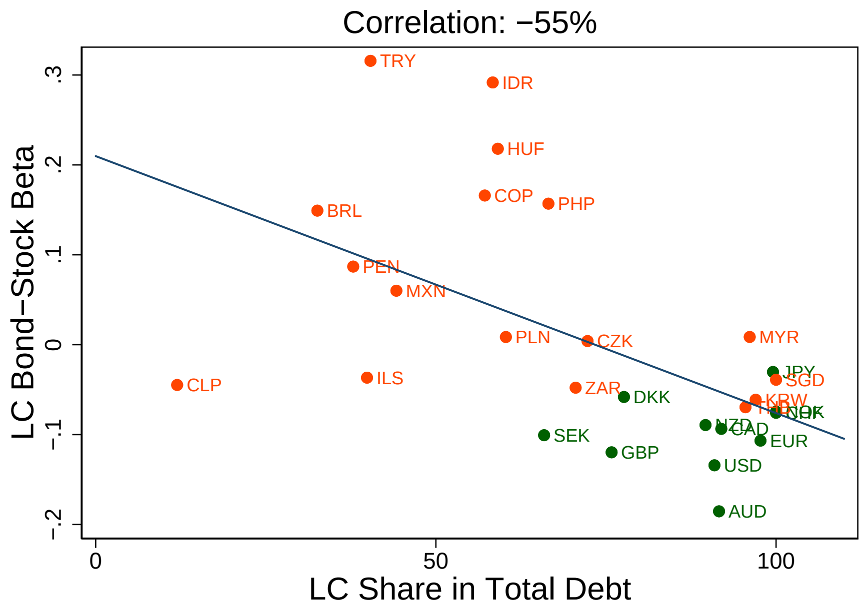
[15]We use the exchange rate regime developed by Reinhart and Rogoff (2004) and the commodity share is defined as the sum of "Ores and Metals" and "Fuel" exports as a percentage of total merchandise exports from World Bank World Development Indicators.

is quantitatively unchanged compared to Table 2. The coefficients are highly statistically significant in univariate regressions and remain significant at 10% level after all the controls are included. These results provide a bridge to the theoretical framework, where we focus on the government borrowing from international lenders.

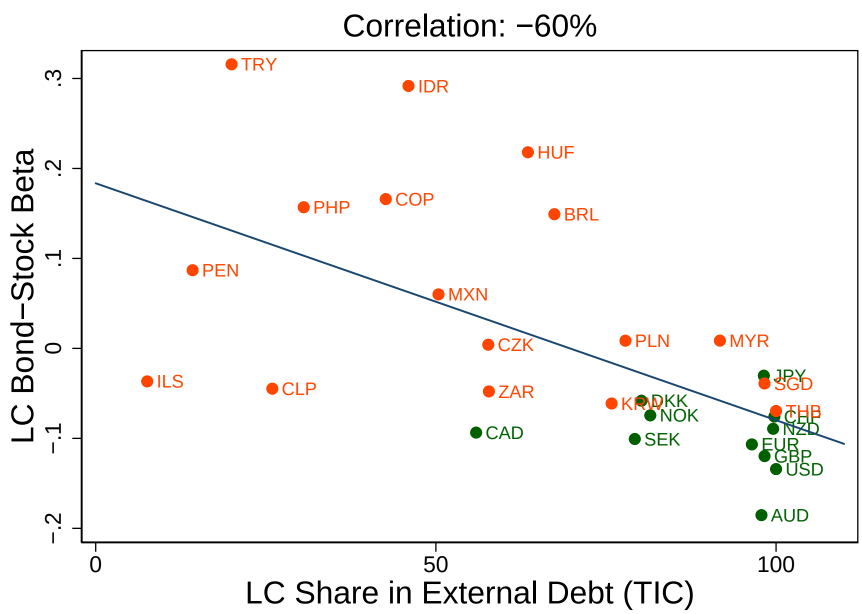
We provide additional robustness checks for our main empirical result in Appendix A.4. We show that our result is robust to using long-term debt, excluding the financial crisis, and adjusting for the FX hedging error. The robust result for the LC debt share in long-term debt is important, as Missale and Blanchard (1994) argue that shorter debt maturity reduces the incentive to inflate away debt. Furthermore, we show that the relationship between the LC debt and LC bond-stock betas holds for all sample years when the betas are estimated using rolling windows over time. The ranking of the bond-stock betas across countries is very persistent over our sample period. Finally, we note that we do not interpret the relationship between the LC debt share and the hedging property of the LC debt as causal. Instead, we document a robust bivariate relationship between two variables that are central to the study of sovereign debt. In our theoretical model, monetary policy credibility drives endogenous variation in both variables.

Figure 1: Local Currency Debt Shares and Bond Betas

(A) Total Government Debt



(B) External Government Debt



Note: Panel (A) shows the LC bond-local stock beta vs. the share of LC debt as a fraction of total central government in percent over the period 2005-2014. Panel (B) shows the LC bond-stock beta vs. the share of LC debt in US investors' holdings of government debt from the TIC data over the period 2007-2014. For each country, the LC bond-stock beta is estimated as the slope coefficient of quarterly LC bond log excess returns onto local stock market log excess returns over the same time period:

$$xr^{LC}_{i,n,t} = a_i + \beta(bond_i, stock_i) \times xr^{m}_{i,t} + \epsilon_{i,t}.$$

Emerging markets are shown in red and developed markets in green. Three-letter codes indicate currencies. For a list of currency codes, see Appendix A.1.

Table 2: LC Bond Return Cyclicality and the LC Debt Share in Total Government Debt

LC Bond-Stock Beta	(1)	(2)	(3)	(4)
s^{TOT}	-0.29***	-0.28***	-0.30***	-0.14*
	(0.08)	(0.08)	(0.09)	(0.08)
$\beta(stock_i, stock_{US})$		0.15	0.15	0.17**
		(0.09)	(0.10)	(0.07)
FX Regime			0.00	0.01
			(0.03)	(0.02)
Commodity Share			-0.07	-0.09
			(0.10)	(0.08)
Log(GDP)				-0.07***
				(0.02)
Constant	0.21***	0.06	0.08	0.60***
	(0.06)	(0.11)	(0.15)	(0.17)
Observations	28	28	28	28
R-squared	0.30	0.37	0.39	0.66

Note: This table shows cross-country regressions of the LC bond-stock beta, $\beta(bond_i, stock_i)$, on the LC debt share in total central government debt, s^{TOT} (between 0 and 1). The control variables are the local stock-US stock beta, $\beta(stock_i, stock_{US})$, the average exchange rate classification from Reinhart and Rogoff (2004), the commodity share of exports, and the average log per capita GDP between 2005 and 2014. The local stock-US stock beta, $\beta(stock_i, stock_{US})$, is estimated as the regression coefficient of local log excess stock returns onto US log excess stock returns. The commodity share of exports is defined as the sum of "Ores and Metals" and "Fuel" exports as a percentage of total merchandise exports from World Bank World Development Indicators. More details on variable definitions can be found in Section 2. OLS standard errors are reported. Significance levels indicated by *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3: LC Bond Return Cyclicality and the LC Debt Share in External Debt

LC Bond-Stock Beta	(1)	(2)	(3)	(4)	(5)	(6)
s^{TIC}	-0.26***			-0.13*		
	(0.07)			(0.07)		
s^{MNS}		-0.28***			-0.14*	
		(0.09)			(0.07)	
s^{BIS}			-0.18***			-0.10*
			(0.07)			(0.05)
$\beta(stock_i, stock_{US})$				0.16**	0.16**	0.15*
				(0.07)	(0.07)	(0.07)
FX Regime				0.01	0.01	0.01
				(0.02)	(0.02)	(0.02)
Commodity Share				-0.10	-0.09	-0.09
				(0.08)	(0.08)	(0.08)
Log(GDP)				-0.07***	-0.07***	-0.08***
				(0.02)	(0.02)	(0.01)
Constant	0.18***	0.21***	0.10**	0.58***	0.61***	0.64***
	(0.05)	(0.07)	(0.04)	(0.17)	(0.17)	(0.17)
Observations	28	28	28	28	28	28
R-squared	0.36	0.30	0.23	0.66	0.67	0.67

Note: This table shows cross-country regressions of the LC bond-stock beta, $\beta(bond_i, stock_i)$, on the LC debt share, s (between 0 and 1), based on external debt (debt held by non-residents). The variable s^{TIC} denotes the share of LC debt in US investors' portfolio holdings of government debt from TIC data. The variable s^{MNS} denotes the LC debt share in cross-border mutual fund portfolio holdings of government debt from Morningstar. The variable s^{BIS} denotes the LC debt share in government debt reported by BIS reporting banks from the BIS Locational Banking Statistics. The control variables are the the local stock-US stock beta, $\beta(stock_i, stock_{US})$, the average exchange rate classification from Reinhart and Rogoff (2004), the commodity share of exports, and average log per capita GDP between 2005 and 2014. The local stock-US stock beta, $\beta(stock_i, stock_{US})$, is estimated as the regression coefficient of local log excess stock returns onto US log excess stock returns. The commodity share of exports is defined as the sum of "Ores and Metals" and "Fuel" exports as a percentage of total merchandise exports from World Bank World Development Indicators. More details on variable definitions can be found in Section 2. OLS standard errors are reported. Significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1.

2.5 What Does the LC Bond-Stock Beta Capture?

In this section, we discuss macroeconomic drivers for the LC bond-stock beta. To the extent that macroeconomic factors are important in driving LC bond return cyclicality, we would expect an inverse relationship between LC bond-stock betas and the betas of expected and realized inflation onto output. The intuition is that an increase in inflation expectations should lead to lower LC bond returns, and increased expected economic activity should lead to higher stock returns. We show empirically that the LC bond-stock beta is indeed highly correlated with the cyclicality of forecast and realized inflation. Furthermore, we show the LC bond-stock beta is also inversely correlated with a de facto measure of monetary policy credibility.

2.5.1 Cyclicality of Inflation Expectations: Inflation-Output Forecast Beta

We construct a new measure for the pro-cyclicality of inflation expectations. Each month, professional forecasters, surveyed by Consensus Economics, forecast inflation and GDP growth for the current and next calendar year. We measure the cyclicality of inflation expectations by regressing the change in the consumer price index (CPI) inflation rate predicted by forecasters on the change in their predicted real GDP growth rate. We pool all revisions for 2006 through 2013 (so that the forecasts were all made post-2005) and run the regression for country i:

$$\Delta\pi_{i,t}^{Survey} = a_i + \beta(\pi_i^{Survey}, gdp_i^{Survey}) \times \Delta gdp_{i,t}^{Survey} + \epsilon_{i,t}, \tag{4}$$

where t indicates the date of the forecast revision. The revisions to inflation forecasts ($\Delta\pi_{i,t}^{Survey}$) and GDP growth forecasts ($\Delta gdp_{i,t}^{Survey}$) are percentage changes of mean forecasts made three months before. The coefficient $\beta(\pi_i^{Survey}, gdp_i^{Survey})$ measures the cyclicality of inflation expectations and is the coefficient of interest.

Because forecasts are made for calendar years, the forecast horizon can potentially vary. Consensus Economics has forecasts for the annual inflation rate up to two years in advance. This means that in January 2008, the forecast of calendar year 2008 inflation is effectively 11 months ahead and the forecast of calendar year 2009 is 23 months ahead. We focus on revisions to the two-year forecast (13—23 months ahead) to minimize variation in the forecast horizon.

2.5.2 Cyclicality of Realized Inflation: Realized Inflation-Output Beta

While asset prices are forward-looking, and hence are most naturally linked to inflation and output forecasts, it is useful to verify that the composition of debt portfolios also lines up with the cyclicality of realized inflation and output. We compute the realized inflation-output beta by regressing the change in the inflation rate on the change in the industrial production growth rate:[16]

$$\Delta\pi_{i,t} \quad = \quad a_i + \beta(\pi_i, IP_i)\Delta IP_{i,t} + \epsilon_t, \tag{5}$$

where $\Delta\pi_{i,t}$ is the 12-month change in the year-over-year inflation rate, and $\Delta IP_{i,t}$ is the 12-month change in the year-over-year industrial production growth rate. We estimate Eqn. (5) using monthly overlapping data of 12-month changes. The coefficient $\beta(\pi_i, IP_i)$ measures the realized inflation cyclicality with respect to output. We obtain the seasonally adjusted CPI and the industrial production index from Haver Analytics between 2005 and 2014.

2.5.3 De Facto Measure of Monetary Policy Credibility

Using *Financial Times* articles over the period 1995—2015, we construct the correlation between the keywords "debt" and "inflation" for each country as a proxy for inverse monetary policy credibility. The intuition is that if inflation is solely determined by the central bank and debt is determined by the fiscal authority, these topics should be discussed separately, and the correlation should be low. On the other hand, if inflation and debt are determined by the same central government, we would expect newspaper articles to discuss both jointly, and the correlation should be high. We count the number of articles containing both keywords and the country name and divide them by the geometric average of the articles that contain one of the keywords combined with the country name.[17]

2.5.4 Correlation Among LC Bond-Stock Betas and Other Cyclicality Measures

Table 4 shows bivariate correlation between the LC bond-stock beta, expected inflation-output beta, the realized inflation-output beta, and the de facto monetary policy credibility measure based on the correlation between "debt" and "inflation" in *Financial Times* articles. We find that the LC bond-stock beta is -68% correlated with expected inflation-output beta, -56% correlated with the realized inflation-output beta, and 71% correlated with our monetary policy credibility measure. Countries with more positive LC bond-stock betas indeed have more countercyclical inflation risk, and for these countries, investors tend to be jointly concerned about debt and inflation.

This strong connection between LC bond-stock betas and measures of macroeconomic

[16] We use industrial production because it is available monthly, whereas GDP and consumption are only available quarterly for most of our countries. Using overlapping observations increases the precision of our estimates. In Appendix A.4.5, we also estimate the realized inflation-output beta using GDP for a large number of countries.

[17] We prefer a de facto measure of central bank credibility because recent measures of de jure central bank independence have been found to be uncorrelated with average inflation (Crowe and Meade, 2007).

cyclicality provide important motivation for our model, suggesting that differences in macroeconomic policy are key drivers of LC bond risks and returns across countries.

Table 4: LC Bond-Stock Beta, Inflation Cyclicality, and Monetary Credibility

	LC Bond-Stock Beta	Inflation-Output Forecast Beta	Realized Inflation-Output Beta
LC Bond-Stock Beta	1		
Inflation-Output Forecast Beta	-0.68	1	
Realized Inflation-Output Beta	-0.56	0.67	1
News Count Credibility	0.71	-0.57	-0.26

Note: This table shows the bivariate cross-country correlations among the LC bond stock beta, $\beta(bond_i, stock_i)$, the inflation-output forecast beta, $\beta(\pi_i^{Survey}, gdp_i^{Survey})$, the realized inflation-output beta $\beta(\pi_i, IP_i)$, and the de facto monetary policy credibility measure, "News Count Credibility", defined as the correlation between "debt" and "inflation" in Financial Times news articles. All numbers shown are bivariate correlations of the point estimates across our 28 sample countries.

2.6 Cyclicality of LC bond returns relative to FC bond returns

To this point, we have measured the hedging properties of LC debt and analyzed its relationship with the share of local currency sovereign debt. Here, we demonstrate that the same relationship holds when we consider the hedging properties of LC debt relative FC debt as our cyclicality measure. However, as discussed shortly, while conceptually one might want to study this relative hedging benefits for our exercise, there are a number of empirical difficulties in doing so.

To calculate the relative hedging benefits of LC bonds to FC bonds, we would in principle like to regress the difference between LC and FC bond returns on local equity returns. By regressing the difference between the sovereign bond returns in the two currencies on local equity returns, this estimation should provide a local currency minus foreign currency bond beta, thereby measuring the relative hedging benefit of LC debt to FC debt. In practice, constructing FC bond returns is empirically challenging because a large share of our sample countries do not have FC sovereign debt or no longer actively issue FC sovereign debt. As a result, the FC bond returns are either unavailable or have significant liquidity issues. To overcome this challenge, we construct two synthetic forms of FC bond yield based on sovereign credit default swaps (CDS) and cross-currency swaps (CCS), respectively, for each of our sample country, and then calculate the FC bond returns with respect to local stock returns. Despite these challenges, we find that the cyclicality of LC bond returns relative to FC bond returns is highly correlated with the cyclicality of LC bond return and has a similar relationship with the LC debt share.

First, we construct a synthetic FC bond yield, $y_{i,n,t}^{FC,CDS}$, using the sum of the US Treasury yield, $y_{US,n,t}$, and the sovereign CDS spread denominated in US dollars, $cds_{i,n,t}$:

$$y_{i,n,t}^{FC,CDS} = y_{US,n,t} + cds_{i,n,t}.$$

The sovereign CDS spread approximates the risk-neutral expected default loss on FC sovereign debt.[18] Assuming that the US Treasury is default-free, the sum of the US Treasury yield and the dollar-denominated sovereign CDS spreads gives us a synthetic FC bond yield for each country.

Second, as an alternative measure, we construct a synthetic FC bond yield, $y_{i,n,t}^{FC,CCS}$ using the difference between the LC bond yield, $y_{i,n,t}^{LC}$, and CCS swap rate between the local currency and the US dollar, $ccs_{i,n,t}$,

$$y_{i,n,t}^{FC,CCS} = y_{i,n,t}^{LC} - ccs_{i,n,t}.$$

The CCS rate gives the risk-neutral long-term forward premium to hedge LC fluctuation against the US dollar. By paying the CCS swap rate, a dollar-based investor can swap all the promised cash flows of a LC bond into dollars without being exposed to currency risk. In other words, the synthetic FC bond yield removes the currency risk component of the LC bond and preserves the credit component of the LC bond, thereby offering a proxy for the yield on bonds denominated in FC issued by the domestic borrower.

Once we have the FC bond yield constructed for each country, either based on CDS or CCS, the quarterly log holding period return on the FC bond measured in LC is given by:

$$r_{i,n,t+1}^{FC} \approx \tau_{i,n,t} y_{i,n,t}^{FC} - (\tau_{i,n,t} - 1/4) y_{i,n-1,t+1}^{FC} + (s_{i,t+1} - s_{i,t}), \tag{6}$$

where $\tau_{i,n,t}$ is the duration of the FC bond in years, and $s_{i,t}$ is the log spot exchange of the local currency (local currency units per dollar). We express the returns on FC bonds in LC units to ensure that we compare the hedging properties for LC and FC bonds in the same units. Similar to equation (1), the first two terms of the FC bond return in equation (6) calculate the holding period return of the FC bond expressed in dollars. By further taking into account local currency fluctuations against the dollar over the holding period, $s_{i,t+1} - s_{i,t}$, we convert the dollar returns into LC returns. Finally, we subtract the LC T-bill rate to obtain the quarterly LC excess return on the FC bond:

$$xr_{i,n,t}^{FC} = r_{i,n,t+1}^{FC} - y_{i,1,t+1}/4. \tag{7}$$

[18] For emerging markets, only a default on FC debt issued in the international debt markets (including bonds and loans) is considered a triggering event for the CDS contracts. For developed markets, the CDS contract can also be triggered by credit events on domestically-issued LC debt.

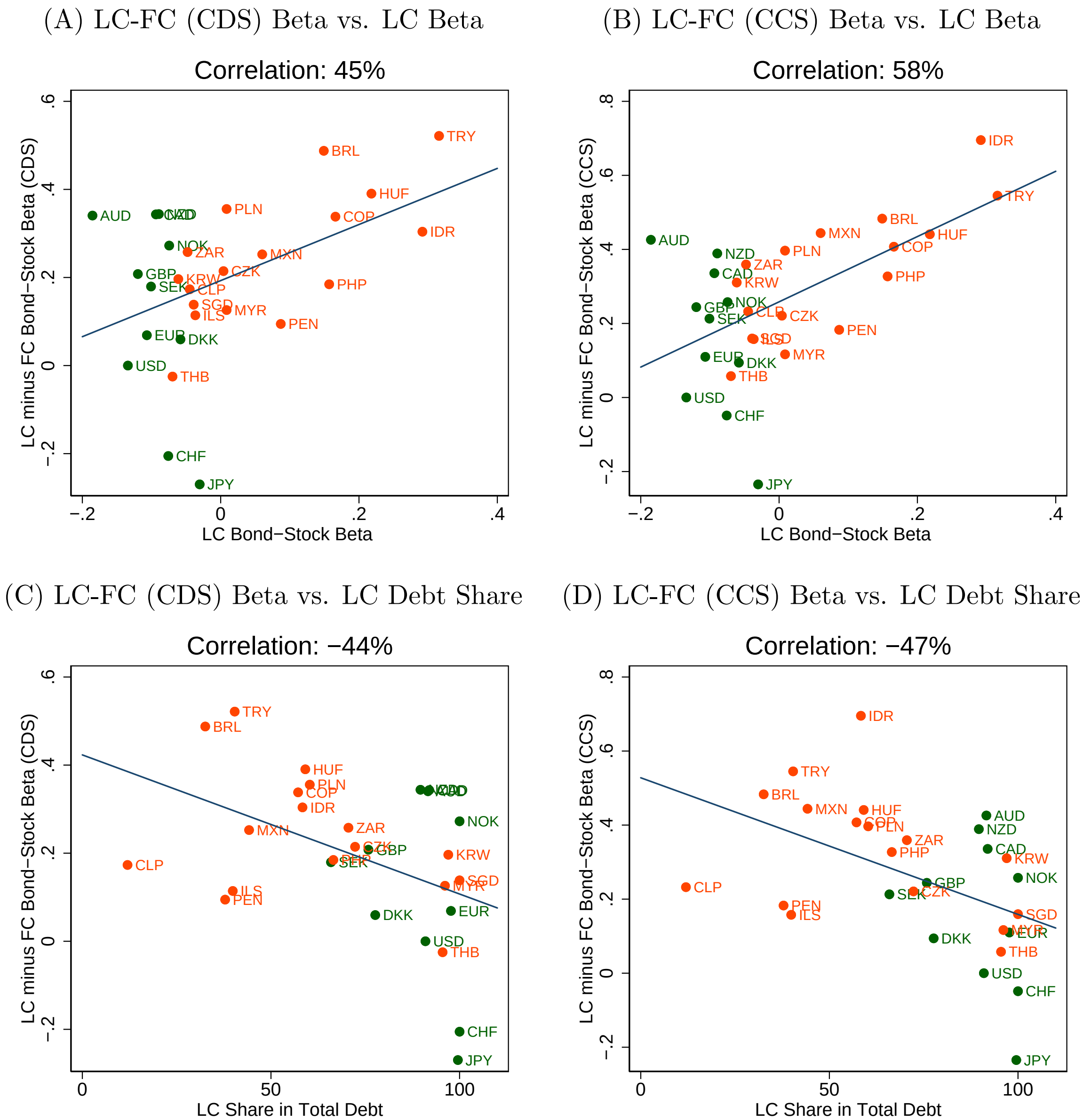
The LC minus FC bond-stock beta $\beta(bond_i^{LC-FC}, stock_i)$ is then obtained by regressing the returns on LC bonds in excess of FC bonds onto local equity log excess returns:

$$xr_{i,n,t}^{LC} - xr_{i,n,t}^{FC} = a_i + \beta(bond_i^{LC-FC}, stock_i) \times xr_{i,t}^m + \epsilon_{i,t}. \tag{8}$$

Panels (A) and (B) of Figure 2 show that the LC minus FC bond-stock beta, based on the CDS and the CCS measure, is 45% and 58% correlated with the LC bond-stock beta, respectively. Panels (C) and (D) show that the correlation between the LC minus FC bond-stock beta and the LC debt share in total debt is -44% and -47% based on the two FC yield measures, respectively. These results imply that the relative hedging properties of LC bonds minus FC bonds are broadly in line with the hedging properties of LC bonds themselves. Further, LC bonds have better hedging properties relative to FC bonds for those domestic borrowers with the lowest LC debt share.

Even though our main empirical result is robust to using the LC minus FC beta measured above, we note that this empirical exercise is subject to several important caveats. For example, using the CDS spread to construct the FC bond yield is likely to be quite imperfect due to the presence of the bond-CDS basis. In addition, the CDS spread is also subject to mispricing. Lando and Klingler (2018) show that the CDS spreads for safe sovereigns are significantly driven by regulatory demand. Furthermore, Du and Schreger (2016a) document a range of market frictions that could lead to differences in LC and FC bond pricing dynamics, which would make proxies for the LC-FC beta noisy measures for the relative cyclicality of LC and FC bond returns.

Figure 2: Local Currency Debt Shares and LC minus FC Bond-Stock Beta



Note: Panels (A) and (B) show the LC minus FC bond-stock beta, $\beta(bond_i^{LC-FC}, stock_i)$, vs. the LC bond-stock beta, $\beta(bond_i, stock_i)$. Panels (C) and (D) show the LC minus FC bond-stock beta vs. the LC debt share in percent. In Panels (A) and (C), the FC bond yield is estimated using the sum of the U.S. Treasury yield and the sovereign CDS spread. In Panels (B) and (D), the FC bond yield is estimated using the difference between the LC bond yield and the cross-currency swap rate between the LC and the dollar. More details on the construction of the LC and FC bond-stock beta differential can be found in Section 2.6. Emerging markets are shown in red and developed markets in green. Three-letter codes indicate currencies. For a list of currency codes, see Appendix A.1.

2.7 LC Bond Risk Premia

In this section, we show that the bond-stock beta is highly correlated with the LC bond risk premium. These additional empirical results motivate us to develop a model that features risk-averse lenders and varying degrees of monetary policy commitment.

We first establish that the LC bonds with the best hedging value for the domestic government are risky for international lenders. To see this, we estimate the beta of LC bond returns with respect to US stock returns from a regression:

$$xr^{LC}_{i,n,t} = a_i + \beta(bond_i, stock_{US}) \times xr^m_{US,t} + \epsilon_{i,t}. \tag{9}$$

The correlation between the LC bond-US stock beta, $\beta(bond_i, stock_{US})$, and the LC bond-local stock beta, $\beta(bond_i, stock_i)$, is 89%.[19]

Second, we establish the relationship between bond-stock betas and the LC bond risk premium, defined as the log expected real return on a LC bond in excess of a global real risk-free rate. We proxy for the risk premium on the LC bond in country i as follows:

$$\overline{RP}_{i,n} = \bar{y}^{LC}_{i,n} - \bar{\pi}^{Survey}_i - \left(\overline{y}_{US,1} - \overline{\pi}^{Survey}_{US}\right), \tag{10}$$

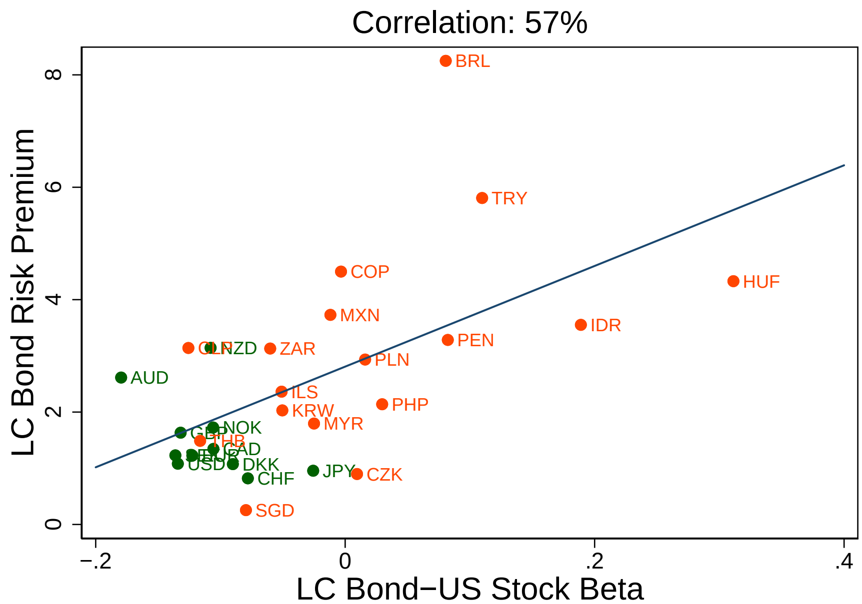
where a bar indicates the mean from 2005 to 2014. This formulation is effectively imputing the risk premium as the difference between currency-specific real interest rates.[20]

Figure 3 shows that the bond-US stock beta, $\beta(bond_i, stock_{US})$, is 57% correlated with the LC bond risk premium. Therefore, international lenders require a higher risk premium for holding LC bonds if LC bond returns are more pro-cyclical. In Appendix A.6.2, we formally estimate the relationship between the risk premium and the bond-US stock beta using the generalized method of moments to account for generated regressors. We obtain a statistically significant coefficient of 8.96, i.e. an asset with a unit beta with respect to the US stock market has a risk premium of 8.96%. This number is very close to and not statistically significantly different from the US equity premium of 8.1% reported by Campbell (2003).

[19] More details on the risk of LC bonds from the international lender's perspective can be found in Appendix A.5.

[20] Due to our short sample, ex post bond risk premia, measured as realized excess returns, are extremely noisy. We therefore prefer ex ante measures, corresponding to those that governments see when making issuance decisions.

Figure 3: LC Bond-US Stock Beta and LC Bond Risk Premia



Note: This figure plots the average risk premium on LC bonds against the LC bond-US stock beta. LC bond risk premia are estimated according to Eqn. (10). The LC bond-US stock beta is estimated from the regression:

$$xr_{i,n,t}^{LC} = a_i + \beta(bond_i, stock_{US}) \times xr_{US,t}^{m} + \epsilon_{i,t}.$$

Emerging markets are shown in red and developed markets in green. Three-letter codes indicate currencies. For a list of currency codes, see Appendix A.1.

3 Model

This section describes a two-period model of a small open economy borrowing from international lenders. The key decisions in our model are made by a benevolent government that acts on behalf of domestic consumers and borrows from international lenders. The domestic government's problem is to maximize the welfare of the representative domestic consumer by choosing the currency composition of its debt and state-contingent inflation. The international investors are competitive price-takers, whose preferences may be different from those of the domestic consumer. We solve this problem for two types of governments: those that can commit to a state-contingent inflation policy function and those that cannot. The model generates endogenous differences in inflation cyclicality and the LC debt share from exogenous differences in governments' ability to commit to an inflation policy. Because LC bond returns are linked to inflation and stock returns to output surprises, the model can explain the empirical relationship between LC bond return cyclicality and LC debt shares that we documented in Section 2.[21] Throughout, we use a superscript asterisk to denote quantities for international lenders and lower-case variables to denote logs.

3.1 Environment

3.1.1 Domestic Government

A benevolent government maximizes the welfare of the representative domestic agent, where the agent has utility with constant relative risk aversion (CRRA) over real domestic consumption C_2 and faces a quadratic loss from inflation:

$$\mathbb{E}U\left(C_2, \pi_2\right) = \mathbb{E}\left[\frac{C_2^{1-\gamma}}{1-\gamma} - \frac{\alpha}{2}\pi_2^2\right]. \tag{11}$$

The government needs to raise an exogenous and fixed amount of real revenue, $\frac{\bar{D}}{R^*}$, and can do so either borrowing in LC or FC

$$Q^{LC}D^{LC} + Q^{FC}D^{FC} = \frac{\bar{D}}{R^*}. \tag{12}$$

Here, Q^{LC} and Q^{FC} denote period 1 bond prices and D^{LC} and D^{FC} debt face values, all measured in real domestic consumption units. D^{LC} and D^{FC} are required to be non-negative. R^* denotes the exogenous real global interest rate. Equivalently, the government chooses the LC debt share, $s \in [0,1]$, defined as

$$s = \frac{Q^{LC}D^{LC}}{\bar{D}/R^*}. \tag{13}$$

LC and FC face values are then given by $D^{LC} = s \times \frac{\bar{D}}{R^*} \times \frac{1}{Q^{LC}}$ and $D^{FC} = (1-s) \times \frac{\bar{D}}{R^*} \times \frac{1}{Q^{FC}}$.

We assume that the domestic government has access to lump-sum taxation. Domestic real consumption in the second period is endogenous and equals the endowment X_2, net of real debt repayments $D_2\left(X_2\right)$:

$$C_2 = X_2 - D_2\left(X_2\right). \tag{14}$$

Real debt repayments $D_2\left(X_2\right)$ equal the real value of LC debt repayments plus FC debt repayments:

[21] Because of the small open economy assumption, the commitment government more closely resembles a small open developed country, such as Switzerland or Sweden, as opposed to the United States, which is a large open economy. We include the United States in our empirical analysis for completeness. However, in our quantitative analysis we compare the commitment government to moments averaged across 11 developed markets, which are not primarily driven by the United States.

$$D_2 = s \times \frac{\bar{D}}{R^*} \times R_2^{LC} + (1-s) \times \frac{\bar{D}}{R^*} \times R_2^{FC}, \tag{15}$$

where R_2^{LC} and R_2^{FC} denote gross returns measured in real domestic consumption units on LC and FC bonds. The real amount of domestic consumption units required to repay the LC debt equals the real revenue raised through LC debt, $s \times \frac{\bar{D}}{R^*}$, times the return on that debt in real domestic consumption units. The real amount of domestic consumption units required to repay FC debt similarly equals the real revenue raised through FC debt, $(1-s) \times \frac{\bar{D}}{R^*}$, times the corresponding return in real domestic consumption units.

The domestic representative agent consumes a domestic consumption good, which differs from the global consumption good consumed by international lenders. We define the real exchange rate $\mathcal{E}_t$ as the number of real domestic consumption goods obtainable in exchange for one unit of the real global consumption good at time t. We normalize the period 1 real exchange rate to one, $\mathcal{E}_1 \equiv 1$. A higher $\mathcal{E}_t$ denotes a real appreciation of the local currency. The returns R_2^{LC} and R_2^{FC} are measured in real domestic consumption units to match the units in Eqn. (15), so we have:

$$R_2^{LC} = \frac{\exp\left(-\pi_2\left(X_2\right)\right)}{Q^{LC}}, \tag{16}$$

$$R_2^{FC} = \frac{R^*}{\mathcal{E}_2}. \tag{17}$$

Eqn. (16) shows that the domestic government's real cost of repaying LC debt falls with inflation. It also shows the relation with the nominal exchange rate. In the special case with a constant period 2 real exchange rate (i.e. purchasing power parity (PPP)) the nominal exchange rate is simply $\exp(-\pi_2)$ and the cost of repaying LC debt is perfectly correlated with the nominal exchange rate. This special case captures the essence of our mechanism. We make the model more realistic by allowing for shocks to the period 2 real exchange rate, which unlike inflation we assume to be realized exogenously. Eqn. (17) shows that if the domestic real exchange rate is appreciated, i.e. $\mathcal{E}_2$ is high, then it is relatively inexpensive for the government to repay its FC debt.

3.1.2 Lenders and Bond Pricing

The government borrows from international lenders and debt is priced by international lenders' first-order conditions. We assume that international lenders consume C_t^* units of a global consumption good, which differs from the good consumed by domestic agents. We assume international lenders maximize time-separable CRRA preferences with risk aversion

γ^* and time discount rate δ^* over their own real consumption C_t^*

$$U^*(C_t^*) = \frac{(C_t^*)^{1-\gamma^*}}{1-\gamma^*}. \tag{18}$$

We further assume that in period 1 international lenders are exogenously endowed with one unit of the global consumption good and in period 2 with $X_2^* = \exp(x_2^*)$ units of the global consumption good. Because the domestic economy is assumed to be small, international lenders' bond holdings are negligible in equilibrium and their consumption equals their endowment in equilibrium, so $C_1^* = 1$ and $C_2^* = \exp(x_2^*)$.

International lenders' SDF, M_2^*, equals their discounted marginal utility from an additional unit of the global consumption good in period 2 divided by their marginal utility in period 1:

$$M_2^* = \delta^* \frac{U^{*'}(C_2^*)}{U^{*'}(C_1^*)} = \delta^* \exp(-\gamma^* x_2^*). \tag{19}$$

The international lenders' SDF is hence exogenous to the government's inflation and debt portfolio policy.

International lenders' first-order conditions over bond holdings imply standard asset pricing Euler equations. Specifically, bond prices must equal the expected real global consumption units that each bond pays discounted at international lenders' SDF M_2^* :

$$Q^{LC} = \mathbb{E}\left[M_2^* \exp\left(-\pi_2(X_2)\right)\mathcal{E}_2\right], \tag{20}$$

$$Q^{FC} = \mathbb{E}\left[M_2^*\right] = 1/R^*. \tag{21}$$

To understand the LC bond price, note that the LC bond pays $\exp(-\pi_2(X_2))$ units of the domestic consumption good, which international lenders convert into $\exp(-\pi_2(X_2))\,\mathcal{E}_2$ units of the global consumption good. It is clear from Eqn. (20) that LC bond prices are endogenous to the government's inflation policy.

3.1.3 Shocks

We assume that domestic output X_2 is log-normally distributed:

$$X_2 = \bar{X}\exp\left(x_2/\bar{X}\right), \ \bar{X} = 1 + \bar{D}, \tag{22}$$

where x_2 has a loading, $\lambda^{x,x*}$, on the international output and is also subject to an independent shock, η_2:

$$x_2 = \lambda^{x,x^*} x_2^* + \eta_2, \tag{23}$$

$$x_2^* \sim N\left(0, (\sigma^*)^2\right), \ \eta_2 \sim N\left(0, \sigma_\eta^2\right). \tag{24}$$

We denote the standard deviation of x_2^* by σ^* and the standard deviation of x_2 by σ_x. Given that we have CRRA preferences, the correlation between domestic and international agents' marginal utility will be a function of the correlation of their endowment processes.[22] Normalizing by $\bar{X}$ ensures that C_2 is centered around 1 for a government that borrows entirely in FC.

We assume that the real exchange rate is distributed according to:

$$\mathcal{E}_2 = \exp\left(\varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right) \tag{25}$$

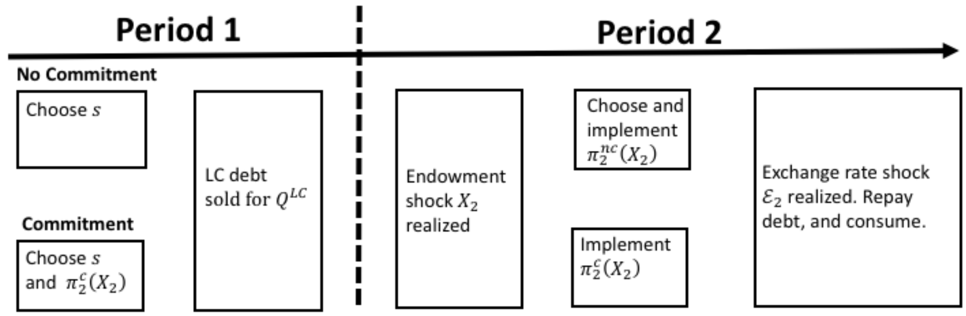
$$\varepsilon_2 = \lambda^{\varepsilon,x^*} x_2^* + e_2, \ e_2 \sim N\left(0, \sigma_e^2\right), \tag{26}$$

where the parameter $\lambda^{\varepsilon,x^*}$ is the loading of the real exchange rate on international output, and e_2 captures the idiosyncratic component uncorrelated with international output. The realizations of x_2^*, η_2, and e_2 are exogenous and uncorrelated. Real exchange rate shocks are included to make the model more realistic, but are not central to our proposed mechanism.

The Jensen's inequality term in (25) ensures that the real exchange rate equals one in expectation. Real exchange rate fluctuations can be microfounded if international lenders and domestic consumers consume different bundles of goods and international lenders experience preference shocks over the good produced by the domestic economy, as in Gabaix and Maggiori (2015). We formalize the assumptions on preferences and shocks that microfound (25) and (26) in Appendix B.1.

[22] As documented in the literature, cross-country correlations of output are higher than cross-country correlations of consumption (Colacito et al. 2018). Colacito et al. (2018) demonstrate that with long-run risks, the correlation of SDFs across countries does not need to be bounded by the correlation of output. However, such an extension is beyond the scope of our static model.

Figure 4: Model Timeline



Note: This figure shows the timing of the government's problem without commitment and with commitment.

3.1.4 Government Problem without Commitment

Figure 4 depicts the timeline of our model. The government without commitment has two endogenous choice variables – the LC debt share, s, and discretionary inflation policy, $\pi_2^{nc}(X_2)$. At the beginning of period 2, it chooses inflation after observing domestic output, taking the debt composition and LC bond prices as given. We assume that the no-commitment government chooses inflation after observing domestic output, but before the real exchange rate is realized. In period 2, the no-commitment government's problem is to choose $\pi_2^{nc}(X_2)$ to maximize domestic consumer welfare taking the LC debt share, s, and bond prices as given:

$$\max_{\pi_2^{nc}(X_2)} \mathbb{E}\left[U(C_2,\pi_2)\middle|\, s, Q^{LC}, X_2\right]. \tag{27}$$

The government chooses the inflation rate $\pi_2^{nc}(X_2) \in \mathbb{R}$ to maximize (27) subject to the budget constraint (14) after having observed the realization for domestic output X_2. $\mathbb{E}\left[\cdot\middle|\, s, Q^{LC}, X_2\right]$ denotes the expectation over $\mathcal{E}_2$, taking s, Q^{LC} and X_2 as given.

In period 1, the no-commitment government chooses the LC debt share, $s \in [0,1]$, to maximize expected domestic consumer utility while rationally anticipating its own future choice of $\pi_2^{nc}(X_2)$. The no-commitment government's problem in period 1 is:

$$\max_{s\in[0,1]} \mathbb{E}\left[U(C_2,\pi_2)\right], \tag{28}$$

subject to the period 1 borrowing requirement (12), the period 2 budget constraint (14), the bond pricing Eqn. (20), and period 2 inflation policy (27). The expectation in (28) is over X_2 and $\mathcal{E}_2$.

3.1.5 Government Problem with Commitment

A government with commitment sets its inflation policy function $\pi_2^c(X_2)$ before its debt is priced and sold to international lenders and before X_2 is realized, as shown in the timeline in Figure 4. It chooses an ex ante function for inflation that is allowed to depend on the future state of domestic output, $\pi_2^c(X_2)$, and its LC debt share, s, to maximize domestic consumer welfare anticipating the endogenous effect on LC bond prices:

$$\max_{\pi_2^c(X_2),\, s} \mathbb{E}\left[U\left(C_2, \pi_2\right)\right], \tag{29}$$

where $\mathbb{E}$ denotes the expectation over X_2 and $\mathcal{E}_2$. The inflation policy function $\pi_2^c(X_2)$ is chosen from the space of functions of X_2, and s is chosen from the unit interval $[0,1]$, subject to the period 1 borrowing requirement (12), the budget constraint (14), and the bond pricing Eqn. (20). Unlike the no-commitment government, when the commitment government chooses its inflation policy it therefore internalizes the effect of this policy on the bond pricing Eqn. (20).

3.2 First-Order Conditions

3.2.1 Optimal Inflation Policy without Commitment

The first-order condition for the optimal inflation policy of the no-commitment government is given by:

$$\underbrace{\alpha\pi_2^{nc}(X_2)}_{Deadweight\ Cost} = \underbrace{\mathbb{E}\left[U'\left(C_2^{nc}\right)\frac{\partial C_2^{nc}}{\partial \pi_2^{nc}}\middle| X_2\right]}_{Static\,Gain}. \tag{30}$$

The no-commitment government optimally inflates until the marginal deadweight cost of higher inflation (left-hand side of the equation) equals the marginal consumption utility from inflating away the LC debt (right-hand side of the equation). Here, $\frac{\partial C_2^{nc}}{\partial \pi_2} = D^{LC}\exp\left(-\pi_2\left(X_2\right)\right) \geq 0$ captures the increase in consumption arising from a reduction in the real value of LC debt repayments. The first-order condition (30) makes clear that the inflation cost, α, is needed because otherwise the optimal inflation problem would not be well-defined.

This equation immediately shows that a no-commitment government chooses countercyclical inflation, i.e. higher inflation when domestic output is low, because the marginal utility of domestic consumption, $U'\left(C_2^{nc}\right)$, tends to be high when domestic output is low. The right-hand side of Eqn. (30) is conditional on X_2 because the government chooses inflation $\pi_2^{nc}(X_2)$ after domestic output X_2 is realized but without observing the real exchange rate shock $\mathcal{E}_2$ or international output X_2^*, and therefore the no-commitment government cannot condition its inflation policy on international output or real exchange rate innovations.

3.2.2 Optimal Inflation Policy with Commitment

The first-order condition for the optimal inflation policy of the government with commitment is more complex, as this government takes into account how its inflation choices affect the pricing of its LC debt. Defining the probability density function of X_2 as $f(X_2)$, the first-order condition takes the following form:

$$\underbrace{\alpha\pi_2^c\left(X_2\right)}_{Deadweight\,Cost} = \underbrace{\mathbb{E}\left[U'\left(C_2^c\right)\frac{\partial C_2^c}{\partial\pi_2^c}\middle| X_2\right]}_{Static\,Gain} + \underbrace{\frac{1}{f(X_2)}\frac{dQ^{LC}}{d\pi_2^c(X_2)}\mathbb{E}\left[U'\left(C_2^c\right)\frac{\partial C_2^c}{\partial Q^{LC}}\right]}_{Dynamic\,Cost}. \quad (31)$$

The first two terms of the commitment government's first-order condition (31) are identical to the no-commitment government's first-order condition (30), capturing the static trade off between the deadweight cost of higher inflation and the gain in marginal consumption utility from inflating away the debt. The final term, the dynamic cost, is only present for the government with commitment.

The dynamic cost captures how additional inflation in state X_2 affects domestic welfare across all states in the second period. The final component, $\left(U'\left(C_2^c\right)\frac{\partial C_2^c}{\partial Q^{LC}}\right)$, captures the effect of a change in the bond price on consumption, scaled by the marginal utility of consumption in that state. The first component $\left(\frac{1}{f(X_2)}\frac{dQ^{LC}}{d\pi_2^c}\right)$, captures the effect of an increase in inflation in state X_2 on the bond price, scaled by the probability of the state occurring. Using the expression for the bond price in Eqn. (20), we see that

$$\frac{1}{f(X_2)}\frac{dQ^{LC}}{d\pi_2^c} = -\exp(-\pi_2^c(X_2))\mathbb{E}\left[M_2^*\mathcal{E}_2\middle| X_2\right] < 0. \quad (32)$$

Because the international lenders' SDF is correlated with domestic marginal consumption utility, the international lenders' SDF tends to be high when X_2 is low.[23] Therefore, Eqn. (32) indicates that increasing inflation in a low domestic output state is particularly costly for the LC bond price. This is the risk-premium channel. If lenders were risk-neutral and the real exchange rate were constant (i.e. PPP holds), this term would be proportional to $-\exp(-\pi_2^c(X_2))$, meaning that the government would face the same effect on the bond price from additional inflation in any state of the world. This would still lead a government with commitment to refrain from an average inflation bias (i.e. the type studied in Barro and

[23] In general, the correlation between $\mathbb{E}\left[M_2^*\mathcal{E}_2\middle| X_2\right]$ and domestic output will depend on international lenders' coefficient of risk aversion, the loading of the domestic economy on global output, and the cyclicality of the real exchange rate.

Gordon (1983)). However, the more highly correlated is the lenders' SDF with domestic output, the more the government with commitment refrains from raising inflation in bad states in order to avoid lowering domestic welfare in *every* state. Later in Section 3.3, we will derive closed-form solutions for optimal inflation policy for a simple case to gain further intuition.

3.2.3 Optimal LC Debt Share

To characterize the governments' choice of the currency composition of debt, we take the first derivative of the objective function with respect to the LC debt share s:

$$\begin{aligned} \frac{d\mathbb{E}U\left(C_2, \pi_2\right)}{ds} &= -\alpha\mathbb{E}\left[\pi_2 \frac{d\pi_2}{ds}\right] - \frac{\bar{D}}{R^*}\mathbb{E}\left[U'(C_2)\left(R_2^{LC} - R_2^{FC}\right)\right] \\ &\quad -\frac{s\overline{D}}{R^*}\mathbb{E}\left[U'(C_2)\left(\frac{dR_2^{LC}}{ds}\right)\right] \end{aligned} \tag{33}$$

Eqn. (33) holds for both commitment and no-commitment governments, albeit with different inflation policy functions and therefore a different pattern of state-contingent domestic consumption. We do not allow governments to hold net long positions in either type of debt and therefore restrict the LC share to the interval between 0 and 1. For an interior choice for the LC debt share, the derivative (33) must equal zero. The derivative is positive if the upper bound $s = 1$ (all LC debt) is binding and negative if the lower bound $s = 0$ (all FC debt) is binding.

The government's incentive to shift towards more LC debt on the margin depends on three terms: First, the marginal change in the deadweight cost of inflation from borrowing more in LC. The second term captures the competing forces from the state-contingency of inflation, which are the main focus of our analysis. On the one hand, if international lenders require a higher LC bond risk premium to compensate for the state-contingency of LC bond payoffs, this raises the domestic government's real cost of repaying LC debt and makes LC debt issuance unattractive. On the other hand, if inflation state-contingency is such that the real cost of repaying LC debt is low in states when domestic marginal utility of consumption is high, this makes LC debt issuance attractive because it provides hedging benefits to domestic consumers. The third term captures the endogenous response of the LC bond risk premium to the government's debt currency choice, as lenders rationally anticipate that borrowing in LC changes the government's incentive to generate more counter-cyclical inflation. All three terms tend to push the government without commitment towards FC debt compared to the government with commitment. Naturally, the risk premium forces will be shut off if lenders have zero risk aversion, as in Calvo and Guidotti (1990).

3.3 Analytical Special Case

Before turning to the quantitative evaluation, we analytically characterize a special case. This allows us to clearly distinguish our risk premium-centered mechanism from the classic Barro and Gordon (1983) inflation bias and provides intuition for the distinct mechanism in our model. For simplicity, we assume that the real exchange rate is constant ($\mathcal{E}_1 = \mathcal{E}_2 = 1$), and that there is only a global endowment shock ($x_2 = x_2^*$).[24] First, we characterize the inflation policies for the commitment and no-commitment governments for a given LC debt share s, and then we discuss the trade-off between LC and FC debt. Since the purpose of the analytic solutions is to illustrate the key features of the equilibrium and we later solve the model numerically, we use a simple log-linearization strategy to convey this intuition. We relegate the algebra behind these approximations to Appendix B.5.

3.3.1 Optimal Inflation Policy

We now present an approximate analytical solution for the commitment and no-commitment governments' optimal inflation policy at a given LC debt share s. We collect the inflation policy functions for the two types of governments in the following proposition:

Proposition 1. *Assume that the real exchange rate is constant ($\mathcal{E}_2 = 1$) and that there is only one global endowment shock ($x_2 = x_2^*$). Taking first-order log-linear Taylor approximations of the inflation first-order conditions (30) and (31) around ($c_2 = 0, \pi_2 = 0$), and imposing that lenders' expectations are rational, gives log-linear approximate solutions for $\pi_2^{nc}(X_2)$ and $\pi_2^{c}(X_2)$:*

$$\pi_2^{nc}(X_2) = \frac{s\bar{D}}{\alpha} - \gamma\frac{s\bar{D}}{\alpha}x_2, \tag{34}$$

$$\pi_2^{c}(X_2) = (\gamma^* - \gamma)\frac{s\bar{D}}{\alpha}x_2. \tag{35}$$

We substitute the exact dependence of the LC bond price on state-contingent inflation (32) into the commitment government's first-order condition (31) and then take a standard log-linear first-order approximation (e.g. Campbell (1994)).[25] This log-linearization proce-

[24] The analytical model solution takes the same form when we allow for a separate domestic output shock, except that international risk aversion needs to be scaled by global-domestic output comovement.

[25] To keep the analytical expressions in Proposition 1 tractable, we show only the lowest-order terms in the debt-to-GDP ratio $\bar{D}$, which dominate when the debt-to-GDP ratio is small.

dure allows us to preserve the risk premium.[26]

Proposition 1 shows two important differences between the policies chosen by commitment and no-commitment governments. First, comparing the intercepts shows that a government without commitment chooses positive inflation on average, whereas a government with commitment finds it optimal to choose zero inflation on average. Because a government with commitment recognizes that its choice of inflation is priced in ex ante, it internalizes that a choice of non-zero average inflation strictly reduces welfare.

The second difference between these two policy functions – and the difference that distinguishes our analysis from that of Barro and Gordon (1983) – is how inflation comoves with domestic output, x_2. The no-commitment government's inflation policy loads onto domestic output with a negative coefficient that is proportional to $-\gamma$. By contrast, the commitment government's inflation policy loads onto domestic output with a coefficient that is proportional to $\gamma^* - \gamma$. At a given LC debt share, the commitment government therefore optimally chooses a less counter-cyclical inflation policy than the no-commitment government, and the difference in cyclicality increases with international lender risk aversion γ^*. Because LC bond prices fall one-for-one with realized inflation, commitment government's bond returns therefore fall less in bad times than the no-commitment government's. The difference arises because the government with commitment internalizes that if it inflates in states when international lenders' marginal consumption utility is high, this disproportionately lowers the price that its LC bonds sell for, as seen in Eqn. (32).

3.3.2 Trade-Offs Between LC and FC Debt

Having characterized how the two types of governments optimally choose their inflation policy conditional on a given LC debt share, we now turn to the trade-offs faced by these governments in deciding how much to borrow in their own currency.[27] There are two costs faced by a government without commitment when it borrows in its own currency: a high average inflation rate and a higher risk premium. The average inflation rate is simple. Taking the unconditional expectations of the inflation policy functions in Eqns. (34) and (35), we

[26] An alternative approximation approach would be to take a log-linear approximation of the international lenders' Euler equation and then substitute an approximate relation for $\frac{1}{f(X_2)}\frac{dQ^{LC}}{d\pi_2^c}$ into the domestic government's first-order condition. However, this alternative approach misses the effect of LC bond risk premia that is at the heart of our mechanism.

[27] We do not explicitly solve for the optimal LC debt share because approximate log-linear solutions are not appropriate for constrained optimization problems. Instead, we use our approximate optimal inflation policies to intuitively demonstrate the main trade-offs faced by governments when they choose the currency composition of their debt.

have:

$$E\left(\pi_2^{nc}\right) = \frac{s\bar{D}}{\alpha}, \tag{36}$$

$$E\left(\pi_2^{c}\right) = 0. \tag{37}$$

In this economy, an average inflation bias is a pure loss: it is priced in ex ante and so provides no consumption benefit in equilibrium. The no-commitment government correctly anticipates that its average inflation bias increases with the share of debt denominated in LC, s, incentivizing it to borrow in FC instead. This is the classic inflationary bias of Barro and Gordon (1983) and Calvo and Guidotti (1990) and not new to our analysis. Formally, this force enters the optimal LC debt choice through the first term on the right-hand side of Eqn. (33).

However, our economy features an additional new force that makes LC debt costly for a government without commitment: the risk premium. To better understand this force, we note that in the special case with log-linear inflation policies as in Eqns. (34) and (35) the LC bond price simplifies to:

$$Q^{LC} = \frac{1}{R^*} exp\left(-\mathbb{E}\pi_2 + \frac{1}{2}Var(\pi_2) + \gamma^* Cov\left(\pi_2, x_2\right)\right). \tag{38}$$

Expected mean inflation, the expected inflation variance, and the expected covariance between output and inflation are all the rational expectations of the international lenders at the time the debt is sold and priced. We define the LC bond risk premium as the log expected real LC bond return in excess of the log global FC interest rate, analogously to our empirical analysis. In this special case, the LC bond risk premium simplifies to:

$$RP = \log \mathbb{E}\frac{\exp\left(-\pi_2\right)}{Q^{LC}} - \log R^* = -\gamma^* Cov\left(\pi_2, x_2\right). \tag{39}$$

Substituting in the inflation policy functions in Eqns. (34) and (35), we have:

$$RP^{nc} = \gamma^*\gamma\frac{s\bar{D}}{\alpha}\sigma_x^2, \tag{40}$$

$$RP^{c} = \gamma^*(\gamma - \gamma^*)\frac{s\bar{D}}{\alpha}\sigma_x^2. \tag{41}$$

LC bond risk premia affect the optimal debt currency choice through two channels. First, at a given level of the LC debt share, s, the LC bond risk premium paid by a government without commitment (Eqn. (40)) is greater than that paid by a government with commitment (Eqn. (41)), conditional on international lender risk aversion being non-zero ($\gamma^* > 0$). The higher LC bond risk premium incentivizes the no-commitment government to tilt away from LC borrowing, because it understands that average real domestic consumption declines with the product of the LC bond risk premium and the share of debt in LC.[28] Second, taking the derivative with respect to s of Eqns. (40) and (41) shows that the LC bond risk premium paid by the government without commitment increases faster with s, again conditional on international lender risk aversion being non-zero ($\gamma^* > 0$). A no-commitment government's tendency to generate counter-cyclical inflation increases with the amount it has borrowed in LC, leading lenders to charge higher LC bond risk premia ex ante. The no-commitment government therefore has an incentive to reduce its LC borrowing to limit its own future incentive to generate counter-cyclical inflation, thereby lowering the LC bond risk premium ex ante.[29]

To summarize, the analytical solutions for this special case suggest that governments without commitment optimally choose more counter-cyclical inflation than governments with commitment. Further, governments without commitment face stronger incentives to borrow in FC, due to endogenous LC bond risk premia and deadweight cost of anticipated inflation. If countries differ in their ability to commit to future monetary policy, this channel can therefore qualitatively generate our main empirical finding that countries borrowing mostly in FC have more counter-cyclical inflation and LC bonds that depreciate in adverse domestic states. We next turn to a quantitative analysis of how these forces determine the equilibrium relationship between the currency composition of sovereign debt and the cyclicality of LC bond returns.

4 Quantitative Evaluation

This section evaluates the model quantitatively. So far, we have emphasized predictions for inflation and output. In order to take the model to the data on bond-stock betas, we assume that domestic stock returns are proportional to the output gap surprise, with the corresponding factor loading estimated from the data. We calibrate the model separately for emerging markets (EM) and developed markets (DM), with the difference being that EMs are modeled as as a no-commitment government and DMs are modeled as a commitment government. We solve the model numerically using global solution methods to account for risk premia. Appendix B gives details of the numerical solution and bond and stock returns.

[28] Formally, this channel changes the incentive to borrow with LC debt through the second term on the right-hand side of Eqn. (33).

[29] Formally, this channel changes the incentive to borrow with LC debt through the third term on the right-hand side of Eqn. (33).

Table 5: Calibration Parameters

Specific to EM and DM		EM (no commitment)	DM (commitment)	Target
Commitment		No	Yes	
Output Volatility	σ_x	2.7%	2.2%	Data
Constant across EM and DM				
International Volatility	σ^*	1.64%		Data
International Lender Risk Aversion	γ^*	74.36		Lustig and Verdelhan (2007)
Domestic Consumer Risk Aversion	γ	29.74		$\gamma^* \times$ equity/assets (He and Krishnamurthy, 2013)
Debt/GDP	$\bar{D}$	14.4%		Data
Domestic - Global Loading	λ^{x,x^*}	0.91		Data
Stock Return - Output Loading	$\lambda^{m,x}$	4.0		Data
Exchange Rate Volatility	σ_ε	10.8%		Data
Exchange Rate Loading	$\lambda^{\varepsilon,x^*}$	1.41		Data
Inflation Cost	α	4.28		EM-DM Expected Inflation

Note: All parameters are in annualized natural units. The empirical proxy for output volatility is the annualized standard deviation of domestic log real GDP growth, where we average separately for EMs and DMs. For the international endowment volatility, σ^*, we target the annualized standard deviation of the quarterly growth in US log real personal consumption expenditure (PCECC96 from FRED from the St. Louis Fed). International lender risk aversion equals $\gamma^* = \frac{2\%}{(\sigma^*)^2} = 74.36$ to match the price of international consumption risk of 2% from Lustig and Verdelhan (2007). We set domestic consumer risk aversion to $\gamma^* \times 0.4$ to account for financial investor leverage, where intermediary equity/assets= 0.4 is from He and Krishnamurthy (2013). The empirical proxy for Debt/GDP is the external debt-to-GDP ratio from Arslanalp and Tsuda (2014a) and Arslanalp and Tsuda (2014b), averaged over EM and DM countries. The empirical proxy for the domestic-global endowment loading is the regression coefficient of quarterly log real GDP growth onto US quarterly log real consumption growth, averaged over EMs and DMs. Domestic stock returns are modeled as proportional to domestic output according to $xr^m_{i,2} - \mathbb{E}xr^m_{i,2} = \lambda^{m,x}(x_{i,2} - \mathbb{E}x_{i,2})$. The empirical proxy for the stock return-output loading, $\lambda^{m,x}$, is the regression coefficient of quarterly domestic stock returns onto quarterly log real domestic GDP growth, averaged over EMs and DMs. The empirical proxy for the exchange rate volatility is the annualized standard deviation of quarterly log exchange rate changes, averaged over EMs and DMs. The empirical proxy for the exchange rate-international endowment loading is the regression coefficient of quarterly log exchange rate changes onto US log real consumption growth, averaged over EMs and DMs. We average over EMs and DMs together whenever the EM- and DM-specific moments are not statistically significantly different at the 95%-level. All empirical moments are over our sample 2005-2014.

4.1 Calibration

EM (no commitment) and DM (commitment) calibrations differ along two dimensions. Most importantly, we assume that developed market governments have commitment and EM governments do not. Second, we match EM and DM output volatilities separately to the data, because EMs have significantly higher output volatility in the data.

To highlight the differences between EMs and DMs that arise from differences in credibility, we choose equal parameter values for EM and DM calibrations whenever this is empirically plausible. In particular, we use equal parameter values when the corresponding EM and DM moments in the data are not statistically different at the 95% level. Since the international lender should be the same for both countries, we choose the same lender risk aversion, and international endowment volatility for both calibrations. We set the international endowment volatility in the model to 1.64% to match the annualized standard deviation of the quarterly growth in US log real personal consumption expenditure.[30] We set international lenders' risk aversion to $\gamma^* = \frac{2\%}{(\sigma^*)^2} = 74.36$ to match the price of international consumption risk of 2% from Lustig and Verdelhan (2007). While this risk aversion coefficient may at first appear high, it is not unusual in the literature seeking to explain the equity premium (Campbell and Cochrane (1999); Lustig and Verdelhan (2007)). One way to interpret this high coefficient of risk aversion is by noting that international lenders in sovereign debt tend to be intermediaries whose risk aversion is amplified by financial leverage (Morelli et al. (2019)). We set domestic consumer risk aversion to be consistent with that of international lenders, assuming that international lenders' are levered with an intermediary equity to total assets ratio of 0.4 as in He and Krishnamurthy (2013). We therefore set domestic consumer risk aversion to $\gamma = 29.74$ $(= \gamma^* \times 0.4)$.

We set the debt-to-GDP ratio to $\bar{D} = 14.4\%$ to match the share of external debt to GDP in Arslanalp and Tsuda (2014a,b), averaged across EMs and DMs. EMs and DMs have similar ratios of external debt-to-GDP (13.2% for EMs and 16.1% for DMs) and the difference is not statistically significant, so we use the average for both calibrations.

We set the loading of local output onto international consumption to $\lambda^{x,x^*} = 0.91$ to match the regression coefficient of quarterly local log real GDP growth onto log real US consumption growth, averaged across EMs and DMs. The loadings in the data are only slightly lower for EMs (0.87) than for DMs (0.97) and the difference is not statistically significant, so we use the average for both calibrations.

We set real exchange rate volatility to the standard deviation of quarterly changes in the local currency-USD exchange rate, $\sigma_\varepsilon = 10.8\%$, after averaging exchange rate volatilities

[30]We use the series PCECC96 from FRED from the St. Louis Fed. We compute the standard deviation over our sample 2004-2015.

of 11 developed markets and 17 emerging markets in our sample with equal weights. We estimate very similar exchange rate volatilities for EMs (10.4%) and DMs (11.4%) and the difference is not statistically significant.

We set the loading of the real exchange rate onto US consumption to $\lambda^{\varepsilon,x^*} = 1.41$ to match the regression coefficient of quarterly log exchange rate changes onto log US real consumption growth, averaged across EMs and DMs. Because exchange rates are about seven times as volatile as US real consumption growth, this loading implies a correlation between the real exchange rate and US consumption growth of $Corr(\varepsilon_2, x_2^*) = \lambda^{\varepsilon,x^*} \times \frac{\sigma^*}{\sigma_\varepsilon} = 0.21$, in line with the real exchange rate-consumption correlation of 0.20 reported in Itskhoki and Mukhin (2019). Finally, we set the inflation cost parameter, α , equal across EMs and DMs and choose it to match the average inflation difference between EMs and DMs.[31]

4.2 Results

Table 6 compares calibrated model moments with the data. By construction, the model matches exactly the EM-DM difference in average inflation of 2.20%.[32]

The model also matches several moments that we did not target in our calibration. Most importantly, the model implies a similarly downward-sloping cross-country relation between LC bond-stock betas and LC debt shares as in the data. The model-implied EM LC debt share is 39%, compared to 55% in the data. The model-implied DM LC debt share is substantially higher at 91%, compared to 90% in the data. Moreover, the model implies that LC bond-stock betas are substantially higher in EMs than in DMs, with an EM-DM difference in LC bond-stock betas of 0.21 in the model, compared to 0.17 in the data. The model therefore succeeds in generating variation in bond-stock betas and LC debt shares across EM (no commitment) and DM (commitment) governments that is quantitatively similar to the variation observed in the data. The model implies that LC debt by EMs has a risk premium that is two percentage points higher than that of DMs. This substantial risk premium differential is entirely due to differences in the inflation risk premium, since

[31] With the ability to commit to future inflation, average model DM inflation is at its optimal level and independent of α. For this reason we cannot choose separate inflation cost parameters to separately match DM and EM average inflation rates. We show in Appendix B.7.4 that calibration moments are robust to a wide range of values for DM α.

[32] We think of the model implication that DM average inflation equals zero as empirically plausible, because zero represents the optimal inflation level in the model. Similarly, DM inflation appears close to optimal in the data, taking into account that in reality there are reasons to optimally target a small but positive inflation rate. One reason for a positive inflation target is if measured inflation tends to overstate true inflation due to quality improvements and index substitutions (Bernanke and Mishkin 1997). Other reasons are related to the risk of hitting the zero lower bound (Coibion et al. 2012). Because a positive optimal rate of inflation should lift both DM and EM inflation equally, our calibration targets the difference in EM and DM inflation.

Table 6: Empirical and Model Moments

	EM (no commitment)		DM (commitment)		EM-DM	
	Data	Model	Data	Model	Data	Model
Average Inflation	3.92%	2.20%	1.73%	0.00%	2.20%	2.20%
LC Bond-Stock Beta	0.07	0.16	-0.10	-0.05	0.17	0.21
LC Debt Share	0.55	0.39	0.90	0.91	-0.35	-0.52
LC Bond RP	3.15%	4.18%	1.53%	2.22%	1.62%	1.96%

Note: All moments are in annualized natural units. Model parameters for the EM and DM calibrations are given in Table 5. Model average inflation is the unconditional average of level inflation. The model bond-stock beta is computed according to Eqn. (B.10). The model LC bond risk premium in percent is computed according to Eqn. (39).

real exchange rate correlations with US consumption are equal for EMs and DMs. It also is similar to the risk premium differential of 1.62 percentage points in the data.

Modeling international lenders as risk averse is crucial for the model's ability to replicate the downward-sloping relationship between LC bond-stock betas and LC debt shares in the data. One way of seeing this is by considering an alternative calibration with international and domestic risk aversion set to conventional values from the real business cycle literature ($\gamma^* = 0, \gamma = 2$), while keeping all other parameters at the values listed in Table 5. Under this alternative calibration, the model implies a slightly higher bond-stock beta for DM (commitment) governments at 0.02 compared to a bond-stock beta for EM (no commitment) governments of 0.01.[33] With these conventional real business cycle model values for risk aversion, the model therefore replicates the standard intuition that countries with more LC debt should derive a higher domestic hedging value, as measured by the bond-stock beta, contradicting our empirical evidence. These results therefore illustrate how the combination of limited commitment and risk-averse lenders rationalizes the empirical findings.

We now turn to the channels generating these results. Figure 5 Panel A shows the LC bond-stock beta as an indicator of the optimal inflation policy for EM (no commitment) and DM (commitment) governments against international lender risk aversion on the x-axis. Because LC bond returns in the model are negatively related with inflation and stock returns are modeled as proportional to output news, a countercyclical inflation policy will show up as a positive LC bond-stock beta.[34] We see that model bond-stock betas for EMs are higher than for DMs, as long as international lender risk aversion is non-zero. This is consistent with the analytical results in Proposition 1, where we saw that a government without commitment chooses more counter-cyclical inflation than a government with commitment at a given LC

[33]We report the results of this alternative calibration in Appendix Table B.1.

[34]For details of the relationship between model LC bond-stock beta and inflation-output beta see Appendix B.2.

debt share. Here, the results are even stronger and directly speak to our main empirical findings: EM (no commitment) governments implement a more counter-cyclical inflation policy than DM (commitment) governments even though they have a lower LC debt share.

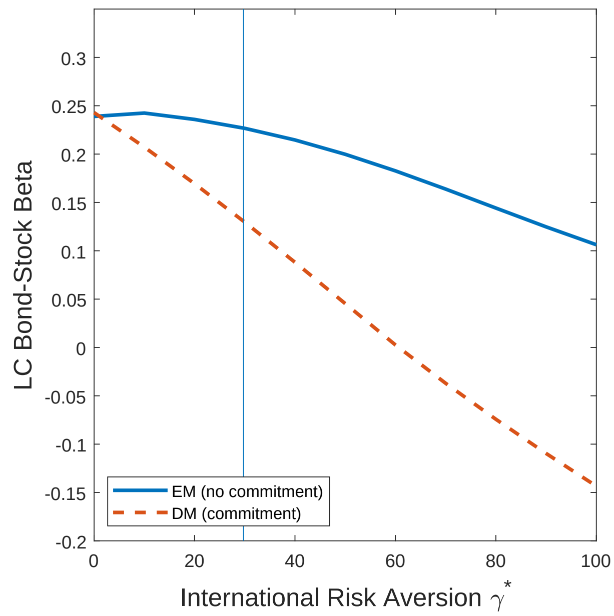
Figure 5 Panel B confirms the intuition from the analytical special case that EMs' lack of commitment leads them to optimally tilt towards FC debt. The risk premia charged by international lenders provide a quantitatively important incentive for EMs to use FC debt, as can be seen from the fact that the EM LC debt share is one when setting international lender risk aversion to zero.

Figure 5 shows that extremely high risk aversion is not necessary to generate a gap between EM and DM LC bond-stock betas. When we assume lenders to be unlevered (indicated with a vertical line at 29.74), the model generates a similarly downward-sloping relation between bond-stock betas and LC debt shares across EMs and DMs, but the overall level of bond-stock betas is higher. As lender risk aversion increases beyond domestic agent's risk aversion the gap between EM and DM LC bond-stock betas stabilizes because EMs constrain their incentive to generate counter-cyclical inflation by choosing a lower LC debt share.[35] Intuitively, as long as international lender risk-aversion is non-zero, this drives a wedge between the risk-sharing incentives of commitment and no-commitment governments, and hence their LC bond-stock betas.

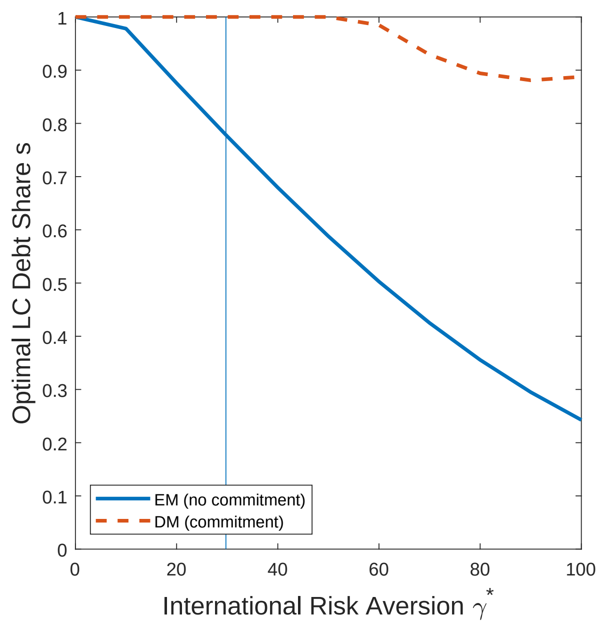
[35]DMs optimally choose a small share of FC debt, but the magnitude is negligible. This arises because international lenders require a risk premium on LC debt as compensation for the correlation between the real exchange rate and the international lenders' SDF.

Figure 5: Optimal Government Policy vs. International Lender Risk Aversion

(A) Model LC Bond-Stock Beta



(B) Model LC Debt Share



Note: This figure shows the model LC bond-stock beta and the LC debt share for the EM and DM calibrations. The solid blue lines indicate the EM calibration, while the dashed red lines indicate the DM calibration. Both panels vary the international lenders' coefficient of risk aversion, γ^*, along the x-axis while holding all other parameters constant at the values shown in Table 5. A vertical line indicates $\gamma^* = 29.74$ (i.e. equal lender and domestic risk aversion). Because LC bond returns in the model are negatively related with inflation and stock returns are modeled as proportional to output news, a government that optimally chooses a countercyclical optimal inflation policy will show up with a positive LC bond-stock beta. For details of the relationship between model LC bond-stock beta and inflation-output beta see Appendix B.2.

5 Conclusion

This paper provides new evidence that countries that borrow the least in their own currency are also the ones that seemingly have the most gain from doing so. We explain this new stylized fact with differences in monetary policy credibility, combined with lenders who require risk premia for holding assets that lose value during global downturns. Governments without monetary policy credibility cannot commit against using inflation to overinsure their domestic consumption ex post, so lenders charge a positive risk premium for holding local currency debt. This discourages governments from borrowing in local currency ex ante. Our simple framework demonstrates that including both risk premia and endogenous monetary policy can qualitatively change our assessment of what constitutes optimal government debt management.

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