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 issue relatively more foreign currency debt. We introduce two features into a government's debt portfolio choice problem to explain this finding: risk-averse lenders and varying degrees of inflation commitment. A government with imperfect commitment chooses an excessively counter-cyclical inflation policy function 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.

1 Introduction

How should a government borrow to finance its deficits? A long-standing literature argues that a government should borrow using instruments that allow it to smooth fluctuations in domestic consumption (for instance, Barro (1979); Bohn (1990a,b); Barro (2003); Lustig et al. (2008)). Borrowing in a country's own currency is thought to help achieve this desired state-contingency, as the government can vary inflation to generate a low real payout on this local currency (LC) debt in bad times.

In this paper, we demonstrate that countries for which LC debt has this desirable state-contingency actually rely on more foreign currency (FC) debt. We explain this puzzling relationship by adding two features to a debt portfolio choice model: risk-averse lenders and limited commitment. If international investors are risk-averse and global and domestic output are correlated, investors will require a risk premium for holding debt that pays off poorly in domestic downturns. If a government has limited commitment, it cannot commit to a state-contingent inflation policy function ex ante, and ex post uses countercyclical inflation to smooth its domestic consumption stream more than is optimal. As a result, lenders charge governments without commitment a sufficiently high risk premium on their LC debt that these borrowers choose FC debt.

We start by investigating empirically whether issuers of LC debt use that debt to smooth domestic consumption, as prescribed by standard theory of optimal government debt. We measure the hedging value to the domestic issuer of LC debt with the regression beta of LC bond excess returns on local stock market excess returns. We refer to this measure as the bond-stock beta. If LC bonds tend to fall in value at the same time as the local stock market, then the bond-stock beta will be positive. In that case, LC debt loses value exactly when a reduction in debt is most valuable to the issuing government, thereby insuring the issuer against economic downturns. Therefore, if governments issue LC debt to take advantage of the domestic 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, empirically we find an inverse relationship between the share of LC debt issued by a country and its 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.

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 debt

burden of LC debt is indeed state-contingent due to inflation variability, LC bond returns should move inversely with investors' 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 Consensus Economics' long-term inflation forecasts with respect to long-term output growth forecasts. 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 domestic issuer are also the riskiest for international investors. 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 investors 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 debt issuance and LC risk patterns documented in the data. We first present a simplified benchmark version of the model to demonstrate the main mechanism. 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, subject to its ability to commit to a future inflation policy. In the benchmark model, the government can choose the inflation-output beta but not average inflation, which is assumed to equal its ex ante optimal level of zero. We thereby emphasize that inflation state contingency is distinct from the tendency to generate higher-than-optimal average inflation, as in Barro and Gordon (1983) or Calvo (1978). Crucially, debt is priced by risk-averse lenders, whose stochastic discount factor (SDF) is assumed to be correlated with domestic output. When choosing the inflation policy function, a government with the ability to commit balances its desire to smooth consumption against the risk premium lenders will charge it for inflating more in bad times. However, a government that lacks commitment and operates under discretion, as in Kydland and Prescott (1977) and Rogoff (1985), will deviate from the ex ante optimal inflation policy. Such a government chooses its inflation policy ex post, taking as given the price of its debt and the currency composition of its debt portfolio.

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The benchmark model allows us to frame the government's problem as a mean-variance trade-off between the average level of domestic consumption, which decreases with the risk premium required by international investors, and domestic consumption volatility. Governments can lower domestic consumption volatility, but only at the cost of lowering the average level of consumption, because investors charge a risk premium on LC debt that tends to get inflated away during bad times. A government operating under discretion will prefer a more countercyclical inflation policy than a government with commitment, because it does not internalize that its countercyclical inflation policy generates a higher risk premium ex ante. If international investors are risk-averse, the model predicts that governments without commitment inflate away their LC debt in downturns relatively more than governments with commitment. As a result, governments without commitment find it relatively more attractive to issue FC debt, because doing so buys them commitment not to overinsure ex post.

Having illustrated the key mechanism, we add a number of realistic features to our model and demonstrate that this mechanism can quantitatively explain the empirical patterns. The full model allows for an inflationary bias, real exchange rate uncertainty, imperfect correlation between domestic and international investors' marginal utility, and investor leverage. We calibrate the model twice, once for emerging markets and once for developed markets. The key difference between these calibrations is that we assume zero inflation commitment for emerging markets and perfect inflation commitment for developed markets.

We trace out combinations of LC debt shares and bond-stock betas generated by different degrees of imperfect commitment and show that the resulting model-generated relationship between LC debt shares and bond-stock betas reproduces the relationship in the data. Importantly, in our model limited commitment alone (without risk premia) cannot generate the positive relationship between LC debt shares and inflation cyclicality. The intuition is that when international investors do not charge a risk premium for insuring domestic consumption risk, high-credibility issuers optimally minimize domestic consumption volatility by using inflation only in bad states of the world. In the absence of risk premia, countries with high LC debt shares therefore have slightly higher bond-stock betas, in contrast to the strongly downward-sloping relationship documented in the data. In our model, it is only the interaction of imperfect commitment and risk-averse lenders that can explain the empirical patterns.

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 issue state-contingent debt that lowers debt repayments in recessions (Barro, 1979; Lucas

and Stokey, 1983; Bohn, 1988, 1990b). This standard prescription makes it puzzling that, in the data, governments whose LC debt has these desirable hedging properties actually issue the lowest share of LC debt, and motivates our emphasis on the additional risk premium channel. The existing literature that features risk-averse investors 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 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.

This paper also contributes to the literature on "original sin" (Eichengreen and Hausmann 1999, 2005), the tendency of emerging market governments to borrow from international investors in foreign currency. Du and Schreger (2016b), Ottonello and Perez (2016), and Engel and Park (2018) examine the shift of emerging market governments towards borrowing in their own currency. The difference between our paper and the prior "original sin" literature is that this prior literature argues that a lack of commitment leads to inflation that is too high on average (Bohn, 1988; Calvo and Guidotti, 1993; Barro, 2003; Alfaro and Kanczuk, 2010; Díaz-Giménez et al., 2008). By contrast, our emphasis is on exploring how a lack of commitment leads to inflation that is excessively countercyclical. Because bond risk premia depend on cyclicality, and not on the average level of inflation, this previously neglected asset pricing channel is the core of our proposed mechanism.

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 returns with a priced factor, and, in particular, international investors' 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, 2017). 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 international government bond yields reflect the insurance value for investors, even though the source of comovement that we focus on – monetary policy credibility – is different.

Finally, we contribute to a recent literature on time-varying bond risks (Baele et al. 2010; David and Veronesi 2013; Campbell et al. 2017; Ermolov 2018; Campbell et al. 2018), which is primarily focused on the US and the UK. Different from those papers, we focus on cross-country patterns in bond-stock correlations.[2]

The structure of the paper is as follows: In Section 2, we present new stylized facts on the relationship between the cyclicality of LC bond risk and shares of LC debt in sovereign

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[2]Vegh and Vuletin (2012) and Poterba and Rotemberg (1990) also examine some cross-country patterns of inflation cyclicality, but do not link them to the currency composition of government debt.

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 now investigate empirically whether issuers of LC debt use that debt to smooth domestic consumption, as prescribed by standard theory of optimal government debt. In contrast with this intuition, we demonstrate robust empirical evidence that countries with the lowest LC debt shares also have the most pro-cyclical LC bond returns. In other words, the countries who issue the least LC debt have LC bonds that should offer the best consumption-smoothing benefits to the issuer.

2.1 Measuring Cyclicality of Nominal Risk and LC Debt Shares

We examine a cross-section of countries as permitted by the availability of long-term LC debt data, including 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).[3] 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.[4]

We use three approaches to measure the hedging value of LC bonds for local issuers. First, we use betas of LC bond returns with respect to the domestic stock market. Second, we estimate betas of two-year inflation forecasts with respect to two-year output forecasts. Third, we estimate betas of realized inflation with respect to industrial production. We will

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

[4]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.

show in Section 2.5 that these measures are highly correlated with the riskiness of LC bonds for global investors.

2.1.1 Cyclicality of LC Bond Returns: Bond-Stock Beta

Our primary proxy for the hedging value of LC bonds is the beta of LC bond returns with respect to local stock returns. We use the beta of LC bond returns with respect to the local stock market to capture the hedging benefit of LC debt for domestic consumption, as emphasized by Barro (1979). Intuitively, a positive LC bond beta indicates that the real expected value of debt repayments declines when local marginal utility is high, and LC bonds serve to reduce the volatility of domestic marginal utility of consumption. 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. 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 issuer. From the perspective of a global investor, 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 measured in USD.[5]

We denote the log annualized yield on a nominal LC n-quarter bond in country i at quarter t by $y_{i,n,t}^{LC}$. The quarterly log holding period return on the bond is given by:

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

where $\tau_{i,n,t}$ is the duration of the LC bond in years.[6] We let $y_{i,1,t}^{LC}$ denote the log annualized 3-month local T-bill yield that can be earned by holding the T-bill from time t to time $t+1$.

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[5]Since the price of the LC bond may increase or decrease at the end of the holding period, the international investor's dollar returns would be slightly different. We show in Appendix A.4.4 that bond-stock betas are nearly identical if instead we use the exact USD excess returns earned by an international investor with a long position in the bond (or stock) and a short position in the LC T-bill.

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

Then the log quarterly excess return on LC bonds over the short rate is given by:

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

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:

$$xr^{LC}_{i,n,t} = a_i + \beta(bond_i, stock_i) \times xr^m_{i,t} + \epsilon_{i,t}. \tag{1}$$

We estimate (1) using daily overlapping data for 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 issuer. The LC bond is a good hedge for the issuer if $\beta(bond_i, stock_i) > 0$ and a risky instrument for the issuer if $\beta(bond_i, stock_i) < 0$.

2.1.2 Cyclicality of Inflation Expectations: Inflation-Output Forecast 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 inflation onto output expectations. 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 construct a new measure for the procyclicality of inflation expectations. Our choice of variables is dictated by the availability of inflation and business cycle forecasts. 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:

$$\Delta\pi^{Survey}_{i,t} = a_i + \beta(\pi^{Survey}_i, gdp^{Survey}_i) \times \Delta gdp^{Survey}_{i,t} + \epsilon_{i,t}, \tag{2}$$

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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.

2.1.3   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:[7]

$$\Delta\pi_{i,t} = a_i + \beta(\pi_i, IP_i)\Delta IP_{i,t} + \epsilon_t, \tag{3}$$

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 (3) 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.

2.2   Local Currency Debt Shares

In this section, we discuss how we measure the LC debt share. In practice, governments have direct control over the LC debt share in total debt outstanding but not the division between the share owned by foreign and domestic investors.[8] However, in a model with Ricardian equivalence for domestic tax payers, it is only the LC debt share in debt held by international investors that should drive the government's inflation decision. We show that the empirical

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[7]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.

[8]This statement assumes the government is not pursuing policies, such as capital controls, to directly affect this share.

relationship between the hedging property of the LC debt and the LC debt shares is robust to using the LC debt share in total government debt and three different measures of the LC debt share in externally held debt.

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.[9]

For emerging markets, we measure the share of LC debt in total government debt using the BIS Debt Securities Statistics, 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 international sovereign debt 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 owned by US investors 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.

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[9]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. (2018).[10] The advantage of this data is that it includes not only US mutual funds, but also those from the euro zone, 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. (2018) 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.[11] 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.

2.3 Summary Statistics

Table 1 reports summary statistics. Emerging market realized inflation is 2.2 percentage points higher than in developed markets, and survey-based expected inflation is 1.8 percentage points higher in emerging markets than in developed markets. In addition, expected inflation and realized inflation are more countercyclical in emerging markets than in developed countries.

For LC bonds, five-year LC yields are 3.4 percentage points higher in emerging markets than in developed markets. LC bond returns are countercyclical in developed markets, as is evident from the negative LC bond-local stock betas, $\beta(bond_i, stock_i)$, estimated from the one-factor model in equation (1). LC bond-local stock betas are positive for emerging markets and are negative for developed markets. In addition, we note that the regression beta of local stock excess returns on US stock returns is close to 1 for both developed and emerging markets.[12]

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[10]We obtain these measures of external debt at the end of 2015 from Appendix Table A.1 of Maggiori et al. (2018).

[11]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.

[12]In Appendix A.3, we provide summary statistics for the t-statistics of these regression betas.

Table 2 reports 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. (2018), and the BIS Locational Banking Statistics. We see that developed market governments borrow almost completely in LC, but emerging markets' LC debt shares are only 60% of total debt and 55% of external debt data from TIC. 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. (2018) are nearly identical in 2015.

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

	(1) π	(2) π^{Survey}	(3) y^{LC}	(4) $\beta(\pi_i^{Survey}, gdp_i^{Survey})$	(5) $\beta(\pi, IP)$	(6) $\beta(bond_i, stock_i)$	(7) $\beta(stock_i, stock_{US})$
(A) Developed Markets ($N = 11$)							
Mean	1.73	1.83	2.71	0.37	0.05	-0.10	0.95
S.d.	0.83	0.64	1.26	0.13	0.06	0.04	0.21
Max	2.71	2.68	4.96	0.56	0.15	-0.03	1.38
Min	0.21	0.32	0.63	0.24	-0.04	-0.19	0.60
(B) Emerging Markets ($N = 17$)							
Mean	3.92	3.65	6.15	0.17	-0.04	0.07	0.98
S.d.	1.72	1.40	2.98	0.25	0.13	0.13	0.24
Max	8.00	6.82	12.33	0.81	0.06	0.32	1.41
Min	2.13	2.06	1.67	-0.25	-0.50	-0.07	0.58
(C) Full Sample ($N = 28$)							
Mean	3.06	2.93	4.80	0.25	0.00	0.00	0.97
S.d.	1.79	1.46	2.96	0.24	0.11	0.13	0.22
Max	8.00	6.82	12.33	0.81	0.15	0.32	1.41
Min	0.21	0.32	0.63	-0.25	-0.50	-0.19	0.58
(D) Mean Difference between Emerging and Developed Markets							
Mean Diff.	-2.20***	-1.82***	-3.44***	0.20**	0.09**	-0.17***	-0.03
	(0.49)	(0.39)	(0.82)	(0.08)	(0.04)	(0.03)	(0.09)

Note: This table reports summary statistics for the cross-sectional mean of 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) $\beta(\pi_i^{Survey}, gdp_i^{Survey})$, inflation-output forecast beta, (5) $\beta(\pi, IP)$, realized inflation-output beta, (6) $\beta(bond_i, stock_i)$, LC bond-local stock beta, and (7) $\beta(stock_i, stock_{US})$, local stock-US stock return beta. The last four variables are defined in equations (1) through (4). 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.

Table 2: Summary Statistics for Total and External Debt Shares

Measure	(1) s^{TOT}	(2) s^{TIC}	(3) s^{MNS}	(4) s^{BIS}
Years	2005-2014	2007-2014	2015	2014-2017
(A) Developed Markets				
Mean	89.16	89.73	87.85	69.58
S.d.	11.33	14.04	12.59	35.48
Max	100.00	100.00	99.75	99.89
Min	65.91	55.92	65.79	8.79
(B) Emerging Markets				
Mean	61.17	54.56	63.96	45.42
S.d.	25.52	28.81	26.83	30.34
Max	100.00	100.00	99.40	99.85
Min	11.97	7.57	20.32	8.26
(C) Full Sample				
Mean	72.16	68.37	73.35	54.91
S.d.	25.04	29.51	25.03	34.00
Max	100.00	100.00	99.75	99.89
Min	11.97	7.57	20.32	8.26
(D) Mean Difference between Emerging and Developed Markets				
Mean Diff.	28.00***	35.17***	23.89***	24.16*
	(7.09)	(8.19)	(7.55)	(12.92)

Note: This table reports summary statistics for the cross-sectional mean of four variables for developed and emerging market groups. The variables include (1) s^{TOT}, percentage share of LC debt in total sovereign debt portfolios for the period 2005-2014, (2) s^{TIC}, percentage share of LC debt in US holdings of sovereign debt, 2007-2014, (3) s^{MNS}, percentage share of LC debt in foreign mutual fund holdings of sovereign debt in 2015 from Maggiori et al. (2018), (4) 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 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 data 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 issuer hedge

domestic shocks. Even more puzzlingly, a substantial fraction of the most prolific LC debt issuers, including both developed and emerging markets, have negative bond-stock betas, so LC debt provides no or even negative marginal utility smoothing benefits to these issuers.

Table 3 examines this relationship more formally and presents cross-sectional regressions of the total LC debt share on measures of LC bond and inflation cyclicality. All specifications control for the beta of the local stock market on the US stock market in order to ensure that the results are not driven by differential exposures of countries' equity markets to the US equity market. The first column shows that a 0.17 increase in the bond-stock beta, corresponding to the average difference between emerging and developed markets, is associated with a 20 percentage point reduction in the LC debt share and this relation is statistically significant at the 1% level. Columns (2) and (3) show that LC debt shares decrease with expected and realized inflation-output betas, as one would expect if LC bonds fall with inflation and stocks rise with output. Column (4) shows that the baseline relation is robust to controlling for mean log GDP per capita, the exchange rate regime, and the share of commodities in total exports.[13]

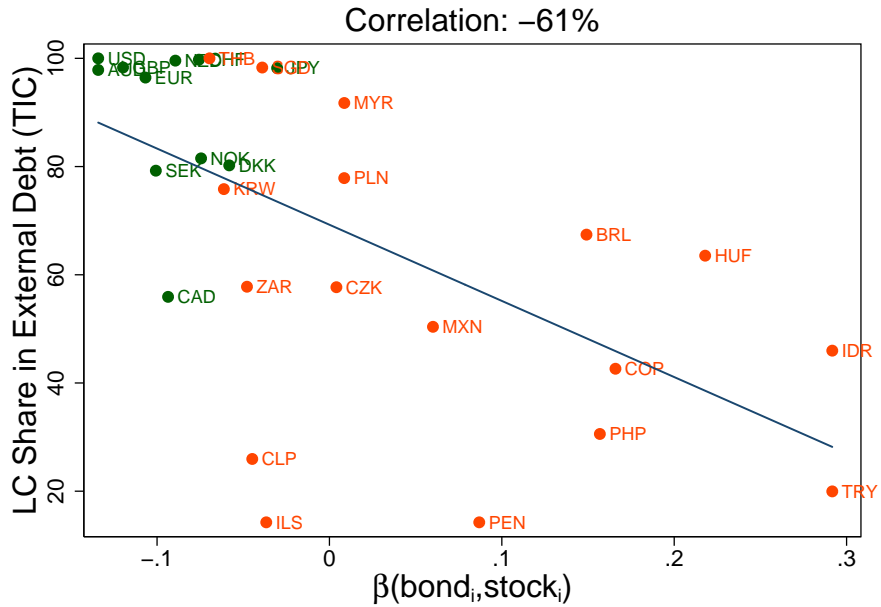[13]We use the exchange rate regime developed by Reinhart and Rogoff (2004) and the commodity share is defined as the sum of "Ores and Metals" and "Fuel" exports as a percentage of total merchandise exports from World Bank World Development Indicators.

Figure 1: Local Currency Debt Shares and Bond Betas

(A) Total Government Debt
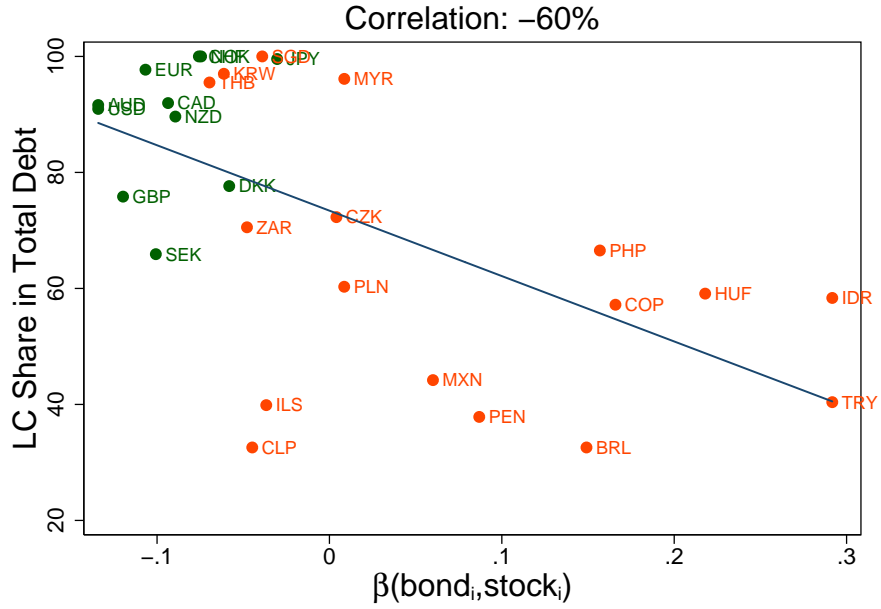
(B) External Government Debt

Note: Panel (A) shows the share of LC debt as a fraction of total central government debt (in %) over the period 2005-2014 vs. the baseline LC bond-local stock beta. Panel (B) shows the share of LC debt in US investors' holdings of government debt from the TIC data over the period 2007-2014 vs. the bond-stock beta. For each country, the 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:

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

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

Table 3: LC Debt Shares in Total Government Debt onto LC Bond Cyclicality

Local Currency Debt Share	(1) s^{TOT}	(2) s^{TOT}	(3) s^{TOT}	(4) s^{TOT}
$\beta(bond_i, stock_i)$	-116.9***			-95.31**
	(22.12)			(36.40)
$\beta(\pi_i^{Survey}, gdp_i^{Survey})$		87.48***		
		(17.44)		
$\beta(\pi, IP)$			138.7**	
			(55.75)	
$\beta(stock_i, stock_{US})$	8.787	10.35	-9.884	4.362
	(20.03)	(23.38)	(25.13)	(20.04)
log(GDP)				2.819
				(4.425)
FX Regime				0.373
				(3.647)
Commodity Share				-0.180
				(0.214)
Constant	64.93***	38.77	80.77***	45.03
	(20.54)	(24.81)	(24.36)	(48.72)
Observations	28	22	28	28
R-squared	0.368	0.444	0.117	0.407

Note: This table shows the cross-country regression results of the LC debt share in total central government debt, s^{TOT} (between 0 and 1), on measures of bond return and inflation cyclicality. The independent variables in the first three columns are the bond-stock beta $\beta(bond_i, stock_i)$, the inflation forecast beta $\beta(\pi_i^{Survey}, gdp_i^{Survey})$, the realized inflation-output beta $\beta(\pi_i, IP_i)$, and the local stock-US stock beta $\beta(stock_i, stock_{US})$, as described in Table 1. In column (4), we control for average log per capita GDP between 2005 and 2014, the average exchange rate classification from Reinhart and Rogoff (2004), and the commodity share of exports. 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. The top and bottom observations are winsorized. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

In Table 4, 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 bond-stock beta is quantitatively unchanged compared to Table 3 and highly statistically significant. These results provide a bridge to the theoretical framework, where we focus on the government borrowing from external creditors.

Table 4: LC Debt Shares in External Debt onto LC Bond Cyclicality

Local Currency Debt Share	(1) s^{TIC}	(2) s^{MNS}	(3) s^{BIS}	(4) s^{TIC}	(5) s^{MNS}	(6) s^{BIS}
$\beta(bond_i, stock_i)$	-143.6***	-110.1***	-123.5***	-107.1*	-104.2**	-146.4**
	(25.25)	(23.47)	(33.58)	(55.14)	(37.78)	(58.51)
$\beta(stock_i, stock_{US})$	6.010	6.267	-10.06	-0.964	6.382	-7.432
	(24.18)	(22.67)	(26.56)	(21.15)	(22.16)	(29.40)
log(GDP)				4.720	0.571	-3.757
				(6.066)	(4.513)	(7.881)
FX Regime				2.378	5.291	-0.172
				(4.086)	(4.180)	(7.831)
Commodity Share				-0.356	-0.247	-0.343
				(0.237)	(0.232)	(0.299)
Constant	63.45**	67.88***	65.20**	25.79	52.25	106.8
	(24.22)	(22.53)	(27.25)	(58.98)	(51.00)	(70.17)
Observations	28	28	28	28	28	28
R-squared	0.370	0.296	0.227	0.464	0.358	0.270

Note: This table shows the cross-country regression results of the LC debt share, s (between 0 and 1), based on external debt (debt held by non-residents) on bond return cyclicality. In columns (1) and (4), the dependent variable s^{TIC} denotes the share of LC debt in US investors' portfolio holdings of government debt from TIC data. In columns (2) and (5), the dependent variable s^{MNS} denotes the LC debt share in cross-border mutual fund portfolio holdings of government debt from Morningstar. In columns (3) and (6), the dependent variable s^{BIS} denotes the LC debt share in government debt reported by BIS reporting banks from the BIS Locational Banking Statistics. The independent variables in the first three columns are the bond-stock beta $b(bond_i, stock_i)$ and the local stock-US stock beta $b(stock_i, stock_{US})$, as described in Table 1. In column (4) through (6), we control for average log per capita GDP between 2005 and 2014, the average exchange rate classification from Reinhart and Rogoff (2004), and the commodity share of exports. 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. The top and bottom observations are winsorized. Robust standard errors are used in all regressions with the significance level indicated by *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Finding consistent cross-country patterns based on both asset returns and macroeconomic data is particularly noteworthy because of the potentially substantial wedges between asset returns and macroeconomic aggregates. These consistent results across asset price based and macroeconomic cyclicality measures, therefore, provide important motivation for our model, suggesting that macroeconomic drivers are at the source of LC bond risks and returns across countries.

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, adjusting for default risk, adjusting for the FX hedging error, using alternative inflation cyclicality measures, and weighting by per capita GDP. 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. We also show the relationship between LC debt and LC bond-stock betas holds for the LC Debt/GDP ratio, rather than the LC debt share. 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.

2.5 LC Bond Return Comovement with US Stock Returns

We next show empirically that the LC bonds with the best hedging value for the domestic government are risky for international investors. In this analysis, we proxy for domestic agents' marginal consumption utility with the local log excess stock return and for international investors' stochastic discount factor with the US log excess stock return. We decompose the local log excess stock return into a global and an idiosyncratic component according to:

$$xr_{i,t}^m = a_i + \beta(stock_i, stock_{US}) \times xr_{US,t}^m + xr_{i,t}^{idio}. \tag{4}$$

Here, we define the systematic global component of local stock returns as the fitted value of equation (4):

$$xr_{i,t}^G = \beta(stock_i, stock_{US}) \times xr_{US,t}^m.$$

It is conceivable that LC bond returns co-move with domestic stock returns only through the idiosyncratic component, $xr_{i,t}^{idio}$, that is orthogonal to US stock returns. In this case, LC bonds would have zero covariance with US stock returns and present no systematic risk to international investors.

We show in two ways that the LC bonds with the best hedging benefit for the domestic issuer are indeed risky for international investors. First, we directly estimate the beta of LC bond returns with respect to US stock returns from a regression:

$$xr_{i,n,t}^{LC} = a_i + \beta(bond_i, stock_{US}) \times xr_{US,t}^m + \epsilon_{i,t}. \tag{5}$$

Panel (A) of Figure 2 shows that $\beta(bond_i, stock_{US})$ is highly correlated with our baseline measure of bonds' hedging value for the domestic issuer, $\beta(bond_i, stock_i)$, estimated in equation (1). The cross-country correlation of these two different bond betas equals 93%, clearly supporting a link between the domestic issuer's hedging value and international investors' risk of holding LC bonds.

Second, we estimate LC bond excess return loadings on the systematic global component

of domestic stock returns using the regression:
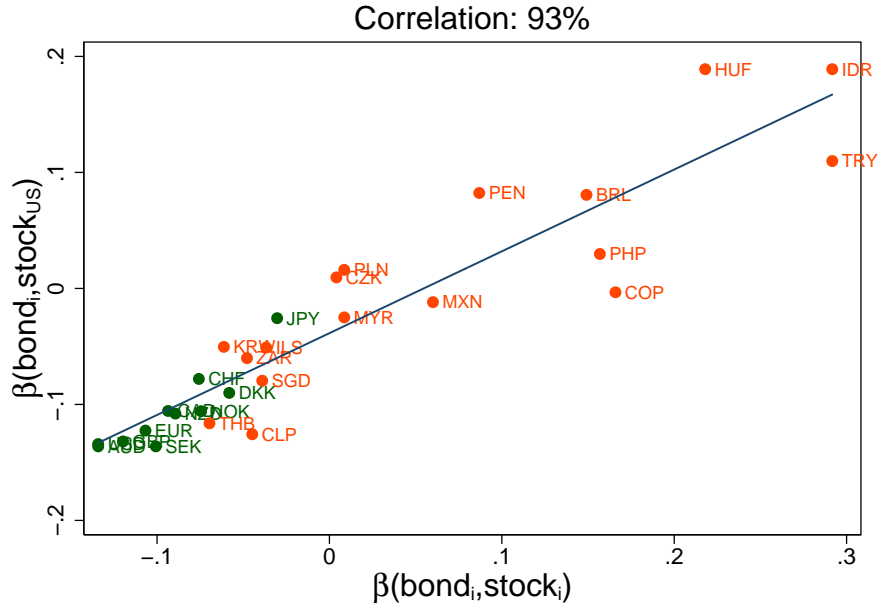
$$xr_{i,n,t}^{LC} = a_i + \beta(bond_i, stock_{i,US}^G) \times xr_{i,t}^G + \epsilon_{i,t}. \tag{6}$$

Panel (B) of Figure 2 shows that $\beta(bond_i, stock_{i,US}^G)$ is 90% correlated with our baseline measure of bonds' hedging value for the domestic issuer $\beta(bond_i, stock_i)$. In other words, LC bond returns co-move with the global component of local LC stock returns.

Figure 2: Local and Global Risks of LC Bonds

(A) Beta onto US Stock Returns

Correlation: 93%

(B) Beta onto Global Component of Local Stock Returns

Correlation: 90%
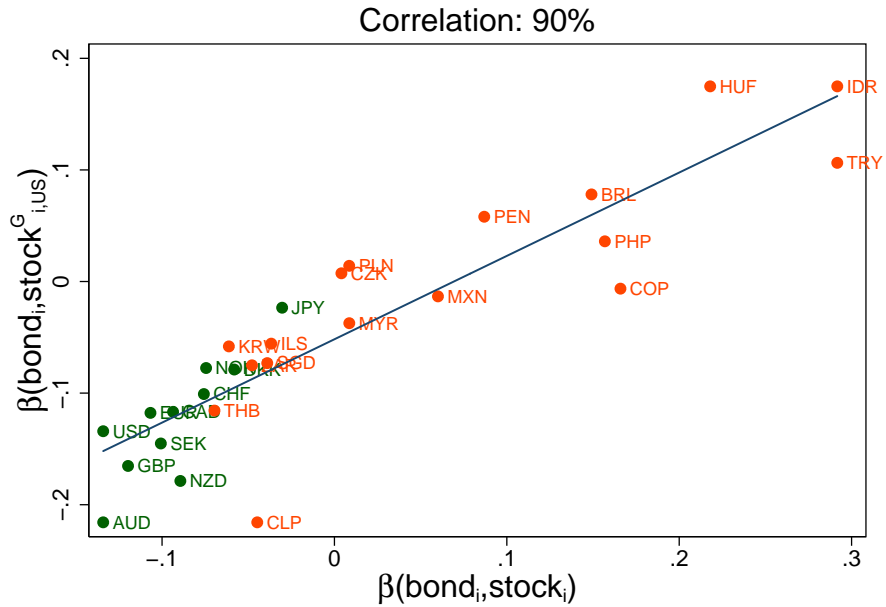
Note: Panel (A) plots on the y-axis the regression beta of LC bond excess returns on US S&P stock excess returns, $\beta(bond_i, stock_{US})$, estimated from equation (5). Panel (B) plots on the y-axis the regression beta of LC bond excess returns on the global component of local LC bond returns, $\beta(bond_i, stock^G_{i,US})$, estimated from equation (6). Our baseline one-factor bond-stock beta with respect to the local stock market, estimated from equation (1), is shown on the x-axis in both panels. The bivariate correlation across countries is shown in the figure title.

2.6 Bond Risk Premia and Monetary Policy Credibility

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

First, we calculate the risk premium on the LC bond in country i as follows,

$$\overline{RP}_{i,n} = \bar{y}_{i,n}^{LC} - \bar{\pi}_i^{Survey} - \left(\overline{y}_{US,1} - \overline{\pi}_{US}^{Survey} \right), \tag{7}$$

where a bar indicates the mean from 2005 to 2014.[14] This formulation is effectively imputing the risk premium as the difference between currency-specific real interest rates. Panel (A) of Figure 3 shows that the bond-US stock beta, $\beta(bond_i, stock_{US})$, is 64% correlated with the LC bond risk premium. Therefore, the international investor requires a higher risk premium for holding LC bonds if LC bond returns are more pro-cyclical. In Appendix A.5.2, 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).

In addition, we provide evidence for a link between the bond-stock beta and a 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 inflation credibility.[15] 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. This de facto monetary policy credibility measure is strongly correlated with the bond-stock beta, with the correlation equal to 71%.

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[14]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.

[15]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).

Figure 3: LC Bond Betas, Bond Risk Premia and Monetary Policy Credibility

(A) Bond-Stock Beta vs. LC Bond Risk Premium

(B) Bond-Stock Beta vs. De Facto Monetary Policy Credibility
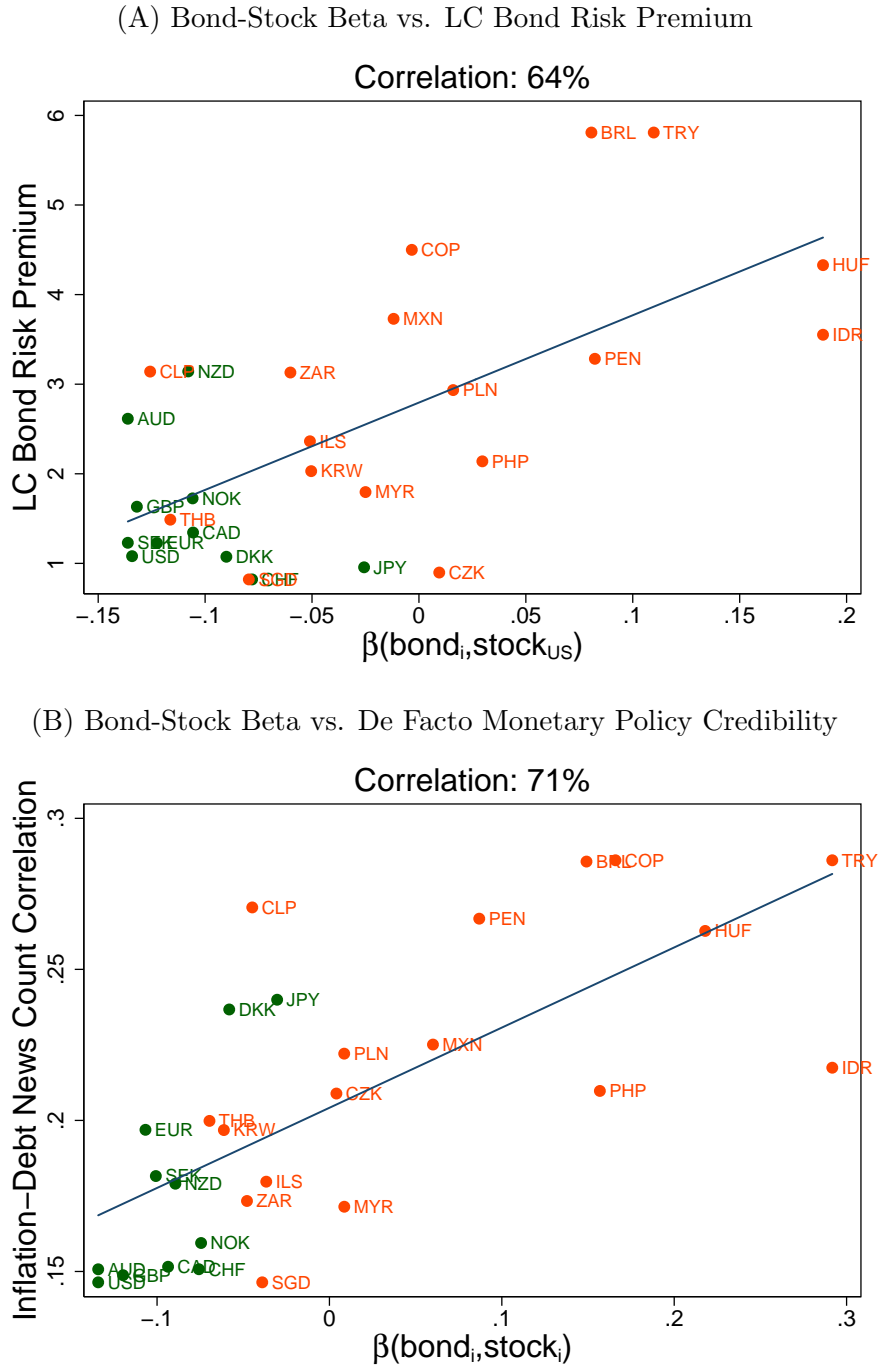
Note: Panel (A) plots the average risk premium on LC bonds against the LC bond-US stock beta. LC bond risk premia are estimated according to equation (7). Panel (B) plots the correlation of the keywords "debt" and "inflation" in *Financial Times* articles from 1996–2015 from ProQuest Historical Newspapers against the LC bond-local stock beta.

3 Benchmark Model

This section describes a two-period model of a small open economy borrowing from international lenders. The key difference between governments is their exogenous ability to commit to an inflation policy. We begin with a simplified version of the model, before extending and calibrating the model in Section 4. Throughout, we use a superscript $*$ to denote quantities for the international investors. Unless otherwise specified, lower-case variable names denote logs of the corresponding upper-case variables.

3.1 Government, Households, and Investors

The problem of the domestic government is to maximize expected domestic utility from household consumption. The government has two choice variables: the currency composition of its debt and the inflation policy. Domestic households consume domestic goods and have power utility with CRRA γ over domestic real consumption in the second period, C_2:

$$U(C_2) = \frac{C_2^{1-\gamma}}{1-\gamma}. \tag{8}$$

In the first period, the government needs to borrow $\bar{D}/R^*$ units of real goods from international investors, where R^* denotes the global foreign currency risk-free rate and $\bar{D}$ is the government's exogenous borrowing need. We do not explicitly model the use of debt, which can be thought of as rolling over existing debt or financing government purchases. This government debt position is the only channel to transfer real resources between domestic agents and international investors in the model. The real exchange rate between the domestic and international economies is assumed to be constant at one, so we can treat domestic and international investors as consuming the same good.

The government issues face values D^{LC} and D^{FC} of LC and FC debt with prices Q^{LC} and Q^{FC} to satisfy the borrowing requirement:

$$Q^{LC}D^{LC} + Q^{FC}D^{FC} = \frac{\bar{D}}{R^*}. \tag{9}$$

Equivalently, the government chooses the share of LC debt s, with debt face values given by $D^{LC} = \frac{\bar{D}/R^*}{Q^{LC}}s$ and $D^{FC} = \frac{\bar{D}/R^*}{Q^{FC}}(1-s)$. In the benchmark model, we assume that the government will borrow either entirely using LC debt or entirely using FC debt, i.e. $s \in \{0,1\}$, a restriction that will be relaxed in Section 4.

The only exogenous shock in the benchmark model is domestic real output in the second

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

$$X_2 = \bar{X} exp\left(x_2/\bar{X}\right), \; x_2 \sim N\left(0, \sigma_x^2\right), \; \bar{X} = 1 + \bar{D}. \tag{10}$$

The normalization by $\bar{X}$ ensures C_2 is centered around one when the government borrows entirely in FC. Due to this normalization the lower-case variable x_2 is only approximately equal to $log\left(X_2\right)$, up to a first-order approximation. We nonetheless refer to x_2 as "log output" for conciseness.

The government has access to lump-sum taxation. Real domestic consumption is endogenous and equals domestic real output less real domestic goods used to repay debt:[16]

$$C_2\left(X_2\right) = X_2 - D_2\left(X_2\right). \tag{11}$$

The amount of real domestic goods required to repay the combined debt portfolio of LC and FC debt in period 2 is determined by the government's inflation and debt policies:

$$D_2\left(X_2\right) = D^{LC} exp\left(-\pi_2\left(X_2\right)\right) + D^{FC}. \tag{12}$$

The difference between local currency and foreign currency debt can be seen in the above expression: because the government controls the inflation rate, it can reduce the real debt payments on its LC debt by raising the inflation rate π_2. By contrast, the real payoff on FC debt is constant and outside the control of the government. Assuming that international inflation is zero, an LC bond pays off $exp(-\pi_2)$ units and an FC bond pays off one unit of real consumption to the international owners of the bonds in period 2.

The government borrows from international investors and debt is priced by international investors' first order conditions. We assume international investors have time-separable CRRA preferences with risk aversion γ^* and time discount rate δ^* over their own real consumption C_t^*:

$$U^*\left(C_1^*, C_2^*\right) = E\sum_{t=1}^{2}\left(\delta^*\right)^t \frac{\left(C_t^*\right)^{1-\gamma^*}}{1-\gamma^*}. \tag{13}$$

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[16]We abstract from sovereign default for tractability. Under the assumption of simultaneous default, which Du and Schreger (2016a) and Jeanneret and Souissi (2016) show is empirically plausible, LC debt and FC debt bear the same default risk premium. Since our goal is to understand the trade-offs between LC and FC debt, we focus on modeling the dimensions along which LC and FC differ, as opposed to those where they are similar. For an analysis of the choice of the currency denomination of sovereign debt with strategic default, see Engel and Park (2018). Incorporating international trade in the goods market is also beyond the scope of this paper. We expect that the downward-sloping relation between real domestic consumption and the domestic government's real liabilities would be preserved if domestic households consumed multiple goods.

International investors' first order conditions over bond holdings then imply standard asset pricing Euler equations. Specifically, bond prices must equal real bond payoffs times the international investors' stochastic discount factor (SDF) M_2^*:

$$Q^{LC} = E\left[M_2^* exp\left(-\pi_2\left(X_2\right)\right)\right], \tag{14}$$

$$Q^{FC} = 1/R^* = E\left[M_2^*\right], \tag{15}$$

The SDF, M_2^*, equals $\frac{dU^*/dC_2^*}{dU^*/dC_1^*}$, i.e. international investors' discounted marginal utility from one unit of real consumption in period 2 divided by their marginal utility of consumption in period 1. We assume that in period 1 international investors are exogenously provided with one unit and in period 2 with $X_2^* = exp(x_2^*)$ units of real consumption goods. Because the domestic economy is assumed to be small, international investors' bond holdings are negligible in equilibrium and international consumption equals the international endowment in equilibrium, so $C_1^* = 1$ and $C_2^* = exp(x_2^*)$. We can then write the SDF as:

$$M_2^* = \delta^* exp\left(-\gamma^* x_2^*\right). \tag{16}$$

In the benchmark model, we assume that domestic and foreign output are perfectly correlated, $x_2^* = x_2$. This assumption will be relaxed in Section 4. The international investors' SDF is hence exogenous to the government's inflation and debt portfolio policy. However, equation (14) makes clear that LC bond prices are endogenous to the government's inflation policy.

We consider two types of governments: those with commitment and those without commitment. A government with commitment is able to set its inflation policy function $\pi_2\left(X_2\right)$ in period 1 before its debt is priced and sold to international investors. Governments without commitment will decide their inflation policy function $\pi_2\left(X_2\right)$ in the second period, after the debt has been priced and sold. Exogenous differences in commitment between governments will drive endogenous differences in both inflation cyclicality and the currency composition of debt.

The government's problem is to choose the debt share s and the inflation policy function $\pi_2\left(X_2\right)$ to maximize expected domestic welfare (8), subject to the borrowing requirement (9), domestic consumption (11), and the bond pricing conditions (14 and 15). In the benchmark model, average expected inflation is restricted to be equal to zero. Governments with commitment will choose the debt share s and the inflation policy function $\pi_2\left(X_2\right)$ jointly in period 1. Governments without commitment will choose their inflation policy function $\pi_2\left(X_2\right)$ in period 2, taking the previously chosen debt s and bond prices as given.

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3.2 Analytical Solution

We now present an analytical solution that illustrates the model mechanism before proceeding to the numerical solution. An exact analytical solution is not available, because the model combines equations that are linear in logs with equations that are linear in levels. In the spirit of Kydland and Prescott (1982) and Campbell (1994), we therefore take a log-quadratic Taylor expansion of the consumption budget constraint (11) and domestic consumer welfare (8) around the steady-state with all-FC debt and solve this approximate problem analytically. See Appendix B for solution details.

3.2.1 LC Bond Prices

The benchmark model's simple correlation structure of shocks leads to intuitive expressions for bond prices. Substituting in the SDF (16) and using that x_2 and π_2 are jointly normal gives LC and FC bond prices:

$$Q^{LC} = \frac{1}{R^*} exp\left(-E\pi_2 + \frac{1}{2}Var\pi_2 + \gamma^* Cov\left(x_2, \pi_2\right)\right), \tag{17}$$

$$Q^{FC} = 1/R^* = \delta^* exp\left(\frac{1}{2}\left(\gamma^* \sigma^*\right)^2\right), \tag{18}$$

where expected mean inflation, expected inflation variance, and the expected covariance between output and inflation are all the rational expectations of the international investors at the time the debt is issued.

Taking logs, the LC bond risk premium equals the log expected real LC bond return in excess of the log global foreign currency interest rate:

$$RP^{LC} = \log E\frac{exp\left(-\pi_2\right)}{Q^{LC}} - r^* = -\gamma^* Cov\left(x_2, \pi_2\right). \tag{19}$$

The expression for LC bond prices (17) illustrates two key channels. First, expected inflation drives down LC bond valuations one-for-one. A government with higher expected inflation therefore needs to issue a higher face value of LC debt to raise the same revenue. Because of this pricing channel, it is impossible for the domestic government to lower real debt repayments through higher expected inflation.

Second, risk premia can lower or raise the government's expected real debt repayments. If the domestic government is expected to inflate during low output states ($Cov\left(x_2, \pi_2\right) < 0$), this drives down international investors' valuations of LC bonds. International lenders will expect to be compensated through higher expected LC bond returns if they anticipate that

LC debt will be inflated away in states of the world when their own marginal utility of consumption is high. As a result, the government has to pay international investors higher real – not just nominal – expected excess returns for holding LC bonds. This is the cost of inflation cyclicality that will drive the equilibrium relationship between LC debt shares and the state-contingency of LC debt.

Having characterized how debt is priced conditional on the inflation policy function, we now turn to the government's optimal inflation policy and debt portfolio.

3.2.2 Mean-Variance Problem

We use log-quadratic expansions to express the government's objective function in terms of actual and expected real domestic consumption volatility. All derivations are contained in Appendix B.3.

With a log-quadratic approximation of welfare, we can now express the government's choice of state contingent inflation, $\pi(x_2)$, in terms of a log-linear policy rule. In the benchmark model, we assume that mean log inflation is zero for both types of governments. We make this assumption to separate our new risk premium channel from the much-studied mean inflationary bias that arises from a lack of commitment, such as in Barro and Gordon (1983) and Calvo (1978). The government's inflation policy choice then reduces to choosing the inflation-output beta, b, such that period 2 log inflation equals:

$$\pi_2 \;=\; bx_2. \tag{20}$$

A procyclical inflation policy ($b > 0$) inflates away debt obligations when output is already high, so the volatility of domestic real consumption increases with the inflation-output beta b chosen by the government:

$$\sigma_c \approx \left(1 + b \times s \times \bar{D}\right)\sigma_x. \tag{21}$$

A superscript e will be used to denote the expectation of lenders at the time debt is issued, so b^e is the inflation policy anticipated by investors at the time of debt issuance. The notation is convenient for highlighting issues of time-consistency. In equilibrium, expectations will be rational.

Real domestic consumption decreases one-for-one with the real domestic resources used to repay debt, and hence with the LC bond risk premium:

$$E\left[C_2\right] \approx -RP^{LC} \times s \times \bar{D}. \tag{22}$$

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The expression (22) omits policy-independent terms. Substituting the inflation-output beta anticipated by investors, b^e, into the expression for the LC bond risk premium (19) gives:

$$E[C_2] \approx \gamma^* b^e \sigma_x^2 \times s \times \bar{D}. \tag{23}$$

Combining the expressions for mean consumption (23) and the volatility of consumption (21), the government's problem conditional on borrowing in LC, can be written as

$$W_{LC} = \max_b \left\{ \underbrace{\gamma^* b^e \sigma_x^2 \times s \times \bar{D}}_{\text{Mean Consumption}} - \frac{\gamma}{2} \underbrace{\left(1 + b \times s \times \bar{D}\right)^2 \sigma_x^2}_{\text{Consumption Variance}} \right\}. \tag{24}$$

The only difference in the maximization problem of governments with and without commitment is in how the two types of governments treat lenders' expectations of the inflation-output beta, b^e. By the time a government without commitment chooses its inflation-output beta b in period 2, investors' expectations of the policy, b^e, are already fixed. A no-commitment government therefore chooses b while treating b^e as given. By contrast, the government with commitment chooses b and b^e simultaneously before issuing debt in period 1, subject to the restriction that $b^e = b$.[17]

To provide intuition for the trade-off between the mean and volatility of consumption, we can use equation (21) to substitute for the inflation-output beta b with consumption volatility σ_c. This shows that the problem in equation (24) is equivalent to:

$$W_{LC} = \max_{\sigma_c} \left\{ \underbrace{\gamma^* \left(\sigma_c^e \sigma_x - \sigma_x^2\right)}_{\text{Mean Consumption}} - \underbrace{\frac{\gamma}{2} \sigma_c^2}_{\text{Consumption Variance}} \right\} \tag{25}$$

Here, σ_c^e denotes lenders' expectations of consumption volatility at the time debt is sold and is obtained by substituting b^e into equation (21). Once again, the no-commitment government views investors expectations, σ_c^e, as a fixed parameter when choosing its policy, whereas the government with commitment internalizes that it chooses σ_c^e and σ_c simultaneously, subject to the restriction that $\sigma_c^e = \sigma_c$. The representation (25) demonstrates that the cost of smoothing consumption ($\sigma_c < \sigma_x$) through state-contingent LC debt is costly because it lowers mean consumption, if investors are risk-averse.

For the no-commitment government, we take the first-order condition of equation (25)

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[17]Our formulation for the expected inflation-output beta, b^e, is deliberately designed to mirror the notation for expected mean inflation in Barro and Gordon (1983).

treating σ_c^e as a constant. For the commitment government, we take the first-order condition of equation (25) subject to $\sigma_c^e = \sigma_c$. This allows us to characterize the inflation-policy function and consumption volatility for both types of governments.

No-Commitment

Conditional on borrowing in LC, the government without commitment optimally chooses consumption volatility $\sigma_c = 0$ by implementing the inflation-output beta $b = -\dfrac{1}{\bar{\bar{D}}}$.

Commitment

Conditional on borrowing in LC, the commitment government optimally chooses consumption volatility $\sigma_c = \dfrac{\gamma^*}{\gamma}\sigma_x$ by implementing the inflation-output beta $b = \left(\frac{\gamma^*}{\gamma} - 1\right)\dfrac{1}{\bar{\bar{D}}}$.

The optimal policy solution makes clear that a no-commitment government chooses a more countercyclical inflation policy than a government with commitment, provided that the correlation between the international investors' SDF and domestic wealth shocks is positive. This shows that ability to commit to inflation endogenously determines the consumption-smoothing properties of LC debt. In particular, LC debt issued by less credible governments is a better hedge for domestic consumption risk.

3.2.3 Optimal Currency Composition of Government Debt

Because FC debt has constant real payoffs, FC debt issuance perfectly replicates the consumption allocation under LC debt and inflation constant at zero, or $\sigma_c = \sigma_x$. Since a commitment government can always achieve the same allocation by issuing LC debt and choosing constant inflation, it is optimal for such a government to borrow in LC ($s = 1$), and the preference is strict if $\gamma \neq \gamma^*$. A government without commitment prefers FC ($s = 0$) if and only if expected welfare with $\sigma_c = \sigma_x$ exceeds the expected welfare with $\sigma_c = 0$. Comparing expected welfare (25) with $\sigma_c = 0$ and $\sigma_c = \sigma_x$ shows that FC is preferred if and only if $\gamma \leq 2\gamma^*$.[18]

3.2.4 Intuition

Figure 4 visualizes the trade-offs faced by the two types of governments. It shows average real domestic consumption on the y-axis against the standard deviation of consumption on the

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[18]The exact threshold of being twice as risk averse is a function of the simplifying assumptions in the benchmark model. The tendency of no-commitment governments to borrow in FC is more general, as we show in the next Section.

x-axis. The order of the x-axis is reversed so that welfare increases moving towards the upper right corner. Different levels of constant domestic welfare are shown with dashed curves and the set of feasible allocations (or "budget set") is plotted with thick lines. The horizontal budget set illustrates the case with risk-neutral lenders ($\gamma^* = 0$) and the sloped budget set illustrates the case with moderately risk-averse international lenders ($0 < \gamma^* < \gamma < 2\gamma^*$).

Point B represents the consumption allocation achieved by either type of government when borrowing with FC debt. This point is identical for all scenarios because the real value of FC debt is constant and investors do not require a risk premium for holding FC debt.

Point A represents the consumption allocation achieved by either type of government when borrowing with LC debt from risk-neutral lenders. The allocation is the same for both types of government because the no-commitment government's ex post policy of full smoothing is also optimal ex ante. Both types of governments strictly prefer LC debt (A) to FC debt (B), as can be seen from the fact that (A) is on a higher iso-utility curve. When investors are risk-neutral, LC debt offers the same average real consumption as FC debt but with zero consumption volatility.

By contrast, when investors are risk-averse, governments face a meaningful trade-off between higher average consumption and lower consumption volatility. Point (C) represents the optimal allocation for a government with commitment that borrows in its own currency and this policy is preferable over borrowing with FC debt (B). Whereas the government with commitment chooses the most preferred allocation available on the budget set, the government without commitment chooses between two allocations: LC debt with $\sigma_c = 0$ (D) and FC debt with $\sigma_c = \sigma_x$ (B). Because full consumption smoothing can only be achieved with significantly countercyclical inflation, point (D) is characterized by high LC bond risk premia and low average domestic real consumption. In the depicted example, the no-commitment government prefers to tie its hands with FC debt to achieve the higher mean and higher volatility consumption allocation.

The benchmark model delivers the intuition for our main empirical finding. It shows that a government without commitment may find LC debt "too expensive" even though its LC debt would appear to hedge domestic consumption perfectly. Governments that would appear to receive the most hedging benefit from LC debt are the least inclined to use it, consistent with our empirical evidence in Figure 1 and Table 3. Governments without commitment can gain from issuing FC debt, even if the government is more risk-averse than its lenders and even if there is no direct deadweight cost from inflation.

Having demonstrated the main mechanism in a simplified model, we next show that embedding this mechanism in a more realistic model can quantitatively match the empirical evidence.

Figure 4: Domestic Government's Mean-Variance Trade-Off
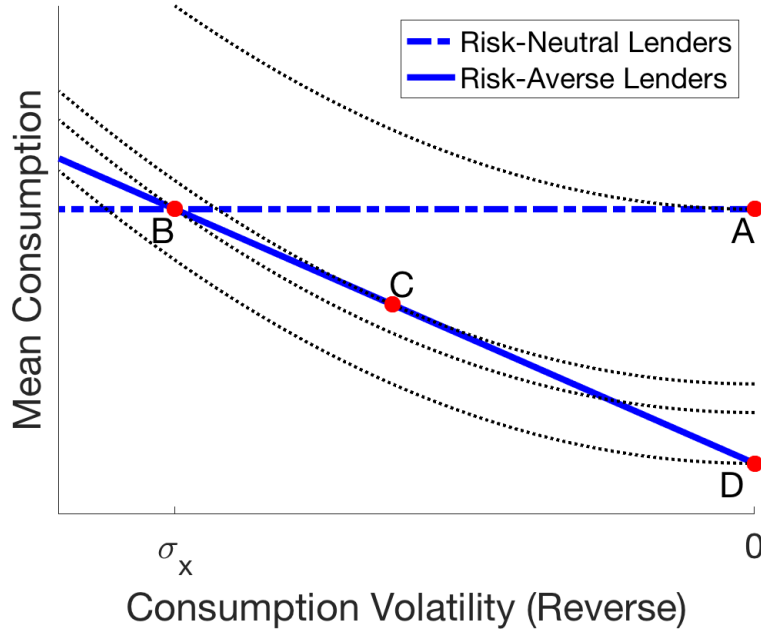
Notes: The y-axis plots mean real domestic consumption and the x-axis plots the standard deviation of real domestic consumption (reverse order). Dashed curves represent the domestic government's iso-preference curves. The thick, dot-dash blue line labeled "Risk-Neutral Lenders" indicates the set of mean consumption and consumption volatility available to the commitment government when debt is priced by risk-neutral lenders. The fact that the line is flat means that for any level of consumption volatility mean consumption is unaffected. The solid blue line labeled "Risk-Averse Lenders" is the set of mean consumption and consumption volatility available to the commitment government when investors are risk-averse. (A) is the allocation of a commitment or no-commitment government borrowing from risk-neutral lenders in LC. (B) is the allocation for either government when borrowing in FC. (C) is the allocation when a government with commitment borrows from risk-averse investors in LC and implements a state-contingent inflation policy function. (D) is the allocation of a government without commitment that borrows in LC from risk-averse lenders.

4   Quantitative Evaluation

This section describes and calibrates a quantitative version of our two-period model. We first describe the full model and then calibrate it separately for emerging markets (EM) and developed markets (DM), with the difference being that DMs can commit to a future inflation policy but EMs cannot.

4.1 Extended Model

4.1.1 Inflation Cost

Domestic households have CRRA utility with risk aversion γ over real consumption with a quadratic inflation cost:

$$U\left(C_2, \pi_2\right) = \frac{C_2^{1-\gamma}}{1-\gamma} - \alpha\pi_2^2. \tag{26}$$

The inflation cost can be thought of as welfare losses from non-optimal product prices and production decisions across firms, as in New Keynesian models (Woodford, 2003, 2011). The inflation cost is important to ensure that the optimal level of inflation is well-defined.

4.1.2 Real Exchange Rate

Real exchange rate variation is an additional source of risk. Real exchange rate volatility introduces a source of risk for borrowing in foreign currency: the government does not know how many units of domestic consumption it will need to repay a foreign currency denominated bond. We define the real exchange rate, $\mathcal{E}_2$, as the number of units of the international consumption bundle required to purchase one unit of the domestic consumption bundle, so an increase in $\mathcal{E}_2$ corresponds to an appreciation of the domestic currency. We assume that domestic real consumption, C_2, is in units of the domestic consumption bundle and international real consumption, C_2^*, is in units of the international consumption bundle.

In order to model a realistic correlation between the real exchange rate and the international business cycle, we assume that the real exchange is distributed according to:

$$\mathcal{E}_2 = exp\left(\varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right) \tag{27}$$

$$\varepsilon_2 = \lambda^{\varepsilon,x^*}x_2^* + e_2, \sim N\left(0, \sigma_e^2\right), \tag{28}$$

where the parameter $\lambda^{\varepsilon,x^*}$ is the loading of the change in the real exchange rate on international output, and e_2 captures the idiosyncratic component uncorrelated with international output. The change in the real exchange rate ε_2 can therefore be written as function of international output and an idiosyncratic shock. The Jensen's inequality term in (27) ensures that the real exchange rate equals one in expectation. Real exchange rate fluctuations can be microfounded if international investors and domestic consumers consume different bundles of goods and international investors 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 (27) and (28) in Appendix B.1.

The real exchange rate enters into the model equations in two important ways. First, the number of real domestic goods required to repay FC debt now decreases with the real exchange rate. To repay the combined government debt portfolio, the domestic government needs the following real resources, measured in units of the domestic consumption bundle:

$$D_2\left(X_2, \mathcal{E}_2\right) = D^{LC} exp\left(-\pi_2\left(X_2\right)\right) + \frac{D^{FC}}{\mathcal{E}_2}. \tag{29}$$

Domestic real consumption, measured in units of the domestic consumption bundle, then equals (11), where $D_2\left(X_2\right)$ is now replaced by (29). When the real exchange rate is volatile, issuing FC debt leads to volatility in real domestic consumption, so even issuers with no inflation credibility may find it optimal to issue some debt in LC.

Second, a higher real exchange rate means that international investors can exchange the payoff from an LC bond for more units of the international consumption bundle. Specifically, the LC bond payoff is worth $exp\left(-\pi_2\left(X_2\right) + \varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right)$ real units of the international consumption bundle. Because M_2^* is the international investors' marginal utility of consumption from an additional real unit of the international consumption bundle, the first-order condition for pricing LC bonds is modified to:

$$Q^{LC} = E\left[M_2^* exp\left(-\pi_2\left(X_2\right) + \varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right)\right]. \tag{30}$$

To match our calculations in the data, we compare the LC bond risk premium in the data to the LC bond risk premium in the model, as defined in (19).

4.1.3 Correlation Structure of Domestic and International Endowments

The extended model relaxes the assumption that domestic and international output are perfectly correlated. Instead, we assume that local output has a component that is perfectly correlated with international output, x_2^*, and an independent shock, η_2.

$$x_2 = \lambda^{x,x^*} x_2^* + \eta_2, \tag{31}$$
$$x_2^* \sim N\left(0, \left(\sigma^*\right)^2\right), \ \eta_2 \sim N\left(0, \sigma_\eta^2\right). \tag{32}$$

The realizations of x_2^* and η_2 are exogenous and x_2^*, η_2, and e_2 are uncorrelated.[19]

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[19]Given that we have CRRA preferences, the degree of correlation between SDFs in the model will be a function of the correlation of endowment processes. 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

4.1.4 Levered Investors

As seen in the benchmark model, we only need non-zero international risk aversion to qualitatively generate the relationship between the ability to commit and inflation cyclicality. In order to match this relation quantitatively, we assume that LC bonds are priced by international investors whose risk aversion is amplified by leverage, motivated by the growing literature arguing that levered intermediaries price assets in both domestic and international markets (He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014; Maggiori, 2017). Limited stock market participation among international agents would act similarly to concentrating risk within a small set of investors (Constantinides et al., 2002). An alternative approach to generate quantitatively reasonable risk premia would be to add long-run risks into an international macroeconomic model, as introduced by Colacito and Croce (2011), or external habits as in Verdelhan (2010).

We assume that international investors' log real consumption is more volatile than the aggregate international endowment by a factor of $\frac{1}{\psi^*}$,

$$c_2^{I*} = \frac{1}{\psi^*}x_2^*. \tag{33}$$

In the simple leverage model of Abel (1999), ψ^* is the equity-to-assets ratio of the investor. The investor has power utility over his real consumption:

$$E\sum_{t=1}^{2}(\delta^*)^t \frac{\left(C_t^{I*}\right)^{1-\gamma^*}}{1-\gamma^*}, \tag{34}$$

where γ^* is international investors' fundamental risk aversion. Substituting (33) into (34) and taking the first-order condition with respect to international consumption shows that the stochastic discount factor for pricing contingent claims to units of the international real consumption bundle is:

$$M_2^* = \delta^* exp\left(-\frac{\gamma^*}{\psi^*}x_2^*\right). \tag{35}$$

As can be seen in 35, the effect of investor leverage is to make investors effectively more risk averse over their own endowment.

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bounded by the correlation of output. However, such an extension is beyond the scope of our static model.

4.1.5 Bond and Stock Returns

In order to compare bond-stock betas in the model and in the data, we need to model bond and stock returns. Log LC bond return innovations are given by the revision to log bond prices from period 1 to period 2 :

$$r_2^{LC} - Er_2^{LC} \;=\; -\left(\pi_2 - E\pi_2\right). \tag{36}$$

We model stocks very simply as an asset class whose log dividends are proportional to log domestic output. In order to focus on the role of government bonds as a tool to hedge domestic consumption, we assume that stocks cannot be traded across borders. Specifically, we model log domestic equity return innovations as proportional to log domestic output:

$$r_2^{m} - Er_2^{m} \;=\; \lambda^{m,x}\left(x_2 - E_1 x_2\right). \tag{37}$$

In our calibration, we set the coefficient $\lambda^{m,x}$ to be consistent with the data. Regressing quarterly local equity excess returns onto log domestic output gives a coefficient of 4, averaged across EMs and DMs, as listed in Table 5. The estimated coefficient for EMs is not statistically different from the one for DMs at the 95% level, so we use the average in the calibration for both EMs and DMs.

With (36) and (37) we obtain a simple relationship between model bond-stock betas and inflation-output betas:

$$\beta\left(bond, stock\right) \;=\; -\frac{1}{\lambda^{m,x}}\beta\left(\pi_2, x_2\right). \tag{38}$$

The relation (38) captures the key intuition that bond-stock betas have the opposite sign from inflation-output betas and will be compressed towards zero, because stocks are more volatile than output. Our two-period model does not allow for time-varying risk premia, which will tend to amplify bond-stock correlations (Campbell et al., 2018).

Table 5: Calibration Parameters

Constant across EM and DM		Value	Target
International Endowment Volatility	σ^*	1.64%	Data
Investor Equity/Assets	ψ^*	0.4	He and Krishnamurthy (2013)
Risk Aversion	γ^*, γ	29.74	2% price of US consumption risk (Lustig and Verdelhan, 2007)
Debt/GDP	$\bar{D}$	14.4%	Data
Local-International Endowment Loading	λ^{x,x^*}	0.91	Data
Exchange Rate Volatility	σ_ε	10.8%	Data
Exchange Rate - International Endowment Loading	$\lambda^{\varepsilon,x^*}$	1.41	Data
Stock Return - Output Loading	$\lambda^{m,x}$	4.0	Data
Inflation Cost	α	2.14	EM-DM Expected Inflation

Specific to EM and DM		EM	DM	
Credibility	p	0	1	
Output Volatility	σ_x	2.7%	2.2%	Data

Note: All parameters are in annualized natural units. 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 the St. Louis Fred). 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 local-international endowment loading is the regression coefficient of quarterly log real GDP growth onto US quarterly log real consumption 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. The empirical proxy for the stock return-output loading 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 output volatility is the annualized standard deviation of domestic log real GDP growth, where we average separately for 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.

Figure 5: Extended Model Timeline
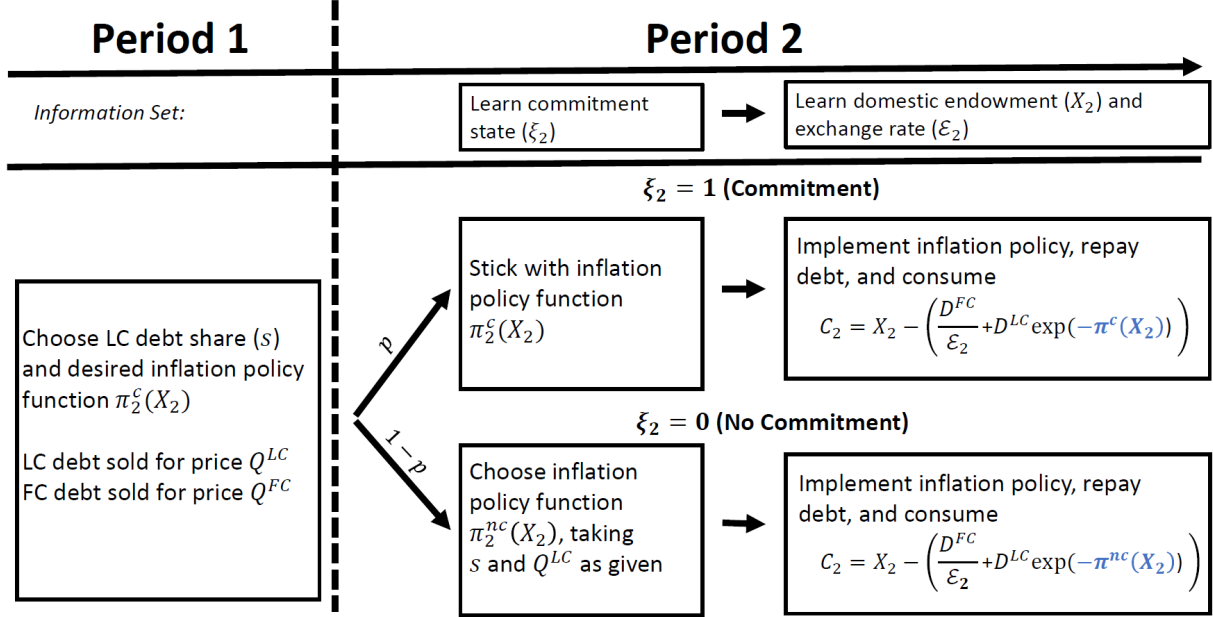
Note: This figure shows the timing of the government's problem in the extended model with partial commitment.

4.1.6 Inflation Problem with Partial Commitment

In order to allow for countries between the extremes of full and no inflation commitment, we follow the "loose commitment" formulation of Debortoli and Nunes (2010). Loose commitment introduces the realization of a commitment state, ξ_2, as an additional source of uncertainty. The random variable ξ_2 equals 1 with probability p and zero otherwise. It is realized exogenously and uncorrelated with domestic output, international output, and the real exchange rate. ξ_2 is realized after debt is issued and priced, but before the domestic output and real exchange rate shocks are revealed. Further, the full model relaxes the assumptions that inflation is log-linear in domestic output and mean zero.

Figure 5 depicts the timeline of the government's problem in the full model with partial commitment. At the time the government borrows, it announces a commitment inflation policy, that is a function of domestic period 2 output, $\pi_2^c(X_2)$. The government honors its commitment to $\pi_2^c(X_2)$ if $\xi_2 = 1$. If $\xi_2 = 0$, the government chooses the no-commitment inflation policy function, $\pi_2^{nc}(X_2)$, so we can write inflation as:

$$\pi_2(X_2, \xi_2) = \begin{cases} \pi_2^c(X_2) & \text{if } \xi_2 = 1 \\ \pi_2^{nc}(X_2) & \text{if } \xi_2 = 0 \end{cases}, \tag{39}$$

No-commitment inflation is chosen to maximize domestic consumer welfare taking the LC debt share, s, and bond prices as given:

$$\max_{\pi_2^{nc}(X_2)} E_{X_2, \mathcal{E}_2} \left[U\left(C_2, \pi_2\right) \middle| s, Q^{LC} \right], \qquad (40)$$

where the maximization is over the space of functions of X_2, subject to the budget constraint (11). $E_{X_2, \mathcal{E}_2} \left[\cdot \middle| s, Q^{LC} \right]$ denotes the expectation over X_2 and $\mathcal{E}_2$, taking s and Q^{LC} as given.

The commitment inflation policy function, $\pi_2^c(X_2)$, and the LC debt share, s, are chosen to maximize domestic consumer welfare, internalizing the effect of these policy choices on bond prices:

$$\max_{s, \pi_2^c(X_2)} E_{X_2, \mathcal{E}_2} \left[U\left(C_2, \pi_2\right) \right]. \qquad (41)$$

The period 1 maximization problem (41) is to choose $\pi_2^c(X_2)$ from the space of functions over X_2, and to choose s from the unit interval $[0, 1]$. The maximization is subject to the period 1 borrowing requirement (9), the period 2 budget constraint (11), the bond pricing equation (30), and the dependence of realized inflation on the commitment state, ξ_2 (39). The period 1 government has rational expectations over the no-commitment policy, $\pi_2^{nc}(X_2)$. The loose commitment setup nests the full commitment and no-commitment cases considered in the benchmark model with $p = 1$ and $p = 0$.

4.1.7 Equilibrium

We solve for a subgame perfect equilibrium with complete information. The equilibrium has three exogenous sources of uncertainty - the commitment state, ξ_2, domestic output, X_2, and the real exchange rate , $\mathcal{E}_2$, - and three endogenous choice variables - the LC debt share s, the commitment inflation policy, $\pi_2^c(X_2)$, and no-commitment inflation policy, $\pi_2^{nc}\left(X_2 \mid s, Q^{LC}\right)$. In addition to the exogenous sources of uncertainty, the state of the economy in period 2 is summarized by $\left(s, Q^{LC}\right)$. We assume that the government learns the commitment state, ξ_2, before domestic output, X_2, and the real exchange rate, $\mathcal{E}_2$, are realized. An equilibrium consists of no-commitment and commitment inflation policy functions $\pi_2^{nc}\left(X_2 \middle| s, Q^{LC}\right)$ and $\pi_2^c(X_2)$, an LC debt share s, and an LC bond price Q^{LC} such that:

1. The government chooses the no-commitment inflation function according to (40).

2. The LC debt share, s, and the commitment inflation function, $\pi_2^c(X_2)$, are chosen to maximize expected domestic utility (41) subject to the period 1 borrowing requirement (9), the period 2 budget constraint (11), the bond pricing equation (30), and the dependence of realized inflation on the commitment state, ξ_2 (39).

We solve for the equilibrium using global solution methods, described in detail in the Appendix.

4.2 Parameter Values

We calibrate the model to the data. To clarify the key differences between EMs and DMs, we choose equal parameter values for EM and DM calibrations whenever the corresponding EM and DM moments in the data are not statistically different at the 95% level. Since the international investor should be the same for both countries, we choose the same fundamental investor risk aversion, investor leverage, 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.[20] We set investor leverage to $\psi^* = 0.4$, from He and Krishnamurthy (2013). We choose equal fundamental risk aversion for domestic consumers and international investors, i.e. $\gamma = \gamma^*$. We set international investors' fundamental risk aversion to $\gamma^* = 2\% \times \frac{\eta^*}{(\sigma^*)^2}$ to match the price of international consumption risk of 2% from Lustig and Verdelhan (2007). With levered investors and equal fundamental risk-aversion, international investors are effectively more risk-averse than the government.

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) and Arslanalp and Tsuda (2014b), 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, $\lambda^{x,x^*} = 0.91$ 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-USD exchange rate, $\sigma_\varepsilon = 10.8\%$, after averaging exchange rate volatilities 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

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

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 (2017).

EM and DM calibrations differ along two dimensions. Most importantly, we set the EM credibility parameter to $p = 0$, corresponding to no commitment. By contrast, we set DM credibility to $p = 1$. Second, we match EM and DM output volatilities separately to the data, because EMs have significantly higher output volatility in the data.

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.[21]

4.3 Calibration 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%.[22]

The model also matches several moments that we did not target in our calibration. Most importantly, the model-implied EM and DM LC debt shares are similar to those found 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 91%, compared to 90% in the data. Moreover, the model implies that bond-stock betas are substantially higher in EMs than in DMs, with a EM-DM difference in bond-stock betas of 0.21 in the model, compared to 0.17 in the data. When we switch off investor leverage (i.e. set $\psi^* = 1$), 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. The model implies that LC bonds issued by EMs have a risk premium that is two percentage points higher than LC bonds issued by DMs. This substantial risk premium differential is entirely due to differences in the inflation risk premium, since real exchange rate correlations with US consumption are

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[21]Because the DM calibration has full credibility ($p = 1$), 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.5.3 that calibration moments are robust to a wide range of values for DM α.

[22]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		DM		EM-DM	
	Data	Model	Data	Model	Data	Model
Average Inflation	3.92%	2.20%	1.73%	0.00%	2.20%	2.20%
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 equation (38). The model LC bond risk premium in percent is computed according to equation (19).

equal for EMs and DMs. It also is similar to the risk premium differential of 1.62 in the data.

Having calibrated the model, we now turn to the inflation policy functions for EMs and DMs. Figure 6 shows inflation as a function of period 2 log domestic output. Consistent with the intuition from the benchmark model, DM inflation decreases in the worst states of the world, thereby providing international investors with safe assets that can be issued at a premium. A government with commitment optimally adopts procyclical inflation, selling insurance to international investors and earning the risk premium. This is similar to the problem studied in Farhi and Maggiori (2018) with a risk-neutral government and risk-averse investors. By contrast, EM inflation increases in the worst states of the world. Intuitively, EM governments cannot commit to limiting their own consumption smoothing and instead have an incentive to use inflation in the worst states of the world to smooth domestic consumption fluctuations.

Finally, Figure 7 compares the relationship between bond-stock betas and the currency composition of sovereign debt in the model and in the data. It shows that by varying credibility we can generate the cross-country relationship between bond cyclicality and the currency composition of sovereign debt. The blue solid line is the fitted line of the empirical LC debt share against the bond-stock beta, where we summarize our empirical data into five equal-weighted beta-sorted portfolios and measure the external LC debt share from TIC data. The baseline model counterfactual generates a similarly downward-sloping relation between LC debt shares and bond-stock betas as in the data. The baseline model counterfactual is generated by tracing out the different combinations of LC debt shares and bond-stock betas generated by different values for the credibility parameter p, while holding all other parameter values constant at their DM values in Table 5. We also show a second counterfactual, that sets international and domestic risk aversion to conventional values from the real business cycle literature ($\gamma^* = 0$, $\gamma = 2$) but is otherwise constructed analogously. This second

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Figure 6: Inflation Policy Functions
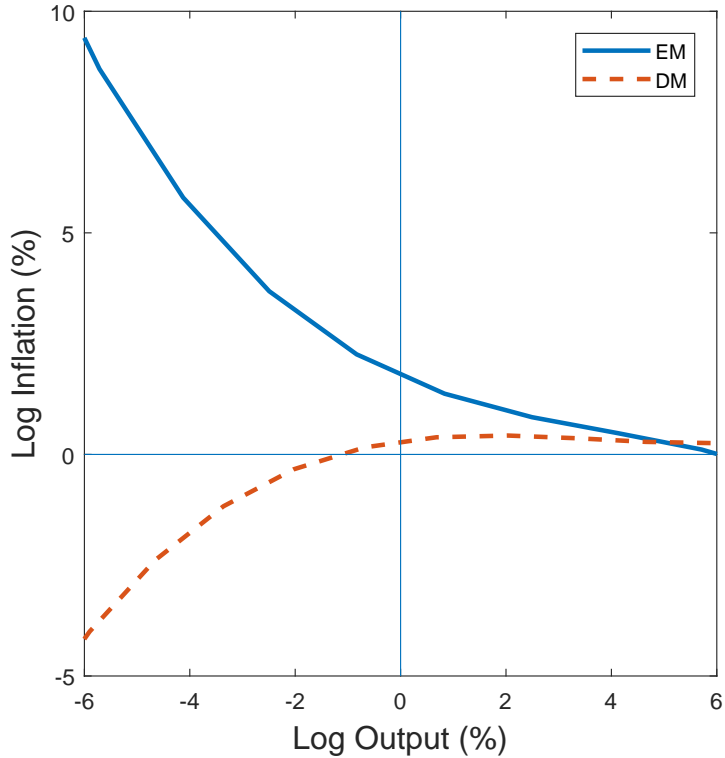
Note: This figure shows log inflation π_2 against log output x_2, defined in (10), both in annualized percent, in the calibrated model. The solid blue lines indicate the EM calibration, while the dashed red lines indicate the DM calibration.

counterfactual shows that in the absence of investor risk aversion the model generates an upward-sloping relation between LC debt shares and bond-stock betas, in contrast to the data. This demonstrates that even though a deadweight cost of inflation (α) along with a lack of commitment can lead governments to tilt their issuance toward foreign currency, these forces alone do not generate our main empirical finding of a downward-sloping relationship between LC debt shares and bond-stock betas. This is the sense in which both features that generate the excessive risk premia introduced in Section 3, limited commitment and risk-averse creditors, are needed to rationalize the empirical findings.

5   Conclusion

This paper provides new evidence that countries that seemingly have the most to gain from borrowing in their own currency do so the least. We explain this new stylized fact with differences in monetary policy credibility, combined with investors who require risk premia

Figure 7: Model and Data
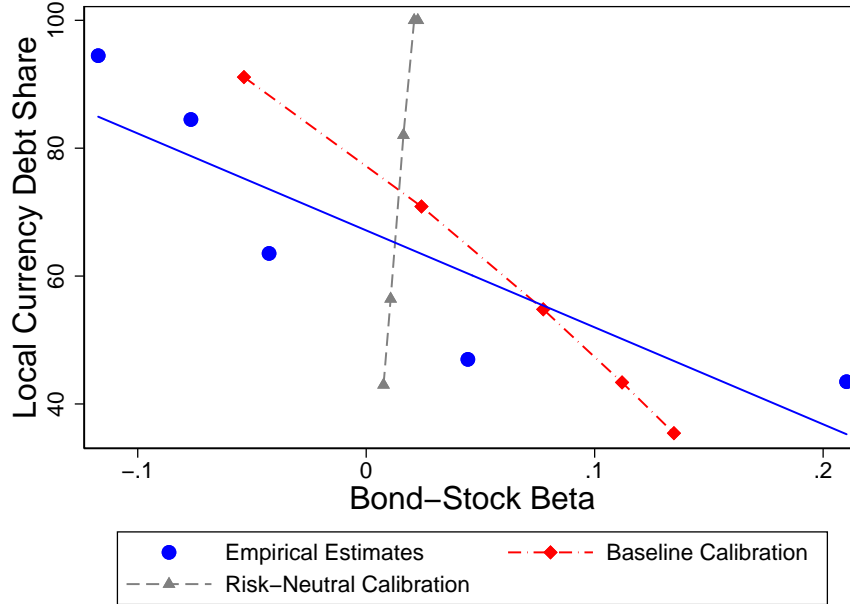
Note: This figure traces out the model bond-stock beta against the LC debt share implied by different values of monetary policy credibility. We vary the credibility parameter, p, over the following values: $p = 0, 0.25, 0.5, 0.75, 1.0$. The baseline calibration counterfactuals set all other parameters equal to the DM values in Table 5. The risk-neutral model counterfactuals are constructed analogously but set $\gamma^* = 0$ and $\gamma = 2$. The empirical estimates show the equal-weighted bond-stock betas and external TIC LC debt shares of five beta-sorted portfolios with a trend line.

for holding assets that lose value during global downturns. Issuers with low monetary policy credibility cannot commit to avoid using inflation to overinsure their domestic consumption ex post, so investors charge a positive risk premium for holding local currency debt. This discourages the issuers from borrowing in local currency ex ante. Our simple framework demonstrates that including both risk premia and endogenous debt issuance can qualitatively change our assessment of what constitutes optimal government debt management.

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Online Appendix for "Sovereign Debt Portfolios, Bond Risks, and the Credibility of Monetary Policy"

(Not for Publication)

Wenxin Du, Carolin E. Pflueger, and Jesse Schreger

This online appendix consists of Section A, "Empirical Appendix", and Section B, "Model Appendix."

A Empirical Appendix

A.1 Currency names and codes

Table A.1 lists the country name, currency name, and the three-letter currency code for our sample countries.

Table A.1: Currency names and codes

Developed markets			Emerging markets		
Country	Currency	Code	Country	Currency	Code
Australia	Australian dollar	AUD	Brazil	Brazilian real	BRL
Canada	Canadian dollar	CAD	Chile	Chilean peso	CLP
Denmark	Danish krone	DKK	Colombia	Colombian peso	COP
Germany	Euro	EUR	Czech Republic	Czech koruna	CZK
Japan	Japanese yen	JPY	Hungary	Hungarian forint	HUF
New Zealand	New Zealand dollar	NZD	Indonesia	Indonesian rupiah	IDR
Norway	Norwegian krone	NOK	Israel	Israeli shekel	ILS
Sweden	Swedish krona	SEK	Malaysia	Malaysian ringgit	MYR
Switzerland	Swiss franc	CHF	Mexico	Mexican peso	MXN
United Kingdom	British pound	GBP	Peru	Peruvian nuevo sol	PEN
United States	US dollar	USD	Philippines	Philippine peso	PHP
			Poland	Polish zloty	PLN
			Singapore	Singapore dollar	SGD
			South Africa	South African rand	ZAR
			South Korea	South Korean won	KRW
			Thailand	Thai baht	THB
			Turkey	Turkish lira	TRY

A.2 Comparing External Debt Sources

Figure A.1: External LC Debt Share in Global Mutual Funds and US TIC, 2015
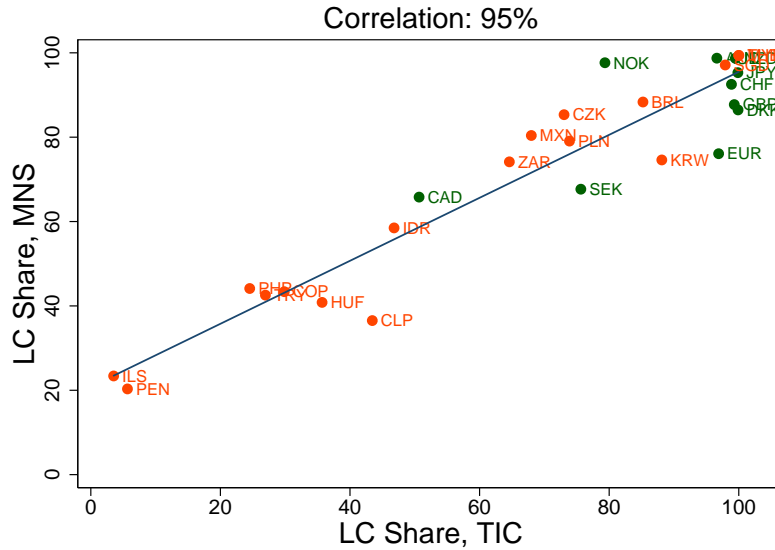
Note: This figure plots the percentage of external government debt denominated in each country's local currency using data from global mutual funds in Maggiori et al. (2018) (MNS) and the US external position in the Treasury International Capital (TIC) data. MNS data uses data for the entire European Monetary Union (EMU). TIC data uses Germany for the Euro area. All data are for end of year 2015.

A.3 T-statistic of regression betas

Table A.2 presents summary statistics for the t-statistic of three regression betas: LC bond-local stock beta, $\beta(bond_i, stock_i)$, local stock-US stock return beta, $\beta(stock_i, stock_{US})$, and realized inflation-output beta, $\beta(\pi_i, IP_i)$. The betas based on daily asset returns, $\beta(bond_i, stock_i)$ and $\beta(stock_i, stock_{US})$, are more precisely estimated than the betas based on monthly macroeconomic data, $\beta(\pi_i, IP_i)$.

Table A.2: Summary Statistics of the t-statistic for Various Betas

|	(1)	(2)	(3)	(4)	(5)	(6)
	Mean	Median	Min	Max	# of countries with $|t| > 1.96$	N
Panel (A) Developed Markets						
$\beta(bond_i, stock_i)$	4.89	4.45	2.86	8.39	11	11
$\beta(stock_i, stock_{US})$	12.89	13.61	9.12	16.81	10	10
$\beta(\pi_i, IP_i)$	2.36	2.10	0.75	4.96	6	11
Panel (B) Emerging Markets						
$\beta(bond_i, stock_i)$	3.03	2.57	0.26	8.55	11	17
$\beta(stock_i, stock_{US})$	9.59	9.74	5.71	15.55	17	17
$\beta(\pi_i, IP_i)$	1.62	1.22	0.18	5.50	4	17
Panel (C) Full Sample						
$\beta(bond_i, stock_i)$	3.76	3.51	0.26	8.55	22	28
$\beta(stock_i, stock_{US})$	10.81	10.33	5.71	16.81	27	27
$\beta(\pi_i, IP_i)$	1.91	1.33	0.18	5.50	10	28

Note: This table presents summary statistics for the absolute value of the t-statistic of three regression betas: LC bond-local stock beta, $\beta(bond_i, stock_i)$, local stock-US stock return beta, $\beta(stock_i, stock_{US})$, and realized inflation-output beta, $\beta(\pi_i, IP_i)$. Newey-West standard errors with 120-day lags are used for $\beta(bond_i, stock_i)$ and $\beta(stock_i, stock_{US})$, which are estimated using daily regressions. Newey-West standard errors with 12-month lags are used for $\beta(\pi_i, IP_i)$, which is estimated using monthly regressions. We do not report the t-statistic of $\beta(stock_i, stock_{US})$ for $i = US$ because it is equal to 1 by definition. Panel (A) shows results for developed markets. Panel (B) shows results for emerging markets. Panel (C) shows results for the full sample.

A.4 Robustness Checks for the Main Empirical Results

A.4.1 Long-Term Debt

The cross-sectional relationship between LC bond-stock betas and LC debt shares is robust to measuring the LC debt share only in long-term debt, as shown in Figure A.2. We obtain face values and issuance dates for all historical individual sovereign bond issuances from Bloomberg for 14 emerging markets and estimate the long-term LC debt share as the outstanding amount of LC debt with five or more years remaining to maturity relative to all outstanding debt with five or more years remaining to maturity.

Figure A.2: LC Debt Share in Long-Term Debt versus Bond-Stock Beta
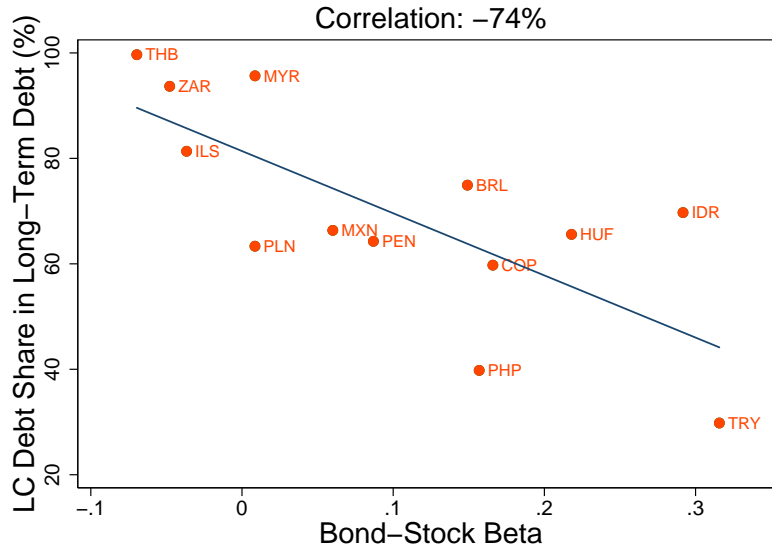
Note: This figure plots the bond-stock beta on the x-axis and the share of LC debt in all outstanding long-term debt on the y-axis. Long-term debt is defined as having a remaining time to maturity of five or more years. The share of LC debt in long-term debt is estimated from individual bond issuance data from Bloomberg.

A.4.2 Excluding the Financial Crisis

One important period in the middle of our sample is the financial crisis of 2008—2009. While this period marked an important recession for the US and many other countries, we show in this section that our main empirical results are not driven by the financial crisis. Figure A.3 shows our baseline LC bond-stock beta on the y-axis against a LC bond-stock beta excluding the financial crisis period on the x-axis. We see that the bond-stock betas are extremely similar when excluding the financial crisis, indicating that our key bond cyclicality measure is not driven by a small number of observations. Figure A.4 shows that our main stylized fact in Figure 1 remains unchanged if we exclude the crisis period in our construction of LC bond betas.

Figure A.3: Local Currency Bond Betas Excluding 2008—2009
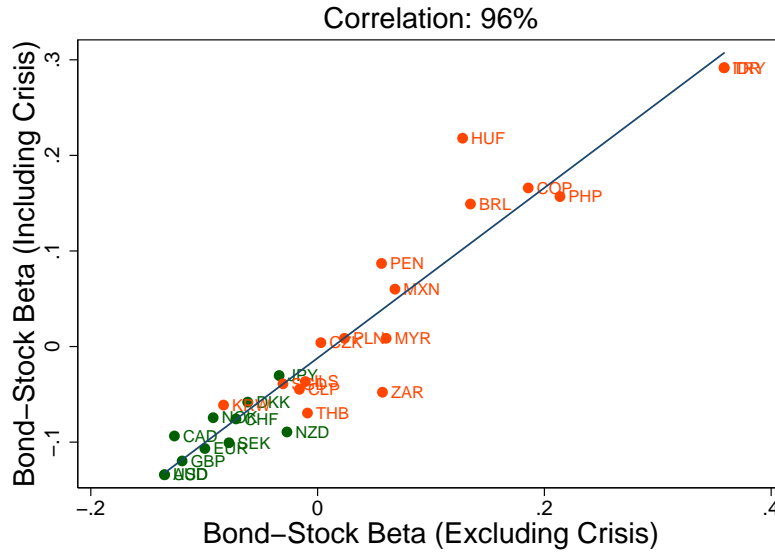
Note: This figure shows LC bond-stock betas excluding the period 2008–2009 on the x-axis and LC bond-stock betas for the full sample (including 2008—2009) on the y-axis. The highest and lowest observations are winsorized.

Figure A.4: Local Currency Debt Shares and Bond Betas Excluding 2008—2009
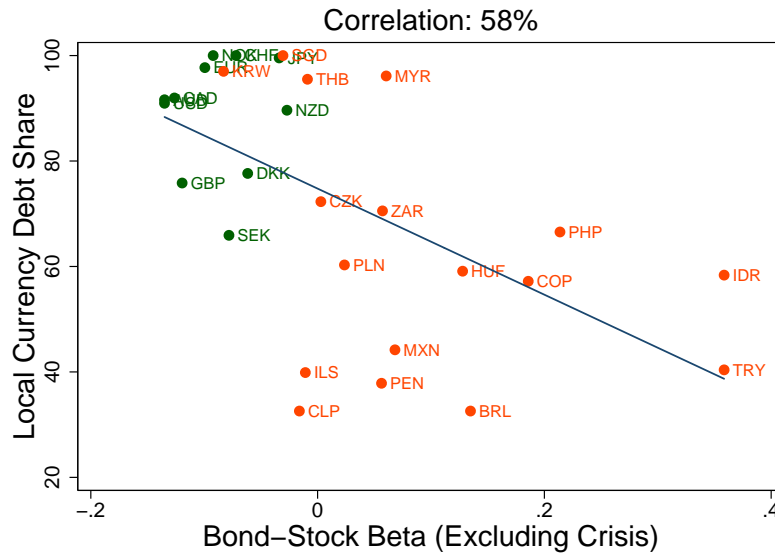
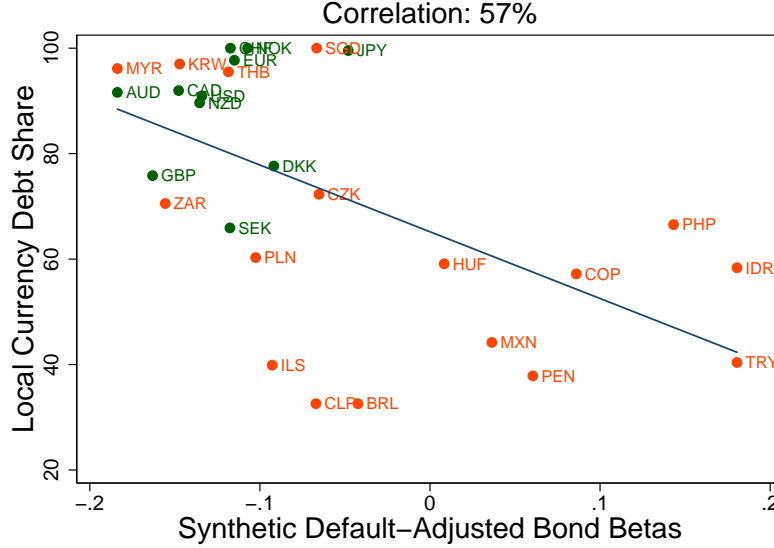Note: This figure differs from Figure 1 only in that it excludes 2008—2009 from the computation of LC bond betas on the x-axis. The highest and lowest observations are winsorized.

A.4.3 Default-Adjusted Bond Risk Premia

To adjust for default risk, we construct a synthetic default-free nominal bond yield. We follow Du and Schreger (2016a) by combining a US Treasury bond with a fixed-for-fixed cross-currency

swap to create a synthetic default-free local bond. Figure A.5 plots the LC debt share against default-adjusted bond-stock betas, which are computed by replacing LC bond yields by synthetic default-free LC bond yields in the computation of LC bond returns. The strong similarity to Figure 1 shows that our main empirical finding is robust to adjusting for the default component of LC bond returns.

Figure A.5: Local Currency Debt Shares and Default-Adjusted Bond Betas

Note: This figure differs from Figure 1 only in that it uses synthetic default-adjusted LC bond log excess returns in equation (1) to estimate bond-stock betas. The highest and lowest observations are winsorized.

A.4.4 Adjusting for FX hedging errors

In Section 2.1.1, we calculated the LC bond excess return over the local T-bill rate in local currency units. We discussed that from the dollar investor's perspective, these excess returns approximately hedge the LC fluctuation against the US dollar for the holding period between quarter t and $t+1$. In this section, we re-calculate the bond-stock beta after adjusting for these FX hedging errors for the USD investor.

In particular, suppose that the USD investor invests \$1 in the LC bond at t and funds the position by shorting \$1 of the LC T-bill. At $t+1$, the gross dollar return on the LC bond is

$$\frac{P_{i,n-1,t+1}^{LC}}{P_{i,n,t}^{LC}}\frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}} = \exp[\tau_{i,n,t}y_{i,n,t}^{LC} - (\tau_{i,n,t}-1)y_{i,n-1,t+1}^{LC}]\frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}},$$

where $P_{i,n,t}^{LC}$ denotes the price of the n-quarter LC bond at time t in country i, and $\mathcal{E}_{i,t}$ denotes the LC exchange rate defined as USD per LC units, so an increase in $\mathcal{E}_{i,t}$ corresponds to a LC appreciation against the USD. Recall that $\tau_{i,n,t}$ is equal to 5 years. The dollar cost of shorting the LC T-bill from time t to time $t+1$ is:

$$\frac{1}{P_{i,1,t}^{LC}}\frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}} = \exp(-y_{i,1,t}^{LC}/4)\frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}}.$$

So the exact USD excess return of going long the LC bond and shorting the LC T-bill becomes:

$$\tilde{x}r_{i,n,t+1}^{LC} = \frac{P_{i,n-1,t+1}^{LC}}{P_{i,n,t}^{LC}}\frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}} - \frac{1}{P_{i,1,t}^{LC}}\frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}} = \frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}}\left[\exp[\tau_{i,n,t}y_{i,n,t}^{LC} - (\tau_{i,n,t}-1)y_{i,n-1,t+1}^{LC}] - \exp(-y_{i,1,t}^{LC}/4)\right].$$

Similarly, for a USD investor, the USD excess return of going long in the LC equity and shorting the LC T-bill is:

$$\tilde{x}r_{i,t+1}^{m} = \frac{\mathcal{E}_{i,t+1}}{\mathcal{E}_{i,t}}[P_{t+1}^{m}/P_{t}^{m} - \exp(-y_{i,1,t}^{LC}/4)].$$

We estimate the bond-stock betas adjusted for FX hedging errors by running the regression:

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

Figure A.6 shows that adjusting these FX hedging errors has no effect on the estimated bond-stock betas. The correlation between the bond-stock beta in local currency units (y-axis) and the bond-stock beta after adjusting for the FX hedging errors (x-axis) is 99.8%.

Figure A.6: Bond-Stock Beta Adjusting for FX Hedging Errors
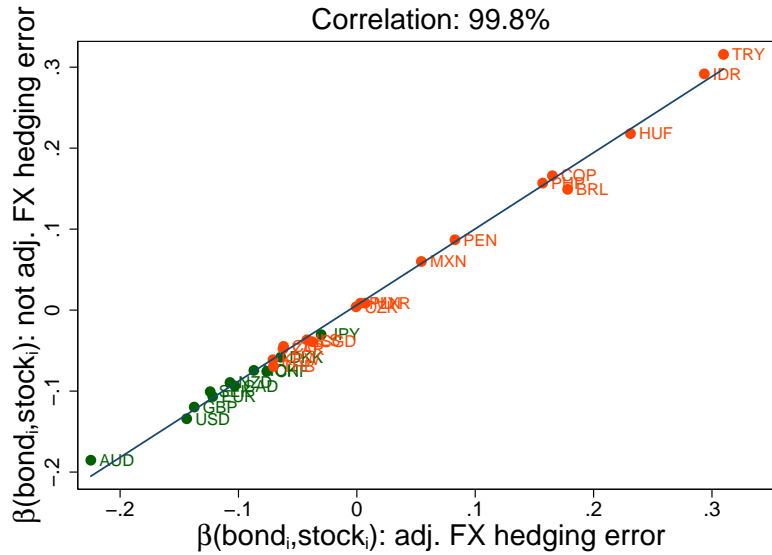
Note: On the horizontal axis, we plot the bond-stock beta using the bond and stock dollar excess returns after adjusting FX hedging errors, as described in Section A.4.4. On the vertical axis, we plot our baseline bond-stock beta in local currency units.

A.4.5 Alternative measures of realized inflation cyclicality

Panel (A) of Figure A.7 provides evidence based on macroeconomic data that LC bonds with the best hedging value for the domestic issuer are riskiest for US investors. It is the analogue of Figure 2 for the cyclicality of realized inflation. For the purpose of this section, we refer to $\beta(\pi, IP_i)$ as defined by equation (3) as the "inflation-output beta". We regress the changes in the realized inflation rate on the US per capita real consumption growth rate. Panel (A) of Figure A.7 shows that the realized inflation-US consumption beta is 56% correlated with the realized inflation-output beta. Realized inflation tends to be procyclical in developed countries and countercyclical in emerging markets

based on both measures.

Next, we now show that the realized inflation-output beta, as defined in equation (3) is not materially affected if we measure inflation cyclicality with respect to stock returns rather than industrial production. We regress the changes in the realized inflation rate on the local stock excess returns. Panel (B) of Figure A.7 shows that the realized inflation-stock return beta is 63% correlated with the realized inflation-output beta.

Figure A.7: Alternative Measures of Realized Inflation Cyclicality

(A) Realized inflation-US consumption beta
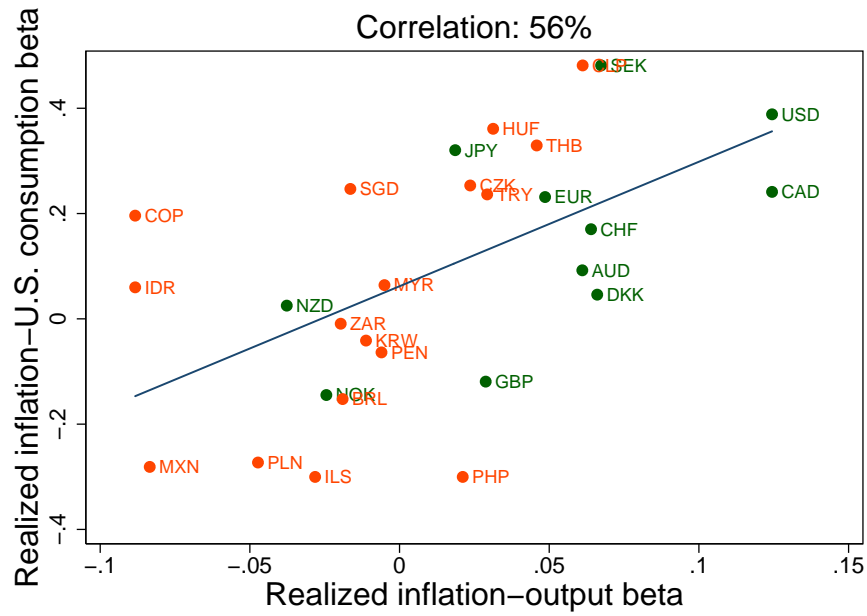
(B) Realized inflation-local stock beta
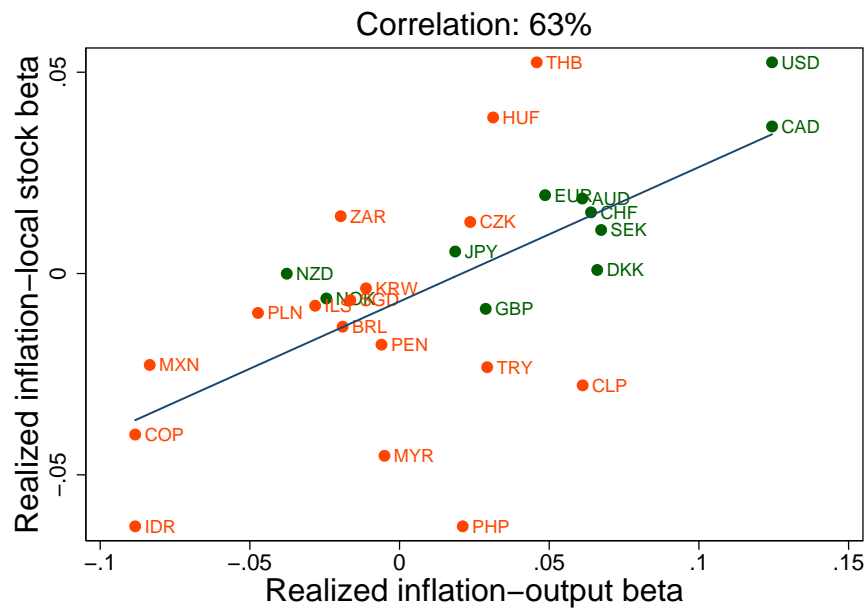
Note: Panel (A) plots the beta of the realized inflation on the US per capita real consumption growth rate against the realized inflation-output beta estimated using equation (3). Panel (B) plots the beta of the realized inflation on local stock excess returns against the realized inflation-output beta estimated using equation (3). Emerging markets are shown in red and developed markets in green. The highest and lowest observations are winsorized.

A.4.6 Controlling for Debt/GDP ratios and using LC Debt/GDP ratio as the dependent variable

We first add the Debt/GDP ratio as an additional control into our benchmark regression. The regression results are shown in Table A.3. The coefficient on $\beta(bond_i, stock_i)$ remains significant and similar in magnitude compared to the benchmark regression results in Tables 3 and 4.

We then repeat our benchmark empirical specification using the LC debt/GDP ratio as the dependent variable. Table A.4 presents the regression results. In column (1), we regress the total LC debt/GDP ratio on the bond-stock beta, after controlling the local-US stock return beta, $\beta(stock_i, stock_{US})$, log GDP, the FX regime, the commodity share, and the total debt/GDP ratio. The coefficient on $\beta(bond_i, stock_i)$ is negative and significant. In columns (2)-(4), we regress the external LC debt/GDP ratio estimated from the TIC, Morningstar, and the BIS data, respectively, on the bond-stock beta, the same set of macroeconomic controls, and the external debt/GDP ratios. The coefficients on $\beta(bond_i, stock_i)$ remain negative and significant.

Table A.3: Controlling for Debt/GDP Ratios

	(1) s^{TOT}	(2) s^{TIC}	(3) s^{MNS}	(4) s^{BIS}
$\beta(bond_i, stock_i)$	-49.48***	-17.15***	-15.85**	-26.38*
	(13.69)	(5.845)	(7.074)	(13.64)
$\beta(stock_i, stock_{US})$	-0.818	-3.713	-0.430	-4.394
	(6.000)	(2.699)	(3.329)	(3.528)
log(GDP)	0.848***			
	(0.115)			
FX Regime		0.852***	0.649***	0.594***
		(0.0715)	(0.104)	(0.204)
Commodity Share	0.390	0.908	0.563	-0.518
	(1.420)	(0.808)	(0.681)	(1.197)
Total government debt/GDP	-0.583	0.284	0.578	-1.028
	(1.899)	(0.602)	(0.789)	(1.884)
External government debt/GDP	-0.0273	-0.0443	-0.0211	-0.0217
	(0.0603)	(0.0257)	(0.0343)	(0.0383)
Constant	-4.436	-6.860	-5.038	11.80
	(16.50)	(8.381)	(8.230)	(11.27)
Observations	26	26	26	26
R-squared	0.493	0.525	0.525	0.280

Note: This table shows the cross-country regression results of the LC debt shares on measures of inflation cyclicality and other macroeconomic controls. In column (1), the dependent variable is the share of LC in total government debt. In column (2), the dependent variable is the LC debt share estimated using the TIC data. In column (3), the dependent variable is the LC debt share estimated using the Morningstar data. In column (4), the dependent variable is the LC debt share estimated using the BIS Locational Banking Statistics. The independent variables are the bond-stock betas $\beta(bond_i, stock_i)$ and the local stock-US stock betas $\beta(stock_i, stock_{US})$. We control for the total Debt/GDP ratio in column (1) and the external Debt/GDP ratio in columns (2) through (4). We also control for average log per capita GDP between 2005 and 2014, the average exchange rate classification used in Reinhart and Rogoff (2004), and the commodity share of exports. 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. The top and bottom observations are winsorized. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table A.4: LC Debt/GDP ratios and LC Bond Cyclicality

	(1) LC debt/GDP Total	(2) LC debt/GDP External-TIC	(3) LC debt/GDP External-MNS	(4) LC debt/GDP External-BIS
$\beta(bond_i, stock_i)$	-49.48***	-17.15***	-15.85**	-26.38*
	(13.69)	(5.845)	(7.074)	(13.64)
$\beta(stock_i, stock_{US})$	-0.818	-3.713	-0.430	-4.394
	(6.000)	(2.699)	(3.329)	(3.528)
log(GDP)	0.390	0.908	0.563	-0.518
	(1.420)	(0.808)	(0.681)	(1.197)
FX Regime	-0.583	0.284	0.578	-1.028
	(1.899)	(0.602)	(0.789)	(1.884)
Commodity Share	-0.0273	-0.0443	-0.0211	-0.0217
	(0.0603)	(0.0257)	(0.0343)	(0.0383)
Total government debt/GDP	0.848***			
	(0.115)			
External government debt/GDP		0.852***	0.649***	0.594***
		(0.0715)	(0.104)	(0.204)
Constant	-4.436	-6.860	-5.038	11.80
	(16.50)	(8.381)	(8.230)	(11.27)
Observations	26	26	26	26
R-squared	0.851	0.913	0.817	0.558

Note: This table shows the cross-country regression results of the LC debt/GDP ratios on measures of inflation cyclicality and other macroeconomic controls. In column (1), the dependent variable is the total LC debt/GDP ratio, including domestic and external government debt. In column (2), the dependent variable is the LC external/GDP ratio, estimated using the TIC data. In column (3), the dependent variable is the LC debt/GDP ratio, estimated using the Morningstar data. In column (4), the dependent variable is the LC debt/GDP ratio, estimated using the BIS Locational Banking Statistics. The independent variables are the bond-stock beta $\beta(bond_i, stock_i)$ and the local stock-US stock beta $\beta(stock_i, stock_{US})$. We control for the total Debt/GDP ratio in column (1) and the external Debt/GDP ratio in columns (2) through (4). We also control for average log per capita GDP between 2005 and 2014, the average exchange rate classification used in Reinhart and Rogoff (2004), and the commodity share of exports. 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. The top and bottom observations are winsorized. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

A.4.7 Weight the benchmark regression by per capita GDP

We show in Table A.5 that weighting the benchmark regression presented in Table 3 by per capita GDP does not change the results.

Table A.5: LC Debt Shares in Total Government Debt onto LC Bond Cyclicality (Weighted by per capita GDP)

Local Currency Debt Share	(1) s^{TOT}	(2) s^{TOT}	(3) s^{TOT}	(4) s^{TOT}
$\beta(bond_i, stock_i)$	-121.8***			-94.48**
	(21.84)			(37.02)
$\beta(\tilde{\pi}, \widetilde{gdp})$		88.59***		
		(18.53)		
$\beta(\pi, IP)$			134.0**	
			(56.52)	
$\beta(stock_i, stock_{US})$	11.41	14.35	-7.372	6.327
	(19.31)	(23.38)	(25.12)	(19.69)
log(GDP)				3.748
				(4.672)
FX Regime				0.570
				(3.584)
Commodity Share				-0.147
				(0.209)
Constant	62.57***	35.16	79.40***	32.84
	(19.98)	(25.02)	(24.19)	(50.87)
Observations	28	22	28	28
R-squared	0.373	0.433	0.107	0.410

Note: This table differs from Table 3 in that observations are weighted by per capital GDP. The top and bottom observations are winsorized. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

A.4.8 Time-varying betas and LC debt shares

We estimate time-varying LC bond-stock betas, $\beta_t(bond_i, stock_i)$, using five-year rolling windows between $t-5$ and t. Panel (A) of Figure A.8 shows the average bond-stock beta for developed and emerging markets. The average beta for developed countries fluctuated between -0.15 and 0, and the average beta for emerging market fluctuated between 0 and 0.1. Panel (B) of Figure A.8 plots the cross-country rankings of the bond-stock betas between 2008 and 2014. We can see that the cross-sectional ranking is very persistent. The average pairwise rank correlation between 2008 and 2014 is 92%.
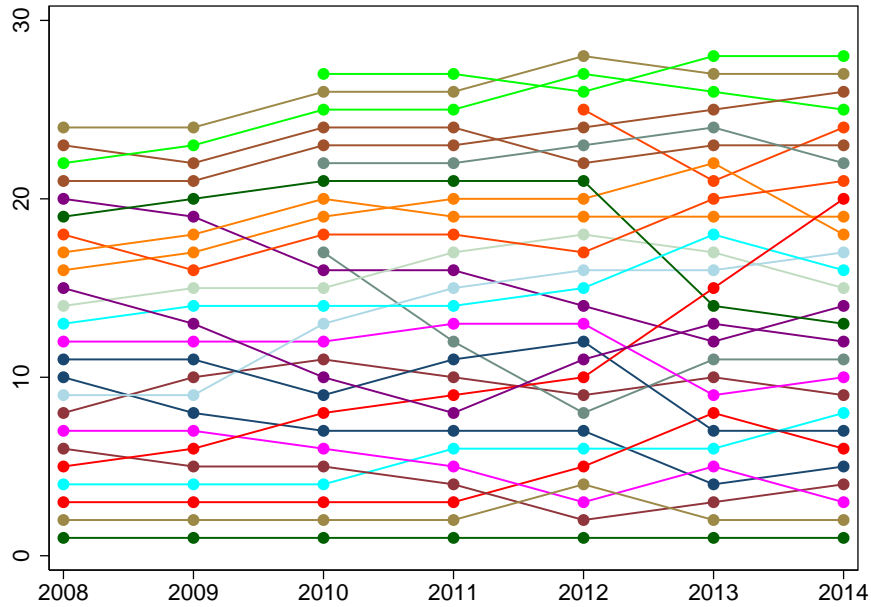
We run the cross-sectional regressions of the LC debt share at time t on $\beta_t(bond_i, stock_i)$. The regression results are shown in Table A.6. The coefficient on $\beta(bond_i, stock_i)$ is negative and statistically significant for all sample years.

Figure A.8: Time variations in the bond-stock beta

(A) Rolling bond-stock betas
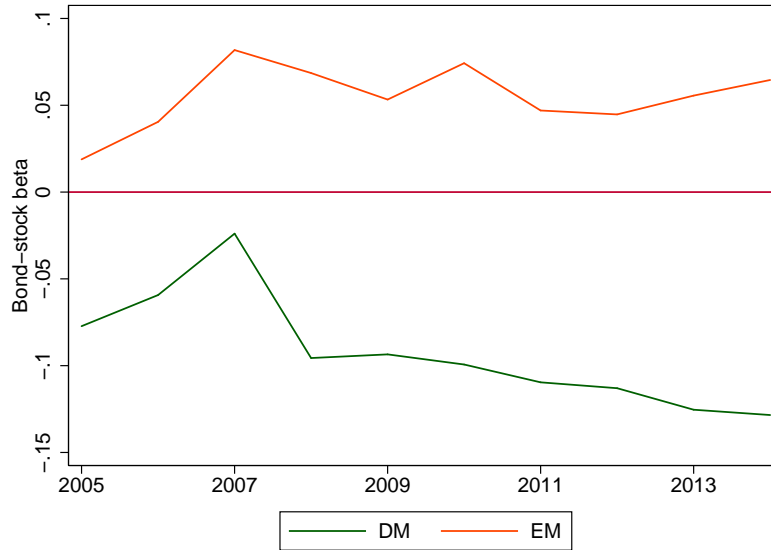
(B) Ranking of rolling betas

Note: Panel (A) plots the average rolling LC bond-local stock beta over time for developed markets (G10) and emerging markets (EM). The bond-stock beta at time t is calculated using a five-year rolling window from $t - 5$ and t. Panel (B) plots the cross-country ranking of the five-year rolling bond-stock betas over time, with each color indicating a sample country.

Table A.6: Regression of the LC debt share by year

	(1) 2005	(2) 2006	(3) 2007	(4) 2008	(5) 2009	(6) 2010	(7) 2011	(8) 2012	(9) 2013	(10) 2014
$\beta(bond_i, stock_i)$	-124.1***	-115.4***	-123.4***	-95.46***	-96.42***	-96.70***	-105.6***	-90.73***	-74.53***	-65.63***
	(22.25)	(20.93)	(33.12)	(13.86)	(15.37)	(17.91)	(22.87)	(23.10)	(14.62)	(18.24)
Constant	79.00***	81.45***	85.50***	78.24***	77.82***	73.98***	70.58***	71.04***	71.34***	71.18***
	(2.627)	(2.628)	(2.762)	(3.213)	(3.217)	(3.959)	(4.012)	(4.064)	(4.143)	(4.262)
Observations	20	20	22	24	24	26	27	27	27	27
R-squared	0.634	0.564	0.468	0.381	0.362	0.321	0.281	0.225	0.194	0.157

Note: This table shows the yearly regression results of the LC debt share in year t on the bond-stock beta estimated using a five-year rolling window between $t-5$ and t.

A.5 Testing the CAPM

A.5.1 GRS Test of the CAPM

The paper treats stock market betas as proxies for expected excess returns. It is, therefore, important to verify that this CAPM approach is not rejected in the data. To this end, we now estimate a standard GRS test for the CAPM, with the US stock market as a proxy for total wealth.

We start by sorting our countries into five equal-sized portfolios, sorted by their LC bond betas with respect to the US stock market. We obtain quarterly bond excess returns (not overlapping) for these five portfolios. Due to our short sample period, it is unsurprising that average excess returns are noisy.

We test the CAPM with the GRS statistic, which Campbell (2017) shows can be written as:

$$GRS = \frac{T - N - 1}{N} \frac{(Sharpe^{LC,tangency})^2 - (Sharpe_{US}^m)^2}{1 + (Sharpe_{US}^m)^2}. \tag{A.1}$$

Here, $Sharpe^{LC,tangency}$ is the Sharpe ratio of the tangency portfolio of the LC bond portfolios, $Sharpe_{US}^m$ is the Sharpe ratio of the US equity market, $T = 42$ is the number of quarterly returns, and $N = 5$ is the number of portfolios. The GRS statistic, hence, increases in the distance between the Sharpe ratios for the tangency portfolio and the US equity market.

We estimate the tangency portfolio Sharpe ratio from the portfolio returns as in Campbell (2018) Chapter 2.2.3. This gives a tangency Sharpe ratio of $Sharpe^{LC,tangency} = 0.52$, compared to a US equity market Sharpe ratio of $Sharpe_{US}^m = 0.17$, over our sample period 2004-2015. The Sharpe ratio for the LC bond tangency portfolio hence exceeds the equity Sharpe ratio over our short sample period. However, the tangency Sharpe ratio is very close to the US equity Sharpe ratio of 0.56 reported in Campbell (2003) for a longer sample that is conventionally used to obtain a more precise estimate of average US equity excess returns. The proximity between the tangency Sharpe ratio and the US equity Sharpe ratio from this longer sample is an intuitive indication that the difference between tangency and US equity Sharpe ratios over the shorter sample is not statistically significantly different.

Substituting the values for $Sharpe^{LC,tangency}$, $Sharpe_{US}^m$, T, and N into (A.1) gives a value for the GRS statistic of $GRS = 1.72$. Comparing this value to the critical values of a $F_{N,T-N-1}$ distribution gives a p-value of 0.16, showing formally that we cannot reject CAPM at any conventional significance level.

A.5.2 GMM Risk Premium Estimation

We next make use of the fact that our assets of interest are bonds and that we can use quoted bond yields to construct ex ante measures of LC bond risk premia. Ex ante bond risk premia may be more precisely measured than the ex post average returns over a limited sample used for the GRS test. We find that ex ante LC bond risk premia have a statistically and quantitatively significant relationship with US stock market betas across countries. This estimation is similar to the GRS test in Section A.5.1, because we seek to estimate whether investors require a higher risk premium for LC bonds that comove more with the US stock market. Further, we want to understand whether this price of risk is statistically distinguishable from the average US equity risk premium.

A concrete example makes clear the advantage of ex ante risk premia measures based on bond yields, whereas realized bond returns are noisy measures of ex ante expected risk premia over our short sample. For instance, the US had extremely low government bond yields throughout our sample, indicating that investors required low risk premia for holding US Treasuries. However,

US Treasury yields dropped even lower during our sample and, in particular, during the financial crisis, an event that would have been very hard to predict ex ante. As a result, looking at US excess returns, it would appear as if the US had a high risk premium, whereas clearly markets price a very low risk premium into US Treasuries.

We estimate a regression of ex ante average expected risk premia onto the beta of LC bond returns with respect to the US stock market, while accounting for the fact that the betas on the right-hand-side of this regression are not known but instead must be estimated.

For comparison and to set the stage, we first estimate this relationship in two steps without accounting for generated regressors. As a first-step, we estimate country-by-country regressions:

$$xr_{i,n,t}^{LC} = \alpha_i + \beta_i xr_{US,t}^m + \epsilon_{i,t}, \tag{A.2}$$

using daily data on overlapping 1-quarter holding returns. Because we use daily overlapping returns, the average number of return observations per country is high at 2513. For comparison, the maximum number of return observations is 2608, so our data is close to a balanced panel. Let $\overline{RP}_{i,n}$ denote the average ex ante risk premium estimated for country i. In a second step, we then estimate the regression:

$$\overline{RP}_{i,n} = \mu + \kappa\beta_i + u_i. \tag{A.3}$$

The coefficient, κ, estimates the cost of exposure to the US stock market and is the coefficient of interest.

To estimate α_i, β_i, μ, and κ in a single step while accounting for estimation error in the first stage, we define the following GMM moments, which we expect to have a population mean of zero:

$$g_{i,t} = \begin{cases} \overline{RP}_{i,n} - \mu - \kappa\beta_i & \text{for} \quad 1 \le i \le N \\ \left(\overline{RP}_{i,n} - \mu - \kappa\beta_i\right)\beta_i & \text{for} \quad N+1 \le i \le 2N \\ xr_t^{LC} - \alpha_i - \beta_i xr_{US,t}^m & \text{for} \quad 2N+1 \le i \le 3N \\ \left(xr_{i,t}^{LC} - \alpha_i - \beta_i xr_{US,t}^m\right)xr_{US,t}^m & \text{for} \quad 3N+1 \le i \le 4N \end{cases} \tag{A.4}$$

Here, N denotes the number of countries in the sample and the parameter vector to be estimated is:

$$\begin{aligned} b &= [\mu, \kappa, \boldsymbol{\alpha}, \boldsymbol{\beta}]', \\ \boldsymbol{\alpha} &= [\alpha_1, \alpha_2, ..., \alpha_N], \\ \boldsymbol{\beta} &= [\beta_1, \beta_2, ..., \beta_N]. \end{aligned}$$

The first $2N$ moment conditions in (A.4) are for the cross-sectional regression in the second stage. Moment conditions $2N+1$ through $4N$ are for the first-stage regressions. In sample, the $4N$ moments (A.4) cannot all simultaneously be set to zero, because we only have $2N+2$ parameters. The GMM estimator $\hat{b}$ is defined by setting:

$$A \times \frac{1}{T}\sum_{t=1}^{T} g_t\left(\hat{b}\right) = 0, \tag{A.5}$$

where A is a weighting matrix of size $(2N+2) \times 4N$ that has full rank. It is a standard result for

GMM that the estimated parameter vector $\hat{b}$ has asymptotic distribution

$$\hat{b} \sim \mathcal{N}(b_0, V) \tag{A.6}$$

$$V = T^{-1}(AD)^{-1} ASA'(AD)^{-1'}, \tag{A.7}$$

where b_0 is the true underlying parameter value, $D = E\left[\frac{\partial g}{\partial b'}\right]$ is the sample average of the derivative of g with respect to the parameter vector, b, and S is the spectral density matrix of g_t at frequency zero.

We implement GMM with weighting matrix $A = [2N + 2 \times 4N]$ that ensures that the GMM estimates for μ and κ agree with the point estimates from the two-step procedure. This requirement pins down the weighting matrix:

$$A = \begin{bmatrix} 1_{1 \times N} & 0_{1 \times N} & 0_{1 \times 2N} \\ 0_{1 \times N} & 1_{1 \times N} & 0_{1 \times 2N} \\ 0_{2N \times N} & 0_{2N \times N} & \mathcal{I}_{2N} \end{bmatrix}. \tag{A.8}$$

Here $0_{M \times P}$ and $1_{M \times P}$ define block matrices of all zeros and ones with size $[M \times P]$, respectively. We use $\mathcal{I}_{2N}$ to denote the identity matrix of size $2N$. For our application, we use the consistent estimator for D:

$$\hat{D} = \begin{bmatrix} -1_{N \times 1} & -\boldsymbol{\beta} & 0_{N \times N} & -\kappa I_N \\ -\boldsymbol{\beta} & -\boldsymbol{\beta}^2 & 0_{N \times N} & -2\kappa \times diag(\boldsymbol{\beta}) \\ 0_{N \times 1} & 0_{N \times 1} & -\mathcal{I}_N & -\mathcal{I}_N \sum_{t=1}^{T} xr_{US,t}^m T^{-1} \\ 0_{N \times 1} & 0_{N \times 1} & -\mathcal{I}_N \sum_{t=1}^{T} xr_{US,t}^m T^{-1} & -\mathcal{I}_N \sum_{t=1}^{T} \left(xr_{US,t}^m\right)^2 T^{-1} \end{bmatrix}, \tag{A.9}$$

where $diag(\boldsymbol{\beta})$ denotes the matrix with the elements of $\boldsymbol{\beta}$ along the diagonal. We estimate the upper left $[2N \times 2N]$ submatrix of S from the cross-section of countries, with the assumption that (β_i, u_i) are independent but not necessarily identically distributed. We also assume that $g_{i,t}, 1 \le i \le 2N$ are independent of $g_{j,t}, 2N < j < 4N$, so we can set the upper-right $2N \times 2N$ and the lower-left $2N \times 2N$ block matrices of the spectral density matrix, S, to zero. We cannot estimate the upper-right $2N \times 2N$ and the lower-left $2N \times 2N$ block matrices of the spectral density matrix, S, because $\overline{RP}_{i,n}$ is constant over time for each country. The spectral density for moments $2N + 1$ through $4N$ is estimated from the time series with a Newey-West kernel with m lags to account for serial correlation and overlapping return observations:

$$\hat{S} = \begin{bmatrix} \mathcal{I}_N \hat{s}_1 & \mathcal{I}_N \hat{s}_{12} & 0_{N \times 2N} \\ \mathcal{I}_N \hat{s}_{12} & \mathcal{I}_N \hat{s}_2 & 0_{N \times 2N} \\ 0_{N \times N} & 0_{N \times N} & T^{-1} \sum_{t=1}^{T} \left(\tilde{g}_t \tilde{g}_t' + \sum_{i=1}^{m} \left(1 - \frac{i}{m+1}\right) \left[\tilde{g}_t \tilde{g}_{t-i}' + \tilde{g}_{t+i} \tilde{g}_t'\right] \right) \end{bmatrix}. \tag{A.10}$$

Here,

$$\hat{s}_1 \;=\; \frac{1}{N-2}\sum_{t=1}^{T}\sum_{i=1}^{N}g_{i,t}^2, \tag{A.11}$$

$$\hat{s}_2 \;=\; \frac{1}{N-2}\sum_{t=1}^{T}\sum_{i=N+1}^{2N}g_{i,t}^2, \tag{A.12}$$

$$\hat{s}_{12} \;=\; \frac{1}{N-2}\sum_{t=1}^{T}\sum_{i=1}^{N}g_{i,t}g_{i+N,t}, \tag{A.13}$$

and $\tilde{g}_t$ refers to the vector containing elements $g_{2N+1,t}$ through $g_{4N,t}$. We choose a lag length of $m = 120$ days to account for the length of overlapping observations of approximately 60 trading days. A lag length of $m = 120$ days is sufficiently small relative to our overall sample length of 2608 trading days that standard asymptotic standard errors apply.

We then compute the GMM standard errors for μ and κ as follows:

$$SE(\hat{\mu}) \;=\; \sqrt{V(1,1)}, \tag{A.14}$$
$$SE(\hat{\kappa}) \;=\; \sqrt{V(2,2)}. \tag{A.15}$$

Table A.7 column (1) starts by reporting the estimated regression equation (A.3) without accounting for generated regressors. We note that the bond-US stock beta enters with a strongly positive coefficient that is also statistically significant. The results suggest that the price of US stock market risk is 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 equity premium of 8.1% reported in Campbell (2003). Column (2) in Table A.7 reports results from the GMM procedure, which accounts for generated regressors. The point estimates are identical to column (1) and the standard errors are only slightly larger without affecting statistical significance, as one would expect if the vector of bond betas, $\boldsymbol{\beta}$, is precisely estimated.

Table A.7: GMM: Bond Risk Premia onto Bond-US Stock Betas

LC Bond Risk Premium	(1) OLS	(2) GMM
β_i	8.96***	8.96***
	(2.69)	(3.31)
Constant	2.80***	2.80***
	(0.33)	(0.39)
Observations	28	28

Note: This table estimates the regression (A.3), where LC bond-US stock return betas are estimated via (A.2). The specification in column (1) does not account for generated regressors. Column (2) accounts for generated regressors by using the GMM procedure described in Appendix A.5.2. Significance levels are indicated by *** p<0.01, ** p<0.05, * p<0.1.

B Model Appendix

The Model Appendix is structured as follows:

- Appendix B.1 microfounds real exchange rate shocks.

- Appendix B.2 shows that as long as Ricardian equivalence holds, the optimal inflation policy depends only on externally-held LC debt, independently of the quantity of LC debt held by domestic agents. This insight allows us to focus on externally-held debt throughout the main paper.

- Appendix B.3 derives the analytic solution for the benchmark model.

- Appendix B.4 describes the numerical solution for the extended model.

B.1 Microfounding the Real Exchange Rate

This section describes the goods and preferences microfounding the real exchange rate.

B.1.1 International Consumers

Following Gabaix and Maggiori (2015), we assume that international consumers consume a consumption basket:

$$C_t^* = (A_t^*)^{\mathcal{E}_t} (O_t^*)^{1-\mathcal{E}_t}, \tag{B.1}$$

where $\mathcal{E}_t$ is a non-negative, potentially stochastic preference parameter.[23] A_t^* denotes the number of apples and O_t^* the number of oranges consumed by international consumers in periods $t = 1, 2$. We normalize the preference shock in period 1 to one. The period 2 preference shock is log-normally distributed according to:

$$
\begin{aligned}
\mathcal{E}_1 &= 1, \\
\mathcal{E}_2 &= exp\left(\varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right), \tag{B.2} \\
\varepsilon_2 &= \lambda^{\varepsilon,x^*} x_2^* + e_2, \tag{B.3}
\end{aligned}
$$

where e_2 is distributed according to:

$$e_2 \sim N(0, \sigma_e^2),$$

independently of x_2 and x_2^*. International consumers' welfare function is given by:

$$U^* = E\sum_{t=1}^{2} (\delta^*)^t \frac{(C_t^*)^{1-\gamma^*}}{1-\gamma^*}. \tag{B.4}$$

---

[23]Pavlova and Rigobon (2007) also consider a similar foundation for real exchange rate fluctuations based on preference shocks.

We assume that the international economy is endowed with an equal amount of apples and oranges in each period. Furthermore, the international economy's endowment of apples and oranges equals $A_1^* = O_1^* = X_1^* = 1$ in period 1 and it equals $A_2^* = O_2^* = X_2^*$ in period 2, where X_2^* follows the distribution described in the main paper. Since the domestic economy is assumed to be small, the effect of domestic bond payoffs on international consumers' consumption is negligible. The international consumers' consumption bundle then equals:

$$
\begin{aligned}
C_1^* &= A_1^* = O_1^* = 1, \\
C_2^* &= A_2^* = O_2^* = X_2^*.
\end{aligned}
$$

B.1.2 Domestic Economy

Domestic consumers have preferences over the real domestic consumption bundle and domestic log inflation:

$$
U(C_2, \pi_2) = \frac{C_2^{(1-\gamma)}}{1-\gamma} - \alpha \pi_2^2. \tag{B.5}
$$

The domestic consumption bundle consists entirely of apples:

$$
C_2 = A_2. \tag{B.6}
$$

The amount of apples consumed in equation (B.6) is endogenous, and depends on the exogenous endowment net of real debt repayment, as specified in the main paper. We define the consumption-weighted real exchange rate as the price that international consumers are willing to pay for apples, where the numeraire is one unit of the international consumers' consumption bundle. With (B.1), (B.4), (B.5), and (B.6), the real exchange rate equals:

$$
\frac{\frac{dU^*}{dA_t^*}}{\frac{dU^*}{dC_t^*}} = \mathcal{E}_t, \tag{B.7}
$$

showing that the real exchange rate indeed follows the process described in the main paper.

B.2 External Debt, Domestic Debt, and Ricardian Equivalence

Ricardian equivalence follows from standard assumptions, in particular that domestic agents are homogeneous and that the government has access to lump-sum taxes. We show that under these conditions, the government's optimal inflation policy depends only on externally-held debt and is independent of domestically-held LC debt.

We assume that the government issues face value $D^{LC,dom}$ of LC debt to domestic consumers and face value D^{LC} of LC to international lenders at prices $Q^{LC,dom}$ and Q^{LC}. Note that we allow for potentially different bond prices paid by domestic consumers and international lenders. We continue to assume that the government needs to raise external financing $\bar{D}/R^*$ in period 1. To leave period 1 consumption normalized at 1, we assume that proceeds from domestic bond sales are rebated to domestic consumers.

The real amount of domestic goods needed to repay the government debt in period 2 becomes:

$$D_2 \;\;=\;\; \frac{D^{FC}}{\mathcal{E}_2} + \left(D^{LC} + D^{LC,dom} \right) exp(-\pi_2). \tag{B.8}$$

Because the government has access to lump-sum taxes, real period 2 domestic consumption equals the domestic endowment minus real resources needed to repay government debt plus the payoff on the domestically-held LC bond portfolio:

$$C_2 \;\;=\;\; X_2 - D_2 + D^{LC,dom} exp(-\pi_2). \tag{B.9}$$

Substituting (B.8) into (B.9) shows that domestic real consumption depends on D^{FC} and D^{LC} but is independent of domestically-held debt $D^{LC,dom}$:

$$C_2 \;\;=\;\; X_2 - \left(\frac{D^{FC}}{\mathcal{E}_2} + D^{LC} exp(-\pi_2) \right). \tag{B.10}$$

Intuitively, surprise inflation reduces domestic consumers' returns on their LC bond portfolio. However, surprise inflation also reduces the taxes required to repay debt. With Ricardian equivalence these two effects exactly cancel and domestic consumption is independent of the return on domestically-held debt.

The finding that real domestic consumption is independent of domestically-held LC debt makes clear that externally-held debt is the key variable for the equilibrium inflation policy and bond risks. In our model, domestic consumers have preferences over domestic consumption and inflation and the government maximizes expected domestic utility. It follows that optimal policies for inflation and external debt composition are independent of how much LC debt is held by domestic agents.

In reality, Ricardian equivalence does not hold exactly. However, we expect that the basic insight – that inflation has offsetting effects on domestic consumers' bond returns and tax obligations – would survive in a more complicated model, and therefore that externally-held debt would be the primary driver of optimal inflation policy.

B.3   Analytical Model Solution

B.3.1   Log-Quadratic Government Objective

For the analytical solution, we will repeatedly use the log-quadratic expansion:

$$exp(z) - 1 \;\;\approx\;\; z + \frac{1}{2}z^2. \tag{B.11}$$

Next, we use that $\bar{X}$ is defined such that $\bar{X} - \bar{D} = 1$ and expand consumption log-quadratically, following Campbell and Viceira (2002):

$$c_2 + \frac{1}{2}c_2^2 \;\;\approx\;\; C_2 - 1 \tag{B.12}$$

$$=\;\; \bar{X} \left(exp\left(x_2/\bar{X} \right) - 1 \right) - \bar{D} \left(\exp\left(xr_2^d \right) - 1 \right), \tag{B.13}$$

$$\approx\;\; x_2 + \frac{1}{2}\frac{x_2^2}{\bar{X}} - \bar{D} \left(xr_2^d + \frac{1}{2}\left(xr_2^d \right)^2 \right), \tag{B.14}$$

where the log excess debt portfolio return is defined as

$$
\begin{aligned}
xr_2^d &= \log\left(\frac{D_2}{\bar{D}/R^*}\right) - \log R^*, \\
&= \log\left(\frac{D^{FC} + D^{LC}exp(-\pi_2)}{\bar{D}/R^*}\right) - \log R^*. \quad\quad\text{(B.15)}
\end{aligned}
$$

B.3.2   Case with All-LC Debt

We first show that the expressions (21) through (25) in the main text hold in the case where $s = 1$. A second-order expansion for the debt portfolio excess return gives:

$$
\begin{aligned}
xr_2^d + \frac{1}{2}\left(xr_2^d\right)^2 &\approx exp(xr_2^d) - 1, \\
&= \frac{exp(-\pi_2)}{Q^{LC} \times R^*} - 1, \\
&= exp\left(-(\pi_2 - E\pi_2) - \gamma^*Cov\left(x_2, \pi_2\right) - \frac{1}{2}Var\pi_2\right) - 1, \\
&\approx -(\pi_2 - E_1\pi_2) + \frac{1}{2}\left(\pi_2 - E_1\pi_2\right)^2 - \gamma^*Cov\left(x_2, \pi_2\right) - \frac{1}{2}Var\pi_2, \\
&\approx -(\pi_2 - E_1\pi_2) + \frac{1}{2}\left(\pi_2 - E_1\pi_2\right)^2 + RP^{LC} - \frac{1}{2}Var\pi_2. \quad\quad\text{(B.16)}
\end{aligned}
$$

Note that (B.16) drops terms that are third- and higher-order in x_2 and π_2. Substituting (B.16) into (B.14) gives the following expression for log real domestic consumption:

$$
\begin{aligned}
c_2 + \frac{1}{2}c_2^2 &\approx x_2 + \frac{1}{2}\frac{x_2^2}{\bar{X}} \\
&\quad -\bar{D}\left(-(\pi_2 - E_1\pi_2) + \frac{1}{2}\left(\pi_2 - E_1\pi_2\right)^2 + RP^{LC} - \frac{1}{2}Var\pi_2\right). \quad\quad\text{(B.17)}
\end{aligned}
$$

Taking the variance of the left-hand-side of (B.17) and dropping third- and higher-order terms in c_2 gives $Var c_2$. Taking the variance of the right-hand-side of (B.17) and dropping third- and higher-order terms in c_2, x_2, and π_2 gives:

$$
Var c_2 \approx \sigma_x^2 + \bar{D}^2 Var\pi_2 + 2\bar{D}Cov(x_2, \pi_2). \quad\quad\text{(B.18)}
$$

To obtain expression (25) in the main paper for the government objective function, we note that if the government follows the inflation policy $\pi_2 = bx_2$, the variance and covariance of log inflation equal $Var\pi_2 = b^2\sigma_x^2$ and $Cov\left(x_2, \pi_2\right) = b\sigma_x^2$. Substituting these expressions into (B.18) and taking the square-root then gives

$$
\sigma_c \approx (1 + b \times \bar{D})\sigma_x, \quad\quad\text{(B.19)}
$$

that is expression (21) in the main paper when $s = 1$.

Substituting (B.16) into (B.14) and taking expectations shows:

$$
E\left[c_2 + \frac{1}{2}c_2^2\right] \approx \frac{1}{2}\frac{\sigma_x^2}{\bar{X}} - \bar{D} \times RP^{LC}. \quad\quad\text{(B.20)}
$$

We then use the log-quadratic expansion $C_2 \approx 1 + c_2 + \frac{1}{2}c_2^2$ and drop policy-independent terms to obtain:

$$EC_2 \quad \approx \quad -\bar{D} \times RP^{LC}, \tag{B.21}$$

so equation (22) holds for the case when $s = 1$. Substituting the inflation-output beta expected by investors into the relation for the LC bond risk premium (19) gives:

$$EC_2 \quad \approx \quad \gamma^* b^e \sigma_x^2 \times \bar{D}, \tag{B.22}$$

showing equation (23) in the case when $s = 1$.

The domestic utility function (8) has the log-quadratic expansion:

$$U(C_2) \quad \approx \quad \left(c_2 + \frac{1}{2}c_2^2\right) - \frac{\gamma}{2}c_2^2, \tag{B.23}$$

$$\approx \quad C_2 - 1 - \frac{\gamma}{2}c_2^2. \tag{B.24}$$

Taking expectations and dropping policy-independent terms gives:

$$EU(C_2) \quad \approx \quad EC_2 - \frac{\gamma}{2}Var c_2,$$

$$\approx \quad \gamma^* b^e \sigma_x^2 \times \bar{D} - \frac{\gamma}{2}(1 + b \times \bar{D})^2 \sigma_x^2, \tag{B.25}$$

that is equation (24) holds in the case $s = 1$. Defining σ_c^e as the consumption volatility implied by the rational expectations inflation-output beta b^e (i.e. the consumption volatility obtained by substituting b^e into equation (B.19)), we can re-write (B.25) as

$$EU(C_2) \quad \approx \quad \gamma^* \left(\sigma_c^e \sigma_x - \sigma_x^2\right) - \frac{\gamma}{2}\sigma_c^2, \tag{B.26}$$

showing equation (25) in the case $s = 1$.

B.3.3 Case with All-FC Debt

We next show that the expressions (21) through (25) in the main text hold in the case when $s = 0$. To derive expressions for the all-FC case ($s = 0$), we note that the second-order expansion for the debt portfolio excess return becomes

$$xr_2^d + \frac{1}{2}\left(xr_2^d\right)^2 \quad \approx \quad 0, \tag{B.27}$$

which is identical to the all-LC ($s = 1$) case with $b = b^e = 0$, because in that case LC bond risk premia are zero ($RP^{LC} = 0$). Substituting $b = b^e = 0$ into the results in the previous subsection, we then see that for the all-FC case (up to policy-independent terms) $EC_2 \approx 0$, $\sigma_c \approx \sigma_x$, $\sigma_c^e \approx \sigma_x$ and $EU(C_2) \approx -\frac{\gamma}{2}\sigma_x^2$. This completes the proof of expressions (21) through (25) in the main paper.

B.4 Numerical Solution

We solve the model numerically using global projection methods. Our strategy for the numerical solution uses the following steps:

1. We choose the no-commitment policy function $\pi_2^{nc}(x_2)$ to minimize the expected Euler equation error while holding constant the LC debt share and the commitment policy function using the MATLAB function fminsearch.

2. We choose the commitment policy function $\pi_2^c(x_2)$ to maximize expected domestic utility conditional on the LC debt share and the no-commitment policy function using the MATLAB function fminsearch.

3. We alternate steps 1 and 2 100 times or until the maximum absolute change in the commitment policy function plus the maximum absolute change in the no-commitment policy is less than 10^{-12}. This gives optimal no-commitment and commitment inflation policies and optimal expected utility conditional on the LC debt share, s.

4. We maximize expected domestic consumer utility with respect to the LC debt share, s. For this step, we use the MATLAB function fminbnd over the interval $[0, 1.001]$. The maximization is over optimal expected domestic consumer utility conditional on the LC debt share, s, which we obtain by repeating steps 1 through 3 above for every value of s.

B.4.1 Functional Form

We solve for commitment- and no-commitment inflation policies of the form:

$$
\begin{aligned}
\pi_2^{nc}(x_2) &= b_1(s) + b_2(s)x_2 + b_3(s)x_2^2 + b_4(s)x_2^3, & \text{(B.28)} \\
\pi_2^c(x_2) &= c_1(s) + c_2(s)x_2 + c_3(s)x_2^2 + c_4(s)x_2^3, & \text{(B.29)}
\end{aligned}
$$

where all coefficients may depend on the LC debt share, s. We use the following vectors as the starting point for our optimization routine:

$$
\begin{aligned}
b &= [0.0183, -0.5363, 7.9462, -60] & \text{(B.30)} \\
c &= [0.0028, 0.2061, -5.8417, 20]. & \text{(B.31)}
\end{aligned}
$$

B.4.2 Bond Pricing Function

To facilitate numerical integration, we first project all exogenous random variables onto x_2 and a shock that is orthogonal to x_2 but is correlated with real exchange rates. We re-write international log real consumption as a component correlated with domestic output plus and an independent shock:

$$
x_2^* = \lambda^* x_2 + \eta_2^*, \tag{B.32}
$$

where we define:

$$
\begin{aligned}
\lambda^* &= \lambda^{x,x^*} \frac{(\sigma^*)^2}{\sigma_x^2}, & \text{(B.33)} \\
\eta_2^* &\perp x_2, & \text{(B.34)} \\
\left(\sigma_\eta^*\right)^2 &= (\sigma^*)^2 - (\lambda^*)^2 \sigma_x^2. & \text{(B.35)}
\end{aligned}
$$

Note that writing the relation between domestic and international endowments as (B.32) is consistent with assumptions (31) through (32) in the main paper. That η_2^* is uncorrelated with x_2 is not

a new assumption and indeed follows from (31) through (32) combined with the definition of λ^* in (B.34).

For the numerical solution, we use the notation $\rho^* = \lambda^{\varepsilon,x^*}$, so the log real exchange rate can be written as:

$$\varepsilon_2 = \rho^* x_2^* + e_2 \tag{B.36}$$

$$\sigma_e^2 = \sigma_\varepsilon^2 - (\rho^*\lambda^*)^2 \sigma_x^2 - (\rho^*)^2 (\sigma_\eta^*)^2, \tag{B.37}$$

where σ_ε is the standard deviation of the real exchange rate and e_2 is uncorrelated with x_2^* and x_2. We can then write the real exchange rate as a component correlated with log domestic log output plus a shock, e_2^*, that is uncorrelated with domestic output:

$$\varepsilon_2 = (\rho^*\lambda^*) x_2 + e_2^*, \tag{B.38}$$

$$e_2^* = e_2 + \rho^*\eta_2^*,$$

$$(\sigma_e^*)^2 = \sigma_\varepsilon^2 - (\rho^*\lambda^*)^2 \sigma_x^2.$$

For given no-commitment and commitment policy functions and a given LC debt share, we use that $1/R^* = \delta^* exp\left(\frac{1}{2}\left(\frac{\gamma^*}{\psi^*}\sigma^*\right)^2\right)$ and compute the ratio of LC bond prices to $1/R^*$:

$$\frac{Q_1^{LC}}{1/R^*} = E_{x_2,e_2^*,\xi_2,\eta_2^*}\left[exp\left(-\frac{\gamma^*}{\psi^*}x_2^* - \frac{1}{2}\left(\frac{\gamma^*}{\psi^*}\sigma^*\right)^2 - \pi_2 + \rho^* x_2^* + e_2 - \frac{1}{2}\sigma_\varepsilon^2\right)\right]$$

$$= E_{x_2,e_2^*,\xi_2,\eta_2^*}\left[exp\left(-\frac{\gamma^*}{\psi^*}x_2^* - \frac{1}{2}\left(\frac{\gamma^*}{\psi^*}\sigma^*\right)^2 - \pi_2 + \rho^* x_2^* - \frac{1}{2}\left(\sigma_\varepsilon^2 - \sigma_e^2\right)\right)\right] \tag{B.39}$$

$$= E_{x_2,e_2^*,\xi_2}\left[exp\left(-(\theta^* - \rho^*\lambda^*) x_2 - \left(\frac{\gamma^*}{\psi^*} - \rho^*\right)\eta_2^* - \pi_2 - \frac{1}{2}\left(\frac{\gamma^*}{\psi^*}\sigma^*\right)^2 - \frac{1}{2}\left(\sigma_\varepsilon^2 - \sigma_e^2\right)\right)\right] \tag{B.40}$$

$$= E_{x_2,e_2^*,\xi_2}\left[exp\left(-(\theta^* - \rho^*\lambda^*) x_2 - \pi_2 + \frac{1}{2}\left(\frac{\gamma^*}{\psi^*} - \rho^*\right)^2 (\sigma_\eta^*)^2 - \frac{1}{2}\left(\frac{\gamma^*}{\psi^*}\sigma^*\right)^2 - \frac{1}{2}\left(\sigma_\varepsilon^2 - \sigma_e^2\right)\right)\right], \tag{B.41}$$

where we define the international investors' effective risk aversion over domestic output as:

$$\theta^* = \frac{\gamma^*}{\psi^*}\lambda^*. \tag{B.42}$$

It then follows that:

$$\frac{Q_1^{LC}}{1/R^* exp\left(\frac{1}{2}\left(\frac{\gamma^*}{\psi^*} - \rho^*\right)^2 (\sigma_\eta^*)^2 - \frac{1}{2}\left(\frac{\gamma^*}{\psi^*}\sigma^*\right)^2 - \frac{1}{2}(\sigma_\varepsilon^2 - \sigma_e^2)\right)} = (1-p) E_{x_2}\left[exp\left(-(\theta^* - \rho^*\lambda^*) x_2 - \pi_2^{nc}\right)\right]$$

$$+ p E_{x_2}\left[exp\left(-(\theta^* - \rho^*\lambda^*) x_2 - \pi_2^c\right)\right] \tag{B.43}$$

We evaluate the expectation (B.43) numerically using Gauss-Legendre quadrature with 30 node points, truncating the interval at -6 and +6 standard deviations of x_2.

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B.4.3 No-Commitment Policy Function

The no-commitment inflation policy function $\pi_2^{nc}(x_2)$ maximizes the expectation (40). By the calculus of variations, optimizing over all functions $\pi_2^{nc}(x_2)$ gives the first-order condition:

$$0 = E_{e_2^*}\left[\left(-2\alpha\pi_2^{nc}(x_2) + (C_2^{nc})^{-\gamma}\frac{dC_2^{nc}}{d\pi_2^{nc}}\right)\bigg| s, Q^{LC}, x_2\right]. \tag{B.44}$$

The expectation (B.44) is averaged over e_2^* but conditional on domestic output x_2. No-commitment consumption is related to no-commitment inflation $\pi_2^{nc}(x_2)$ via:

$$C_2^{nc} = \bar{X}exp(x_2/\bar{X}) - \bar{D}\left((1-s)exp\left(-\varepsilon_2 + \frac{1}{2}\sigma_\varepsilon^2\right) + s\frac{1/R^*}{Q_1^{LC}}exp(-\pi_2^{nc}(x_2))\right). \tag{B.45}$$

$$= \bar{X}exp(x_2/\bar{X}) - \bar{D}\left((1-s)exp\left(-(\rho^*\lambda^*)x_2 - e_2^* + \frac{1}{2}\sigma_\varepsilon^2\right) + s\frac{1/R^*}{Q_1^{LC}}exp(-\pi_2^{nc}(x_2))\right),$$

so the derivative of no-commitment consumption with respect to no-commitment inflation is:

$$\frac{dC_2^{nc}}{d\pi_2^{nc}} = \bar{D}s\frac{1/R^*}{Q_1^{LC}}exp(-\pi_2^{nc}). \tag{B.46}$$

Note that only the ratio $\frac{Q^{LC}}{1/R^*}$ enters into (B.44) and (B.45), so we only need to solve for this ratio and not for Q^{LC} and R^* separately. Our numerical solution minimizes the Euler equation error $Error(x_2)$, defined as the difference between the right-hand-side of (B.44) evaluated at the numerical solution and zero. We evaluate the expectation over e_2^* numerically using Gauss-Legendre quadrature with 30 nodes and truncation at -6 and +6 standard deviations.

We choose the vector of coefficients (b_1, b_2, b_3, b_4) to minimize the expected squared Euler equation error averaged over possible realizations of x_2, $E_{x_2}\left[Error(x_2)^2\right]$. That is, we minimize the weighted average of the squared Euler equation errors, where each realization of x_2 is weighted by its probability. To take the expectation over x_2, we again use Gauss-Legendre quadrature with 30 nodes and truncation at -6 and +6 standard deviations.

B.4.4 Commitment Policy Function

We next find the commitment inflation policy function, subject to the LC debt share, s, the no-commitment inflation policy function, π_2^{nc}, and the relation between the commitment inflation policy and bond prices (B.43). We choose the vector (c_1, c_2, c_3, c_4) to maximize the expectation:

$$pE_{x_2, e_2^*}\left[\left(-\alpha\left(\pi_2^c\right)^2 + \frac{C_2^{c,1-\gamma}}{1-\gamma}\right)\right], \tag{B.47}$$

where we evaluate commitment consumption numerically:

$$C_2^c = \bar{X}exp(x_2/\bar{X}) - \bar{D}\left((1-s)exp\left(-(\rho^*\lambda^*)x_2 - e_2^* + \frac{1}{2}\sigma_\varepsilon^2\right) + s\frac{1/R^*}{Q_1^{LC}}exp(-\pi_2^c(x_2))\right). \tag{B.48}$$

and LC bond prices update with the commitment and no-commitment inflation policy functions through (B.43). Note again that only the ratio $\frac{Q^{LC}}{1/R^*}$ enters into (B.48), so we only need to solve for this ratio and not for Q^{LC} and R^* separately. All expectations are again evaluated numerically using Gauss-Legendre quadrature using the same grid points as before.

B.4.5   Model Moments

We use Gauss-Legendre quadrature to evaluate inflation moments numerically. For both x_2 and e_2^*, we use 30 nodes and truncate the interval at -6 and +6 standard deviations. We evaluate average inflation, the bond-stock beta and the LC bond risk premium numerically as:

$$E\pi_2 \quad = \quad pE_{x_2,e_2^*}\pi_2^c(x_2) + (1-p)E_{x_2,e_2^*}\pi_2^{nc}(x_2), \tag{B.49}$$

$$\beta(bond, stock) \quad = \quad \frac{-1}{\lambda^{e,x}}\left[\frac{pE_{x_2,e_2^*}[(\pi_2^c(x_2) - E\pi_2)x_2] + (1-p)E_{x_2,e_2^*}[\pi_2^{nc}(x_2) - E\pi_2)x_2]}{\sigma_x^2}\right] \tag{B.50}$$

$$RP^{LC} \quad = \quad \log E_{x_2,e_2^*}[exp(-\pi_2)] - \log Q^{LC} - r^*. \tag{B.51}$$

B.5   Calibration Robustness

B.5.1   Separate EM and DM Local-International Endowment Loadings

We now verify that calibration results are unchanged if we match the domestic-international endowment loadings to the data separately for emerging and developed markets. We set $\lambda^{x,x^*} = 0.87$ for EMs and $\lambda^{x,x^*} = 0.97$ for DMs to match the average slope coefficients of domestic output growth with respect to US consumption growth averaged separately for EM and DM data. All other parameter values are as listed in Table 5. Table B.1 shows that the model moments are qualitatively and quantitatively unchanged compared to Table 6 in the main paper.

Table B.1: Model Moments with Separate Local-International Endowment Loadings

	EM		DM		EM-DM	
	Data	Model	Data	Model	Data	Model
Average Inflation	3.92%	2.12%	1.73%	0.00%	2.20%	2.11%
Bond-Stock Beta	0.07	0.15	-0.10	-0.06	0.17	0.21
LC Debt Share	0.55	0.38	0.90	0.96	-0.35	-0.58
LC Bond RP	3.15%	4.27%	1.53%	2.03%	1.62%	2.24%

Note: All moments are in annualized natural units. Model parameters for the EM and DM calibrations are given in Table 5, except for the local-global endowment loadings, which we set to set to $\lambda^{x,x^*} = 0.87$ for EMs and $\lambda^{x,x^*} = 0.97$ for DMs. Model average inflation is the unconditional average of level inflation. The model bond-stock beta is computed according to equation (38).

B.5.2   Separate EM and DM Exchange Rate Processes

We now verify that the calibration results are qualitatively and quantitatively unchanged if we calibrate EM and DM real exchange rate processes separately to the data. To match the data moments averaged separately over EMs and DMs, we set $\sigma_\varepsilon = 10.4\%$ and $\lambda^{\varepsilon,x^*} = 1.33$ for the EM calibration and $\sigma_\varepsilon = 11.4\%$ and $\lambda^{\varepsilon,x^*} = 1.56$ for the DM calibration. All other parameter values are as listed in Table 5. The resulting model moments are shown in Table B.2.

Table B.2: Model Moments with Separate Exchange Rate Processes

	EM		DM		EM-DM	
	Data	Model	Data	Model	Data	Model
Average Inflation	3.92%	2.07%	1.73%	0.00%	2.20%	2.06%
Bond-Stock Beta	0.07	0.15	-0.10	-0.05	0.17	0.20
LC Debt Share	0.55	0.37	0.90	0.91	-0.35	-0.54
LC Bond RP	3.15%	3.95%	1.53%	2.53%	1.62%	1.42%

Note: All moments are in annualized natural units. Model parameters for the EM and DM calibrations are given in Table 5, except for the exchange rate processes, which we calibrate separately to the data in this table. We set $\sigma_\varepsilon = 10.4\%$ and $\lambda^{\varepsilon,x^*} = 1.33$ for the EM calibration and $\sigma_\varepsilon = 11.4\%$ and $\lambda^{\varepsilon,x^*} = 1.56$ for the DM calibration. Model average inflation is the unconditional average of level inflation. The model bond-stock beta is computed according to equation (38).

B.5.3 Varying the DM Inflation Cost Parameter

We now verify the robustness of our calibration results to choosing different inflation cost parameters for the DM calibration. In our baseline calibration, the inflation cost parameter, α, is pinned down by the average difference in inflation between EMs and DMs in the data. In our baseline calibration, we choose the same inflation cost parameter for EMs and DMs for symmetry and to focus on the effect of credibility, which also varies across EM and DM calibrations. However, it appears plausible that the inflation cost of DMs is different from EMs. The DM inflation cost could be higher if DM policy makers assign a higher cost to inflation. Or it could be lower, if DM institutions are better able to smooth out frictions caused by inflation.

Here, we verify that the calibration results are similar for a range of values for the DM inflation cost parameter, α^{DM}. We consider a wide range of values for α^{DM}, setting it to one half and twice the baseline value of $\alpha = 2.14$. All other parameter values are set to the DM values in Table 5. The resulting model moments in Table B.3 show that DM model moments are largely insensitive to α^{DM}. Average inflation is equal to zero – the optimal level in the model – for all values of α, because a government with full commitment always chooses average inflation equal to the optimal level. The LC debt share is close to 0.90 for a wide range of inflation cost parameters, and the bond-stock beta varies within a relatively narrow range from -0.03 to -0.09.

Table B.3: Model Robustness to Different Inflation Costs

	DM Data	Baseline $\alpha = 2.14$	Low Inflation Cost $\alpha = 1.07$	High Inflation Cost $\alpha = 4.28$
Average Inflation	1.73%	0.00%	0.00%	0.00%
Bond-Stock Beta	-0.10	-0.05	-0.09	-0.03
LC Debt Share	0.90	0.91	0.92	0.90
LC Bond RP	1.53%	2.22%	1.90%	2.46%

Note: All moments are in annualized natural units. Model parameters are given by the DM calibration in Table 5, except for the inflation cost, α, which is listed in the column header. Model average inflation is the unconditional average of level inflation. The model bond-stock beta is computed according to equation (38).