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

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Abstract

Nominal government debt can be inflated away, potentially providing valuable flexibility in recessions. However, we show empirically that governments with more countercyclical inflation issue less nominal debt. We propose that imperfect monetary policy credibility drives both inflation cyclicality and currency choice. In an analytically tractable model with risk-averse investors, nominal debt creates a bias towards excessively countercyclical inflation, in addition to the standard inflationary bias. Low credibility governments issue foreign currency debt to mitigate the incentive for countercyclical inflation and to lower risk premia on their nominal debt. Consistent with the model, we find significantly higher nominal bond risk premia for countries with low nominal debt shares.

1 Introduction

Over the past decade, the market for emerging market government debt has undergone a remarkable transformation. In the 1980s and 1990s, most emerging market sovereigns and several developed country governments relied heavily on foreign currency (FC) in their foreign borrowing. This left borrowers vulnerable to currency fluctuations and financial crises (Eichengreen and Hausmann, 2005). Since the Asian Financial Crisis, the share of government bonds issued in local currencies (LC) has grown rapidly and now constitutes more than half of external debt issued by major emerging market sovereigns (Du and Schreger, 2015). However the shift towards local currency government bonds has been highly uneven across markets, raising the question of what drives these differences.

The standard approach to optimal government finance suggests that governments should smooth the costs of taxation across states of the world. If deadweight costs are higher during recessions, due to risk aversion or distortionary taxes (Barro, 1979), it is optimal to issue bonds that require low repayments in recessions and higher repayments in expansions (Bohn, 1990a,b; Barro, 1997). So a key benefit of nominal local currency debt is that the government can inflate away the real debt burden when relief is needed most. However we find that countries where nominal local currency debt provides little or no flexibility during adverse states of the world, issue the most. A positive beta of nominal local currency bond returns with respect to stock returns indicates that bonds pay off less during stock market downturns and hence provide fiscal flexibility. Figure 1 summarizes the key stylized fact that countries with the most positive local currency bond betas have the lowest local currency debt shares.[2]

We begin by documenting significant cross-country heterogeneity in local currency bonds' hedging properties and inflation cyclicality in a sample of 30 developed and emerging markets with sizable nominal local currency bond markets. Over the last decade local currency

[2] We show average local currency debt shares in central government debt and the estimated slope coefficient of local currency government bond returns against local stock market returns for the period 2005-2014 for a sample of 30 emerging and developed countries. For details see Section 2.1.

bond-stock betas range from significantly negative (-0.2) to significantly positive (0.3). Bond-stock betas in developed markets, such as the US, tend to be negative. Emerging markets' bond-stock betas span a wide range, but tend to be positive. Since local currency bonds lose value when inflation expectations increase, and stock returns are pro-cyclical, we expect that positive bond-stock betas coincide with countercyclical inflation. We verify this prediction in the data, consistent with inflation expectations being a key driver of the hedging properties of local currency bonds. We measure inflation cyclicality both as the beta of inflation expectations with respect to output expectations and as the beta of realized inflation with respect to industrial production. Our second set of stylized facts expands on Figure 1 to document the relation between the hedging properties of local currency debt and the share of local currency debt in sovereign debt portfolios. We show that countries with more pro-cyclical local currency bond returns and counter-cyclical inflation expectations rely less on nominal local currency debt relative to real or foreign currency debt. This is the opposite of what we would expect if governments issue local currency debt to smooth taxes across states of the world.

What explains this apparently puzzling relation? We demonstrate that it is the equilibrium outcome of a model, where monetary policy credibility drives the cyclicality of inflation, with investors who require a risk premium to hold positive-beta assets. We build on the loose commitment mechanism of Debortoli and Nunes (2010), where the government communicates a contingent plan for future inflation, but it may revert to a myopic policy(Kydland and Prescott, 1977; Barro and Gordon, 1983; Rogoff, 1985). When commitment fails, the government uses inflation to reduce the real burden of local currency debt. The incentive to inflate is more pronounced during low output states, when marginal utility is highest. Crucially, debt is priced by risk-averse lenders, whose stochastic discount factor (SDF) is correlated with domestic output. In addition to the classic inflationary bias, we hence obtain that a low credibility government generates excessively countercyclical inflation. A high credibility government therefore has an incentive to constrain its desire to inflate in low output states in order to provide investors with safe nominal local currency debt.

The key insight of the model is that when governments with imperfect credibility borrow in nominal terms from risk-averse lenders, they not only have an inflationary bias, but also lack the ability to commit to a degree of state-contingency on the debt. With risk-averse lenders, a government's temptation to inflate more in bad states leads lenders to charge a risk premium on nominal borrowing. This lowers average borrower consumption. But a government with full commitment that borrows from risk-averse lenders can lower its LC return premium. It achieves this by committing to an inflation process that keeps LC bond payouts relatively stable during recessions, when investors' marginal utility is high. In contrast, a government lacking commitment cannot credibly promise to restrict itself to such a limited amount of state-contingency and therefore pays a higher-than-optimal risk premium. Because of this, in equilibrium governments that obtain little consumption-smoothing from issuing nominal debt (those with more pro-cyclical inflation) issue the most nominal debt, and those that could obtain the most consumption-smoothing from issuing nominal debt (those with more countercyclical inflation) issue the least.

Significantly, limited commitment cannot resolve the stylized fact in Figure 1 if lenders are risk-neutral. With risk-neutral lenders, the model implies a flat or even upward-sloping relation between bond-stock betas and local currency debt shares, in contrast with the empirical downward-sloping relation in Figure 1. In this case, while governments with low credibility may optimally issue less local currency debt to avoid inducing an inflationary bias, high credibility governments have as much an incentive to smooth consumption as low credibility governments. It is only the interaction of imperfect commitment and risk-averse lenders that can explain the empirical patterns.

Finally, we present empirical support linking local currency risk premia with the credibility of monetary policy. First, we test the model prediction that LC bond risk premia decline with LC debt shares in equilibrium. We find that the bottom third of LC debt issuers on average have risk premia that are two to three percent higher than those of the top third of

LC debt issuers, depending on the default risk adjustment. These differences are economically significant and consistent with a calibrated version of the model. Second, we show empirical evidence that higher local currency bond-stock betas are associated with significantly higher local currency bond risk premia, supporting the model mechanism, whereby investors require a premium for holding local currency bonds that tend to depreciate during downturns. Finally, we provide direct evidence for the model mechanism by relating local currency bond-stock betas and local currency bond risk premia to two de-facto measures of monetary policy credibility, based on official central bank inflation targets and newspaper text analysis. We find that a 0.5 percentage point increase in the gap between survey inflation and the official central bank inflation target is associated with an increase in the local currency bond-stock beta of 0.12.

This paper contributes to a recent literature on inflation commitment and debt limits when the debt denomination is exogenous (Araujo et al., 2013; Aguiar et al., 2014; Chernov et al., 2015; Sunder-Plassmann, 2014; Bacchetta et al., 2015; Du and Schreger, 2015; Corsetti and Dedola, 2015) and the large literature on government debt and inflation (Sargent and Wallace, 1981; Leeper, 1991; Sims, 1994; Woodford, 1995; Cochrane, 2001; Davig et al., 2011; Niemann et al., 2013). We expand on these papers along two dimensions. First, we model the government's optimal share of internationally held local currency debt. Second, we allow the central bank to engage in optimal forward guidance with partial credibility. While a long-standing literature has considered dollarization or monetary unions as commitment devices for central banks (Obstfeld, 1997), we consider how the government optimally chooses the denomination of sovereign debt to mitigate limited monetary policy credibility. We add to the related quantitative frameworks of Alfaro and Kanczuk (2010); Díaz-Giménez et al. (2008) by matching stylized cross-sectional facts about inflation cyclicality and bond return cyclicality. In simultaneous work, Ottonello and Perez (2016) and Engel and Park (2016) also explain the currency composition of sovereign debt by emphasizing the time-consistency problem in monetary policy. Compared to Ottonello and Perez (2016) and Engel and Park

(2016), we focus on the cyclicality of monetary policy, and the role of local currency bond risk premia for government debt portfolio choice.

The paper is also related to a recent literature on time-varying bond risks (Baele et al., 2010; Andreasen, 2012; David and Veronesi, 2013; Campbell et al., 2014; Song, 2014; Ermolov, 2015; Campbell et al., 2015), that is primarily focused on the US and the UK. Vegh and Vuletin (2012) also emphasize the evolution and cross-country heterogeneity in the cyclicality of monetary policy, but do not study implications for sovereign debt portfolios. This paper differs from the previous literature, in that we focus on the joint determination of governments' optimal debt issuance and bond risks for emerging markets. We do not take a stand in this paper on the interest rate policy needed to implement the optimal inflation process. The link between a Taylor-type monetary policy rule, inflation cyclicality and local currency bond risks is studied in Campbell et al. (2015).

The structure of the paper is as follows. In Section 2, we present new stylized facts on the relation between the cyclicality of local currency bond risk and shares of local currency debt in sovereign portfolios. In Sections 3 and 4 we lay out the model, provide analytical intuition for the key mechanisms, and calibrate the model to demonstrate that it can replicate the observed patterns of the currency composition of sovereign debt and the cyclicality of monetary policy. Section 5 tests additional model implications for risk premia and relates bond betas and risk premia to de-facto monetary policy credibility measures. Section 6 concludes.

2 Empirical Evidence

In this section, we establish the empirical relation between local currency bond risks, inflation cyclicality, and the currency composition of sovereign debt portfolios. We first describe the data and variable construction and present summary statistics by emerging and developed market groups. We then show that there is a strong and robust correlation between measures of local currency risk and sovereign debt portfolios.

2.1 Data and Variable Construction

We focus on inflation and default dynamics, bond risks and sovereign debt portfolios in 11 developed markets (Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, United States and United Kingdom) and 19 emerging markets (Brazil, Chile, China, Colombia, Czech Republic, Hungary, Indonesia, Israel, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Singapore, South Africa, South Korea, Thailand and Turkey).

For LC bond yields, we use primarily Bloomberg fair value (BFV) curves. 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 only have a handful of fixed-rate bonds and hence do not have a BFV curve. As for most emerging markets in our sample BFV curves are available starting in the mid-2000s, we focus on the period 2005-2014 to maintain a balanced panel.

To measure inflation risk and the perceived cyclicality of inflation, we use realized inflation from Haver and inflation forecasts from Consensus Economics, respectively. Finally, we measure the share of local currency debt in total sovereign debt portfolios with data from BIS Debt Securities Statistics, OECD Central Government Debt Statistics, and several individual central banks.

2.1.1 Nominal Bond Risks: Bond-Stock

Asset markets incorporate investors' forward-looking information at much higher frequency than surveys and can therefore provide additional proxies for inflation cyclicality, that are potentially less subject to measurement error. Local currency bond-stock betas serve as an asset market based proxy of inflation cyclicality. If stock returns are pro-cyclical, we expect bond-stock betas to be inversely related to the cyclicality of inflation expectations.

We denote the log yield on a nominal LC n-year bond as y_{nt}^{LC}, where $y_{nt} = \log(1 + Y_{nt}^{LC})$. The log holding period return on the bond is given by

$$r_{n,t+\Delta t}^{LC} \approx \tau_n y_{nt}^{LC} - (\tau_n - \Delta t) y_{n-1,t+\Delta t}^{LC},$$

where $\tau_n = \frac{1-(1+Y_{nt}^{LC})^{-n}}{1-(1+Y_{nt}^{LC})^{-1}}$ is the duration of a bond selling at par (Campbell et al. (1997)). We approximate $y_{n-\Delta t,t+\Delta t}^{LC}$ by $y_{n,t+\Delta t}^{LC}$ for the quarterly holding period. We let y_{1t}^{LC} denote the three-month T-bill yield and then the excess return on LC bonds over the short rate is given by

$$xr^{LC} = r_{n,t+\Delta t}^{LC} - y_{1t}^{LC}.$$

From a dollar investor's perspective, we can rewrite the excess return as

$$xr^{LC} = [r_{n,t+\Delta t}^{LC} - (y_{1t}^{LC} - y_{1t}^{US})] - y_{1t}^{US}.$$

The dollar investor can hedge away the currency risk of the holding period Δt by going long a US T-bill and shorting a LC T-bill with the same market value as the LC bond. By doing so, any movement in the spot exchange rate of the LC has the same offsetting first-order impact on the bond position and the local T-bill position and hence cancels out. After hedging currency risk for the holding period, the dollar investor bears duration risk of the LC bond.

We define the local equity excess returns as the log return on local benchmark equity over the three-month LC Treasury bill:

$$xr_{t+\Delta t}^{m} = (p_{t+\Delta}^{m} - p_t^{m}) - y_{1t}^{LC},$$

where p_t^m denotes the log benchmark equity return index at time t. Country subscripts are suppressed to keep the notation concise. We then compute the local bond-stock beta

$b(bond, stock)$ by regressing LC bond excess returns $xr^{LC}_{t+\Delta t}$ on local equity excess returns $xr^{m}_{t+\Delta t}$:

$$xr^{LC}_{t+\Delta t} = \alpha + b(bond, stock) \times xr^{m}_{t+\Delta t} + \epsilon_t.$$

Bond-stock betas measure the risk exposure of LC bond returns on local equity returns.

2.1.2 Cyclicality of Inflation Expectations: Forecast Beta

We construct a new measure for the pro-cyclicality of inflation expectations at the country level, by regressing the change in the CPI inflation rate predicted by forecasters on the change in their predicted real GDP growth rate. Each month, professional forecasters surveyed by Consensus Economics forecast inflation and GDP growth for the current and next calendar year. We use revisions of inflation and GDP forecasts each month relative to forecasts made three months ago to infer shocks to investors' expectation of inflation and output. We pool all revisions for 2006 through 2013 (so that the forecasts themselves were all made post-2005), and run the country-by-country regression

$$\Delta\tilde{\pi}_t = b_0 + b(\tilde{\pi},\widetilde{gdp}_t) \times \Delta\widetilde{gdp}_t + \epsilon_t, \tag{1}$$

where t indicates the date of the forecast revision. The revisions to inflation forecasts ($\Delta\tilde{\pi}_t$) and GDP growth forecasts ($\Delta\widetilde{gdp}_t$) are measured as percentage changes of forecasts made three months before. The coefficient $b(\tilde{\pi},\widetilde{gdp}_t)$ 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 forecasts 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. We focus on revisions to the two-year forecast (13-23 months ahead).

2.1.3 Cyclicality of Realized Inflation: Realized Inflation-Output Beta

While investors' beliefs about inflation cyclicality enter into government debt prices and hence sovereign debt portfolio choice, it is useful to verify that the composition of debt portfolios also lines up with the cyclicality of realized inflation and output. We measure the realized inflation cyclicality with respect to output. To avoid the problem of non-stationarity, we compute the realized inflation-output beta by regressing the change in the inflation rate on the change in the industrial production growth rate:

$$\Delta\pi_t = b_0 + b(\pi, IP)\Delta IP_t + \epsilon_t, \tag{2}$$

where $\Delta\pi_t$ is the 12-month change in the year-over-year inflation rate and ΔIP_t is the 12-month change in the year-over-year industrial production growth rate. The coefficient $b(\pi, IP)$ measures the realized inflation cyclicality with respect to output. We obtain the seasonally adjusted consumer price index and the industrial production index from Haver between 2005 and 2014.

2.1.4 Nominal Debt Shares

For developed countries, we construct the share of local currency debt based on the OECD Central Government Debt Statistics and supplement this data with hand-collected statistics from individual central banks.[3] Central banks typically directly report the instrument composition of debt securities outstanding issued by the central government.

For emerging markets, we measure the share of local currency debt in sovereign debt portfolios using the BIS Debt Securities Statistics, supplemented with statistics from individual central banks. Table 16C of the 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 Debt Securities Statistics reports total international debt

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

securities outstanding issued by the general government (D_t^{int}). For emerging markets, as the vast majority of international sovereign debt is denominated in foreign currency, and local governments rarely tap international debt markets, D_t^{int} offers a very good proxy for central government foreign currency debt outstanding. Data for developed countries are from individual central banks or the OECD. The share of local currency debt is computed as the ratio of the fixed-coupon domestic sovereign debt outstanding (D_t^{int}) 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. In our baseline results, we do not distinguish between foreign and domestically-owned debt, but we provide evidence in Appendix B that empirical results are similar for foreign-owned debt.

2.2 Summary Statistics

Table 1 reports summary statistics for inflation, inflation expectations, local currency bond yields, bond-stocks betas, inflation-output forecast betas, realized inflation-output betas, and local currency debt shares by developed and emerging market groups. Emerging market realized inflation is 2.4 percentage points higher and survey-based expected inflation is 2.0 percentage points higher. In addition, expected inflation and realized inflation are less pro-cyclical in emerging markets than in developed countries.

For local currency bonds, five-year local currency yields are 3.4 percentage points higher in emerging markets than in developed markets. Nominal bond returns are counter-cyclical in developed markets, as evident from negative bond-stock betas. By contrast, local currency bond returns are pro-cyclical in emerging markets. Finally, developed markets borrow almost entirely with local currency debt, while the local currency debt share in emerging market averages only 60%.

2.3 Comovement among Nominal Risk Measures

If changes to inflation expectations are an important driver of local currency bond returns, the cyclicality of local currency bond returns should be inversely related to the cyclicality of inflation expectations. In Figure 2, Panel (A) confirms this intuition, showing a strong negative relation between bond-stock betas and inflation forecast betas across countries. Panel (B) shows the corresponding relation for realized inflation cyclicality.

We can see from the y-axis that all developed markets (indicated by red dots) have negative bond-stock betas during the past decade. Among emerging markets (indicated by green dots), bond-stock betas range from slightly negative -0.07 for Thailand to positive 0.32 for Turkey. From the sovereign issuer's perspective, local currency bonds are risky for developed markets, where the debt burden is higher in bad times. Conversely, local currency bonds issued by most developed markets act as hedges from the investors' perspective.

In Panel (C), we show the strong relationship between local bond-stock betas and the bond betas with respect to returns on the S&P, our proxy for global equity returns. We see that bonds that are better hedges from the issuing government's perspective tend to be riskiest from a US investor's perspective.

2.4 Relation between Nominal Risk Betas and Sovereign Debt Portfolios

Figure 3 adds to the evidence in Figure 1 on the relation between bond return cyclicality and the share of local currency debt in sovereign debt portfolios. In particular, we find that countries with lower inflation forecast betas, lower inflation-output betas, and higher bond-S&P betas tend to have lower shares of local currency sovereign debt. Emerging markets have lower local currency debt shares and more pro-cyclical local currency risk, whereas developed countries have high local currency debt shares and more counter-cyclical nominal risk.

Table 2 shows a cross-sectional regression of the local currency debt shares on the different measures of inflation cyclicality. The first four columns show that all nominal risk betas are significantly correlated with nominal debt shares. A 0.1 increase in the bond-stock beta is associated with an eleven percentage point reduction in the nominal debt share. Columns 5 and 6 show that the relation between local currency debt shares and bond-stock betas is robust to controlling for mean log GDP per capita and exchange rate regimes as classified by Reinhart and Rogoff (2004).

The cross-sectional relationship between local currency risk betas and local currency debt shares is robust to measuring the local currency debt share only in long-term debt, as shown in Figure 4. This is important, because Missale and Blanchard (1994) argue that a shorter debt maturity can reduce the incentive to inflate away debt. 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 local currency debt share as the outstanding amount of LC debt with 5 or more years remaining to maturity relative to all outstanding debt with 5 or more years remaining to maturity.[4] Additional robustness checks, excluding the financial crisis, adjusting for default risk, and using only externally held government debt, are available in Appendix B.

3 Model

This section describes the model, derives second-order expansions, and solves for the optimal government policy under these second-order expansions. Government credibility can be interpreted as the probability that the government will implement a previously communicated contingent plan for inflation. The government objective is standard, reflecting domestic agents' power utility over consumption and a quadratic inflation cost. The model

[4] These sample countries are the same as the ones used in Du and Schreger (2015).

adds that investor marginal utility is correlated with domestic outputs. If investors' marginal utility is high during recessions, they require positive local currency bond risk premia from governments that tend to inflate more during low output states.

The model has two periods. In period 1, the government chooses the share of local currency debt in its sovereign debt portfolio and announces a contingent plan for inflation. In period 2, output is realized. If the commitment state is realized in period 2, the government implements the previously announced contingent plan for inflation. If the no-commitment state is realized in period 2, the government re-optimizes myopically by trading off inflation costs against the benefit of inflating away the real value of local currency debt. While the model is deliberatively stylized and features only two periods, in the appendix we specify an infinite-period extension that has identical solutions.

3.1 Government Objective

We use lower-case letters to denote logs. The government's loss function combines quadratic loss in log inflation π_2 and power utility over consumption:

$$L_2 = \alpha\pi_2^2 - \frac{C_2^{1-\gamma}}{1-\gamma}. \tag{3}$$

We do not take a stand on the source of inflation costs. A quadratic inflation cost of the form (6) may arise from price-setting frictions leading to production misallocation as in New Keynesian models (see Woodford (2003)). We assume that period 2 output is log-normally distributed

$$X_2 = \bar{X}\exp(x_2), \tag{4}$$

$$x_2 \sim N\left(0, \sigma_x^2\right). \tag{5}$$

The budget constraint is such that period 2 consumption equals output minus real debt repayments to investors, D_2:

$$C_2 \quad = \quad X_2 - D_2. \tag{6}$$

3.2 Asset Prices

We assume that financial markets are integrated in the sense that all assets are priced by the same international investor. However, markets are incomplete from the domestic borrower's point of view, who has access only to LC and FC debt, cannot go long bonds, and must split his debt portfolio between these two instruments. Inflation in the investor's home currency is assumed to be zero, so one unit of international currency delivers the international investor with one unit of international consumption. International consumption and domestic consumption can differ if international agents prefer a different consumption bundle from domestic agents. The international investor uses the following real log stochastic discount factor (SDF) to price state-contingent claims on real international consumption

$$m_2^* \quad = \quad \log \beta - \phi \bar{X} x_2 - \frac{1}{2}\phi^2 \bar{X}^2 \sigma_x^2. \tag{7}$$

Intuitively, the international investor's stochastic discount factor is correlated with factors driving the domestic stochastic discount factor. This assumption implies that bonds that have high betas with respect to domestic marginal utility also tend to have high betas with respect to international investors' consumption utility, consistent with the evidence in Figure 2 Panel (C). We normalize the real exchange rate in period 1 to one. The period 2 real exchange rate (in units of international goods per domestic goods) is given by

$$exp\left(\varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right). \tag{8}$$

We specify the shock ε_2 as uncorrelated with all other shocks:

$$\varepsilon_2 \sim N\left(0, \sigma_\varepsilon^2\right). \tag{9}$$

The period 2 real exchange rate has mean one, implying that changes in the real exchange rate are unforecastable. We assume ε_2 is realized after the government has chosen inflation, effectively assuming that monetary policy takes effect more slowly than exchange rate shocks. In the context of the model, this random variation in the real exchange rate introduces a cost of borrowing in foreign currency, because the amount of domestic consumption required to repay one unit of international real consumption is random. The international investor hence prices state-contingent claims on real domestic consumption using the log SDF

$$m_2 = m_2^* + \varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2. \tag{10}$$

We can now price three different bonds: a foreign currency bond, a nominal local currency bond, and a real local currency bond. A real local currency bond here is defined as delivering one unit of real domestic consumption. The real local currency bond will not be issued by the government in the model but is priced here to clarify the difference between real local currency and foreign currency debt. The price of this bond is

$$q^{LC,real} = E\left[exp\left(m_2\right)\right], \tag{11}$$

$$= E\left[exp\left(\log\beta - \phi\bar{X}x_2 - \frac{1}{2}\phi^2\bar{X}^2\sigma_x^2 + \varepsilon_2 - \frac{1}{2}\sigma_\varepsilon^2\right)\right], \tag{12}$$

$$= \beta. \tag{13}$$

A nominal LC bond delivers $exp(-\pi_2)$ real domestic consumption units at time 2. The corresponding price is

$$
\begin{aligned}
q^{LC} &= E\left[exp\left(m_2\right)exp(-\pi_2)\right], && (14)\\
&= E\left[exp\left(\log\beta-\phi\bar{X}x_2-\frac{1}{2}\phi^2\bar{X}^2\sigma_x^2+\varepsilon_2-\frac{1}{2}\sigma_\varepsilon^2\right)exp(-\pi_2)\right], && (15)\\
&= E\left[exp\left(\log\beta-\phi\bar{X}x_2-\frac{1}{2}\phi^2\bar{X}^2\sigma_x^2\right)exp(-\pi_2)\right]. && (16)
\end{aligned}
$$

The real exchange rate does not enter into the pricing of real and nominal LC bonds, because in expectation one unit of real domestic consumption buys one unit of real international consumption and exchange rate shocks are assumed to be uncorrelated with all other shocks. Finally, a FC bond pays one unit of real international consumption. The price of a FC bond is

$$
\begin{aligned}
q^{FC} &= E\left[exp\left(m_2^*\right)\right], && (17)\\
&= \beta. && (18)
\end{aligned}
$$

We are interested in the amount of real consumption that the domestic borrower has to give up in order repay different types of bonds. To capture this notion, we define log excess returns in terms of real domestic consumption in excess real LC bonds. In order to service one unit of FC bonds, the domestic borrower must give up an amount of real domestic consumption, that is equal to the inverse of the exchange rate. The FC log real bond excess return from the borrower's point of view hence is:

$$
xr_2^{FC} = -\varepsilon_2+\frac{1}{2}\sigma_\varepsilon^2. \qquad (19)
$$

With the Jensen's inequality adjustment, the expected excess return on FC debt in domestic consumption units is

$$
Exr_2^{FC}+\frac{1}{2}Varxr_2^{FC} = \sigma_\varepsilon^2. \qquad (20)
$$

The positive real excess return on FC debt arises, because while the mean exchange rate is one, the mean inverse exchange rate is not equal to one due to Jensen's inequality. To purchase one unit of international consumption, the domestic borrower expects to give up more than one unit of real domestic consumption, because he has to average over states with different exchange rates.[5] The nominal LC log excess return depends on inflation, but not on exchange rates:

$$xr^{LC} = -\pi_2 - \log \frac{q^{LC}}{\beta}. \tag{21}$$

We denote one-period log bond yields by

$$\begin{aligned} y_1^{LC} &= -\log q^{LC}, \\ y_1^{FC} &= -\log q^{FC}. \end{aligned}$$

We assume that domestic equity is a claim on domestic output and is priced by the same international investor, giving the equity risk premium faced by the international investor as

$$E\left(r_2^e\right) + \frac{1}{2}Var\left(r_2^e\right) - y_1^{FC} = \phi \bar{X}^2 Var(x_2). \tag{22}$$

Equity is in zero supply to financial investors, thereby not entering into domestic consumption. The expression for the equity premium will be useful in Section 4 to calibrate the magnitude of risk premia.

3.3 Budget Constraint

To focus on the portfolio choice component of the government's decision, we assume that the government must raise a fixed amount V. The government chooses face values D^{FC} and

[5] The divergence between the expected return on risk-free real FC and LC bonds is also known as Siegel's paradox (Siegel (1972), Karolyi and Stulz (2003)).

D^{LC} to satisfy the budget constraint[6]

$$D^{FC}q^{FC} + D^{LC}q^{LC} \;\; = \;\; V. \tag{23}$$

Let s denote the share of nominal LC bonds in the government's portfolio:

$$s \;\; = \;\; \frac{q^{LC}D^{LC}}{V}. \tag{24}$$

Defining the log excess return on the sovereign debt portfolio from the domestic issuer's point of view as

$$xr_2^d \;\; = \;\; \log\left(\frac{D^{FC}exp\left(-\varepsilon_2 + \frac{1}{2}\sigma_\varepsilon^2\right) + D^{LC}exp\left(-\pi_2\right)}{V exp\left(y^{FC}\right)}\right), \tag{25}$$

period 2 consumption equals

$$C_2 \;\; = \;\; \bar{X}exp(x_2) - \bar{D}exp\left(xr_2^d\right),$$
$$\bar{D} \;\; = \;\; \beta^{-1}V.$$

We normalize steady-state period 2 consumption to one, so α captures the cost of inflation distortions in units of period 2 consumption.[7] Formally, we require

$$\bar{X} \;\; = \;\; 1 + \bar{D}. \tag{26}$$

[6]Here, we do not explicitly allow the government to issue inflation-indexed LC debt. In contrast to the hypothetical real LC bond considered in the previous section, in practice inflation-indexed bond issuance appears to be costly. Inflation-indexed bond issuance can be costly for reasons analogous to those for foreign currency debt, if indexation is imperfect, either because the inflation index does not correspond perfectly to the domestic borrower's consumption basket, or because indexation occurs with lags. In addition, empirical evidence from the US suggests that inflation-indexed debt requires a substantial liquidity premium (Pflueger and Viceira (2016)).For this reason, in our empirical analysis we combine inflation-indexed and foreign currency debt to capture inflation-insulated debt issuance.

[7]Allowing period 2 steady-state consumption different from one would scale the loss function (6) by a constant, leaving the analysis unchanged.

3.4 Log-Quadratic Expansion for Loss Function

We now derive a log-quadratic expansion of the government loss function. The log-quadratic expansion provides intuition and we will use it to obtain a log-linear analytic solution. In contrast, the numerical solutions will not rely on the log-quadratic expansion and instead use the exact expressions in sections 3.1 through 3.3. Approximating local currency bond returns as log-normal, we obtain the following second-order expression for local currency bond prices

$$q^{LC} = \beta \exp\left(-E_1\pi_2 + \frac{1}{2}\sigma_\pi^2 + \phi\bar{X}Cov\left(x_2, \pi_2\right)\right). \tag{27}$$

The approximate risk premium on local currency bonds required by the international investor is given by

$$y_1^{LC} - E_1\pi_2 + \frac{1}{2}Var_1\pi_2 - y_1^{FC} = -\phi\bar{X}Cov(x_2, \pi_2). \tag{28}$$

Next, we repeatedly use second-order log-quadratic expansions of the form

$$exp\left(z\right) - 1 = z + \frac{1}{2}z^2. \tag{29}$$

Using a second-order log-linear expansion, the loss function (3) becomes (ignoring constants)

$$L_2 = \alpha\pi_2^2 - \left(c_2 + \frac{1}{2}c_2^2\right) + \frac{\gamma}{2}c_2^2 \tag{30}$$

We expand consumption in terms of output and the excess return on the debt portfolio

$$c_2 + \frac{1}{2}c_2^2 = C_2 - 1, \tag{31}$$

$$= \bar{X}\left(exp(x_2) - 1\right) - \bar{D}\left(\exp\left(xr_2^d\right) - 1\right), \tag{32}$$

$$= \bar{X}\left(x_2 + \frac{1}{2}x_2^2\right) - \bar{D}\left(xr_2^d + \frac{1}{2}\left(xr_d^2\right)^2\right). \tag{33}$$

We expand the bond portfolio excess return similarly to Campbell and Viceira (2002):

$$
\begin{aligned}
xr_2^d + \frac{1}{2}\left(xr_d^2\right)^2 &= exp(xr_2^d) - 1, && (34)\\
&= (1-s)\left(exp(\varepsilon_2 + \frac{1}{2}\sigma_\varepsilon^2) - 1\right) + s\left(\frac{\beta}{q^{LC}}exp(-\pi_2) - 1\right), && (35)\\
&= (1-s)\left(\varepsilon_2 + \frac{1}{2}\left(\varepsilon_2^2 + \sigma_\varepsilon^2\right)\right)\\
&\quad +s\left(-(\pi_2 - E_1\pi_2) + \frac{1}{2}\left((\pi_2 - E_1\pi_2)^2 - \sigma_\pi^2\right) - \phi\bar{X}Cov(x_2,\pi_2)\right) && (36)
\end{aligned}
$$

Substituting back into the loss function gives (ignoring policy independent terms):

$$
\begin{aligned}
L_2 &= \alpha\pi_2^2 + \bar{D}(1-s)\left(\varepsilon_2 + \frac{1}{2}\left(\varepsilon_2^2 + \sigma_\varepsilon^2\right)\right)\\
&\quad +\bar{D}s\left(-(\pi_2 - E_1\pi_2) + \frac{1}{2}\left((\pi_2 - E_1\pi_2)^2 - \sigma_\pi^2\right) - \phi\bar{X}Cov(x_2,\pi_2)\right)\\
&\quad +\frac{\gamma}{2}\left(\bar{X}x_2 - \bar{D}(1-s)\varepsilon_2 + \bar{D}s(\pi_2 - E_1\pi_2)\right)^2. && (37)
\end{aligned}
$$

Taking expectations over x_2, π_2, and ε_2 gives the period 1 loss function:

$$
\begin{aligned}
\mathcal{L} &= \underbrace{\alpha E_1\pi_2^2}_{\text{Inflation Cost}} + \underbrace{s\bar{D}\bar{X}\left(\gamma - \phi\right)Cov(x_2,\pi_2)}_{\text{Hedging - Nominal Risk Premium}} + \underbrace{\frac{\gamma}{2}\bar{D}^2 s^2 Var_1\pi_2}_{\text{Volatility LC Debt}}\\
&\quad \underbrace{+\frac{\gamma}{2}\bar{D}^2\sigma_\varepsilon^2(1-s)^2 + \bar{D}\sigma_\varepsilon^2\left(1-s\right).}_{\text{Volatility+Convexity FC Debt}} && (38)
\end{aligned}
$$

We divide the expected loss function into four terms. The first term "Inflation Cost" is simply the expected welfare cost of inflation. The second term "Hedging - Nominal Risk Premium" is new and is the focus of our analysis. This term captures the welfare benefits and costs of the state contingency of local currency debt. There are two opposing forces: the welfare benefit of domestic consumption smoothing from a positive inflation-output covariance is counteracted by the risk premium that can be earned by selling insurance to risk-averse investors. If $\gamma > \phi$, the model formalizes the intuition from the introduction, where a government inflates in bad times in order smooth consumption, and the benefits of doing so outweigh the risk-premium that needs to be paid for this insurance. In contrast, if $\phi > \gamma$, then the benefit to the government from selling insurance to foreign investors outweighs the desire to smooth domestic consumption. In this case, the loss function decreases with the inflation-output covariance, because a government that inflates during good times and deflates during bad times earns a risk premium from risk-averse investors, thereby raising average domestic consumption. To preview our results, one of the most important considerations in solving this problem is to understand when the government can credibly promise a less negative or even positive inflation-output covariance. As long as the investor has non-zero risk aversion ($\phi > 0$), the government wants to limit the tendency to inflate during bad states of the world ex-ante, but may deviate ex-post. In the numerical section we will focus on the case $\gamma = \phi$. In addition to being a natural benchmark, in this case a government with perfect commitment has no benefit to inflation variation.

The final two terms capture losses from consumption volatility induced by the volatility in debt repayments. The volatility of debt repayments enters into expected domestic consumption utility, because domestic consumers have a non-diversified, non-zero debt position, and consumption utility is concave. The third term, "Volatility Nom. Debt" captures the utility losses from consumption volatility caused by the fact that inflation volatility induces movements in the real amount repaid on local currency debt. If the country has no local currency debt ($s = 0$) this effect disappears. The final term "Volatility+Convexity Real Debt" captures losses from borrowing in foreign currency induced by random fluctuations in the exchange rate and disappears if the country has no FC debt ($s = 1$). Exchange rate volatility lowers both expected consumption through a convexity effect and induces variation in domestic real consumption, which is costly due to utility curvature. In the same way that inflation volatility induces fluctuations in consumption by inducing volatility in local currency debt repayments, so do exchange rate fluctuations through their effect on real debt repayments on foreign currency debt. In addition, foreign currency debt is costly because the expected inverse exchange rate is greater than one over the expected exchange rate. Through the fourth term, exchange rate volatility ensures that in the model full credibility governments with no constraints on their debt portfolio choice, such as the United States, finance themselves by borrowing in their own local currency.

3.5 Analytic Solution

This section solves the model analytically. We present the solution in three steps for expositional ease. We first consider the special cases of full commitment and no commitment. We then solve the model for partial or loose commitment, similarly to Debortoli and Nunes (2010). In the full commitment case the government always adheres to its announced contingent plan. In the no commitment case the government never adheres to its announced contingent plan and always reoptimizes. In the partial commitment case, with probability p, the government implements the previously announced policy and with probability $1-p$ it behaves myopically. The full commitment and no commitment solutions correspond to the partial commitment solution when $p=1$ and $p=0$, respectively. Throughout the analytic solution, we keep only first-, and second-order terms of $\bar{D}$ in the loss function. This approximation is justified if the debt-to-GDP ratio is small and helps strengthen the intuition of the results. In the no-commitment state, we use a first-order approximation for the local currency bond return in terms of log inflation, to simplify the analytic solution and provide sharper intuition. In the Appendix, we provide analytic model solutions that keep higher-order terms in $\bar{D}$ and show numerically that the analytic solution captures key features of the calibrated model both qualitatively and even quantitatively.

3.5.1 Full Commitment

In this case, we assume that the government can commit to a state-contingent inflation policy function of the form $\pi_2(x_2 \mid s)$. Because inflation volatility is costly, and we have approximated the model to second order, optimal period 2 inflation is perfectly correlated with x_2. We hence assume without loss of generality, that the government follows an inflation rule that is log-linear in second period output x_2 :

$$\pi_2 \;=\; \bar{\pi} + \delta x_2. \tag{39}$$

We can substitute this policy function into the expected loss function (38) and simplify:

$$\begin{aligned} \mathcal{L}|_{p=1} &= \alpha\left(\bar{\pi}^2 + \delta^2\sigma_x^2\right) \\ &\quad + s\bar{D}\left(\gamma - \phi\right)\bar{X}\delta\sigma_x^2 + \frac{\gamma}{2}\bar{D}^2 s^2\delta^2\sigma_x^2 + \frac{\gamma\bar{D}^2\sigma_\varepsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2\left(1-s\right). \end{aligned} \tag{40}$$

Expression (40) shows that it is optimal to set expected inflation to zero $\bar{\pi} = 0$. The first-order-condition for δ becomes:

$$\begin{aligned} \delta &= -\frac{\left(\gamma - \phi\right)\bar{X}\bar{D}s}{2\alpha + \gamma\bar{D}^2 s^2}, \\ &= -\frac{\left(\gamma - \phi\right)\bar{X}\bar{D}s}{2\alpha} + \mathcal{O}\left(\bar{D}^3\right). \end{aligned} \tag{41}$$

Corresponding to the definition in the empirical section of the paper, we define the inflation-output beta as the model-implied slope coefficient from regressing period 2 log inflation π_2 onto period 2 log output $\bar{X}x_2$. Using the approximation (41), the mean, variance, and inflation-output beta for period 2 inflation hence become

$$E_1\pi_2 \;=\; 0, \tag{42}$$

$$Var_1\pi_2 \;=\; \frac{\left(\gamma - \phi\right)^2\bar{X}^2\bar{D}^2 s^2\sigma_x^2}{4\alpha^2}, \tag{43}$$

$$Beta\left(\pi_2, x_2\right) \;=\; -\frac{\left(\gamma - \phi\right)\bar{D}s}{2\alpha}. \tag{44}$$

Provided that the local currency debt share is greater than zero, the sign of δ is the same as $\phi - \gamma$. The government wants to commit to pro-cyclical inflation if and only if investors are more risk-averse than the government, because government debt has hedging value to investors and sells at a premium. Substituting back in for the optimal commitment policy and keeping only $\mathcal{O}\left(\bar{\mathcal{D}}^2\right)$ terms gives:

$$\mathcal{L}|_{p=1} = -\frac{(\gamma-\phi)^2 \bar{X}^2\bar{D}^2 s^2}{4\alpha}\sigma_x^2 + \frac{\gamma\bar{D}^2\sigma_\epsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2(1-s) \tag{45}$$

All terms in (45) are strictly decreasing in s over $s \in [0,1]$. Equation (45) therefore shows that a perfectly credible government optimally issues only local currency debt ($s=1$).

3.5.2 No Commitment

Next, we consider the case with no commitment. In this case, the announced contingent plan is irrelevant because in period 2, the government always re-optimizes and chooses no-commitment inflation to minimize $E\left(L_2\,|x_2\right)$. We derive the analytic solution for inflation policy in the no-commitment state using the following first-order expansion for log debt portfolio excess returns:

$$\begin{aligned} xr_2^d &= exp(xr_2^d) - 1, \\ &= (1-s)\varepsilon_2 - s(\pi_2 - E_1\pi_2). \end{aligned}$$

While we can solve for the no-commitment policy while retaining the second-order relation between debt portfolio returns and log inflation as given in (36), using a first-order solution gives much more intuitive analytic solutions. No-commitment inflation is independent of real interest rate shocks, which are not known at the time of choosing inflation, and of any terms that are constant ex-post, in particular risk premia. It follows that the no-commitment government chooses π_2^{nc} to minimize

$$L_2^{nc} = \alpha\pi_2^2 - \bar{D}s\left(\pi_2 - E_1\pi_2\right) + \frac{\gamma}{2}\left(\bar{X}x_2 + \bar{D}s(\pi_2 - E_1\pi_2)\right)^2. \tag{46}$$

The first-order condition for no-commitment inflation (keeping only second-order terms in $\bar{D}$) gives

$$\begin{aligned} \pi_2 &= \frac{s\bar{D}}{2\alpha + \gamma s^2 \bar{D}^2} + \frac{\gamma s^2 \bar{D}^2}{2\alpha + \gamma s^2 \bar{D}^2} E_1 \pi_2 - \frac{\gamma s \bar{D} \bar{X}}{2\alpha + \gamma s^2 \bar{D}^2} x_2 &(47)\\ &= \frac{s\bar{D}}{2\alpha} + \frac{\gamma s^2 \bar{D}^2}{2\alpha} E_1 \pi_2 - \frac{\gamma s \bar{D} \bar{X}}{2\alpha} x_2 + \mathcal{O}\left(\bar{D}^3\right) &(48) \end{aligned}$$

Provided that the government is risk-averse ($\gamma > 0$) and has local currency debt outstanding ($s > 0$), it inflates more during states of low output x_2, and more so when the local currency debt share s is high. We use (47) to solve for the expectation, variance, and output beta of period 2 inflation (again keeping only $\mathcal{O}\left(\bar{D}^2\right)$ terms):

$$\begin{aligned} E_1 \pi_2 &= \frac{s\bar{D}}{2\alpha}, &(49)\\ Var_1 \pi_2 &= \frac{\gamma^2 \bar{X}^2 \sigma_x^2}{4\alpha^2} \bar{D}^2 s^2, &(50)\\ Beta\left(\pi_2, x_2\right) &= -\frac{\gamma}{2\alpha} \bar{D} s. &(51) \end{aligned}$$

Importantly, for a given level of debt, the inflation-output beta with no commitment (51) equals the beta under full commitment (44) if and only if investors are risk-neutral ($\phi = 0$). If $\phi > 0$, (51) is more negative than (44), indicating that in the absence of commitment and for any given local currency debt share s, inflation exhibits more state-contingency than is optimal ex-ante. Unlike in the case with full commitment, now the government recognizes that issuing local currency debt induces an inflationary bias on the part of the future government. Whereas in the commitment case, we can think of s and $\pi_2\left(x_2 \mid s\right)$ as being chosen simultaneously, the government now recognizes they are chosen sequentially. Substituting back for period 2 inflation:

$$\mathcal{L}|_{p=0} = \frac{\bar{D}^2 s^2}{4\alpha} + \frac{\left(\phi - \frac{\gamma}{2}\right)\gamma}{2\alpha} \bar{X}^2 \bar{D}^2 \sigma_x^2 s^2 + \frac{\gamma \bar{D}^2 \sigma_\varepsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2 (1-s). \qquad (52)$$

The first term of this expression shows how a higher local currency debt share s raises second period inflation expectations. The second terms combines the "Hedging - Nominal Risk Premium" and "Volatility Nom. Debt" Term. If investors are at least half as risk-averse as the domestic government, this term is strictly increasing in $s > 0$. The third and fourth terms again capture losses from exchange rate volatility, which are decreasing for $s \in [0, 1]$. If σ_ε is sufficiently small and investors are sufficiently risk-averse, we can therefore see that the first two terms in (52) dominate and a government with no commitment would issue only foreign currency debt.

3.5.3 Partial Commitment

Having provided intuition for the two extremes, we next solve the general case. As before, inflation in the commitment state optimally follows a rule

$$\pi_2^c = \bar{\pi} + \delta x_2. \tag{53}$$

In the Appendix, we show that the commitment inflation policy is the same as in the full commitment case with $\bar{\pi} = 0$ and δ given by (41), and so we do not re-derive the result here.

We next solve for the inflation policy function in the no-commitment state, which occurs with probability $1-p$. As in Section 3.5.2, the government chooses inflation myopically with first-order condition

$$\pi_2^{nc} = \frac{s\bar{D}}{2\alpha} + \frac{\gamma s^2 \bar{D}^2}{2\alpha}(1-p)E_1\pi_2^{nc} - \frac{\gamma s\bar{X}\bar{D}}{2\alpha}x_2. \tag{54}$$

This equation is identical to (47), where we have plugged in $E_1\pi_2 = pE_1\pi_2^c + (1-p)\, E_1\pi_2^{nc} = (1-p)\, E_1\pi_2^{nc}$. With the two inflation policy functions, we can then solve for closed-form expressions for the expectation, variance, and inflation-output beta for period 2 inflation for a given local currency debt share s (again keeing only $\mathcal{O}\left(\bar{D}^2\right)$ terms:

$$\begin{aligned}
E_1\left(\pi_2\right) &= (1-p)\frac{s\bar{D}}{2\alpha}, && (55)\\
Var_1\left(\pi_2\right) &= p(1-p)\left(\frac{s\bar{D}}{2\alpha}\right)^2 + \frac{\gamma^2 - p\phi\left(2\gamma-\phi\right)}{4\alpha^2}\bar{X}^2\bar{D}^2 s^2\sigma_x^2, && (56)\\
Beta\left(\pi_2, x_2\right) &= \frac{\left(p\phi-\gamma\right)\bar{D}s}{2\alpha}, && (57)
\end{aligned}$$

Expressions (55) and (57) show that both expected inflation and the inflation-output beta decrease with credibility p, holding the local currency debt share s constant. While it is well understood that a lack of credibility can lead to an inflationary bias, our contribution is to show that a lack of credibility can also affect inflation cyclicality, which in turn affects optimal debt issuance.

Substituting (55) through (57) into the expected loss function (38) gives:

$$\begin{aligned}
\mathcal{L} &= (1-p)\frac{s^2\bar{D}^2}{4\alpha} - \frac{(\gamma-\phi)^2}{4\alpha}\bar{X}^2\bar{D}^2 s^2\sigma_x^2 + \frac{(1-p)\phi^2}{4\alpha}\bar{X}^2\bar{D}^2 s^2\sigma_x^2\\
&\quad + \frac{\gamma\bar{D}^2\sigma_\varepsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2\left(1-s\right), && (58)
\end{aligned}$$

Comparing (58) and (38), the first term in (58) reflects the impact of the inflationary bias in the no-commitment state, which increases expected losses through the quadratic cost of inflation and by increasing the volatility of local currency debt repayments across commitment and no-commitment states. The second and third terms in (58) reflect the effect of inflation variability within commitment- and no-commitment states, which enters into expected losses through the "Hedging-Nominal Risk Premium" but also through the "Inflation Cost" and "Volatility Nom. Debt Repayment" terms in (38). The second term in (58) equals the loss from inflation fluctuations under perfect commitment, while the third term captures expected losses from the incentive to inflate when commitment fails. The remaining terms in (58) reflects volatility and convexity of foreign currency debt repayments, as before.

The first-order-condition of (58) then gives that if the local currency debt share has an interior solution it must equal:

$$s = \frac{2\alpha\left[\gamma + 1/\bar{D}\right]\sigma_{\varepsilon}^{2}}{(1-p)\left(1+\phi^{2}\bar{X}^{2}\sigma_{x}^{2}\right) - (\gamma-\phi)^{2}\bar{X}^{2}\sigma_{x}^{2} + 2\alpha\gamma\sigma_{\varepsilon}^{2}}. \tag{59}$$

The optimal local currency debt share decreases in credibility p and increases in the volatility of FC debt repayments σ_{ε}. The local currency debt share also increases whenever $(\gamma-\phi)^{2}\bar{X}^{2}\sigma_{x}^{2}$ is high, which is the case either when debt provides a good domestic consumption smoothing mechanism or if investors are willing to pay a local currency risk premium under the first-best full-commitment inflation policy.

3.6 Intuition

3.6.1 Policy Functions

We are now in a position to understand the properties of the inflation policy functions in the commitment- and no-commitment states. To make the intuition as clear as possible, we set $\gamma = \phi$ for the purpose of only of this subsection. This case implies that inflation in the commitment case is constant. Substituting (55) into (54) and keeping using the same approximation as in the previous section, log inflation in the no-commitment and commitment states becomes

$$\begin{aligned} \pi_2^{nc} &= \frac{s\bar{D}}{2\alpha}\left(1-\gamma\bar{X}x_2\right), \\ \pi_2^{c} &= 0. \end{aligned} \tag{60}$$

Inflation in the no-commitment state is higher on average by $\frac{s\bar{D}}{2\alpha}$. This term is intuitive, because $s\bar{D}$ is simply the amount of local currency debt outstanding and α is the real quadratic cost of inflation. In addition, inflation is more counter-cyclical in the no-commitment state, increasing during low-output states and decreasing during high-output states. The degree of counter-cyclicality depends on $\frac{\gamma s\bar{X}\bar{D}}{2\alpha}$. This term is also intuitive, because γ is the curvature of the domestic agents' consumption utility and determines how much the marginal utility of consumption increases in low-consumption states. The amount of local currency debt $s\bar{D}$ and the cost of generating inflation α enter similarly as for the inflation level.

The different inflation policy functions in no-commitment and commitment states determine how many real resources are needed to repay bond holders. The second-period budget constraint implies that any increase in debt portfolio returns must come directly out of domestic consumption. Taking the conditional expectation over ε_2 in (36), the conditional expected excess return on the debt portfolio becomes:

$$\begin{aligned} E^c\left[xr_2^d+\frac{1}{2}\sigma_d^2|x_2\right] &= (1-s)\,\sigma_\varepsilon^2 - s\left(\pi_2^c - E_1\pi_2 - \frac{1}{2}\left((\pi_2^c-E_1\pi_2)^2 - Var_1\pi_2\right)\right) \\ &\quad -s\gamma\bar{X}Cov\left(x_2,\pi_2\right), \\ &= (1-s)\,\sigma_\varepsilon^2 + \frac{s^2\bar{D}}{2\alpha}(1-p)\left(1+\gamma^2\bar{X}^2\sigma_x^2\right) + \frac{s}{2}\left((\pi_2^c-E_1\pi_2)^2 - Var_1\pi_2\right), \\ E^{nc}\left[xr_2^d+\frac{1}{2}\sigma_d^2|x_2\right] &= (1-s)\,\sigma_\varepsilon^2 - s\left(\pi_2^{nc} - E\pi_2 - \frac{1}{2}\left((\pi_2^{nc}-E_1\pi_2)^2 - Var_1\pi_2\right)\right) \\ &\quad -s\gamma\bar{X}Cov\left(x_2,\pi_2\right), \\ &= E^c\left[xr_2^d+\frac{1}{2}\sigma_d^2|x_2\right] - \frac{s^2\bar{D}}{2\alpha}\left(1-\gamma\bar{X}x_2\right) + \frac{s}{2}\left((\pi_2^{nc}-E_1\pi_2)^2 - Var_1\pi_2\right) \end{aligned}$$

Even in the commitment state, credibility has a direct effect on expected real excess returns of the sovereign bond portfolio. Credibility enters because ex-ante local currency bond prices reflect non-zero inflation expectations and local currency bond risk premia, which can raise the cost of repaying local currency debt ex-post. The expected excess return averaged across commitment and no-commitment states then equals

$$E\left[xr_2^d+\frac{1}{2}\sigma_d^2\right] = (1-s)\,\sigma_\varepsilon^2 + (1-p)\,\frac{s^2\bar{D}}{2\alpha}\gamma^2\bar{X}^2\sigma_x^2. \tag{61}$$

Expression (61) equals the foreign currency debt share times the expected excess return required on foreign currency debt plus the local currency debt share times the local currency bond risk premium. Investors understand that local currency bonds issued by a high credibility government provide better hedging and require lower returns in excess of the real risk-free rate. This drives home a key insight of the model, namely that low credibility countries have an incentive to inflate away their local currency debt during the states of the world that investors also value most, which leads those governments to pay more in expectation on their debt portfolio. Importantly, the average inflationary bias does not enter in (61) and does not lead to higher debt repayments and lower consumption on average. The reason is that bond prices adjust one-for-one with expected inflation and only the co-movement between inflation and investor marginal utility commands a risk premium.

3.6.2 Comparative Statics

In this subsection, we no longer require that $\gamma = \phi$. From the first-order condition (59), we can derive the comparative static for the local currency debt share with respect to credibility

$$\begin{aligned} \frac{ds}{dp} &= s^2 \frac{1 + \phi^2 \bar{X}^2 \sigma_x^2}{2\alpha \left[\gamma + 1/\bar{D}\right] \sigma_\varepsilon^2}, \\ &> 0. \end{aligned} \tag{62}$$

Hence, as long as we are at an interior solution, the local currency debt share unambiguously increases with credibility. As credibility increases, the government faces smaller risk premia for issuing local currency debt. Moreover, the probability of inefficiently high inflation for a government with local currency debt declines. Both of these factors reinforce each other to increase the local currency debt share for high credibility governments. Formally, (62) shows that the sensitivity of the local currency debt share with respect to credibility is larger if the local currency debt share is already high, if risk premia required by investors are high, if inflation costs are low, or if the exchange rate volatility is low.

The total derivative of the inflation-output beta with respect to credibility combines (57) and (62) to give

$$\begin{aligned} \frac{dBeta(\pi_2, x_2)}{dp} &= \frac{\partial Beta(\pi_2, x_2)}{\partial p} + \frac{\partial Beta(\pi_2, x_2)}{\partial s}\frac{ds}{dp} \\ &= \frac{\phi \bar{D}}{\alpha} + \frac{1 + \phi^2 \bar{X}^2 \sigma_x^2}{2\alpha\gamma\sigma_\varepsilon^2} s Beta(\pi_2, x_2) \end{aligned} \tag{63}$$

The inflation-output beta varies with credibility p through two channels. First, lower credibility increases the likelihood that the government will choose the counter-cyclical no-commitment inflation policy. This direct effect induces a non-negative relation between credibility and inflation-output betas, as captured by the partial derivative with respect to p. The magnitude of this first channel is proportional to investor risk aversion, ϕ, because a high credibility government has a stronger incentive to limit inflation state-contingency, when risk premia are large.

Second, lower credibility induces the government to choose a lower local currency debt share, which alters the trade-off between debt relief and inflation in the no-commitment state, thereby reducing the state-contingency of inflation. If the inflation-output beta is negative, which can be ensured if $\phi \leq \gamma$, this second channel induces a negative relation between credibility and inflation-output betas, hence counteracting the first channel.

The case $\phi = 0$ illustrates forcefully that limited commitment alone cannot generate the upward-sloping relation between inflation-output betas and local currency debt shares that we see in the data. Since the local currency debt share is increasing in credibility, we need expression (63) to be positive to match the data. In the case with $\phi = 0$, the first term in (63) is zero and the second one is negative, so the model implies a downward-sloping relation between inflation-output betas and local currency debt shares, counter to the data. The intuition is that with risk-neutral investors, the myopic degree of inflation cyclicality at any given local currency debt share is also optimal ex-ante, so credibility has no direct effect on inflation-output betas. However, a high credibility government chooses a higher local currency debt share and in the absence of risk premia, this increases the benefits of inflation state-contingency.

4 Calibrating the Model

In this section, we calibrate the model to examine whether the forces discussed in Section 3 can quantitatively replicate the empirical patterns of inflation cyclicality and the local currency debt share. Throughout the calibration exercise, we use the analytic solution derived in section 3 to pin down calibration parameters from empirical moments. The analytic solution helps us select a plausible part of the parameter space without needing to conduct an expensive grid search. We then use global solution methods to approximate the full non-linear solution (i.e. not the analytic solution). Table 3 reports the calibration parameters and Table 4 compares model and empirical moments. We set $\phi = \gamma$, which gives particularly intuitive solutions for the analytic full credibility benchmark. Under this assumption, the analytic solution for the full credibility government with $p = 1$ has perfect inflation targeting, setting inflation constant at zero. Moreover, a full credibility government finances itself entirely with local currency debt, similar to most developed countries in our empirical sample. We use subscripts L and H to distinguish model moments for the low credibility calibration from those for the high credibility benchmark. We choose the low credibility calibration to target the difference in empirical moments between emerging markets and developed markets, reported in the leftmost column of Table 3.

We set the government's borrowing need to 13% of GDP, corresponding to the average share of external sovereign debt in emerging markets. With $E_1\pi_{L,2} = (1 - p_L)E_1\pi^{nc}_{L,2}$, p_L is pinned down by the ratio of average emerging market survey inflation to maximum survey inflation (after subtracting average developed market survey inflation), giving $p_L = 1 - \frac{2.00\%}{6.07\%} = 0.67$. We set exchange rate volatility to $\sigma_\varepsilon = 14\%$ to match the median volatility of emerging market exchange rate returns since 1990. A substantial cost of borrowing in foreign currency implies that the share of local currency debt falls relatively slowly with respect to p in equilibrium, ensuring that even low credibility countries have some local currency debt in equilibrium.

We calibrate the inflation cost to match an empirical average inflation rate of 2.0%. With (55), this gives an an inflation cost α:

$$\alpha = \frac{(1-p_L)s_L\bar{D}}{2E_1\pi_{2,L}} = \frac{0.33 \times 0.5 \times 0.13}{2 \times 0.02} = 0.5. \tag{64}$$

We choose government and investor risk aversion (γ and ϕ) to match the empirical difference in inflation-output betas of -0.21. Expression (57) pins down risk-aversion at

$$\begin{aligned} Beta_L(\pi_2, x_2) - Beta_H(\pi_2, x_2) &= -\frac{\phi\bar{D}s_L}{2\alpha}(1-p_L), && (65)\\ &= -\frac{\phi \times 0.13 \times 0.5}{2 \times 0.5} \times 0.33, && (66)\\ &= -\phi \times 0.0215, && (67) \end{aligned}$$

indicating that risk aversion on the order of $\phi = 10$ is required to match the empirical difference in inflation-output betas across emerging and developed markets. While a risk aversion parameter of 10 is high, it is at the upper end of values considered plausible by Mehra and Prescott (1985).

Finally, a high level of output volatility $\sigma_y = 7\%$ is needed to generate a plausible level for the equity premium. While this volatility is higher than emerging market output volatility in our sample, a higher volatility may be priced into asset markets if emerging markets are subject to crashes and crises. We do not attempt to explain the equity volatility puzzle (Shiller, 1981; LeRoy and Porter, 1981), which can be resolved if consumption and dividend growth contain a time-varying long-run component (e.g., Bansal and Yaron (2004)) or if preferences induce persistent fluctuations in risk premia (e.g., Campbell and Cochrane (1999)).

Table 4 shows model moments for the calibrated model. The model is solved using global solution methods.[8] The calibration matches the empirical moments quite well. We obtain average low commitment inflation of around 3% and maximum no-commitment inflation of 8%. The inflation-output beta for the low credibility calibration is -0.27 compared to a high credibility beta of 0, matching the difference in betas in the data. Apart from showing that the model can quantitatively match empirical moments, it is also reassuring to see that these moments are close to what we expect from the analytic solution.

4.1 Policy Functions

Figure 5 contrasts the government's policy function for high and low credibility governments. The top two panels show log inflation (left) and the conditional expected real debt portfolio excess excess return (right), averaged across commitment and no-commitment states. Blue solid lines correspond to low credibility and red dashed lines correspond high credibility.

The numerical model solution replicates the policy function features uncovered in section 3.6.1. A low credibility government implements a state-contingent inflation policy function, which is higher on average than for the high credibility government, and especially so during low output states. The top right panel shows that countercyclical inflation translates into pro-cyclical real debt repayments for the low credibility country. Moreover, the low credibility country's debt portfolio excess returns are on average 1.75 percentage points higher than those of the high credibility country. With local currency bond risk premia of approximately $RP_L = -\phi \bar{X}^2 \times Beta(\pi_2, x_2)_L \times \sigma_x^2 = 1.70\%$, about $s_L RP_L = 0.54 \times RP_L = 0.91\%$ of this average excess return is due to local currency bond risk premia, with the remainder due to real exchange rate volatility and the expected excess return on foreign currency debt.

The middle and lower panels of Figure 5 decompose the differences between high and low credibility governments into their difference across commitment- and no-commitment states.

[8] We minimize the Euler equation error for the inflation policy function in the no-commitment state over the no-commitment policy function. We then minimize the loss function over the commitment policy function and the local currency debt share. Both commitment- and no-commitment policy functions for log inflation are quadratic in log output. For details see Appendix A.

In the commitment state, the low credibility government sets inflation to zero exactly like the high credibility government. However, the low credibility government makes higher real debt repayments in the no-commitment state, because with a higher risk premium and higher ex-ante inflation expectations it had to issue a larger face value of local currency debt to raise a given amount of real resources.

In the no-commitment state, the low credibility government inflates away its local currency debt and set inflation higher the lower is output. The high credibility government has more local currency debt outstanding and therefore the incentive to inflate is even greater, but for the high credibility government this is a zero probability event and therefore does not enter into the average inflation profile.

4.2 Comparative Statics

In this section, we analyze how local currency debt issuance, inflation, inflation-output betas, and local currency risk premia vary with credibility and investor risk aversion.

4.2.1 Credibility

Figure 6 shows that changes in credibility, or the probability of honoring the previously announced contingent plan for inflation, can explain substantial differences along key dimensions. An increase in credibility makes it less likely that the government will be tempted to inflate away the debt, leading to lower inflation expectations. A low credibility government is especially tempted to inflate away the debt during recessions, generating an upward-sloping relation between inflation-output betas and credibility. Risk-averse international investors require a return premium for holding local currency bonds that lose value precisely when marginal utility is high, driving up local currency risk premia for low credibility governments. Finally, low credibility governments issue a smaller share of local currency debt, to constrain themselves from inflating in low output states, thereby reducing the real costs of inflation and risk premia.

4.2.2 Investor Risk Aversion

Figure 7 shows that investor risk aversion has substantial effects on inflation and debt issuance policy. When investor risk aversion is low, the risk premium charged by investors for a given inflation-output covariance is low. The low credibility government therefore issues more local currency debt, generates higher inflation, and a strongly negative inflation-output beta.[9]

While the benchmark calibration in Tables 3 and 4 replicates the empirical fact that inflation-output betas are greater in developed than emerging markets, it can only generate non-positive inflation-output betas. In the data, however, the US has a substantially positive inflation-output beta of 0.15. Figure 7 shows that the model generates both positive and negative inflation-output betas, if we relax the assumption of equal investor and government risk aversion. In order to obtain positive inflation-output betas for the high credibility government, we need that investors are more risk-averse than the government. With the investor more risk-averse than the government, it is the government that sells insurance to the global investor by issuing local currency debt, rather than the risk-neutral investor insuring the government by buying it.[10] Of course, the reason why foreign investors would be more risk-averse than the government is not immediately clear. If global investors are risk-averse with respect to global output and domestic and global output are correlated, we would expect investors to be risk-averse over domestic output. This type of argument is similar to those made by Borri and Verdelhan (2011) in explaining the risk premium on defaultable sovereign debt and Lustig et al. (2011) for currency risk premia. Higher investor risk-aversion than government risk-aversion could be due to political economy reasons, that induce the government to not fully adjust for risk. For instance, the risk of losing elections

[9] The equilibrium relation between investor risk-aversion and local currency risk premia is hump-shaped, because the inflation-output beta (the amount of local currency risk) goes to zero as investor risk aversion increases over the range considered.

[10] A similar force is at play in Farhi and Maggiori (2016) where the reserve currency is provided by a risk-neutral government to risk-averse investors with the reserve currency country committing not to depreciate in bad times. In that model, however, the issuing country is a large country that internalizes its effect on the global SDF in contrast to our simplifying small open economy assumption.

may lead to a divergence between private and government incentives especially during low output states, much as in Aguiar and Amador (2011), where a lower discount factor driven by political economy forces can engender a bias toward more debt.

4.3 Calibration Sensitivity

Table 5 shows how the model properties change as we change one calibration parameter at a time. Column (1) reproduces the benchmark calibration for reference. Columns (2) and (3) show the effect of setting investor risk aversion to 0 and 12 respectively. For $\phi = 0$, both governments hit the constraint of a 100% local currency debt share and therefore the inflation-output betas are almost equal. For $\phi = 12$, the model generates reasonable local currency debt shares, a positive inflation-output beta for the high credibility government, and a negative inflation-output beta for the low credibility government, similarly to the data. Increasing the inflation cost α compresses inflation-output betas towards zero, but does not change the model properties otherwise. Choosing a lower output volatility leaves inflation-output betas and local currency debt shares largely unchanged, but reduces the equity risk premium. Column (6) shows that reducing both investor and government risk-aversion to 5 reduces the variation in inflation-output betas and risk premia. Column (7) shows that, on the other hand, increasing the debt-to-GDP ratio increases the gap between high credibility and low credibility inflation-output betas. Finally, column (8) shows that reducing the exchange rate volatility to $\sigma_\varepsilon = 0.11$ reduces the local currency debt share for the low credibility government, but still generates an economically meaningful negative inflation-output beta.

5 Testing Additional Empirical Implications

The model presented in the previous two sections highlights the importance of monetary policy credibility for the level and cyclicality of local currency risk and sovereign debt portfolios across countries. This section tests additional model predictions and provides more direct evidence for our proposed mechanism. We provide evidence for the following three predictions: First, low credibility and low local currency debt issuance countries should have higher local currency bond risk premia. Second, these bond risk premia should be driven by local currency bond-stock betas. Third, direct measures of monetary policy credibility should be closely related to both bond risk premia and local currency bond-stock betas. We construct two de-facto measures of monetary policy credibility, the first one based on textual analysis of newspaper articles and the second one based on the gap between official inflation targets and survey inflation.[11]

5.1 Risk Premia

The model in sections in sections 3 and 4 attributes an important role to local currency bond risk premia as a driver of local currency bond issuance. In this subsection, we construct empirical proxies for local currency bond risk premia for our cross-section of countries and show that they are closely related to local currency debt shares, as predicted by the model. We define the risk premia to correspond as closely as possible to the left-hand-side of (28). To approximate the risk premia empirically we calculate

$$\bar{RP} = y^{\bar{LC}} - \bar{\pi} + \frac{1}{2} Var\pi - \left(y^{US} - \bar{\pi}^{US} + \frac{1}{2} Var\pi^{US} \right) \tag{68}$$

where a bar indicates the mean from 2005-2014. Intuitively, (68) removes average local inflation from local currency bond yields to isolate the risk premium component. Unlike in the model, we correct for the fact that US inflation is non-zero. Our baseline results do not adjust for sovereign default risk, but we show in the Appendix that the empirical results are robust to using synthetic default-free local currency bonds, as in Du and Schreger (2016).

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

In Figure 8 and Table 6, we see that cross country differences in local currency risk premia explain a large fraction of the variation in nominal debt share. This result holds even when we control for macroeconomic variables, including inflation. This latter result is important evidence for our story that low credibility countries have high LC bond yields not only because of high inflation expectations but also because of high risk premia.

In the model, LC bond risk premia are driven by $\phi \bar{X} Cov(x_2, \pi_2)$. Table 7 provides evidence of a strong empirical relation between our preferred cyclicality measure, the local currency bond-stock beta, and local currency bond risk premia. We view these results as providing strong evidence in favor of our proposed mechanism.

5.2 News Counts

So far, we have shown that the share of LC debt issuance lines up with a broad range of macroeconomic, survey, and asset pricing proxies, that all proxy for monetary policy credibility in the model. While it is comforting that the theory is consistent with a large number of moments, none of these measure monetary policy credibility directly.

Using Financial Times articles over the period 1995-2015, we construct the correlation between the key words "debt" and "inflation" for each country as a proxy for inverse inflation credibility. The intuition is that if inflation is solely determined by the central bank and debt is determined by the fiscal authority, these topics should be discussed separately, and the correlation should be low. On the other hand, if inflation and debt are determined by the same central government, we would expect newspaper articles to discuss both jointly, and the correlation should be high.

We count the number of articles containing both keywords and the country name and divide them by the geometric average of the articles that contain one of the keywords combined with the country name. Consistent with the model, Columns (1) and (3) of Table 8 show that this de-facto monetary policy credibility measure is strongly correlated with risk premia and bond-stock betas across countries, with R^2 of 42.4% and 49.4%, respectively.

5.3 Announced Inflation Targets

Another way to gauge cross-country differences in monetary policy credibility is from the gap between announced inflation targets and survey expectations. In countries with low monetary policy credibility, we expect survey inflation to exceed announced inflation targets. We define the "Credibility Gap" as the greater of the average difference between the central bank inflation target and survey inflation expectations and zero. Over the past decade, on average, the emerging markets in the sample have a mean credibility gap of 0.6 percent, whereas the developed markets in the sample have a mean credibility gap of 0.1 percent.

Columns (2) and (4) of Table 8 show that the credibility gap is strongly correlated with the risk premium and bond-stock beta across countries, with an R^2 of 50.5% and 44.4%, respectively. Column (4) suggests that a 0.5 percentage point increase in the credibility gap, corresponding to the average difference between emerging and developed countries, is associated with a 0.12 decrease in local currency bond-stock betas.

6 Conclusion

This paper argues that differences in monetary policy credibility, combined with investors that require a risk premium for holding positive-beta bonds, explain the relation between sovereign debt portfolios and government bond risks across countries. We document the cross-sectional stylized fact that those sovereign debt issuers, whose local currency bonds tend to depreciate during recessions and hence provide the borrower with consumption-smoothing benefits, issue very little local currency debt. We explain this stylized empirical fact in a model, where low monetary policy credibility generates an incentive to devalue local currency debt especially during recessions. Risk-averse investors charge a premium for holding local currency bonds that depreciate during recessions, thereby making local currency debt expensive for low credibility governments and driving them towards foreign currency debt issuance. Importantly, both limited commitment on the issuer's part and investor risk-aversion are necessary to match the empirical evidence. The key contribution of the paper is to demonstrate how the interaction of lender risk-aversion and monetary credibility can explain why countries with positive bond-stock betas, that apparently would gain the most consumption-smoothing from issuing local currency debt, have the lowest local currency debt share. Our simple framework gives rise to a number of testable predictions on inflation, inflation-cyclicality, sovereign debt portfolios, and proxies of effective monetary policy credibility, which we verify in the data.

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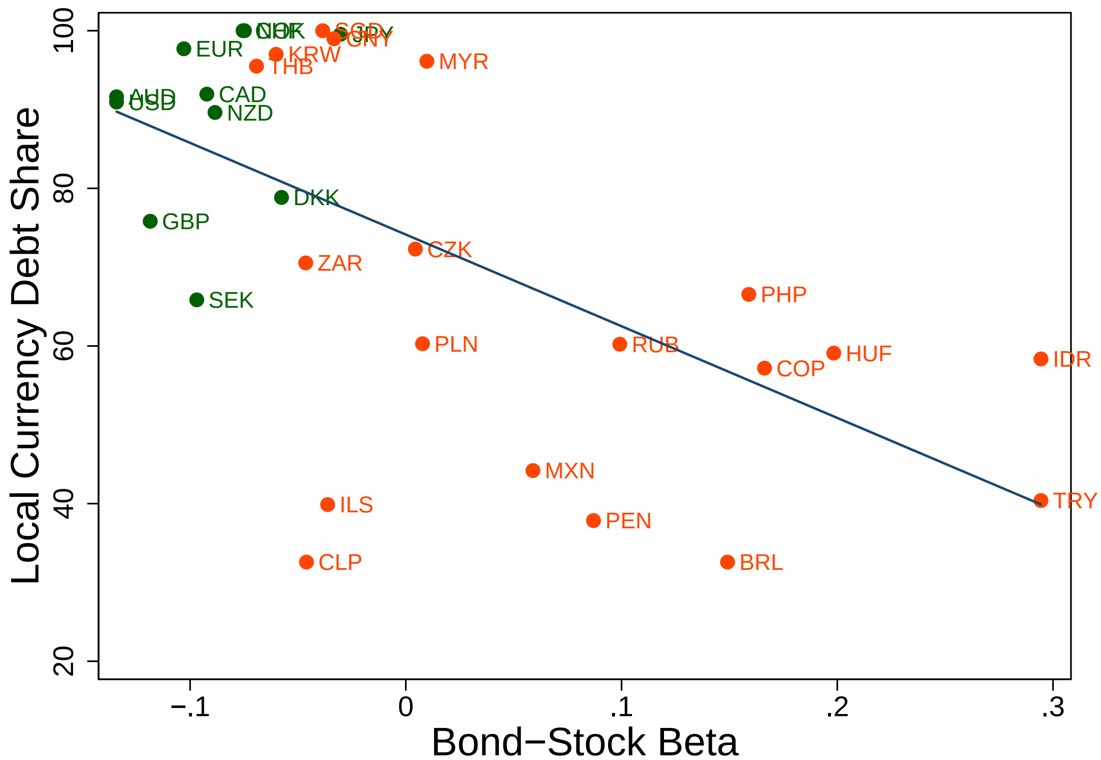
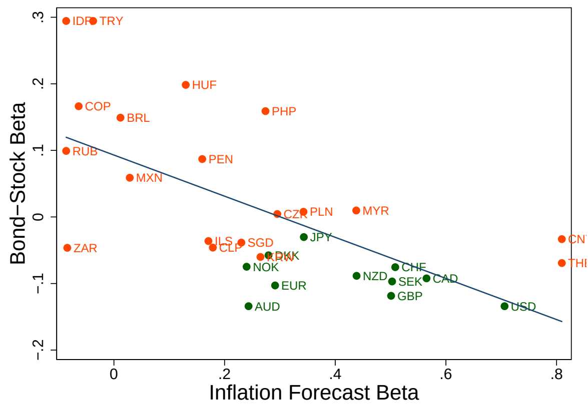
Figure 1: **Local Currency Debt Shares and Local Currency Bond Betas**



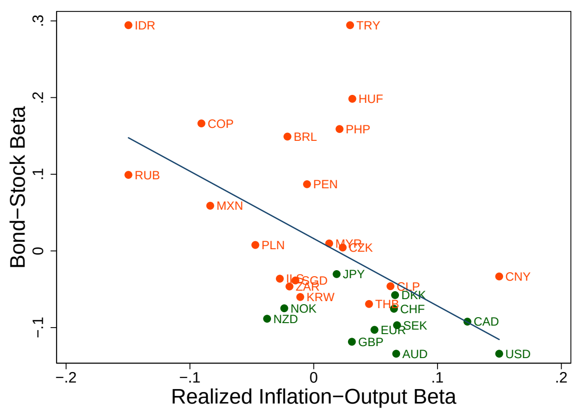
Note: This figure shows the share of local currency debt as a fraction of central government debt (in %) over the period 2005-2014. Bond-stock betas are estimated as the slope coefficient of quarterly local currency bond log excess returns onto local stock market log excess returns over the same time period. Three-letter codes indicate currencies. Emerging markets are shown in red and developed markets in green. The highest and lowest observation are winsorized.

Figure 2: **Comovement Among Nominal Risk Measures**

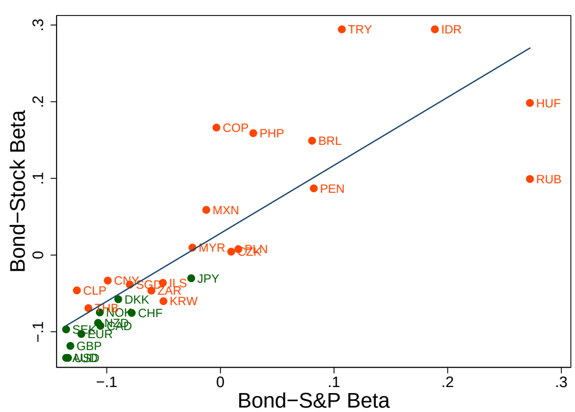
(A) Bond-Stock Betas vs. Inflation Forecast Betas



(B) Bond-Stock Betas vs. Realized Inflation-Output Betas



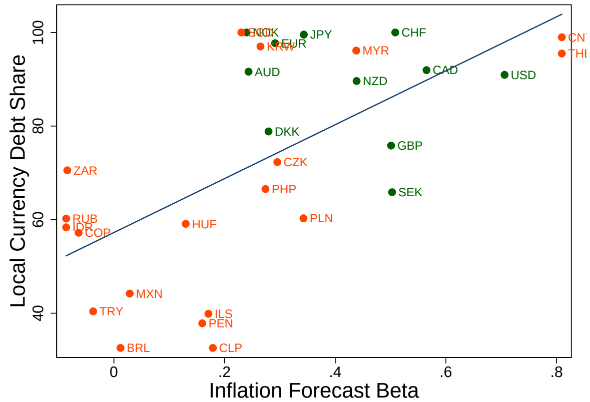
(C) Bond-Stock Betas vs. Bond-S&P Betas



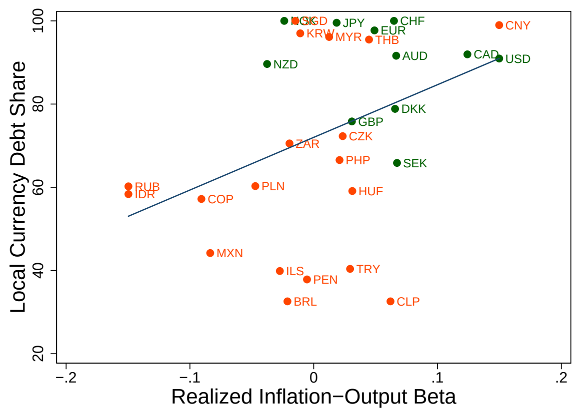
Note: Panel (A) plots local currency bond-stock betas on the y-axis and expected inflation-output betas on the x-axis. Panel (B) plots local currency bond-stock betas on the y-axis and realized inflation-output betas on the x-axis. Panel (C) plots local currency bond-stock betas on the y-axis and the beta of local currency bond returns with S&P returns on the x-axis. Developed markets are denoted by green dots and emerging markets are denoted by red dots. The three-letter currency code is used to label countries. The highest and lowest observation are winsorized. More details on variable definitions can be found in Section 2.1.

Figure 3: **Local Currency Debt Shares and Local Currency Risk Measures**

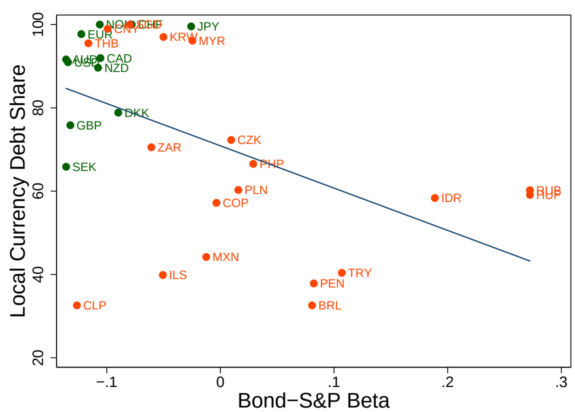
(A) Nominal Debt Share vs. Inflation Forecast Beta



(B) Nominal Debt Share vs. Realized Inflation-Output Beta

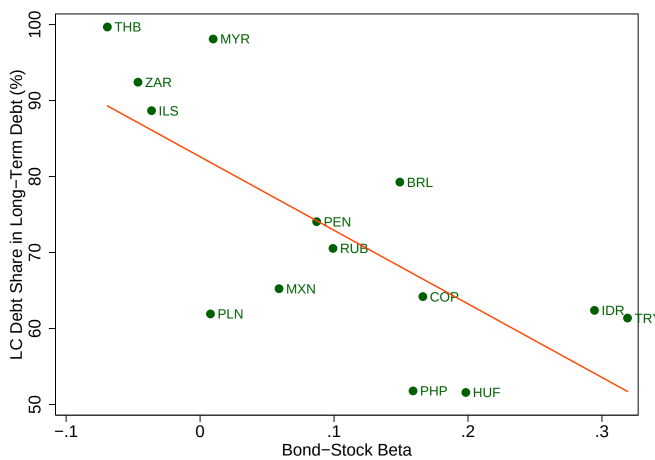


(C) Nominal Debt Share vs. Bond-S&P Betas



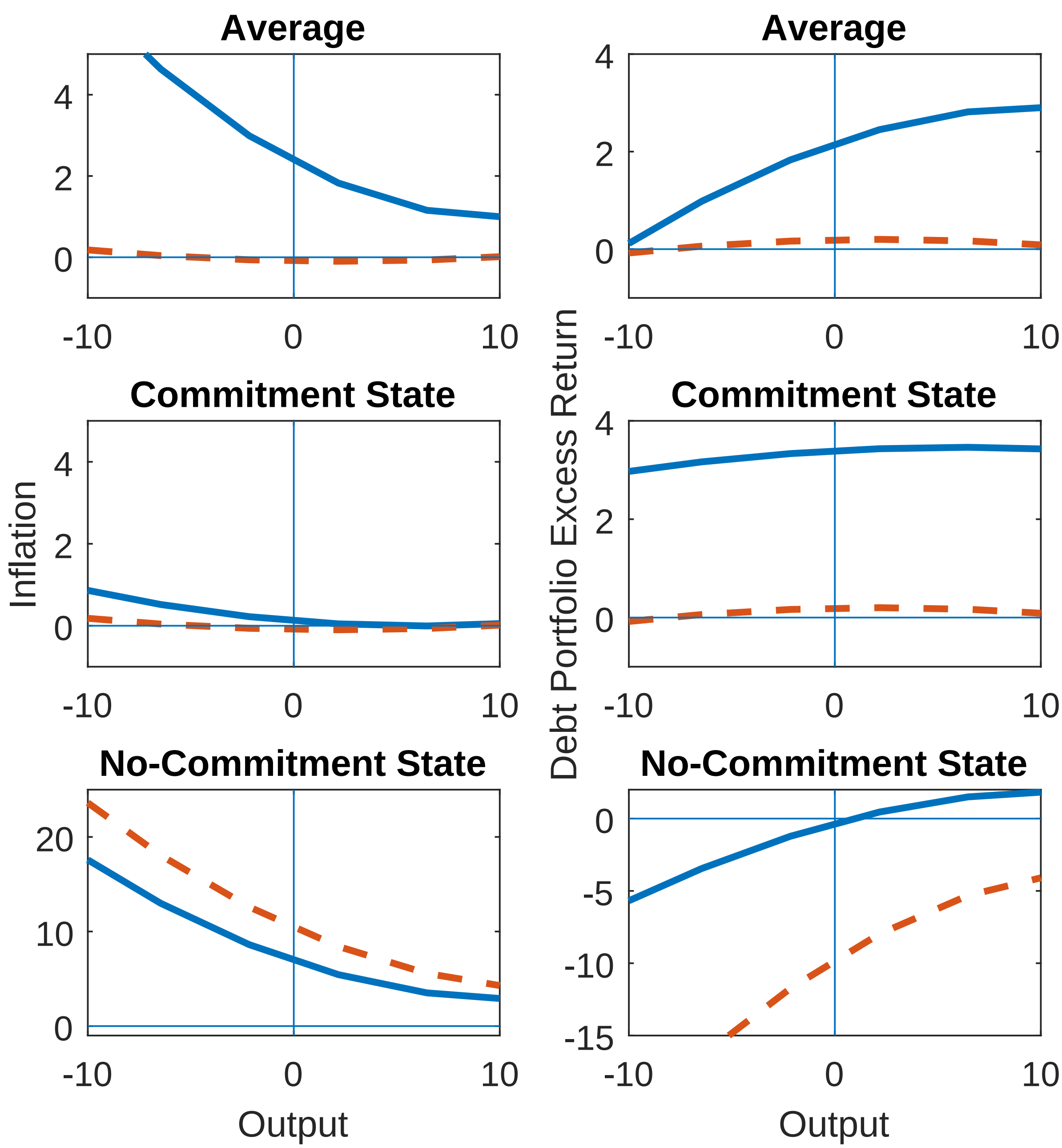
Note: Panels (A), (B), and (C) plot the share of local currency debt in the sovereign debt portfolio on the y-axis against expected inflation-output betas, realized inflation-output betas, and the beta of local currency bond returns with S&P returns, respectively. Developed markets are denoted by green dots and emerging markets are denoted by red dots. The three-letter currency code is used to label countries. The highest and lowest observation are winsorized. More details on variable definitions can be found in Section 2.1.

Figure 4: Local Currency Debt Share in Long-Term Debt vs. Bond-Stock Beta



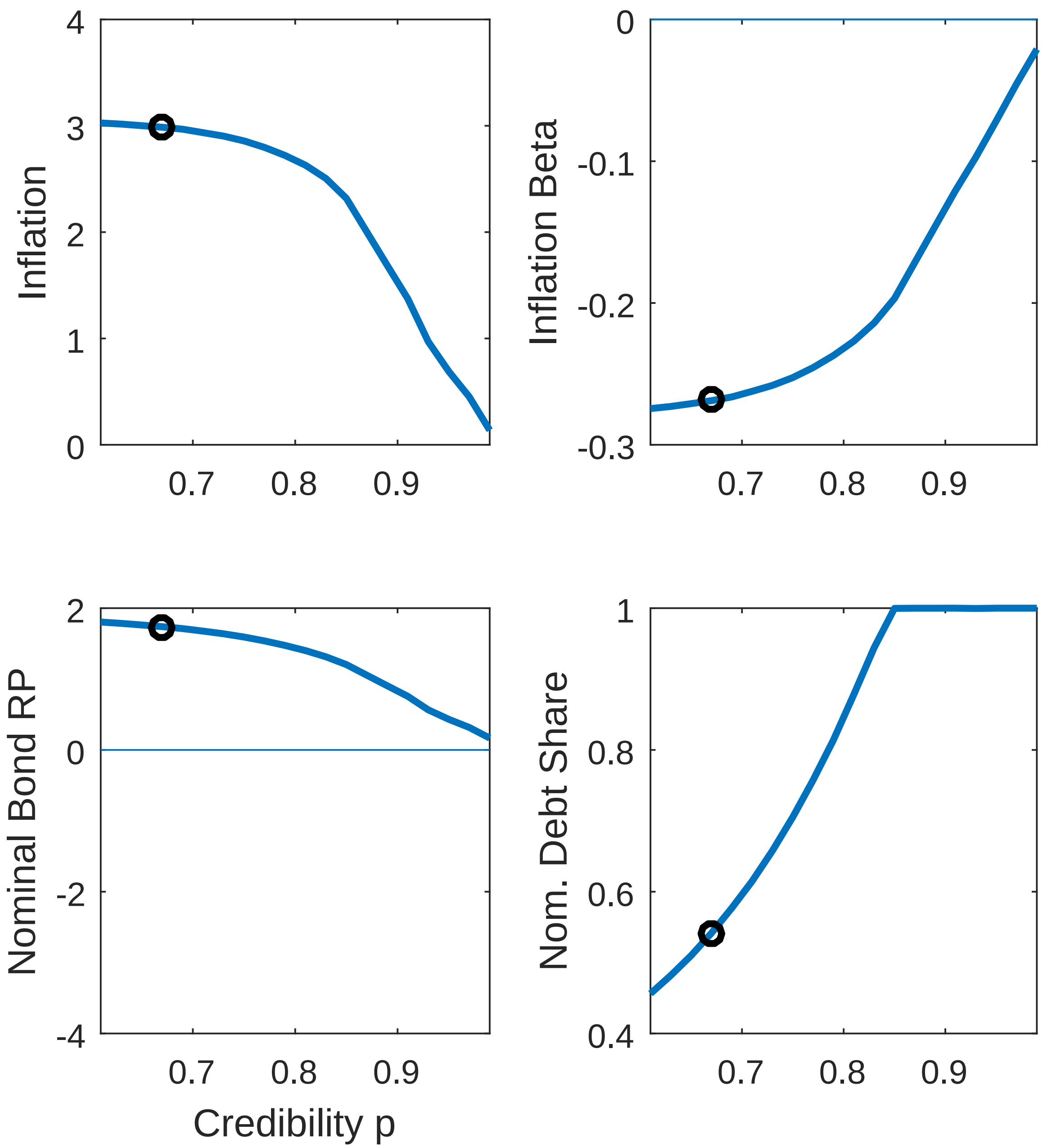
Notes: This figure plots the bond-stock beta on the x-axis and the share of LC debt in all outstanding long-term debt on the y-axis. Long-term debt is defined as having a remaining time to maturity of five or more years. The share of LC debt in long-term debt is estimated from individual bond issuance data from Bloomberg.

Figure 5: Policy Functions



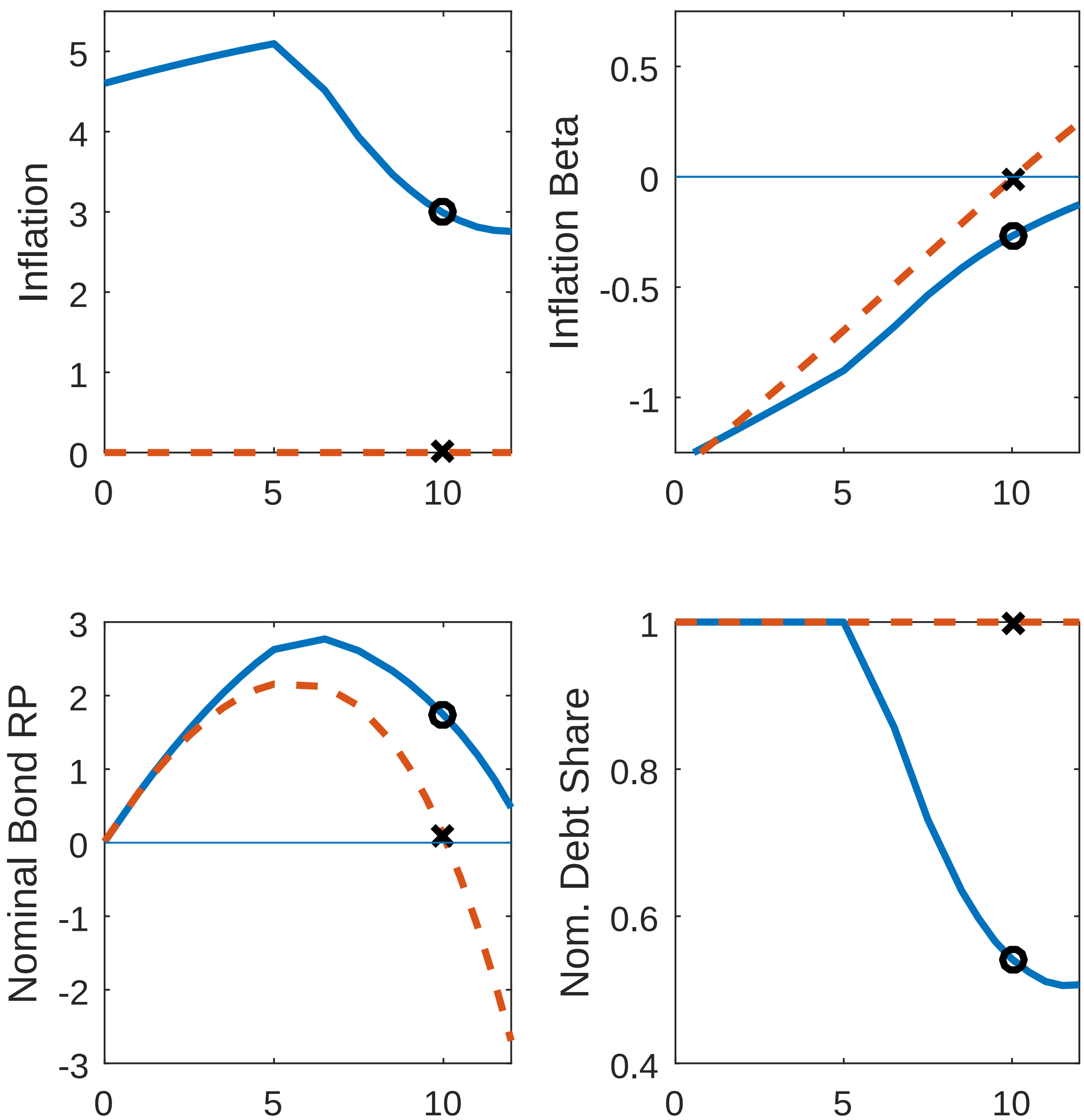
Note: Blue solid indicates the low credibility calibration, while red dashed indicates the high credibility calibration. Left panels show log inflation. Right panels show real debt portfolio excess returns in percent, following equation (25). The y-axis shows log output in percent deviations from the steady-state. "Average" refers to the weighted average across commitment and no-commitment states, where the weights are given by credibility p.

Figure 6: Varying Credibility



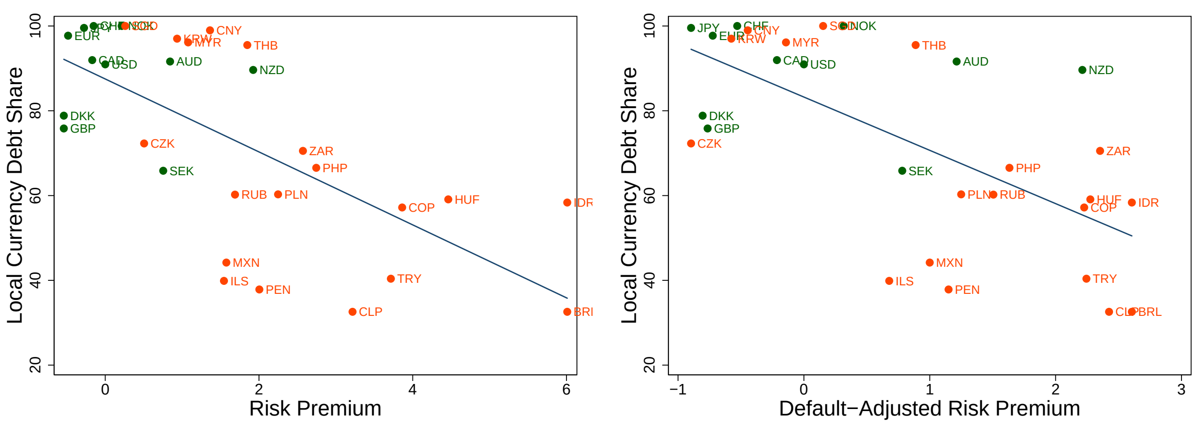
Note: This figure shows average inflation, the inflation-output beta, local currency bond risk premia, and the local currency debt share while varying credibility p. All other parameters are held constant at values shown in Table 3.

Figure 7: Varying Investor Risk Aversion



Note: This figure shows average log inflation, the inflation-output beta, local currency bond risk premia, and the local currency debt share against investor risk aversion ϕ. All other parameters are held constant at values shown in Table 3.

Figure 8: Risk Premia and Nominal Debt Share



Note: This figure plots the nominal debt share against the average risk premium as defined in Equation (68). The right panel uses a synthetic default free local bond yield, obtained by combining a US Treasury with a fixed-for-fixed cross currency swap following Du and Schreger (2016). Developed markets are denoted by green dots and emerging markets are denoted by red dots. The three-letter currency code is used to label countries. The highest and lowest observation are winsorized. More details on variable definitions can be found in Section 2.1.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	π	Survey π	$b(\tilde{\pi},\widetilde{gdp})$	$b(\pi, IP)$	y^{LC}	$b(bond, stock)$	s
(A) Developed Markets ($N = 11$)							
Mean	1.70	1.83	0.42	0.05	2.62	-0.10	89.27
S.d.	0.81	0.64	0.15	0.06	1.24	0.04	11.23
Max	2.68	2.68	0.71	0.15	4.87	-0.03	100.00
Min	0.26	0.32	0.24	-0.04	0.61	-0.18	65.85
(B) Emerging Markets ($N = 19$)							
Mean	4.09	3.83	0.20	-0.02	6.01	0.06	63.11
S.d.	2.05	1.66	0.32	0.15	2.91	0.12	25.58
Max	9.07	7.90	1.07	0.35	12.33	0.32	100.00
Min	2.05	2.06	-0.25	-0.50	1.67	-0.07	11.97
(C) Full Sample ($N = 30$)							
Mean	3.21	3.10	0.28	0.01	4.77	0.01	72.70
S.d.	2.05	1.68	0.28	0.13	2.92	0.13	24.78
Max	9.07	7.90	1.07	0.35	12.33	0.32	100.00
Min	0.26	0.32	-0.25	-0.50	0.61	-0.18	11.97
(D) Mean Difference between Emerging and Developed Markets							
Mean Diff.	-2.391***	-2.004***	0.215**	0.0736*	-3.388***	-0.160***	26.16***
	(0.531)	(0.428)	(0.0858)	(0.0388)	(0.767)	(0.0303)	(6.791)

Note: This table reports summary statistics for the cross-sectional mean of seven variables for developed and emerging market groups. The variables include (1) π, realized inflation (%), (2) Survey π, survey inflation (%), (3) $b(\tilde{\pi},\widetilde{gdp})$, inflation-output forecast beta, (4) $b(\pi, IP)$, realized inflation-output beta, (5) y^{LC}, five-year local currency LC bond yield, (6) $b(bond, stock)$, bond-stock beta, and (7) s, percentage share of local currency debt in total sovereign debt portfolios. 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: Cross-Sectional Regression of Nominal Debt Shares on Nominal Risk Betas

	(1)	(2)	(3)	(4)	(5)
Local Currency Debt Share	s	s	s	s	s
$b(bond, stock)$	-110.0***			-94.50**	-93.55**
	(20.45)			(36.85)	(37.02)
$b(\tilde{\pi}, \widetilde{gdp})$		50.35***			
		(8.872)			
$b(\pi, IP)$			58.91**		
			(21.50)		
log(GDP)				2.512	2.759
				(4.784)	(4.766)
FX Regime					-2.320
					(3.388)
Constant	73.33***	58.42***	72.36***	49.40	53.72
	(3.854)	(5.191)	(4.376)	(47.43)	(49.65)
Observations	30	30	30	30	30
R-squared	0.310	0.334	0.094	0.317	0.322

Notes: This table shows the cross-country regression results of the local currency debt share, s (between 0 and 1), on measures of inflation cyclicality. The independent variables in the first three columns are the bond-stock beta ($b(bond, stock)$), the inflation forecast beta ($b(\tilde{\pi}, \widetilde{gdp})$) and the realized inflation- output beta ($b(\pi, IP)$), respectively. In Column (4), we control for the mean log per capita GDP level between 2005 and 2014, log(GDP). In Column (5), we control for the average exchange rate classification used in Reinhart and Rogoff (2004), FX regime. More details on variable definitions can be found in Section 2.1. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Calibration Parameters

Parameter		Low Credibility	High Credibility
Credibility	p	0.67	1.00
Inflation Cost	α	0.50	
Output Vol.	σ_x	0.07	
Government Risk Aversion	γ	10	
Investor Risk Aversion	ϕ	10	
Debt/GDP	$\bar{D}$	0.13	
Exchange Rate Vol.	σ_ε	0.14	

Note: All parameters are in annualized natural units.

Table 4: Empirical and Model Moments

	Data	Model	
	Emerging-Developed	Low Credibility	High Credibility
Average Inflation	2.00	2.99	0.00
No-Commitment Inflation	6.07	8.48	12.00
Inflation Beta	-0.21	-0.27	-0.01
Nominal Debt Share	0.63	0.54	1.00
Equity Risk Premium	6.00	6.25	6.25

Note: All moments are in annualized natural units. The empirical moment for average inflation is the difference between average survey inflation for emerging and developed markets in Table 1. The empirical inflation-output beta is computed as the difference between average expected inflation-output betas in emerging and developed markets. The empirical no-commitment inflation is computed as the difference between maximum emerging market survey inflation and average developed market survey inflation in Table 1. All model moments are computed using global solution methods.

Table 5: Calibration Sensitivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Low Credibility	Benchmark	$\phi = 0$	$\phi = 12$	$\alpha = 1$	$\sigma_x = 0.05$	$\gamma = \phi = 5$	$\bar{D} = 0.18$	$\sigma_\varepsilon = 0.11$
Average Inflation	2.99	4.60	2.76	2.21	2.90	2.58	4.61	1.91
No-Commitment Inflation	8.48	12.84	7.89	6.25	8.25	7.63	12.48	5.62
Inflation Beta	-0.27	-1.29	-0.13	-0.20	-0.29	-0.13	-0.53	-0.18
LC Debt Share	0.54	1.00	0.51	0.79	0.66	0.61	0.40	0.34
Equity Risk Premium	6.26	0.00	7.51	6.26	3.19	3.13	6.26	6.26
High Credibility								
Average Inflation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No-Commitment Inflation	12.01	11.96	11.53	6.98	11.21	11.34	20.49	12.07
Inflation Beta	-0.01	-1.34	0.25	-0.01	0.00	0.00	-0.12	-0.01
LC Debt Share	0.99	1.00	1.00	0.99	1.00	1.00	1.00	1.00
Equity Risk Premium	6.26	0.00	7.51	6.26	3.19	3.13	6.26	6.26

Note: This table varies one parameter at a time as indicated in each column. All other parameters are as in Table 3.

Table 6: Local Currency Debt Share and Bond Risk Premia

	(1)	(2)	(3)	(4)
Local Currency Debt Share	s	s	s	s
Risk Premium	-8.604***	-9.731***	-7.155***	-8.497***
	(1.481)	(2.511)	(1.951)	(2.526)
Log (GDP)		-2.036		-3.163
		(4.423)		(4.555)
FX Regime		3.174		3.402
		(3.096)		(2.981)
Average Inflation			-1.901	-2.309
			(1.603)	(1.725)
Constant	87.50***	99.55**	91.17***	114.9**
	(3.766)	(46.66)	(5.528)	(50.19)
Observations	30	30	30	30
R-squared	0.448	0.458	0.460	0.475

Note: In this table we regress the average local currency debt share onto our empirical risk premium proxy, defined in Equation (68). The FX Regime is from Reinhart and Rogoff (2004). Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Risk Premia and Bond-Stock Betas

	(1) Risk Premium	(2) Risk Premium	(3) Risk Premium	(4) Risk Premium
Bond-Stock Beta	12.01***	9.234***	8.423***	7.537***
	(1.734)	(2.489)	(2.018)	(2.477)
Log (GDP)			-0.569***	-0.526***
			(0.168)	(0.182)
FX Regime			0.534***	0.500**
			(0.160)	(0.182)
Average Inflation		0.231		0.0964
		(0.195)		(0.167)
Constant	1.563***	0.847	5.452***	4.839**
	(0.198)	(0.552)	(1.805)	(1.945)
Observations	30	30	30	30
R-squared	0.646	0.673	0.746	0.750

Note: In this table we regress our empirical proxy for LC risk premia, defined in Equation (68) on the local currency bond-stock beta and controls. The FX Regime is from Reinhart and Rogoff (2004). Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Credibility Measures, Risk Premia, and Bond Betas

	(1) Risk Premium	(2) Risk Premium	(3) Bond-Stock Beta	(4) Bond-Stock Beta
News Count	26.04***		1.883***	
	(4.725)		(0.325)	
Credibility Gap		4.017***		0.238***
		(0.907)		(0.0770)
Constant	-3.721***	0.163	-0.381***	-0.0858***
	(0.858)	(0.311)	(0.0594)	(0.0197)
Observations	30	22	30	22
R-squared	0.424	0.505	0.494	0.444

Note: This Table regresses our empirical proxy for local currency bond risk premia in Equation (68) on de-facto measures of monetary policy credibility. "News Count" is the correlation of the keywords "debt" and "inflation" in Financial Times articles 1996-2015 from ProQuest Historical Newspapers. We compute the correlation as the number of articles mentioning both "debt" and "inflation" divided by the geometric average of articles that mention either "debt" or "inflation". We require articles to also mention the country name. The inflation credibility gap is measured as the mean difference between the survey inflation expectations from Consensus Economics and the announced inflation target since 2005. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

Appendix - For Online Publication Only

A Model Appendix

A.1 Analytic Model Solution

In this section, we solve the model analytically. Throughout the solution, we do not approximate the model around a small $\bar{D}$ (keeping the third order terms), and only use the small $\bar{D}$ approximation (dropping third order terms in $\bar{D}$) at the end of the subsection.

A.1.1 Full Commitment

We assume without loss of generality that the government follows an inflation rule that is a linear function of second period output y_2 :

$$\pi_2 = \bar{\pi} + \delta x_2. \tag{69}$$

We can then substitute this policy function into the loss function and simplify:

$$\begin{aligned}\mathcal{L}^{p=1} &= \alpha\left(\bar{\pi}^2 + \delta^2\sigma_x^2\right) \\ &\quad + s\bar{D}\left(\gamma - \phi\right)\bar{X}\delta\sigma_x^2 + \frac{\gamma}{2}\bar{D}^2 s^2\delta^2\sigma_x^2 + \frac{\gamma\bar{D}^2\sigma_\varepsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2(1-s).\end{aligned} \tag{70}$$

Expression (70) shows that it is optimal to set expected inflation to zero $\bar{\pi} = 0$. The first-order-condition for δ becomes

$$\delta = -\frac{\left(\gamma - \phi\right)\bar{X}\bar{D}s}{2\alpha + \gamma\bar{D}^2 s^2} \tag{71}$$

The mean, variance, and output beta for period 2 inflation hence become

$$E_1\pi_2 = 0, \tag{72}$$

$$Var_1\pi_2 = \frac{\left(\gamma - \phi\right)^2\bar{X}^2\bar{D}^2 s^2\sigma_x^2}{\left(2\alpha + \gamma\bar{D}^2 s^2\right)^2}, \tag{73}$$

$$Beta\left(\pi_2, y_2\right) = -\frac{\left(\gamma - \phi\right)\bar{D}s}{2\alpha + \gamma\bar{D}^2 s^2}. \tag{74}$$

Substituting back into the loss function gives

$$\mathcal{L}|_{p=1} = -\frac{\left(\gamma - \phi\right)^2\bar{X}^2\bar{D}^2 s^2}{4\alpha + 2\gamma\bar{D}^2 s^2}\sigma_x^2 + \frac{\gamma\bar{D}^2\sigma_\varepsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2(1-s) \tag{75}$$

Dropping terms that are third-order in $\bar{D}$ gives the expressions in the paper.

A.1.2 No Commitment

The first-order condition for inflation becomes

$$\pi_2 = \frac{s\bar{D}\left(1-\gamma\bar{X}x_2\right)}{2\alpha+\gamma s^2\bar{D}^2} + \frac{\gamma s^2\bar{D}^2}{2\alpha+\gamma s^2\bar{D}^2}E_1\pi_2 \tag{76}$$

We can now use (76) to solve for the expectation, variance, and output beta of period 2 inflation

$$E_1\pi_2 = \frac{s\bar{D}}{2\alpha}, \tag{77}$$

$$Var_1\pi_2 = \frac{\gamma^2\bar{X}^2\sigma_x^2}{\left(2\alpha+\gamma s^2\bar{D}^2\right)^2}\bar{D}^2s^2, \tag{78}$$

$$Beta\left(\pi_2,x_2\right) = \frac{-\gamma}{2\alpha+\gamma s^2\bar{D}^2}\bar{D}s. \tag{79}$$

We can then substitute the inflation policy function back into the expected loss function to obtain

$$\begin{aligned}\mathcal{L}^{p=0} &= \alpha\left(E_1\pi_2\right)^2 + s\bar{D}\bar{Y}\left(\gamma-\phi\right)Cov_1\left(y_2,\pi_2\right) \\ &\quad + \left(\alpha+\frac{\gamma}{2}\bar{D}^2s^2\right)Var_1\pi_2 + \frac{\gamma\bar{D}^2\sigma_\epsilon^2}{2}(1-s)^2, \end{aligned}\tag{80}$$

$$= \frac{\bar{D}^2s^2}{4\alpha} + \frac{\left(\phi-\frac{\gamma}{2}\right)\gamma}{2\alpha+\gamma s^2\bar{D}^2}\bar{Y}^2\bar{D}^2\sigma_y^2s^2 + \frac{\gamma\bar{D}^2\sigma_\epsilon^2}{2}(1-s)^2 \tag{81}$$

Dropping third-order terms in $\bar{D}$ gives the expressions in the main paper.

A.1.3 Partial Commitment

As before, inflation in the commitment state optimally follows a rule

$$\pi_2^c = \bar{\pi} + \delta y_2. \tag{82}$$

We next derive the optimal expressions for $\bar{\pi}$ and δ. In the no-commitment state, the government chooses inflation myopically with first-order condition

$$\pi_2^{nc} = \frac{s\bar{D}\left(1-\gamma\bar{X}x_2\right)}{2\alpha+\gamma s^2\bar{D}^2} + \frac{\gamma s^2\bar{D}^2}{2\alpha+\gamma s^2\bar{D}^2}\left(p\bar{\pi}+(1-p)E_1\pi_2^{nc}\right). \tag{83}$$

Expected no-commitment inflation then equals

$$E_1\pi_2^{nc} = \frac{s\bar{D}}{2\alpha+p\gamma s^2\bar{D}^2} + \frac{\gamma s^2\bar{D}^2}{2\alpha+p\gamma s^2\bar{D}^2}p\bar{\pi}. \tag{84}$$

Unconditional expected inflation equals

$$
\begin{aligned}
E_1\pi_2 &= p\bar{\pi} + (1-p)E_1\pi_2^{nc}, & (85)\\
&= (1-p)\frac{s\bar{D}}{2\alpha + p\gamma s^2\bar{D}^2} + \frac{2\alpha + \gamma s^2\bar{D}^2}{2\alpha + p\gamma s^2\bar{D}^2}p\bar{\pi}. & (86)
\end{aligned}
$$

The variance and covariance of period 2 inflation then become

$$
\begin{aligned}
Var_1\pi_2 &= p(1-p)\left(\frac{s\bar{D}}{2\alpha + p\gamma s^2\bar{D}^2} - \frac{2\alpha}{2\alpha + p\gamma s^2\bar{D}^2}\bar{\pi}\right)^2\\
&\quad + p\delta^2\sigma_x^2 + (1-p)\frac{\gamma^2\bar{Y}^2\sigma_x^2}{\left(2\alpha + \gamma s^2\bar{D}^2\right)^2}\bar{D}^2 s^2, & (87)\\
Cov_1(x_2,\pi_2) &= p\delta\sigma_x^2 - (1-p)\frac{\gamma\bar{Y}\sigma_x^2}{2\alpha + \gamma s^2\bar{D}^2}\bar{D}s. & (88)
\end{aligned}
$$

The inflation sensitivity in the commitment state δ enters into the variance and covariance exactly as before, but scaled by the commitment probability p. It hence follows that the optimal commitment sensitivity δ takes the form

$$
\delta = -\frac{(\gamma - \phi)\,\bar{X}\bar{D}s}{2\alpha + \gamma\bar{D}^2 s^2}.
$$

Average commitment inflation $\bar{\pi}$ is chosen to minimize

$$
\begin{aligned}
&\alpha\left((1-p)\frac{s\bar{D}}{2\alpha + p\gamma s^2\bar{D}^2} + \frac{2\alpha + \gamma s^2\bar{D}^2}{2\alpha + p\gamma s^2\bar{D}^2}p\bar{\pi}\right)^2\\
&+\left(\alpha + \frac{\gamma}{2}\bar{D}^2 s^2\right)p(1-p)\left(\frac{s\bar{D}}{2\alpha + p\gamma s^2\bar{D}^2} - \frac{2\alpha}{2\alpha + p\gamma s^2\bar{D}^2}\bar{\pi}\right)^2.
\end{aligned} \quad (89)
$$

Dividing by common factors, optimal $\bar{\pi}$ minimizes

$$
\alpha\left((1-p)s\bar{D} + \left(2\alpha + \gamma s^2\bar{D}^2\right)p\bar{\pi}\right)^2 + \left(\alpha + \frac{\gamma}{2}\bar{D}^2 s^2\right)p(1-p)\left(s\bar{D} - 2\alpha\bar{\pi}\right)^2. \quad (90)
$$

Taking the first-order condition of (90) with respect to $\bar{\pi}$ then shows that inflation in the commitment state equals

$$
\bar{\pi} = 0. \quad (91)
$$

With the two inflation policy functions, we can then solve for closed-form expressions for the expectation, variance, and output beta for period 2 inflation, taking the local currency debt share s as given:

$$E_1(\pi_2) = (1-p)\frac{s\bar{D}}{2\alpha + p\gamma s^2\bar{D}^2}, \tag{92}$$

$$Var_1(\pi_2) = p(1-p)\left(\frac{s\bar{D}}{2\alpha + p\gamma s^2\bar{D}^2}\right)^2 + \frac{\gamma^2 - p\phi(2\gamma - \phi))}{\left(2\alpha + \gamma s^2\bar{D}^2\right)^2}\bar{X}^2\bar{D}^2 s^2\sigma_x^2, \tag{93}$$

$$Beta(\pi_2, y_2) = \frac{(p\phi - \gamma)\bar{D}s}{2\alpha + \gamma s^2\bar{D}^2}, \tag{94}$$

Substituting in the inflation policy functions, the expected loss function simplifies to

$$\mathcal{L} = \frac{1-p}{2}\frac{s^2\bar{D}^2}{2\alpha + p\gamma s^2\bar{D}^2} + \frac{1}{2}\frac{-(\gamma-\phi)^2 + (1-p)\phi^2}{2\alpha + \gamma s^2\bar{D}^2}\bar{X}^2\bar{D}^2 s^2\sigma_x^2 + \frac{\gamma\bar{D}^2\sigma_\varepsilon^2}{2}(1-s)^2 + \bar{D}\sigma_\varepsilon^2(1-s) \tag{95}$$

Dropping third-order and higher terms in $\bar{D}$ again gives the expressions in the main paper.

A.2 Numerical Solution

We solve the model numerically using global projection methods. To reduce the dimensionality of the optimization problem, we use the following numerical steps.

1. Starting from the analytic solution, we minimize the Euler equation error for the no-commitment policy function while holding constant the local currency debt share and the commitment policy function.

2. We choose the commitment policy function to minimize the loss function, while holding constant the local currency debt share and the no-commitment policy function.

3. We alternate steps 1 and 2 until the maximum absolute change in both policy functions is less than 10^{-12}. This gives the loss function at a given local currency debt share.

4. We optimize over the local currency debt share that minimizes the expected loss function, where for every single value of s we repeat steps 1. through 3. to evaluate the loss function.

A.2.1 Functional Form

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

$$\pi_2^{nc} = b_1(s) + b_2(s)y_2 + b_3(s)y_2^2, \tag{96}$$

$$\pi_2^{c} = c_1(s) + c_2(s)y_2 + c_3(s)y_2^2, \tag{97}$$

where all coefficients may depend on the local currency debt share s. We start our optimization routine at the analytic solution, that is

$$b_1 = \frac{s\bar{D}}{2\alpha}, \tag{98}$$

$$b_2 = \frac{-s\bar{D}\gamma\bar{X}}{2\alpha}, \tag{99}$$

$$b_3 = 0, \tag{100}$$

$$c_1 = c_2 = c_3 = 0. \tag{101}$$

The starting value for the local currency debt share is as given in Table 3 in the main paper.

A.2.2 No Commitment Policy Function

For given no-commitment and commitment policy functions and a given local currency debt share, we compute local currency bond prices numerically as

$$\begin{aligned} \frac{q^{LC}}{\beta} &= (1-p)E\left[exp\left(-\phi\bar{X}x_2 - \frac{1}{2}\phi\bar{X}^2\sigma_x^2\right)exp(-\pi_2^{nc})\right] \\ &\quad + pE\left[exp\left(-\phi\bar{X}x_2 - \frac{1}{2}\phi^2\bar{X}^2\sigma_x^2\right)exp(-\pi_2^{c})\right]. \end{aligned} \tag{102}$$

We evaluate the expectation in (102) using Gauss-Legendre quadrature with 30 node points, truncating the interval at -6 and +6 standard deviations.

We choose the vector (b_1, b_2, b_3) to minimize squared expected Euler equation error

$$Error = 2\alpha\pi_2^{nc} - E_{\varepsilon_2}\left(C_2^{nc,-\gamma}\right)\bar{D}s\frac{\beta}{q^{LC}}exp(-\pi_2^{nc}), \tag{103}$$

where we evaluate no-commitment consumption numerically according to

$$C_2^{nc} = \bar{X}exp(x_2) - \bar{D}\left((1-s)exp\left(\varepsilon_2 + \frac{1}{2}\sigma_\varepsilon^2\right) + s\frac{\beta}{q^{LC}}exp(-\pi_2^{nc})\right). \tag{104}$$

We evaluate the expectation $E\left[Error^2\right]$ again using Gauss-Legendre quadrature with 30 nodes and truncating the interval at -6 and +6 standard deviations.

A.2.3 Commitment Policy Function

For a given nominal debt share a given no-commitment policy function, the commitment inflation policy function minimizes

$$E\left[\alpha\pi_2^2\right] - p\left[\frac{C_2^{c,1-\gamma}}{1-\gamma}\right] - (1-p)\left[\frac{C_2^{nc,1-\gamma}}{1-\gamma}\right], \tag{105}$$

where we evaluate commitment consumption numerically

$$C_2^c = \bar{X}exp(x_2) - \bar{D}\left((1-s)exp\left(\varepsilon_2 + \frac{1}{2}\sigma_\varepsilon^2\right) + s\frac{\beta}{q^{LC}}exp(-\pi_2^c)\right), \tag{106}$$

and no-commitment consumption and the ratio of bond prices are given by (104) and (102). All expectations are again evaluated numerically using Gauss-Legendre quadrature using the same grid points as before.

A.3 Numerical Model Moments

We use Gauss-Legendre quadrature to evaluate inflation moments for the numerical solution according to

$$E_1\pi_2 = pE\pi_2^c + (1-p)E\pi_2^{nc}, \tag{107}$$
$$Var_1\pi_2 = pE\left((\pi_2^c)^2\right) + (1-p)\,E\left((\pi_2^{nc})^2\right) - (E_1\pi_2)^2\,, \tag{108}$$
$$Beta(\pi_2, x_2) = (pE\left((\pi^c - E_\pi)x_2\right) + (1-p)E\left((\pi^{nc} - E_\pi)x_2\right))\,\sigma_x^2. \tag{109}$$

We obtain the local currency risk premium as

$$RP^{LC} = \log\left(q^{FC}\right) - \log q^{LC} - E_1\pi_2 + \frac{1}{2}Var_1\pi_2.$$

A.4 Accuracy of Analytic Solution

Table A.1 shows model moments for the analytic model solution. The analytic solution for the low credibility local currency debt share decreases slightly to 47% and all model moments remain broadly similar.

Figure A.1 compares analytic (blue solid) and numerical (red dashed) policy functions while holding the local currency debt share constant at its solution value of 0.54. Given the simplicity of the analytic solution, it is remarkably accurate. The main difference is that the numerical policy function is more convex, bounding no-commitment inflation away from zero in high-output states.

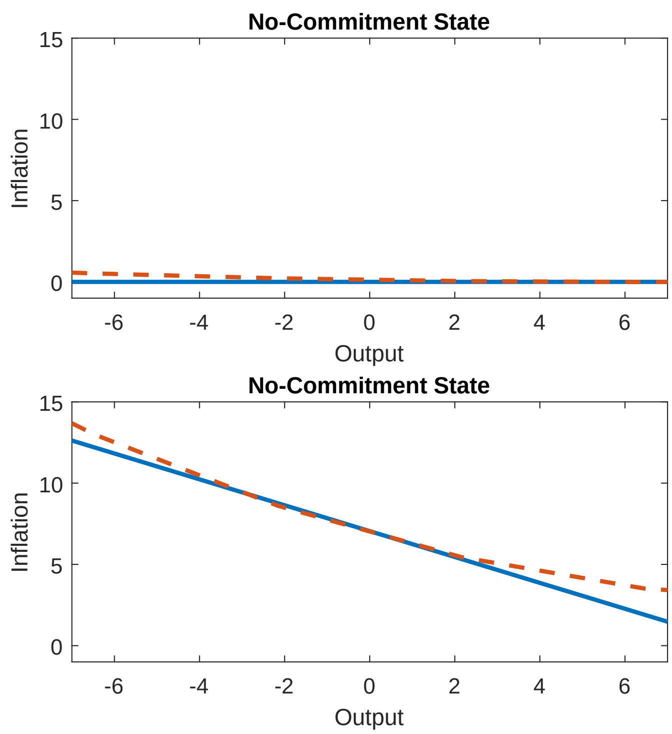
Finally, Figures A.2 and A.3 reproduce the comparative statics with respect to credibility p and risk aversion ϕ using the analytic solution. The strong similarity with Figures 6 and 7 indicates that the analytic model solution is indeed valuable for understanding the drivers of local currency bond issuance, both qualitatively and even quantitatively.

Table A.1: Analytic Solution for Model Moments

	Data	Model	
	Emerging-Developed	Low Credibility	High Credibility
Average Inflation	2.00	2.03	0.00
Average No-Commitment Inflation	6.07	6.15	13.00
Inflation Beta	-0.21	-0.23	0.00
Nominal Debt Share	0.63	0.47	1.00
Equity Risk Premium	6.00	6.25	6.25

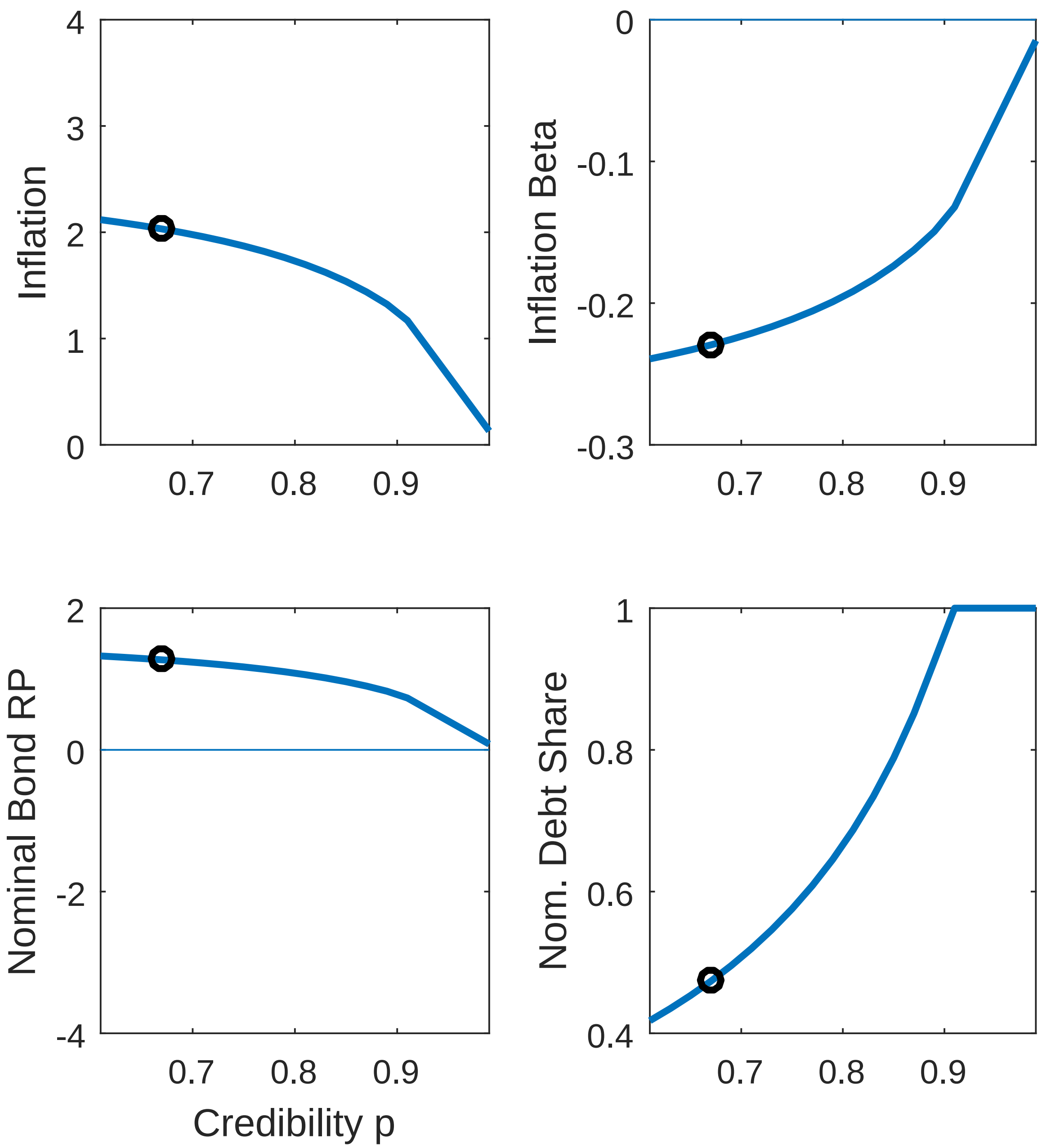
Note: All moments are in natural annual units. The difference between this table and Table 4 in the main paper is that this table uses the analytic models solution instead of global solution methods.

Figure A.1: Numerical Policy Functions



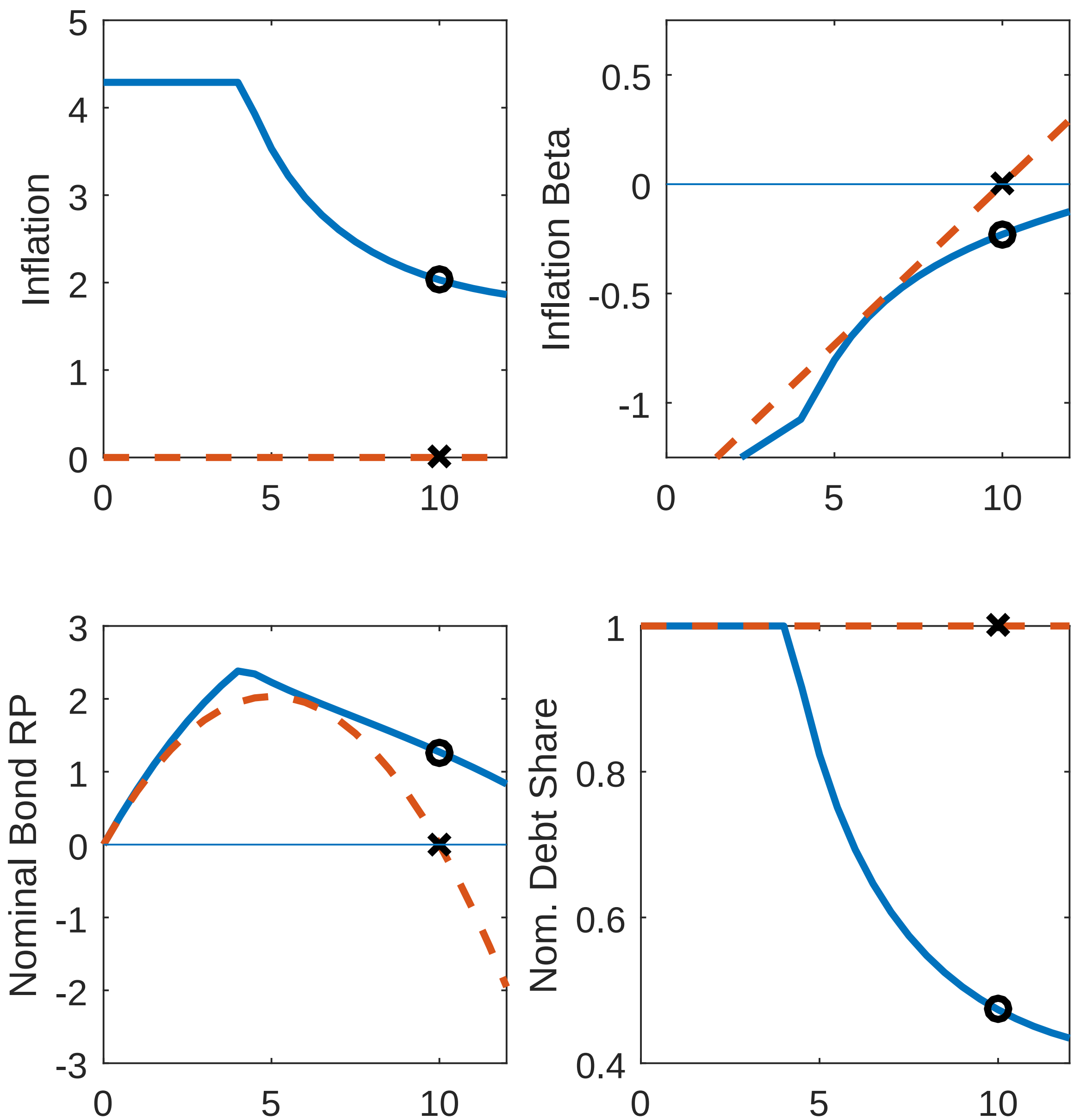
Note: The left panels show log inflation (in percent) against log output in percent deviations from the steady-state in the commitment state. The right panels show log inflation in the no-commitment state. The solid blue lines show the analytic solutions, while the red dashed lines show numerical solutions using projection methods.

Figure A.2: Analytic Solution: Varying Credibility



Note: This figure differs from Figure 6 only in that it shows the analytic solution instead of the numerical model solution

Figure A.3: Varying Investor Risk Aversion



Note: This figure varies from Figure 7 only in that it uses the analytic solution instead of the numerical model solution.

A.5 Dynamic Model

This section specifies a simple dynamic extension of the two-period model, where solutions take the same form as in the two-period model. This extension illustrates that the solutions to the two-period model can be interpreted more broadly as the outcome of a dynamic setup. We assume that log output growth is i.i.d. and log-normal:

$$\Delta x_t = \mu + \eta_t, \tag{110}$$
$$\eta_t \overset{i.i.d}{\sim} N(0, \sigma_x^2). \tag{111}$$

The government minimizes the expected discounted sum of single-period losses:

$$W_0 = E_0 \sum_{t=0}^{\infty} \delta^t L_t, \tag{112}$$

where the period-t loss equals:

$$L_t = \alpha \pi_t^2 - \frac{\left(\frac{C_t}{X_{t-1}}\right)^{1-\gamma}}{1-\gamma}. \tag{113}$$

The period t loss function can be interpreted as a combination of quadratic inflation costs, as in the two-period model, and power utility over consumption. We introduce external multiplicative habit similarly to Abel (1990). Introducing habit formation implies that the government faces a meaningful trade-off between the marginal cost of inflation and the marginal benefit of consumption along the growth path. Without habit, either the inflation loss component or the consumption utility component would get to dominate the loss function as $t \to \infty$ and there would no longer be a trade-off between consumption and inflation. We specify habit in terms of lagged output instead of lagged consumption, because otherwise the government would have an incentive to lower aggregate consumption to reduce future habit. Specifying habit in terms of lagged output therefore is the natural extension of external habits to a government, whose policies can affect aggregate consumption but not aggregate output.

The international investors uses the following real log SDF to price contingent claims on real international consumption goods:

$$m_t^* = \log \delta - \phi \Delta x_t - \frac{1}{2}\phi^2 \sigma_x^2. \tag{114}$$

We denote the real exchange rate (in units of FC in terms of LC) by $\mathcal{E}_t$. We assume that the real exchange rate follows a martingale, with the change in the log exchange rate given by:

$$\Delta e_t = \varepsilon_t - \frac{1}{2}\sigma_\varepsilon^2, \tag{115}$$
$$\varepsilon_t \overset{i.i.d}{\sim} N\left(0, \sigma_\varepsilon^2\right). \tag{116}$$

The specification (116) implies that there is no predictability in real exchange rate returns, thereby precluding any incentive to time the real exchange rate by issuing FC debt. The international investor hence uses the following log SDF to price contingent claims on real domestic consumption goods:

$$m_t = \log\delta - \phi\bar{X}\Delta x_t - \frac{1}{2}\phi^2\bar{X}^2\sigma_x^2 + \varepsilon_t - \frac{1}{2}\sigma_\varepsilon^2, \tag{117}$$

Prices for FC and LC bonds are then given by

$$q_{t-1}^{FC} = E_{t-1}\left[exp(m_t^*)\right], \tag{118}$$

$$= \underbrace{\delta exp\left(-\phi\mu\right)}_{\beta}. \tag{119}$$

From now on, we use $\beta = \delta exp\left(-\phi\mu\right)$ to denote the growth-adjusted discount rate. The prices for nominal and real LC bonds equal:

$$q_{t-1}^{LC} = E_{t-1}\left[exp(m_t)exp(-\pi_t)\right], \tag{120}$$

$$= \beta E_{t-1}\left[exp(-\phi\eta_t - \frac{1}{2}\phi^2\bar{X}^2\sigma_x^2)exp(-\pi_t)\right], \tag{121}$$

$$q_{t-1}^{LC,real} = E_{t-1}\left[exp(m_t)\right], \tag{122}$$

$$= \beta. \tag{123}$$

The exchange rate shock ε_t drops out of the expressions for real and nominal LC bond prices, because it is assumed to be uncorrelated with all other shocks.

At the very end of period $t-1$, after consumption and inflation are realized, the government must raise a fixed amount that is proportional to output $X_{t-1}V$ by issuing nominal LC and FC debt. If the government raises face values D_{t-1}^{LC} and D_{t-1}^{FC} of LC and FC debt, the budget constraint becomes:

$$\frac{q_{t-1}^{FC}}{\mathcal{E}_{t-1}}D_{t-1}^{FC} + q_{t-1}^{LC}D_{t-1}^{LC} = X_{t-1}V. \tag{124}$$

The FC debt price enters into the budget constraint (124) divided by the real period $t-1$ exchange rate, because q_{t-1}^{FC} units of international goods translate into $\frac{q_{t-1}^{FC}}{\mathcal{E}_{t-1}}$ units of domestic consumption goods.

We define the period $t-1$ local currency debt share as:

$$s_{t-1} = \frac{q_{t-1}^{LC}D_{t-1}^{LC}}{X_{t-1}V}. \tag{125}$$

The real domestic resources required to repay the debt portfolio at time t are:

$$\frac{D_{t-1}^{FC}}{\mathcal{E}_t} + D_{t-1}^{LC}exp(-\pi_2). \tag{126}$$

The FC face value (126) appears divided by the period-t exchange rate $\mathcal{E}_t$, because the domestic government must give up $\frac{1}{\mathcal{E}_t}$ units of domestic goods to repay one unit of foreign goods. Similarly to the two-period model, we define the debt portfolio log return in real domestic goods in excess of the log real LC bond as

$$xr_t^d = \log\left(\frac{D_{t-1}^{FC}/\mathcal{E}_t + D_{t-1}^{LC} exp(-\pi_t)}{\beta^{-1} X_{t-1} V}\right), \tag{127}$$

$$= \log\left((1-s)\frac{\mathcal{E}_{t-1}}{\mathcal{E}_t} + s\frac{\beta}{q_{t-1}^{LC}} exp(-\pi_t)\right), \tag{128}$$

$$= \log\left((1-s) exp\left(-\varepsilon_t + \frac{1}{2}\sigma_\varepsilon^2\right) + s\frac{\beta}{q_{t-1}^{LC}} exp(-\pi_t)\right). \tag{129}$$

A.5.1 Dynamic Model Solution

Now, we guess and verify a particular solution. We guess that the period t objective function can be written as

$$W_t = \alpha\pi_t^2 - \frac{C_t^{1-\gamma}}{1-\gamma} + t.i.p, \tag{130}$$

where "t.i.p" denotes terms that are independent of period t policy.

We verify that there is a solution of this form by induction show and that it implies a constant nominal debt share. Assume that the solution (130) holds from time t onwards. In period t, consumption equals

$$C_t = exp\left(X_{t-1}\right)\left(exp(\mu+\eta_t) - V\beta^{-1}exp(xr_t^d)\right), \tag{131}$$

so the period t government minimizes

$$W_t = \alpha\pi_t^2 - \frac{\left(exp(\mu+\eta_t) - V\beta^{-1}exp(xr_t^d)\right)^{1-\gamma}}{1-\gamma} + t.i.p. \tag{132}$$

We define a scaled value function

$$\tilde{W}_t = \frac{W_t}{\left(exp(\mu) - V\beta^{-1}\right)^{1-\gamma}}, \tag{133}$$

$$= \bar{\alpha}\pi_t^2 - \frac{\left(\bar{X}exp(\eta_t) - \bar{D}exp(xr_t^d)\right)^{1-\gamma}}{1-\gamma} + t.i.p.,, \tag{134}$$

where

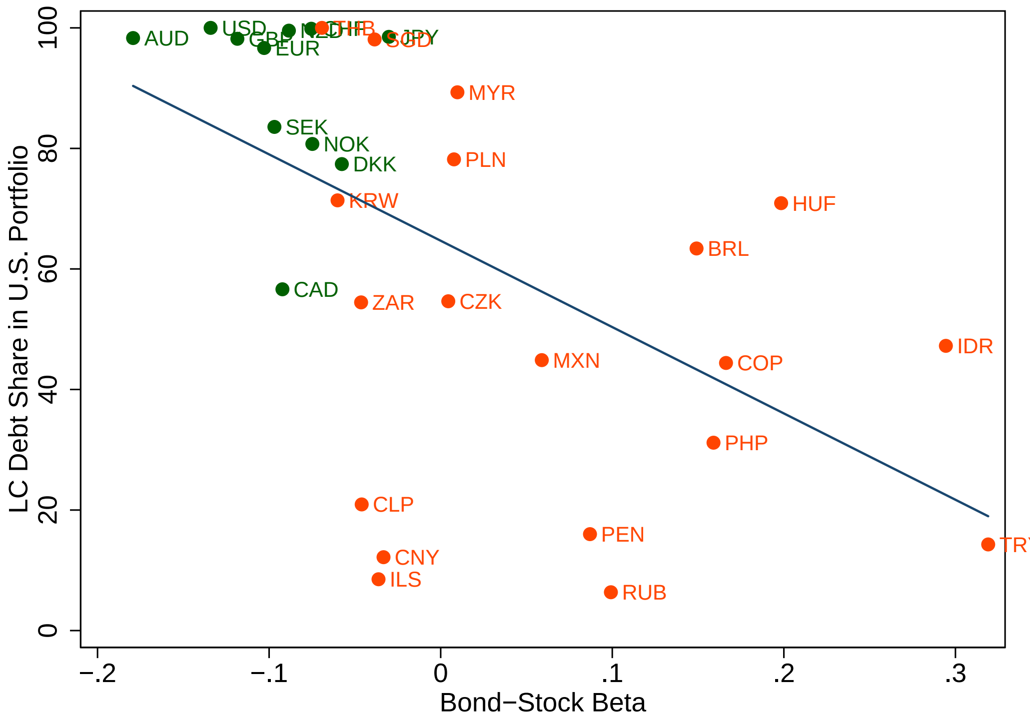
$$\bar{\alpha} = \frac{\alpha}{\left(exp(\mu) - V\beta^{-1}\right)^{1-\gamma}}, \tag{135}$$

$$\bar{X} = \frac{exp(\mu)}{\left(exp(\mu) - V\beta^{-1}\right)^{1-\gamma}}, \tag{136}$$

$$\bar{D} = \frac{V\beta^{-1}}{\left(exp(\mu) - V\beta^{-1}\right)^{1-\gamma}}. \tag{137}$$

By definition, $1 + \bar{D} = \bar{X}$ and therefore the objective function (134) takes the same form as in the two-period model. If we define $\bar{\phi} = \frac{\phi}{\bar{X}}$, the stochastic discount factor also takes the same form as in the two-period model (with ϕ replaced by $\bar{\phi}$). At the end of period $t-1$, the government's problem hence is to choose a nominal debt share s_{t-1} and a commitment inflation policy $\pi_t^c(\eta_t)$ to minimize (134), subject to the pricing relation (120), the debt portfolio return (129), and that the no-commitment inflation policy π_t^{nc} minimizes $E(\tilde{W}_t\,|\eta_t)$. This is exactly the same problem as in the two-period model, so the solutions for the inflation policy and nominal debt shares are also the same. In particular, the $t-1$ nominal debt share and period t inflation policy functions do not depend on period $t-1$ consumption or inflation. It follows that W_{t-1} can be written in the form (130). q.e.d.

Figure B.4: Nominal Share in External Debt



B Empirical Robustness

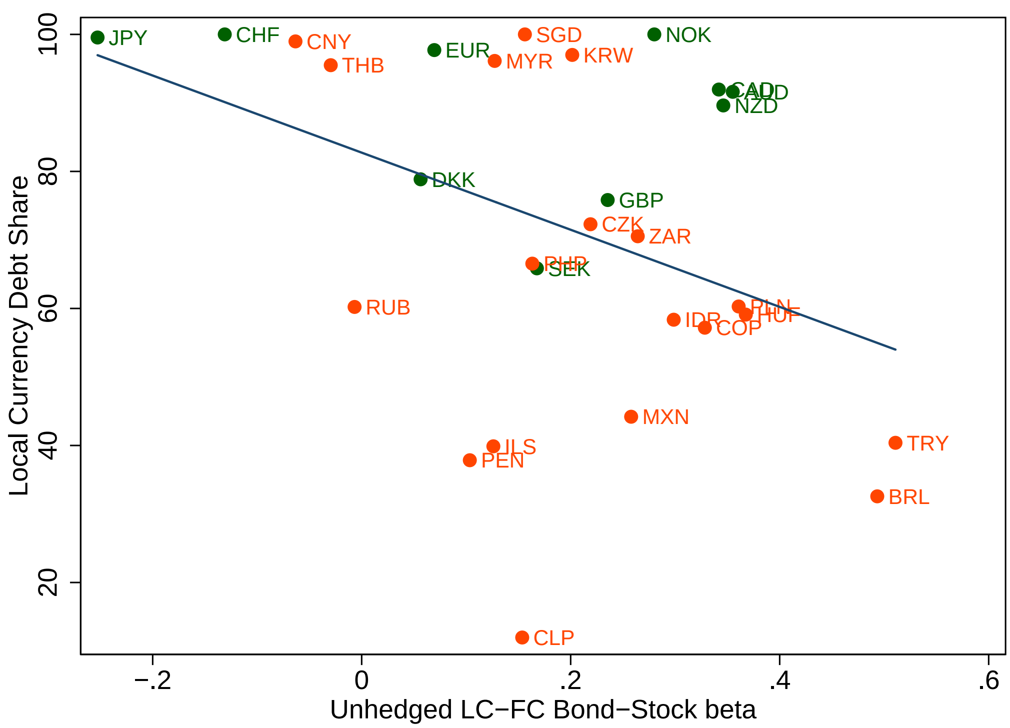
B.1 TIC Data

In this section, we demonstrate that our results are robust to examining external debt separately, rather than all central government debt as in the main paper. The primary reason for not doing so is that it would be reduce country coverage. Here, we approximate foreign-owned debt by looking only at the debt owned by US domiciled investors. US investors report their security level holdings as part of the Treasury International Capital (TIC) data. Here, we calculate the LC debt share in the US portfolio 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. Figure B.4 shows that the negative relation between bond-stock betas and LC debt shares is robust to using this alternative measure of LC debt shares.

B.2 LC vs. FC Bond Betas

So far, we have assume that real exchange rates are uncorrelated with all other shocks. This is clearly a simplification. However, what matters for the domestic borrower's choice between LC and FC debt is the relative hedging properties and the relative risk premia of these two types of debt. If real exchange rate cyclicality is similar across countries, inflation cyclicality and LC bond return cyclicality are the relevant margins for understanding cross-sectional differences in LC debt shares. Figure B.5 shows the relation between LC debt shares on the x-axis against LC bond betas in excess of FC bond betas. We see that countries with lower LC debt shares have higher LC bond betas in excess of FC betas, confirming the empirical evidence in Figure 1.

Figure B.5: LC minus FC Bond-Stock Betas



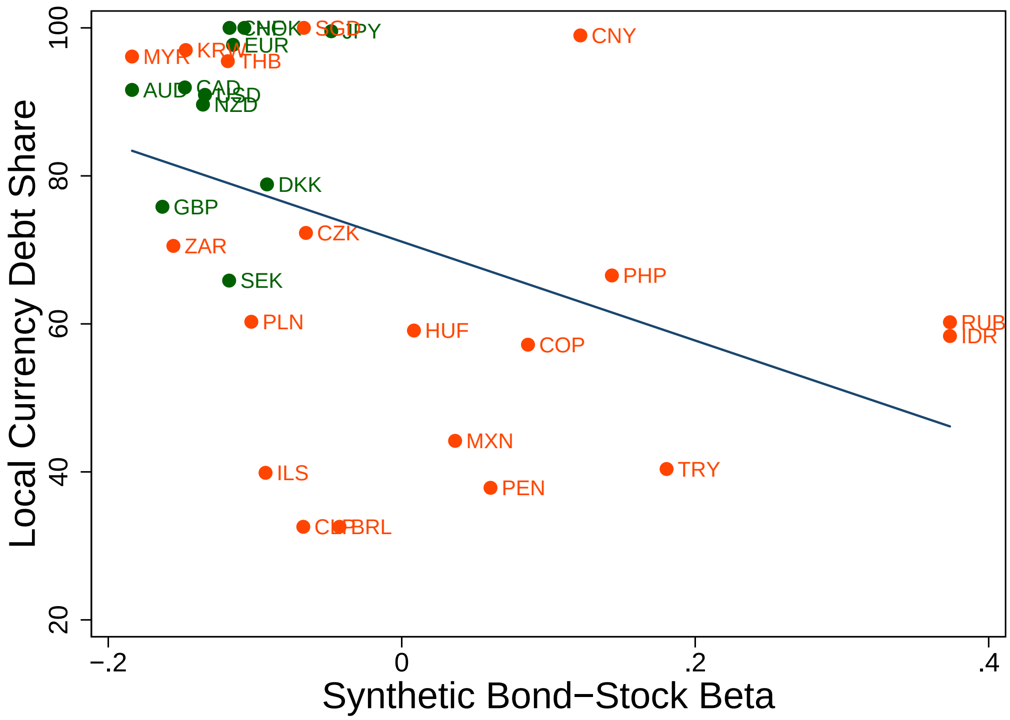
Note: This figure shows the difference between unhedged LC bond betas and FC betas for dollar investors on the x-axis against local currency debt shares on the y-axis.

B.3 Adjusting for Default Risk

In order to adjust for default risk, we construct a synthetic default free nominal bond yield. We follow Du and Schreger (2016) by combining a US Treasury with a fixed-for-free cross currency swap to create a synthetic default free local bond. In the absence of financial market frictions and sovereign default risk, we would expect $y^{LC} = y^{LC*}$. Figure B.6 shows betas of these synthetic LC bonds against local currency debt shares, showing forcefully that our basic stylized empirical fact in Figure 1 is robust to controlling for LC default risk.

We also verify that results for LC bond risk premia are robust to adjusting for default risk. We define an alternative measure of the risk premium that removes sovereign default risk from the nominal bond yield.

Figure B.6: Nominal Debt Share vs. Default-Adjusted Local Currency Bond Betas



Note: This figure shows betas of default-adjusted LC bonds on the x-axis against local currency debt shares on the y-axis. We follow Du and Schreger (2016) by combining a US Treasury with a fixed-for-free cross currency swap to create a synthetic default free local bond.

$$
\begin{aligned}
\bar{RP}_{alt} &= y^{\bar{LC}*} - \bar{\pi} + \frac{1}{2}Var\pi - \left(y^{US} - \bar{\pi}^{US} + \frac{1}{2}Var\pi^{US}\right) \\
&\bar{=} \left(y^{US} + ccs\right) - \bar{\pi} + \frac{1}{2}Var\pi - \left(y^{US} - \bar{\pi}^{US} + \frac{1}{2}Var\pi^{US}\right), \qquad (138)
\end{aligned}
$$

where ccs denotes the fixed-for-free cross currency swap rate. In the right panel of Figure 8 and Tables B.2, B.3 and B.4 we replicate the results on risk premia in Section 5 and find the results qualitatively unchanged.

B.4 Robustness to 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 B.7 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 bond-stock betas are extremely similar when excluding the financial crisis, indicating that our key bond cyclicality

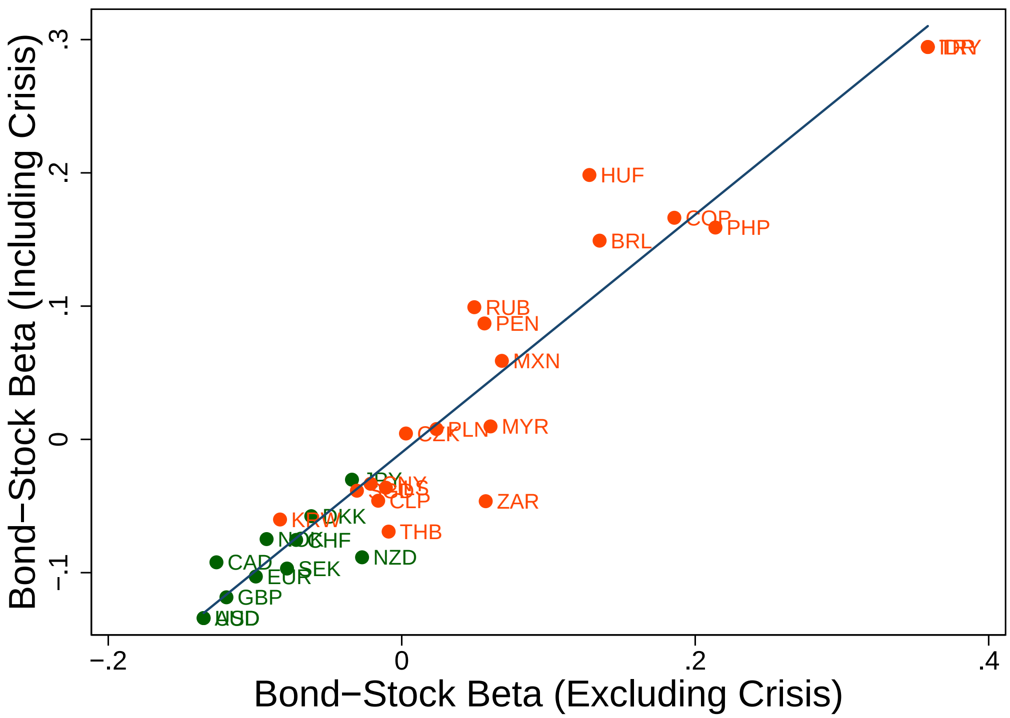
Table B.2: Nominal Debt Share and Default-Free Bond Risk Premia

	(1)	(2)	(3)	(4)
Local Currency Debt Share	s	s	s	s
Risk Premia	-12.57***	-12.56***	-10.13**	-11.20**
	(2.382)	(4.080)	(3.958)	(4.943)
Log (GDP)		1.461		0.425
		(4.186)		(4.145)
FX Regime		4.535		4.467
		(3.714)		(3.807)
Average Inflation			-2.194	-1.700
			(2.124)	(2.374)
Constant	83.24***	56.35	88.30***	70.71
	(3.405)	(39.15)	(6.418)	(42.99)
Observations	30	30	30	30
R-squared	0.434	0.462	0.451	0.470

Note: In this table we regress the average nominal debt share our alternate empirical proxy for the risk premia in Equation 138. The FX Regime is from Reinhart and Rogoff (2004). Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

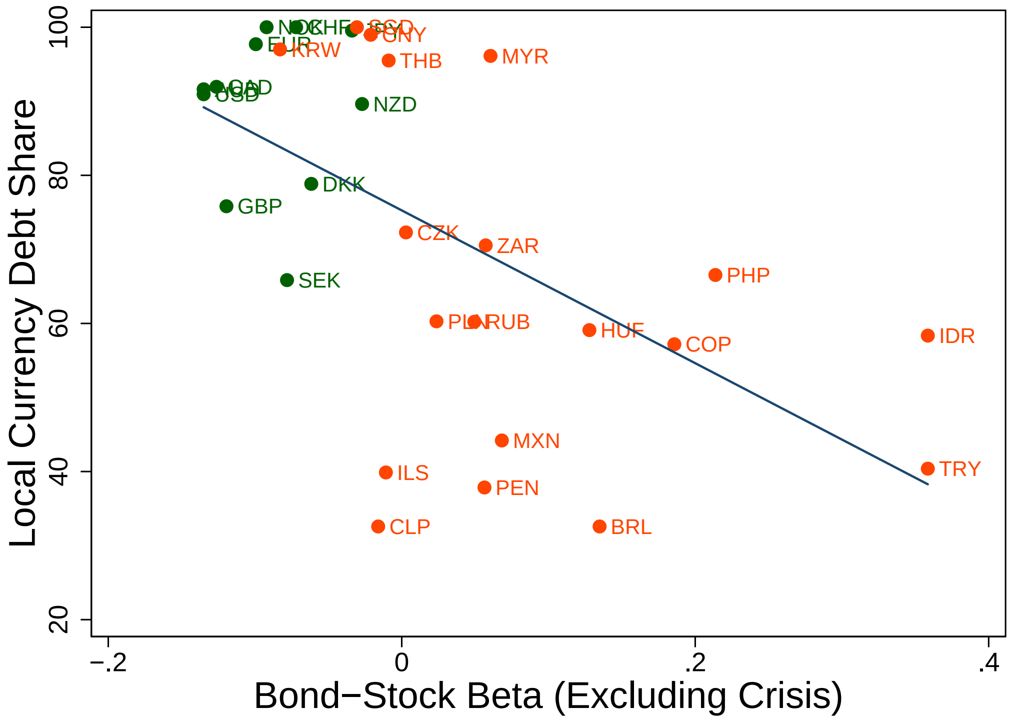
measure is not driven by a small number of observations. Figure B.8 shows that our main stylized fact in Figure 1 remains unchanged if we exclude the crisis period in our construction of LC bond betas.

Figure B.7: 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.

Figure B.8: 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.

Table B.3: Default-Free Risk Premia and Bond Betas

VARIABLES	(1) RP	(2) RP	(3) RP	(4) RP
Bond-Stock Beta	6.187***	2.057	4.055**	1.625
	(1.004)	(2.049)	(1.495)	(2.090)
Log (GDP)			-0.345*	-0.227
			(0.171)	(0.155)
FX Regime			0.543***	0.452***
			(0.187)	(0.151)
Mean Inflation		0.344**		0.264**
		(0.136)		(0.118)
Constant	0.744***	-0.323	2.472	0.792
	(0.183)	(0.416)	(1.835)	(1.694)
Observations	30	30	30	30
R-squared	0.378	0.508	0.519	0.588

Note: In this table we regress our alternate empirical proxy for the risk premia in Equation 138 on the bond stock beta and controls. The FX Regime is from Reinhart and Rogoff (2004). Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table B.4: Credibility Measures, Risk Premia, and Bond Betas

	(1) RP	(2) RP
News Count	13.28***	
	(3.258)	
Credibility Gap		2.630***
		(0.498)
Constant	-1.951***	-0.268
	(0.683)	(0.222)
Observations	30	22
R-squared	0.243	0.555

Note: In Column (1) we regress our alternate empirical proxy for the risk premia in Equation 138 on "News Count" the correlation of the keywords "debt" and "inflation" in Financial Times articles 1996-2015 from ProQuest Historical Newspapers. We compute the correlation as the number of articles mentioning both "debt" and "inflation" divided by the geometric average of articles that mention either "debt" or "inflation". We require articles to also mention the country name. In Column (2) we regress the risk premium on the inflation credibility gap, measured as the mean difference between the survey inflation expectations from Consensus Economics and the announced inflation target since 2005. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.