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

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Abstract

We document large cross-country variations in the cyclicality of nominal bond returns across 30 developed and emerging markets over the past decade. We show that countries with more procyclical nominal bond returns rely less on nominal debt in their sovereign debt portfolios, despite of the better hedging properties of nominal debt from the issuer’s perspective. We explain these findings using a tractable model with imperfect monetary policy credibility and endogenous currency composition of sovereign debt. A low credibility government issues foreign currency debt to constrain the future government’s incentive to inflate away the debt. Cost-push shocks to a New-Keynesian Phillips curve create high inflation during recessions and positive local currency bond betas when the government has low credibility. In contrast, a high credibility government issues local currency debt and offsets recessionary cost-push shocks by strengthening its commitment to low future inflation, thereby raising local currency bond returns in recessions.


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 the 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, constituting more than half of external debt issued by major emerging market sovereigns (Du and Schreger, 2015b). 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 minimize the deadweight costs of taxation (Barro, 1979). If deadweight costs are higher during recessions, it is optimal to issue instruments that require low repayments in recessions and higher repayments in expansions (Bohn, 1990; Barro, 1997). For a country with a positive beta of nominal government bonds with respect to the local stock market, nominal debt depreciates exactly in the worst states of the world and nominal debt should be highly attractive. However, in contrast with this simple intuition, Figure 1 shows that the share of nominal debt in the government debt portfolio decreases with the country’s nominal bond beta for a cross-section of 30 developed and emerging markets.²

We reconcile this puzzling relationship between nominal debt shares and bond return cyclicality in a framework based on the credibility of monetary policy. A negative bond beta indicates the central bank’s ability to steer inflation expectations, similarly to Campbell, Pflueger, and Viceira (2015), and governments with a credible monetary policy authority choose to issue debt denominated in their own currency. The model generates additional predictions for the comovement of inflation, inflation cyclicality, and credit risk across coun-

²We show average nominal debt shares in central government debt and the estimated slope coefficient of local currency nominal government bond returns against local stock market returns for the period 2005-2014. For details see Section 2.1.
tries, that are consistent with the data.

We begin by documenting significant cross-country heterogeneity in the hedging properties of nominal debt. In a sample of 30 developed and emerging markets with sizable nominal local currency bond markets, we find that over the last decade nominal bond-stock betas range from negative 0.2 to positive 0.3. Bond-stock betas in developed markets, such as the US, tend to be negative. For emerging markets, bond-stock betas range from nearly negative 0.1 to positive 0.3. Positive bond-stock betas coincide with negative bond-CDS betas, consistent with credit default swaps (CDS) widening during stock market downturns. Furthermore, we show that bond-stock betas are strongly negatively related to the cyclicality of inflation expectations across countries, as would be expected if inflation expectations were a key driver of the hedging properties of nominal bonds.

Our second set of stylized facts documents the relation between the hedging properties of nominal debt and the share of nominal debt in sovereign debt portfolios. We show that countries with more pro-cyclical nominal bond returns and counter-cyclical inflation expectations tend to rely less on nominal local currency debt relative to real or foreign currency debt. It might at first appear puzzling that countries, where nominal debt has the most favorable hedging properties to the issuer, issue the smallest share of nominal debt.

To reconcile these empirical findings, we develop an analytically tractable model where monetary policy credibility is the key driver of both bond return cyclicity and sovereign debt portfolios. The model integrates the government’s optimal choice between nominal local currency debt and real foreign currency debt into a standard log-linearized New Keynesian framework. The monetary policy authority communicates a contingent plan for future monetary policy – similar to forward guidance in practice. However, a low credibility central bank is likely to act myopically (Kydland and Prescott, 1977; Barro and Gordon, 1983; Rogoff, 1985) and has an incentive to inflate away nominal debt.

The government’s trade-off between LC and FC debt can be very different depending on the monetary policy authority’s inflation credibility. We model the costs of issuing foreign
currency debt by assuming that expected sovereign default costs increase in the share of FC debt.\(^3\) On the other hand, the next-period incentive to inflate increases with the proportion of LC debt, which is costly if inflation has real economic costs. A country with a non-credible monetary policy faces a higher likelihood that next period’s monetary policy will be myopic, pushing it towards issuing FC debt.

On the monetary policy side, we build on a two-period canonical New-Keynesian monetary policy framework (Clarida, Gali, and Gertler, 1999)(CGG) and its small open economy extensions (Gali and Monacelli, 2005). Inflation and output move along an upward-sloping forward-looking New Keynesian Phillips curve, which is subject to cost-push shocks. We keep the model tractable by assuming that local currency bonds and stocks are priced by a continuum of risk-neutral international investors and that purchasing power parity holds. Nominal bond prices move inversely with inflation expectations and stock prices increase in expansions and decrease in recessions, so pro-cyclical inflation expectations coincide with negative bond-stock betas.

In the model, negative bond-stock betas indicate high monetary policy credibility. A high credibility government mitigates recessionary and inflationary cost-push shocks by credibly promising low future inflation, thereby lowering inflation expectations in recessions. With high credibility, we therefore obtain pro-cyclical inflation expectations and negative bond-stock betas. In contrast, a low credibility government can only partially offset cost-push shocks, leading to counter-cyclical inflation expectations and positive bond-stock betas.

Despite its simplicity, the model generates numerous testable predictions. Governments with more credible monetary policies borrow more in local currency. In addition, high credibility leads to more positive comovement between inflation and output expectations, more negative comovement between LC bond returns and local stock returns, and more

\(^3\)While we model the costs of FC debt by assuming that more FC debt increases sovereign default risk, we think of these default costs as a stand-in for a wider class of potential losses from FC debt, which are not modeled explicitly. In particular, the costs of FC debt could include state-contingency in crises. In addition, shocks to the exchange rate could increase the volatility of debt service costs for FC debt. For conciseness, we summarize the welfare costs of FC debt as “default costs”.

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positive comovement between LC bond returns and sovereign default risk. In addition, the level of inflation, nominal bond yields, and sovereign default risk decrease with monetary policy credibility, which is strongly supported by the data.

Finally, we construct a new measure of monetary policy credibility from newspaper counts to provide direct evidence for the proposed model mechanism. We measure inverse monetary policy credibility as the correlation between Financial Times articles containing the key words “debt” and “inflation” for each country. Intuitively, if investors consider monetary and fiscal policies independent, the financial press should analyze monetary and fiscal issues in separate articles. In contrast, if investors perceive monetary and fiscal policies as interlinked, news articles should discuss both debt and inflation at the same time. We find that this news-based measure of inverse inflation credibility is 71% correlated with nominal bond betas across countries, consistent with model predictions.

This paper contributes to a recent literature on inflation commitment and debt limits when the debt denomination is exogenous (Araujo, Leon, and Santos, 2013; Aguiar, Amador, Farhi, and Gopinath, 2014; Chernov, Schmid, and Schneider, 2015; Sunder-Plassmann, 2014; Bacchetta, Perazzi, and Van Wincoop, 2015; Du and Schreger, 2015b; 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, Leeper, and Walker, 2011; Cochrane, 2011; Niemann, Pichler, and Sorger, 2013). We expand on these papers along two dimensions. First, we model the government’s optimal time-varying 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 (i.e. (Obstfeld, 1997)), we consider how the government optimally chooses the denomination of sovereign debt to mitigate its limited monetary policy credibility. We add to the related quantitative frameworks of Alfaro and Kanczuk (2010); Díaz-Giménez, Giovannetti, Marimon, and Teles (2008) by matching stylized facts about inflation cyclicality and bond return cyclicality.
The paper is also related to a recent literature on time-varying bond risks (Baele, Bekaert, and Inghelbrecht, 2010; Andreasen, 2012; David and Veronesi, 2013; Campbell, Sunderam, and Viceira, 2014; Campbell, Pflueger, and Viceira, 2015; Song, 2014; Ermolov, 2015), that is primarily focused on the US and the UK. This paper differs from the previous literature, in that we focus on governments’ optimal debt issuance as an important margin for bond risks.

The structure of the paper is as follows. In Section 2, we present the new stylized fact on the relationship between the cyclicality of nominal bond risk and shares of nominal debt in sovereign portfolios. In Section 3, we present a New Keynesian model with a government debt portfolio choice and sovereign default risk. In Section 4 we solve the model and discuss the model implications. In Section 5, we test additional implications of the model explanations and presents our monetary policy credibility measure based on newspaper counts. Section 6 discusses alternative channels. Section 7 concludes.

2 Nominal Bond Risks and Sovereign Debt Portfolios

In this section, we establish the relationship between nominal bond risks and the currency composition of sovereign debt portfolios. We first describe the data and variable construction used in our analysis and present some summary statistics by emerging and developed market groups. We then show that there is a strong correlation between nominal risk measures 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 default risk, we use sovereign credit default swap spreads (CDS) from Markit. Sovereign CDS contracts offer insurance for investors in the event of sovereign default. All sovereign CDS contracts are denominated in U.S. dollars and hence CDS spreads offer an approximation for the shadow costs of issuing a U.S. dollar debt for different sovereign issuers.\footnote{For developed countries, CDS contracts insure against defaults on all Treasury bonds denominated in local currency under domestic law. However, in emerging markets, CDS contracts are exclusively linked to external debt denominated in foreign currencies. US sovereign CDS contracts are denominated in Euros.}

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 nominal debt in total sovereign debt portfolios with data from BIS Debt Securities Statistics, OECD Central Government Debt Statistics, and several individual central banks.

\subsection{Bond Bond Risks: Bond-Stock and Bond-CDS Betas}

We denote the log yield on an \( n \)-year bond traded at par as \( y_{nt} \), where \( y_{nt} = \log(1 + Y_{nt}) \). The log holding period return on the bond is given by

\[
y_{n,t+\Delta t}^b \approx D_n y_{nt} - (D_n - \Delta t)y_{n-1,t+\Delta t},
\]
where $D_n = \frac{1-(1+Y_{cnt})^{-n}}{1-(1+Y_{cnt})^{-1}}$ is the duration of a bond selling at par (Campbell, Lo and MacKinlay, 1997). We approximate $y_{n-\Delta t, t+\Delta t}$ by $y_{n, t+\Delta t}$ for the quarterly holding period. We let $y_{t1}$ denote the three-month T-bill yield and then the excess return on LC bonds over the short rate is given by

$$rx^b_{n, t+\Delta t} = r^b_{n, t+\Delta t} - y_{t1}.$$

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

$$rx^b_{n, t+\Delta t} = [r^b_{n, t+\Delta t} - (y_{t1} - y^*_{t1})] - y^*_{t1}.$$

The dollar investor can hedge away the currency risk of the holding period $\Delta t$ by going long a U.S. 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:

$$rx^m_{t+\Delta t} = (p^m_{t+\Delta} - p^m_t) - y_{t1},$$

where $p^m_t$ 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 $\beta^{b,s}$ by regressing LC bond excess returns $rx^b_{t+\Delta t}$ on local equity excess returns $rx^s_{t+\Delta t}$:

$$rx^b_{t+\Delta t} = \alpha + \beta^{b,s} rx^s_{t+\Delta t} + \epsilon_t.$$

Bond-stock betas measure the risk exposure of LC bond returns on local equity returns. In addition, we also compute the bond-CDS beta as the regression coefficient of LC bond excess
returns on changes in CDS spreads:

\[
rx_{t+\Delta t}^b = \alpha + \beta_{b,cds} \Delta css_{t,t+\Delta t} + \epsilon^L_t.
\]

### 2.1.2 Cyclicality of Inflation Expectations: Forecast Beta

To measure the expected pro-cyclicality of inflation expectations, we regress 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

\[
\Delta \tilde{\pi}_t = \beta_0 + \beta_{\tilde{\pi},gdp} \Delta \tilde{gdp}_t + \epsilon_t,
\]

where \( t \) indicates the date the revision is made. The revisions to inflation forecasts (\( \Delta \tilde{\pi}_t \)) and GDP growth forecasts (\( \Delta \tilde{gdp}_t \)) are measured as percentage changes of forecasts made three months before. The coefficient \( \beta_{\tilde{\pi},gdp} \) 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 in order to minimize variation in the forecast horizon.
2.1.3 Nominal Debt Shares

For developed countries, we construct the share of nominal debt based on the OECD Central Government Debt Statistics and individual central banks, which directly report the instrument composition of debt securities outstanding issued by the central government.

For emerging markets, we measure the share of nominal debt in sovereign debt portfolios using the BIS Debt Securities Statistics. 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 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 from are from individual central banks or the OECD. The share of nominal debt is computed as the ratio of the fixed-coupon domestic sovereign debt outstanding \( D_{t}^{Dom,Fix} \) over the sum of domestic and international government debt:

\[
\alpha_{t}^{Nom} = \frac{D_{t}^{Dom,Fix}}{D_{t}^{Dom} + D_{t}^{Int}}.
\]

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

2.2 Summary Statistics

Table 1 reports summary statistics for inflation, inflation expectations, CDS spreads, nominal bond yields, bond-stocks betas, bond-CDS betas, inflation-output forecast betas, and nominal debt shares by developed and emerging market groups. Compared with developed markets, emerging market CDS spreads are 91 basis points higher on average. While CDS spreads across countries share a large common component (Longstaff, Pan, Pedersen, and Singleton, 2011; Ang and Longstaff, 2013), our empirical results focus on the substantial
cross-country differences in the level of CDS spreads and bond-CDS betas. Emerging mar-
ket realized inflation is 2.4 percentage points higher and survey-based expected inflation is 
2.0 percentage points higher. In addition, inflation is expected to be less pro-cyclical in 
emerging markets than in developed countries.

For nominal bonds, five-year nominal yields are 3.4 percentage points higher in emerging 
markets than in developed markets. Nominal bond returns are counter-cyclical in devel-
oped markets, as evident from negative bond-stock betas and positive bond-CDS betas. By 
contrast, nominal bond returns are pro-cyclical in emerging markets. Finally, the share of 
nominal debt in total debt portfolios is 26 percentage points higher in developed than in 
emerging markets.

2.3 Co-movements among Nominal Risk Betas

Figure 2 shows the strong co-movement between bond-stock betas and bond-CDS betas in 
Panel (A) and between bond-stock betas and inflation forecast betas in Panel (B). Developed 
markets are denoted by green dots and emerging markets are denoted by red dots. We can 
see from the y-axis that all developed markets have negative bond-stock betas during the 
past decade. Among emerging markets, bond-stock betas range from slightly negative -0.07 
for Thailand to positive 0.32 for Turkey.

The cross-sectional pattern for bond-stock betas maps almost exactly to the pattern for 
bond-CDS betas. In Panel (A), we can see that countries with high nominal bond betas tend 
to have low bond-CDS betas, which implies nominal bonds have high excess returns when 
stock market returns are high and CDS spreads are narrow. From the sovereign issuer’s 
perspective, nominal bonds are risky for developed markets, where the debt burden is higher 
in bad times. In contrast, nominal bonds can be a good hedge for some emerging market 
issuers, that have with negative bond-stock betas and positive bond-CDS betas.

If changes to inflation expectations are an important driver of nominal bond returns, 
the cyclicality of nominal bond returns should be highly correlated with the cyclicality of
inflation expectations. Panel (B) confirms this intuition, showing a strong negative relationship between bond-stock betas and inflation forecast betas across countries. In other words, in countries with more negative bond-stock betas, inflation is expected to be more pro-cyclical with respect to output. During bad times, lower inflation expectations lead to higher nominal bond returns.

2.4 Relationship between Nominal Risk Betas and Sovereign Debt Portfolios

Figure 3 adds to the evidence in Figure 1 on the relationship between bond return cyclicality and the share of nominal debt in sovereign debt portfolios. In particular, we find that countries with higher bond-stock betas, lower bond-CDS betas and lower inflation forecast betas tend to have lower shares of nominal sovereign debt. Thus, countries with more pro-cyclical bond returns and less pro-cyclical inflation expectations use more nominal debt. Emerging markets have lower nominal debt shares and more pro-cyclical nominal risk, whereas developed countries have high nominal debt shares and more counter-cyclical nominal risk.

The negative relationship between nominal debt shares and the pro-cyclicality of nominal risk is at first puzzling since it is at odds with the prediction from a standard portfolio model with exogenous inflation cyclicality, which could be due to a combination of supply and demand shocks or monetary policy. In particular, if the marginal cost of transferring resources to foreign bond holders is highest in recessions, the government should want to shift debt repayments towards good states of the world. In countries with positive bond betas, such as Brazil or Turkey, the real value of nominal debt repayments is low in bad states of the world, which should make nominal debt an attractive way of borrowing. The gain from consumption smoothing across the states using nominal debt is greater for countries with more pro-cyclical nominal bond returns. However, these countries actually have the lowest shares of nominal debt in their portfolios.

In the following section, we show that we can resolve the puzzle between nominal risk
betas and sovereign debt portfolios using a model with endogenous monetary policy under imperfect monetary policy credibility.

3 Model

This section describes the model assumptions and setup. We study a two-period version of the standard New Keynesian model. We add two new features to this standard model. First, we allow the government to optimally choose the currency denomination of sovereign debt. Second, we model government credibility by introducing a parameter that allows us to vary the probability that the government implements its promised future policy or implements discretionary policy.

This means that in addition to setting short-term nominal interest rate policy, the government also decides in which currency to fund itself. The government’s optimal liabilities problem has parallels to the international household portfolio choice problem (Devereux and Saito, 1997; Campbell, Serfaty-De Medeiros, and Viceira, 2010; Devereux and Sutherland, 2011; Evans and Hnatkovska, 2014), but differs in that the government’s debt portfolio can affect future monetary policy and default.

In order to decide in which currency to borrow, the government trades off the increased sovereign default risk from borrowing using FC debt with the temptation for future inflation from using LC debt. This trade-off is very different depending on the level of the government’s credibility and the interactions between debt denomination and monetary policy will generate a host of predictions.

3.1 Setup and Timing

The model has two time periods, as illustrated in Figure 4. In period 1, the government has no debt outstanding. After observing the period 1 cost-push shock, it chooses period 1 monetary policy and the sovereign debt portfolio. The government also determines a
contingent plan for period 2 monetary policy, knowing that it will only be able to implement 
this plan probability $p$. This probability $p$ that the government sticks to its announced 
plan is how we parameterize central bank credibility. It can be thought of as capturing 
the effectiveness of institutions in overcominng the incentive problems often faced by central 
banks, as in Persson and Tabellini (1993).

In period 2, the government simply implements the contingent plan with probability $p$. 
However, with probability $1 - p$ the government acts myopically.\footnote{This approach to 
modeling monetary policy credibility is similar to the “incomplete commitment” 
extension of (Calvo and Guidotti, 1993), which however does not study implications for inflation cyclicality.} 
A myopic government 
faces an incentive to inflate away LC bonds held by foreigners. Finally, at the end of the 
period the government defaults or repays the debt. Sovereign default is exogenous and the 
probability of default depends on the debt composition and will be discussed in detail below.

### 3.2 Debt Issuance

Let $D_1^{LC}$ and $D_1^{FC}$ denote the face values of LC and FC debt issued in period 1 and maturing 
in period 2. We use $q_1^{LC}$ and $q_1^{FC}$ to denote the corresponding prices per unit of face value.

FC and LC debt differ in terms of the real repayment in case of no default. While the 
government is required to repay FC bond holders their real initial face value, the required 
payments to LC bond holders decrease with inflation. To preserve tractability and focus on 
the first-order effect of inflation surprises on bond returns, we approximate real repayments 
to LC bond holders log-linearly around conditional expected log inflation

\[
\exp(-\pi_2) \approx \exp(-E_1\pi_2)(1 - (\pi_2 - E_1\pi_2)). \tag{2}
\]

To focus the analysis on the government’s allocation decision across LC and FC debt, 
we abstract from intertemporal consumption decisions, taking total real borrowing as given. 
Denoting the real financing need by $V$, the government chooses debt issuance subject to the
The budget constraint is

\[ q_1^{FC} D_1^{FC} + q_1^{LC} D_1^{LC} = V. \]  

(3)

The assumption (3) can be justified if the government either needs to finance an exogenous path of aggregate public consumption purchases (Obstfeld, 1997) or if it needs to borrow a constant amount in order to invest in the country’s decreasing returns to scale productive technology (Grossman and Van Huyck, 1988).

Letting \( P_1 \) denote the expected default probability. With risk-neutral international investors and purchasing power parity, FC and LC bond prices are equal to the discounted expected payoff on the debt:

\[ q_1^{FC} = \beta (1 - P_1), \]

(4)

\[ q_1^{LC} = \beta (1 - P_1) \exp(-E_1 \pi_2). \]

(5)

For expressing the model solution, it is convenient to define

\[ s_1 = D_1^{LC} (1 - P_1^d) \exp(-E_1 \pi_2). \]

(6)

The share of real funds raised as LC debt is closely related to \( s_1 \) and given by \( \frac{s_1}{V} \). In an abuse of notation, we also refer to \( s_1 \) as the “local currency debt share”.

### 3.3 Government Objective Function

The government’s objective function combines a standard monetary policy objective to smooth fluctuations in the output gap and inflation with a desire to minimize debt repayments and default costs. Rather than explicitly deriving the objective function from microfoundations, we build on Woodford (2003, Chapter 6), who formally derives a second-order Taylor expansion to consumer utility in a monetary policy model with Calvo (1983)
price setting. The period $t$ loss function is given by

$$L_t = \alpha_x x_t^2 + \alpha_\pi \pi_t^2 + (1 - P_{t-1}) \left( D_{t-1}^{FG} + D_{t-1}^{LC} \exp(-E_{t-1} \pi_t)(1 - (\pi_t - E_{t-1} \pi_t)) \right)$$

$$+ \text{Cost}_{t-1},$$

where $x_t$ is the log output gap and $\pi_t$ is log inflation.

The first term in the loss function captures losses due to price-setting frictions and monopolistically competitive firms. As in Woodford (2003, Chapter 6), welfare depends quadratically on inflation and the output gap and can be thought of as a second-order approximation to consumer welfare. Since in period 1 the government has no debt outstanding, this is the only term in the period 1 loss function. Intuitively, the output gap enters quadratically into the monetary policy criterion, because firms need labor to produce output and worker-consumers are close to their optimal consumption-leisure trade-off. In the presence of price-setting frictions inflation is costly, because it distorts firms’ prices and hence quantities from the first-best. Woodford (2003) suggests output and inflation weights for plausible price-setting frictions of $\alpha_x / \alpha_\pi = 0.05$.

The real debt repayment term captures expected real payoffs to foreign bondholders with the approximation (2). Ex-post inflation redistributes wealth from foreign bond holders to domestic consumers. Real debt repayments therefore decrease in inflation and more so when the government has more LC debt outstanding.

There is also a large literature on the optimality of inflationary taxation in the domestic setting (Calvo, 1978; Barro and Gordon, 1983; Kydland and Prescott, 1977; Bohn, 1988, 1990; Calvo and Guidotti, 1993). Even in a domestic setting, there may be an incentive to inflate away the debt, if all other forms of taxation are distortionary and inflation allows to tax wealth with little tax distortions. The incentive to create surprise inflation is plausibly even stronger when debt is held by international agents (Bohn, 1991), which is the focus here. The third term in the loss function captures expected losses from default.
The government minimizes the discounted sum of period losses

$$\min_{\pi_1, x_1, D_1^{FC}, D_1^{LC}, \pi_2, x_2} E_1 \sum_{t=1}^{2} \beta^t L_t,$$

subject to $x_t$ and $\pi_t$ satisfying a New-Keynesian Phillips Curve and the budget constraint (3).

### 3.4 Irrelevance Example

We first present a simple set of assumptions, where the government is indifferent between issuing LC and FC debt in the spirit of Modigliani and Miller (1958), as a useful baseline for our analysis. The government’s indifference in this example is a result of the government objective function (7) combined with no default and no real economic cost of inflation.

For this example, we assume that $P_1 = \text{Cost}_1 = \alpha^x = \alpha^\pi = 0$. Assume that expected inflation is a function of $s_1$

$$E_1 \pi_2 = E_1 \pi_2(s_1).$$

(9)

An upward-sloping relation of the form (9) arises within the full model, because the incentive to inflate away debt increases with the LC debt share.

Debt repayments are transfers from domestic agents to foreign bond holders and the risk-neutral government minimizes expected debt repayments. The loss function hence becomes

$$L_t = (D_t^{FC} + D_t^{LC} \exp(-E_1 \pi_2(s_1))).$$

(10)

Substituting $P_1 = 0$ into the pricing relations (4)-(5) and the budget constraint (3) gives

$$L_t \equiv \beta^{-1} V.$$

(11)
The government’s loss function is hence constant and in particular independent of expected inflation and the share of debt issued in local currency.

Intuitively, higher expected period 2 inflation depresses the period 1 price of LC debt, thereby reducing the government’s revenue per face value of LC debt, which makes LC debt less attractive. On the other hand, higher inflation expectations reduce the government’s period 2 real debt service for LC debt, making LC debt more attractive. The two effects cancel exactly, leaving the government indifferent between issuing LC and FC debt.

The goal of this paper is to explain the currency composition of sovereign debt portfolios and we therefore need to introduce frictions that break the government’s indifference between LC and FC debt. Our main model will do this by introducing real costs of inflation and default costs. As discussed in the introduction, making the government averse to pay-outs in recessions due to tax distortions would also generate a determinate sovereign debt portfolio, but would predict the opposite of the empirical finding in Figure 1. We turn to the macroeconomic dynamics and default costs next.

3.5 Macroeconomic Dynamics and Monetary Policy

Output and inflation dynamics build on the standard log-linearized New Keynesian model with optimal monetary policy (Clarida, Galí, and Gertler, 1999)\(^6\)(CGG).\(^6\) The output gap – the difference between actual real output and potential output with no nominal rigidities – is pro-cyclical and serves as the business cycle variable in our model. The dynamics for the log output gap \(x_t\), log inflation \(\pi_t\) and the log nominal interest rate \(i_t\) satisfy the consumer’s Euler equation and a log-linearized forward-looking Phillips curve.

\(^6\)(Gali and Monacelli, 2005) obtain analogous expressions for inflation and output dynamics and welfare in a small open economy model. They find that degree of openness and the substitutability of goods across countries may affect the slope of the Phillips Curve relation, but the basic functional forms also are unchanged.
For $t = 1, 2$ we have that

$$x_t = E_t x_{t+1} - \psi [i_t - E_t \pi_{t+1}], \quad (12)$$

$$\pi_t = \lambda x_t + \beta E_t \pi_{t+1} + u_t. \quad (13)$$

The Euler equation (12) arises from the consumer’s intertemporal trade-off. In New Keynesian models, it is standard to derive the forward-looking Euler equation (12) by assuming power utility and setting consumption equal to the output gap.

Relation (13) is the New Keynesian Phillips curve (PC), capturing firms’ price-setting and production decisions. Current period inflation increases with the output gap and future expected inflation. A forward-looking PC of the form (13) can be derived if firms update their prices infrequently as in Calvo (1983). The shock $u_t$ simultaneously increases inflation and decreases output and captures cost-push shocks, wage-markup shocks, or productivity shocks.

Monetary policy determines the nominal policy rate $i_t$, thereby setting output according to the Euler equation. It can therefore achieve any output-inflation trade-off along the PC (13) by choosing the appropriate nominal interest rate.

Cost-push shocks follow an AR(1) process with autocorrelation $\rho_u$

$$u_t = \rho_u u_{t-1} + \varepsilon_{u,t}, \quad (14)$$

$$\varepsilon_{u,t} \overset{iid}{\sim} N(0, \sigma_u^2). \quad (15)$$

To more clearly exhibit the mechanism at work, we consider a two-period version of the standard New Keynesian macroeconomic model, as in Romer (2006). We set $u_0 = 0$ without loss of generality. We assume that inflation and the output gap are constant at zero from
Besides clarifying the exposition, the assumption (16) is plausible if a partially credible government controls policy over the medium run, but takes long-run inflation as given. A further advantage is that a finite-period model always has a unique solution. This need not be the case for infinite-period New Keynesian models, which may have multiple equilibria (Evans, 1985; Uhlig, 1999; Cochrane, 2011).

### 3.6 Expected Default Costs

Next, we specify default probabilities and costs. Expected default costs are a function of the initial debt issuance decision and increase more sharply in FC than in LC debt. Expected default costs are minimized when the government is entirely financed by LC debt and increases convexly as the government finances itself with a larger share of FC debt, capturing key features of sovereign and corporate default models (Merton, 1974; Aguiar and Gopinath, 2006; Arellano, 2008). While we refer to our reduced form loss from FC debt as a “default cost,” these losses from FC debt could come through a variety of channels, such as the presence of exchange rate shocks that increase the volatility of real debt service for FC debt.

Eichengreen and Hausmann (2005) argue forcefully that issuing FC debt exposes emerging countries to increased default risk, with accompanying default costs. Moreover, the costs of issuing a small amount of FC debt would appear small, so we model expected default costs (up to a constant that does not matter for optimal policy) as an decreasing and convex
function in the LC debt share

\[
\text{Cost}_1 = -\frac{c}{2(\alpha^2 \lambda^2 + \alpha^x)} s_1 + \frac{d}{4(\alpha^2 \lambda^2 + \alpha^x)} s_1^2,
\]

(18)

where both \(c\) and \(d\) are positive and \((\alpha^2 \lambda^2 + \alpha^x)\) is a positive scaling factor.

### 3.6.1 Default Probability and Cost Upon Default

We can decompose (18) into the product of the default probability and the cost upon default, where both quantities are functions of the face values \(D^{FC}\) and \(D^{LC}\). However, only the product (18) enters into welfare considerations and optimal debt issuance, so the specific decomposition is much less crucial for our predictions and should be regarded as an example.

We model the default probability as an increasing function in the weighted sum of the face value of FC debt \(D_1^{FC}\) and the expected real face value of LC debt \(D_1^{LC} \exp(-E_1 \pi_2)\). The weights are given by \(\theta^{FC} > \theta^{LC} \geq 0\), implying that the default probability increases more sharply in FC debt than in LC debt. We assume that the default probability conditional on time 1 information is given by

\[
P_1 = \frac{\theta^{FC} D_1^{FC} + \theta^{LC} \exp(-E_1 \pi_2) D_1^{LC}}{1 + \theta^{FC} D_1^{FC} + \theta^{LC} \exp(-E_1 \pi_2) D_1^{LC}}.
\]

(19)

The functional form (19) satisfies several desirable properties. The default probability increases from zero to one as the face value of debt goes from zero to infinity. Moreover, the default probability increases more sharply in the face value of FC debt.

We model real economic costs upon default as increasing with the total expected real face value of debt, but bounded above by a constant \(a\), consistent with evidence that larger sovereign defaults are costlier (Cruces and Trebesch, 2013). For some \(b > 0\) and \(a \geq \frac{b}{\beta^{-1} \nu}\), real default costs are

\[
a - b \frac{1}{D_1^{FC} + D_1^{LC} \exp(-E_1 \pi_2)}.
\]

(20)
Expected default costs are real default costs (20) multiplied by the default probability (19). We formally assume full default, so investors recover nothing in default. However, optimal debt issuance would be unchanged if we assumed instead that expected default costs (20) are net of investors’ expected default recovery. Intuitively, investors’ expected recovery raises bond prices at issuance, allowing the government to raise more funds for each dollar of face value.

Substituting in the budget constraint (3), we can then write expected default costs in the form (18) (up to a constant) with

\[
\begin{align*}
c &= 2(\alpha^x\lambda^2 + \alpha^x)(\theta^{FC} - \theta^{LC}) \left( a + 2b\theta^{FC} - \frac{b}{\beta^{-1}V} \right), \\
d &= 4(\alpha^x\lambda^2 + \alpha^x)b(\theta^{FC} - \theta^{LC})^2 \frac{\beta^{-1}V}{\beta^{-1}V}.
\end{align*}
\]

The government defaults on all its liabilities simultaneously. In practice, governments frequently default on LC and FC sovereign debt simultaneously (Du and Schreger, 2015a). A theoretical literature, beginning with Broner, Martin, and Ventura (2010); Broner and Ventura (2011), argues that secondary markets effectively prevent governments from defaulting only on one class of bondholders.\(^7\)

### 3.7 Bond and Stock Returns

In keeping with the qualitative nature of the model, we make the simplest possible assumptions to price bonds and stocks. Bonds and stocks are priced by a risk-neutral international investor with a constant discount factor \(\beta\) and the exchange rate obeys purchasing power parity.

\(^7\)While this literature focuses on defaulting on foreigners versus residents, a similar argument may apply to LC and FC debt.
Log excess returns on a one-period LC bond are given by

\[ r_1^{LC} - E_0 r_1^{LC} = - (E_1 - E_0) (q_1^{LC} - \log(1 - P_1)), \]
\[ = - (E_1 - E_0) (\pi_2 - \log(1 - P_1)) \] (23)

Positive LC bond excess returns hence reflect either a decline in period 2 inflation expectations or a decline in the default probability \( P_1 \).

We model stocks as a pro-cyclical asset by assuming that dividends are given by

\[ div_t = x_t. \] (24)

We approximate log equity excess returns using Campbell (1991)'s loglinear decomposition. For a log-linearization constant \( \rho \) close to one, log equity excess returns are

\[ r_1^e - E_0 r_1^e = (E_1 - E_0) \sum_{j=0}^{2} \rho^j \Delta x_{1+j}, \]
\[ = (1 - \rho) (E_1 - E_0) (x_1 + \rho x_2). \] (25)

Equity excess returns hence increase when there is positive news about the current and future output gaps.

The expression (24) follows the asset pricing literature, which models dividends as a levered claim on consumption (Abel, 1990; Campbell, 1986, 2003). Small New Keynesian models often set consumption equal to the output gap (CGG), in which case stocks become a levered claim on consumption. While equity prices and returns in this model are highly stylized, Campbell, Pflueger, and Viceira (2015) consider a New Keynesian asset pricing model, which explicitly accounts for the consumption-output gap relation, and where time-varying risk premia amplify the relation between the cyclicality of inflation expectations and bond-stock betas.
4 Model Solution

We solve the model recursively, first solving for the government’s optimal period 2 policy and then for optimal period 1 policy.

4.1 No-Commitment Regime

Let $\pi_{2}^{nc}$ and $x_{2}^{nc}$ denote period 2 inflation and the output gap in the no-commitment regime. The solution in the no-commitment regime is particularly simple. Without commitment, the government minimizes period 2 welfare (7) subject to the PC constraint (13). The first-order condition is

$$2\alpha^{x}\lambda^{-1}x_{2}^{nc} + 2\alpha^{\pi}\pi_{2}^{nc} - s_{1} = 0, \quad (27)$$

implying that

$$\pi_{2}^{nc} = \frac{\lambda^{2}s_{1} + 2\alpha^{x}u_{2}}{2(\alpha^{\pi}\lambda^{2} + \alpha^{x})}, \quad (28)$$

$$x_{2}^{nc} = -\frac{\lambda\alpha^{\pi}\pi_{2}^{nc}}{\alpha^{x}} + \frac{\lambda}{2\alpha^{x}}s_{1}. \quad (29)$$

The first-order condition (28) shows that no-commitment inflation increases in the LC debt share $s_{1}$. Issuing a higher share of LC debt therefore increases the no-commitment government’s incentive to inflate.

Up to an exogenous component that does not affect policy, the weighted sum of output and inflation deviations then becomes

$$\alpha^{x}(x_{2}^{nc})^{2} + \alpha^{\pi}(\pi_{2}^{nc})^{2} = \frac{\lambda^{2}s_{1}^{2}}{4(\alpha^{\pi}\lambda^{2} + \alpha^{x})}. \quad (30)$$

Welfare losses increase quadratically in the LC debt share $s_{1}$, because a higher LC debt share increases the incentive to inflate away debt.
4.2 Commitment Regime

Next, we solve for the government’s optimal period 1 policy and the commitment plan for period 2 inflation and the output gap, which we denote $\pi_2^c$ and $x_2^c$. Let $\phi_1$ and $\phi_2$ denote the Lagrange multipliers for the period 1 and period 2 Phillips Curves. Substituting in the no-commitment solution and again ignoring constants, the government minimizes the Lagrangian

$$L = \alpha^x x_1^2 + \alpha^\pi \pi_1^2 + \beta p E_1 \left[ \alpha^x (x_2^c)^2 + \alpha^\pi (\pi_2^c)^2 \right]$$

Inflation and Output Distortions with Commitment

$$+ \beta (1-p) \frac{\lambda^2 s_1}{4(\alpha^x \lambda^2 + \alpha^x)}$$

Inflation and Output Distortions without Commitment

$$- \beta \frac{c}{2(\alpha^x \lambda^2 + \alpha^x)} s_1 + \beta \frac{d}{4(\alpha^x \lambda^2 + \alpha^x)} s_1^2$$

Expected Default Cost

$$+ \phi_1 \left[ \pi_1 - \lambda x_1 - \beta p E_1 \pi_2^c - \beta (1-p) \frac{\lambda^2 s_1 + 2 \alpha^x \rho_u u_1}{2(\alpha^x \lambda^2 + \alpha^x)} - u_1 \right]$$

Period 1PC

$$+ \beta p \phi_2 \left[ \pi_2^c - \lambda x_2^c - u_2 \right]$$

Period 2PC

(31)

(32)

(33)

(34)

(35)

Expected period 2 inflation enters into the period 1 PC as a weighted sum of commitment and no-commitment regimes. Rational expectations together with the budget constraint (3) imply that expected debt repayments are constant and hence do not affect optimal policy. The Lagrange multipliers $\phi_1$ and $\phi_2$ reflect the shadow cost of relaxing the PC constraints in periods 1 and 2, or the marginal costs of adverse supply shocks.

The first-order condition with respect to the LC share is

$$s_1 = \frac{c}{\lambda^2 (1-p) + d} + 2 \alpha^x \frac{\lambda (1-p)}{\lambda^2 (1-p) + d} x_1,$$

(36)

The cost of a higher LC share is higher inflation expectations, which enter both into no-commitment inflation and output distortions (32) and into the period 1 PC (34). The
benefit of a higher LC debt share is a reduction in expected default costs, as captured by (33). The optimal LC share equates the marginal costs with the marginal benefits. The intercept in (36) increases in \( p \). Intuitively, the higher credibility, the smaller are the costs of LC debt. With full commitment \( (p = 1) \), the LC debt share \( s_1 \) drops out of (32) and (34) and the government chooses \( s_1 \) to minimize expected default costs.

Figure 5 shows the costs of LC debt for high credibility (red solid) and low credibility (blue dashed). The optimal \( s_1 \) equates the marginal cost with the marginal benefit, which is indicated with black dotted tangency lines. With low credibility, period 2 costs decrease more slowly in the LC debt share, and hence for any given marginal cost the optimal LC debt share is lower.

Next, we need the first-order-conditions for optimal period 1 and period 2 commitment inflation. These are given by

\[
\pi_1 = -\frac{\alpha^x}{\lambda \alpha^\pi} x_1, \quad (37)
\]

\[
\pi^c_2 = -\frac{\alpha^x}{\lambda \alpha^\pi} (x^c_2 - x_1), \quad (38)
\]

The first-order-condition (38) shows that period 2 commitment inflation is positively related to the period 1 output gap, so commitment inflation is low when the output gap is low. Intuitively, the government seeks to anchor inflation expectations in bad states of the world, using low inflation expectations to offset a positive shock \( u_t \) to the PC (13).

When credibility is high, consumers and investors form inflation expectations largely based on \( \pi^c_2 \) and inflation expectations decline when the output gap is low. On the other hand, when commitment is low and consumers and investors put little weight on \( \pi^c_2 \) in forming inflation expectations, an inflationary and recessionary cost-push shock is expected to persist and inflation expectations are high when the output gap is low.
4.3 Model Implications

We summarize the model implications in several propositions. Despite its simplicity, the model has numerous testable implications for inflation and output dynamics, bond risks, the sovereign debt portfolio, and default risk. Proofs and closed-form model solutions are provided the appendix.

Primary Implications

1. The LC bond-stock beta decreases with credibility.

Stock returns are positively related to current and future expected output gaps and LC bond returns move inversely with expected inflation and the probability of default (see (23) and (26)). Since inflation cyclicality increases with credibility, LC bond betas decrease with credibility. Time-varying default risk further strengthens the negative relation between credibility and bond-stock betas.

2. The LC debt share increases with credibility.

One of the key distortions from issuing LC debt is the possibility of inflation when commitment breaks down in period 2. When credibility is high, the government is less concerned about inefficiently high inflation in period 2 and hence issues a larger LC debt share.

Secondary Implications

3. The level of inflation decreases with credibility.

When monetary policy is credible, it is unlikely that the government will inflate away LC debt, lowering inflation expectations. Through the New Keynesian PC, inflation today is positively related to inflation expectations, so current inflation decreases in credibility.

4. The default probability decreases with credibility.
The default probability increases more steeply in FC debt than in LC debt. Since a credible government issues more LC debt and less FC debt, it has lower default risk.

5 The expected inflation-output beta increases with credibility.

When credibility is low, cost-push shocks simultaneously decrease the output gap and increase inflation. The central bank trades off output against current-period inflation through the PC, but it can never reverse the sign of the initial shock. With persistent cost-push shocks, expected inflation also increases and the expected inflation-output beta is negative.

A credible central bank can credibly signal future policy, or engage in forward guidance. Following a positive cost-push shock, the central bank mitigates the increase in inflation and decrease in the output gap by committing to lower future inflation. It follows that optimal forward guidance increases the expected inflation-output gap beta.

6 Default risk varies counter-cyclically.

Despite not making any explicit assumptions about the cyclicality of default risk, we obtain the plausible prediction that expected default rises during recessions, consistent with empirical evidence by Tomz and Wright (2007). During recessions, the commitment value of FC debt is especially valuable. The government therefore issues a larger share of FC debt, thereby incurring higher default risk in exchange for lower inflation expectations. It is important to note, however, that this is a different mechanism than what would drive the cyclical properties of default risk in models of strategic sovereign default. In a framework where the government is choosing whether to repay the debt, defaults are more likely in recessions because the marginal utility of consumption is high and so the government places a high value on additional resources.

7 The LC bond-default risk beta increases with credibility.

This follows from LC bond returns being more countercyclical when credibility is high and default risk being countercyclical.
5 Empirical Analysis

In addition to matching the cyclicality of nominal risk and nominal shares in the sovereign debt portfolios as summarized in Section 2, the model also generates predictions on levels of inflation and default risk. In Figure 6, we plot the correlation between bond-stock betas and bond-CDS betas against CDS spreads and realized inflation. Consistent with the model’s prediction, countries with more pro-cyclical bond returns also tend to have higher levels of inflation and default risk.

In addition, Table 2 reports cross-country correlations between measures of default risk, inflation, inflation expectations, bond-stock betas, inflation-output expectation betas, nominal bond yields, and bond-CDS betas. All measures are highly correlated with each other. In last row of Table 2, we report the correlation between the first PC and each of the seven individual risk measures. Countries with high first PC scores are associated with high default, inflation risk and nominal bond yields, more counter-cyclical inflation and more pro-cyclical LC nominal bond returns. If we interpret a high PC score as the lack of monetary policy credibility, the last row of Table 2 confirms all propositions of the model listed in Section 4.3. All proxies have an absolute bivariate correlation of at least 71% with the first principal component, supporting a unifying explanation of default, inflation and bond risks.

5.1 Evidence from News Counts

So far, we have shown that the share of LC debt issuance lines up with a broad range of macroeconomic, asset pricing, and default risk 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 at the same time, 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, Figure 7 shows that the news count correlation of “debt” and “inflation” is strongly correlated with the bond-stock beta across countries, with a univariate correlation of 71%, supporting the proposed mechanism.

6 Alternative Explanations

Having shown that monetary policy credibility generates predictions along a large number of dimensions, we now discuss how the empirical evidence helps us rule out alternative explanations.

6.1 Differential Exposure to Inflationary Shocks

In the model, bond betas and the cyclicality of inflation expectations are the result of monetary policy credibility. However, commodity prices are important for many emerging markets and some developed markets, making some countries more likely to suffer stagflationary recessions than others. More generally, bond betas and expected inflation-output comovements could reflect the dominance of supply and demand shocks rather than monetary policy.

However, differential exposure to shocks cannot explain the empirical relation between bond-stock betas and the nominal debt shares in Figure 1. In this case the government should choose the sovereign debt portfolio to smooth tax rates over time (Barro, 1979) and across states of the world (Bohn, 1990). Governments should hence issue securities that have low real payouts in periods of low output. In that sense, tax-smoothing works as if the
government was risk-averse, valuing real payoffs more during recessions. If inflation is countercyclical, the real value of local currency debt falls in recessions. If tax smoothing is the main driver of government debt portfolio choice, countries with countercyclical inflation and positive bond-stock betas should hence borrow in local currency. In contrast, we see the exact opposite in Figure 1.

6.2 Endogenous Default

If the government is more likely to default when the real cost of repaying the debt is high, such as when the real debt burden is high and the taxable base is low, this may have implications for the optimal choice between FC and LC debt. However, Appendix C presents a model showing that this trade-off again cannot explain the downward-sloping relation between the nominal debt share and bond-stock betas shown in Figure 1.

Appendix C presents a model, where the country is most likely to default when real debt repayments are high relative to the country’s output. With countercyclical inflation, local currency debt loses value during recessions, hence reducing the country’s debt burden when default risk is highest. With procyclical inflation, the real value of local currency debt is highest in recessions. The issuer experiences low real output and high real debt payments at the same time, which increases default risk and expected deadweight costs. This channel is similar to the one in Kang and Pflueger (2015) for corporate debt.

This channel hence again predicts that countries with exogenously countercyclical inflation and positive bond-stock betas should issue local currency debt, contrasting with the evidence in Figure 1.

6.3 Strategic Inflation

In order to exhibit clearly the key mechanisms, our model does not include a strategic inflation motive. However, if surprise inflation reduces the real debt burden of local currency debt and reduces default risk (Fisher, 1933), countries local currency debt might use inflation...
to avoid costly default (Du and Schreger, 2015b). Extending the main model along this dimension would further strengthen the no-commitment government’s incentive to inflate away local currency debt, and hence the model’s main mechanism. While this additional incentive might matter quantitatively, it is unlikely that this would alter the qualitative model predictions.

7 Conclusion

This paper argues that differences in monetary policy credibility explains the relationship between sovereign debt portfolios and government bond risks across countries. By endogenizing both the business cycle dynamics and the currency choice of sovereign debt, our simple framework gives rise to a number of testable predictions. The key contribution of the paper is to demonstrate how a single change, an increase in monetary credibility, can explain a host of patterns, from the currency denomination of sovereign debt to the cross-country heterogeneity in bond-stock covariances. The empirical support that we find for the testable predictions of model provides strong evidence in favor of the proposed channel.

Our paper is, however, silent on the reason for the increase in central bank credibility. Understanding why some countries have been able to develop institutions that allowed the central bank to become more credible is an obvious direction for future research. Connecting the results in this paper to the earlier theoretical literature on central bank institutional design, such as Persson and Tabellini (1993) and Walsh (1993), may be promising.

The framework’s simplicity also presents opportunities for future research to build on the model along several dimensions. First, investors in the model are risk-neutral, but risk premia are likely to be quantitatively important for bond-stock comovements and the international term structure of interest rates (Campbell, Pflueger, and Viceira, 2015). Second, we model the government’s objective function and type as perfectly known. With uncertainty about the central bank’s inflation target (Orphanides and Williams, 2004) or the central bank’s
References


Aguiar, Mark, Manuel Amador, Emmanuel Farhi, and Gita Gopinath, 2014, Coordination and Crisis in Monetary Unions, Discussion paper, National Bureau of Economic Research.


34


36


Note: This figure shows the share of nominal 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 returns onto local stock market returns over the same time period. Three-letter codes indicate currencies. Emerging markets are shown in red and developed markets in green.
Figure 2: Comovement Among Nominal Risk Betas

(A) Bond-Stock Betas v.s. Bond-CDS Betas

(B) Bond-Stock Betas v.s. Inflation Forecast Betas

Note: Panel (A) plots the nominal bond-stock betas on the y-axis and nominal bond-CDS betas on the x-axis. Panel (B) plots the nominal bond-stock betas on the y-axis and expected inflation-output betas 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. More details on variable definitions can be found in Section 2.1.
Figure 3: Nominal Debt Shares and Nominal Risk

(A) Nominal Debt Share v.s. Bond-CDS Beta

(B) Nominal Debt Share v.s. Inflation Forecast Beta

Note: Panels (A) and (B) plot the share of nominal debt in the sovereign debt portfolio on the y-axis against bond-CDS betas and expected inflation-output betas, 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. More details on variable definitions can be found in Section 2.1.
Figure 4: Model Timeline

- Observe cost-push shock $u_1$
- Choose period 1 monetary policy
- Contingent plan for period 2 monetary policy
- Choose local currency debt share $s_1$

- Observe cost-push shock $u_2$
- Probability $p$: Obey contingent plan
- Probability $1-p$: Myopic monetary policy
- Repay or default
Figure 5: **Debt Issuance Trade-Off**

Note: This figure shows the combined expected period 2 cost, defined as the sum of expected default costs and the cost of ex-post inflation, with high credibility (red solid) and low credibility (blue dashed). The figure indicates optimal LC debt shares. At the optimum, the marginal expected period 2 benefit of increasing the LC debt share, indicated by dotted black tangency lines, must equal the marginal period 1 cost of increasing the LC debt share.
Figure 6: Bond Betas, Default, and Inflation Risk (2005-2014)

Note: Panels A and B plot bond-stock betas and bond-CDS betas against mean CDS spreads, respectively. Panels C and D plot bond-stock betas and bond-CDS betas against mean inflation risks, 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.
Figure 7: Bond-Stock Betas and News Counts

Note: This figure shows bond-stock betas against 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.
Table 1: Summary Statistics for Developed and Emerging Markets (2005-2014)

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<td>Mean</td>
<td>0.91</td>
<td>3.21</td>
<td>3.10</td>
<td>0.28</td>
<td>4.77</td>
<td>0.01</td>
<td>0.05</td>
<td>72.70</td>
</tr>
<tr>
<td>S.d.</td>
<td>0.65</td>
<td>2.05</td>
<td>1.68</td>
<td>0.28</td>
<td>2.92</td>
<td>0.13</td>
<td>0.17</td>
<td>24.78</td>
</tr>
<tr>
<td>Max</td>
<td>2.17</td>
<td>9.07</td>
<td>7.90</td>
<td>1.07</td>
<td>12.33</td>
<td>0.32</td>
<td>0.51</td>
<td>100.00</td>
</tr>
<tr>
<td>Min</td>
<td>0.14</td>
<td>0.26</td>
<td>0.32</td>
<td>-0.24</td>
<td>0.61</td>
<td>-0.18</td>
<td>-0.30</td>
<td>11.97</td>
</tr>
<tr>
<td>(D) Mean Difference between Emerging and Developed Markets ($N = 30$)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean Diff.</td>
<td>0.953***</td>
<td>2.391***</td>
<td>2.004***</td>
<td>-0.214**</td>
<td>3.388***</td>
<td>0.160***</td>
<td>-0.248***</td>
<td>-26.16***</td>
</tr>
<tr>
<td></td>
<td>(0.137)</td>
<td>(0.531)</td>
<td>(0.428)</td>
<td>(0.086)</td>
<td>(0.767)</td>
<td>(0.0303)</td>
<td>(0.0466)</td>
<td>(6.791)</td>
</tr>
</tbody>
</table>

Note: This table reports summary statistics for the cross-sectional mean of eight variables for developed and emerging market groups. The variables include (1) CDS, five-year sovereign credit default swap spreads in percentage points, (2) $\pi$, realized inflation (%), (3) Survey $\pi$, survey inflation (%), (4) $\beta_{\pi, y}$, inflation-output forecast beta, (5) $y$, five-year nominal LC bond yield, (6) $\beta_{b,s}$, bond-stock beta, (7) $\beta_{b,cds}$, bond-CDS beta, and (8) $\alpha^{Nom}$, percentage share of nominal 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 the parentheses. Significance levels are denoted by *** $p<0.01$, ** $p<0.05$, * $p<0.1$. 

Table 2: Cross-Country Correlations Among Default, Inflation and Nominal Bond Risks

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
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<tr>
<td>CDS</td>
<td>1.00</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>π</td>
<td>0.81</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey π</td>
<td>0.82</td>
<td>0.99</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β_{\pi,\text{gdp}}</td>
<td>-0.61</td>
<td>-0.63</td>
<td>-0.61</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>0.85</td>
<td>0.86</td>
<td>0.86</td>
<td>-0.66</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β_{b,s}</td>
<td>0.91</td>
<td>0.72</td>
<td>0.72</td>
<td>-0.61</td>
<td>0.77</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β_{b,\text{cds}}</td>
<td>-0.87</td>
<td>-0.62</td>
<td>-0.62</td>
<td>0.49</td>
<td>-0.68</td>
<td>-0.84</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.60</td>
<td>-0.51</td>
<td>-0.49</td>
<td>0.58</td>
<td>-0.67</td>
<td>-0.56</td>
<td>0.56</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>First PC</td>
<td>0.95</td>
<td>0.90</td>
<td>0.90</td>
<td>-0.74</td>
<td>0.93</td>
<td>0.90</td>
<td>-0.83</td>
<td>-0.71</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: This table reports cross-country correlations for nine empirical measures across 30 countries during 2005-2014. The variables include (1) CDS, five-year sovereign credit default swap spreads in percentage points, (2) π, realized inflation (%), (3) Survey π, survey inflation (%), (4) β_{\pi,y}, inflation-output forecast beta, (5) y, five-year nominal LC bond yield, (6) β_{b,s}, bond-stock beta, (7) β_{b,\text{cds}}, bond-CDS beta, (8) and (9) First PC, the first principal component of the first eight variables.
Appendix

A Monetary Policy Credibility Ranking

The strong common component of the empirical measures in Table 2 supports a unifying explanation of default, inflation and bond risks. We perform a principal component (PC) analysis of the seven empirical measures of default, inflation and nominal bond risks discussed above. While it is difficult to map the level of this measure to a particular level of $p$ in the model, the first principal component of our empirical proxies provides a natural empirical measure to rank countries according to their credibility.

The first PC explains 77% of total variation in all seven of the empirical measures. In the last row of Table 2, we report the correlation between the first PC and each of the seven individual risk measures. Countries with high first PC scores are associated with high default, inflation risk and nominal bond yields, more counter-cyclical inflation and more pro-cyclical LC nominal bond returns.

We create a monetary policy credibility ranking by sorting the first PC score by country. Figure A1 visualizes the relationship between the monetary policy credibility ranking and CDS spreads, inflation, inflation-output forecast betas and bond-stock betas. Switzerland, Norway and Germany are ranked as top three, and Indonesia, Russia and Turkey are ranked as bottom three in terms of monetary policy credibility. All 11 developed markets are ranked before the emerging markets.

A.1 Credibility Ranking and Sovereign Debt Portfolios

We test an important implication of the model that countries with higher monetary policy credibility use more nominal debt. In Figure A1 Panel (A), we plot the credibility ranking against the mean share of nominal debt at the country level. The correlation between the two variables is equal to negative 68 percent. Countries with higher monetary policy commitment (lower credibility rankings) indeed use more nominal debt as a fraction of total sovereign borrowing. In Figure A1 Panel (B), we sort the 30 sample countries into 6 portfolios based on credibility, and plot the mean credibility ranking against the mean nominal debt share for each portfolio. The general pattern that nominal debt shares increase with the credibility ranking also holds at the portfolio level. This provides strong support for model implication 2.

Table A3 shows the regression coefficient and R-squared of running nominal debt shares on the monetary policy credibility index and other empirical moments. In column (1), we regress the nominal debt share on the monetary policy credibility index and obtain a statistically significant negative coefficient -1.9. A one-standard-deviation move in the credibility ranking is associated with a 17 percentage point decrease in the LC debt share. The R-squared of the regression using the credibility index is equal to 46%, higher than using each individual moment alone in columns (2) through (8). In column (9), we control for per capita income and exchange rate regimes of the country. The credibility index remains significant in explaining the nominal debt share. Neither per capita income nor the exchange rate regime enters significantly after including the credibility index.
Figure A1: Monetary Policy Credibility Ranking v.s. Other Empirical Moments

(A) Country-Level Correlation

![Graph showing country-level correlation between monetary policy credibility ranking and share of nominal debt.](image)

Note: In Panel (A), we plot the country-level monetary policy credibility ranking against the share of nominal debt in the sovereign debt portfolio. In Panel (B), we sort 30 sample countries into six portfolios based on monetary policy credibility rankings and plot the mean credibility rankings against the mean nominal debt share in each portfolio.

(B) Portfolio-Level Correlation

![Graph showing portfolio-level correlation between monetary policy credibility ranking and share of nominal debt.](image)
Table A3: Cross-Sectional Regression of Nominal Debt Shares

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>credibility ranking</td>
<td>-2.407*** (0.579)</td>
<td>-1.905*** (0.261)</td>
<td>CDS</td>
<td>-22.79*** (3.719)</td>
<td>π</td>
<td>-6.154*** (1.564)</td>
<td>Survey π</td>
<td>-7.285*** (1.829)</td>
<td>$\beta_{\pi,y}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>π</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>y</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\beta_{b,s}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\beta_{b,cds}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP/Capita</td>
<td></td>
<td></td>
<td>102.2*** (4.136)</td>
<td></td>
<td>93.47*** (5.278)</td>
<td>92.46*** (6.335)</td>
<td>95.26*** (7.050)</td>
<td>74.53*** (4.336)</td>
<td>99.67*** (4.628)</td>
</tr>
<tr>
<td>FX Regime</td>
<td></td>
<td></td>
<td>-0.601 (2.760)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observations | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
R-squared | 0.458 | 0.362 | 0.259 | 0.243 | 0.136 | 0.457 | 0.310 | 0.310 | 0.470 |

Note: This table reports regression coefficients of nominal debt shares on eight variables. The variables include (1) monetary policy credibility index, (2) CDS, five-year sovereign credit default swap spreads in percentage points, (3) π, realized inflation (%), (4) Survey π, survey inflation (%), (5) $\beta_{\pi,y}$, inflation-output forecast beta, (6) y, five-year nominal LC bond yield, (7) $\beta_{b,s}$, bond-stock beta, and (8) $\beta_{b,cds}$, bond-CDS beta, (9) “GDP/capita”: per capita GDP obtained from World Development Indicator. (10) “FX regime”, Reinhart and Rogoff (2004) de facto exchange rate regime classification.
B Model Solution

The cost upon default takes the functional form

$$a - b \frac{1}{D_1^{FC} + D_1^{LC} \exp(-E_t \pi_t)}.$$  \hfill (39)

The expected default cost (39) simplifies to

$$a - b \frac{1}{D_1^{FC} + D_1^{LC} \exp(-E_t \pi_t)},$$  \hfill (40)

$$= a - \frac{b}{\beta^{-1}V}(1 - P_1),$$  \hfill (41)

$$= \frac{b}{\beta^{-1}V}P_1 + \left(a - \frac{b}{\beta^{-1}V}\right).$$  \hfill (42)

It hence follows that the condition $a \geq \frac{b}{\beta^{-1}V}$ is sufficient to ensure that default costs are always positive.

The expected default cost is the product of (39) and the default probability

$$\text{Cost}_1 = \left(\frac{b}{\beta^{-1}V}P_1 + \left(a - \frac{b}{\beta^{-1}V}\right)\right)P_1,$$  \hfill (43)

$$= \left(\frac{b}{\beta^{-1}V}(\beta^{-1}V\theta^{FC} - (\theta^{FC} - \theta^{LC})s_1) + \left(a - \frac{b}{\beta^{-1}V}\right)\right)(\beta^{-1}V\theta^{FC} - (\theta^{FC} - \theta^{LC})s_1).$$

Clearly, $\text{Cost}_1$ decreases in $s_1$ for all $s_1 < \beta^{-1}V$. We can then write (up to a constant that does not matter for optimal policy)

$$\text{Cost}_1 = -\frac{c}{2(\alpha \pi \lambda^2 + \alpha^2)}s_1 + \frac{d}{4(\alpha \pi \lambda^2 + \alpha^2)}s_1^2$$  \hfill (44)

Here, we can express $c$ and $d$ in terms of the fundamental parameters as

$$c = 2(\alpha \pi \lambda^2 + \alpha^2)(\theta^{FC} - \theta^{LC})(a + 2b\theta^{FC} - \frac{b}{\beta^{-1}V}),$$  \hfill (45)

$$d = 4(\alpha \pi \lambda^2 + \alpha^2)\frac{b(\theta^{FC} - \theta^{LC})^2}{\beta^{-1}V}.$$  \hfill (46)

We first solve for no-commitment inflation and output. Without commitment, the government’s objective function is to minimize $L_2$ subject to the PC

$$\pi_2^{nc} = \lambda x_2^{nc} + u_2.$$  \hfill (47)

The first-order condition then is

$$2\alpha \pi \lambda^{-1}x_2^{nc} + 2\alpha \pi \pi_2^{nc} - s_1 = 0.$$  \hfill (48)
It then follows that
\[
\pi_{nc}^2 = \frac{\lambda^2 s_1 + 2\alpha^x u_2}{2(\alpha^x \lambda^2 + \alpha^x)},
\]
(49)
and
\[
x_{nc}^2 = -\frac{\lambda \alpha^\pi \pi_{nc}^2}{\alpha^x} + \frac{\lambda}{2\alpha^x s_1}.
\]
(50)

With (49) and (50), the weighted sum of output and inflation deviations in the no-commitment case is (up to an exogenous component)
\[
\alpha^x (x_{nc}^2)^2 + \alpha^\pi (\pi_{nc}^2)^2 = \frac{\lambda^2 s_1}{4(\alpha^\pi \lambda^2 + \alpha^x)}.
\]
(51)

Substituting (49) into time-1 inflation expectations gives
\[
E_1 \pi_2 = pE_1 \pi_c^2 + (1-p)\frac{\lambda^2 s_1 + 2\alpha^x \rho u_1}{2(\alpha^\pi \lambda^2 + \alpha^x)}.
\]
(52)

Let \(\phi_1\) and \(\phi_2\) denote the Lagrange multipliers for the time-1 and time-2 PC. The government’s problem can be written as the Lagrangian
\[
\alpha^x x_1^2 + \alpha^\pi \pi_1^2 + \beta p E_1 \left[\alpha^x (x_2^c)^2 + \alpha^\pi (\pi_2^c)^2\right] + \beta \frac{(1-p)\lambda^2 + d}{4(\alpha^\pi \lambda^2 + \alpha^x)} s_1^2 - 2cs_1
\]
\[
+ \phi_1 \left[\pi_1 - \lambda x_1 - \beta p E_1 (\pi_2^c - \beta (1-p) \frac{\lambda^2 s_1 + 2\alpha^x \rho u_1}{2(\alpha^\pi \lambda^2 + \alpha^x)} - u_1\right]
\]
\[
+ \beta \phi_2 \left[\pi_2^c - \lambda x_2^c - u_2\right].
\]
(53)

The first-order conditions with respect to \(x_1\) and \(x_2^c\) give the shadow cost of relaxing the PC constraint
\[
\phi_1 = \frac{2\alpha^x}{\lambda} x_1,
\]
(54)
\[
\phi_2 = \frac{2\alpha^x}{\lambda} x_2^c.
\]
(55)

The first-order conditions with respect to \(\pi_1\) and \(\pi_2^c\) give
\[
x_1 = -\frac{\lambda \alpha^\pi}{\alpha^x} \pi_1,
\]
(56)
\[
x_2^c = -\frac{\lambda \alpha^\pi}{\alpha^x} (\pi_2^c + \pi_1)
\]
(57)

Now, the first-order condition with respect to \(s_1\) is
\[
s_1 = \frac{c}{\lambda^2 (1-p) + d} - 2\alpha^\pi \frac{\lambda^2 (1-p)}{\lambda^2 (1-p) + d} \pi_1,
\]
(58)
Substituting (56) into the time-1 PC gives $\pi_1$ as a function of $E_1\pi_2$

$$\pi_1 = \frac{\alpha^x (\beta E_1\pi_2 + u_1)}{\alpha^x \lambda^2 + \alpha^x},$$

$$= \frac{\alpha^x \left[ \beta p E_1\pi_2 + \beta (1 - p) \frac{\lambda^2 s_1 + 2 \alpha^x \rho_u u_1}{2 (\alpha^x \lambda^2 + \alpha^x)} + u_1 \right]}{\alpha^x \lambda^2 + \alpha^x} \quad (59)$$

Similarly, we substitute (57) into the time-2 PC to get

$$E_1\pi_2^c = \frac{-\alpha^x \lambda^2 \pi_1 + \alpha^x \rho_u u_1}{\alpha^x \lambda^2 + \alpha^x}. \quad (60)$$

Now, define $w(p)$ and $v(p)$ as functions of $p$

$$w(p) = \frac{\lambda^2 (1 - p) + dp}{\lambda^2 (1 - p) + d}, \quad (62)$$

$$w'(p) > 0, \quad (63)$$

$$v(p) = \frac{\lambda^2 (1 - p)}{\lambda^2 (1 - p) + d}, \quad (64)$$

$$v'(p) < 0. \quad (65)$$

Then we can substitute (61) into (60) to obtain

$$\pi_1 = \frac{\beta c \alpha^x}{2} \left( \frac{v}{(\alpha^x \lambda^2 + \alpha^x)^2 + \beta \alpha^x \alpha^x \lambda^2 w} \right)$$

$$+ \frac{\alpha^x ((\alpha^x + \alpha^x \lambda^2) + \beta \rho_u \alpha^x)}{(\alpha^x \lambda^2 + \alpha^x)^2 + \beta \alpha^x \alpha^x \lambda^2 w u_1}. \quad (66)$$

Since $v$ decreases in $p$ and $w$ increases, it is clear that the average inflation level decreases with credibility. The sensitivity to the cost-push shock also decreases with credibility.

We can now compute the unconditional average LC debt share as

$$E_0s_1 = \frac{c}{\lambda^2 (1 - p) + d} - \frac{\beta c \alpha^x \alpha^x}{(\alpha^x \lambda^2 + \alpha^x)^2 + \beta \alpha^x \alpha^x \lambda^2 w}. \quad (67)$$

With $v'(p) < 0$ and $w'(p) > 0$, (67) shows that the unconditional average LC debt share increases in credibility.

Expected inflation is given by

$$E_1\pi_2 = \frac{cv}{2 (\alpha^x \lambda^2 + \alpha^x)} - \frac{\alpha^x \lambda^2 w}{\alpha^x \lambda^2 + \alpha^x \pi_1}. \quad (68)$$

The beta of expected inflation with respect to the output gap is hence given by

$$Beta_0(E_1\pi_2, x_1) = \frac{\alpha^x \lambda w}{\alpha^x \lambda^2 + \alpha^x}, \quad (69)$$

52
which increases in $w$ and hence in $p$. Note that the timing here is expected inflation in period 2 and the output gap in period 1.

Next, we look at bond and stock returns. Approximate equity-excess returns are

$$r_1^e - E_0r_1^e = \delta (1 - \rho) (E_1 - E_0) (x_1 + \rho x_2),$$

$$= \delta (1 - \rho) (E_1 - E_0) \left( \frac{-\lambda \alpha^\pi}{\alpha^x} \pi_1 + \rho x_2 \right),$$

$$= \delta (1 - \rho) (E_1 - E_0) \left( \frac{-\lambda \alpha^\pi}{\alpha^x} \pi_1 + \rho [p x_2^c + (1 - p)x_2^{nc}] \right),$$

$$= \delta (1 - \rho) (E_1 - E_0) \left( \frac{-\lambda \alpha^\pi}{\alpha^x} \pi_1 + \rho \left[ \frac{-\lambda \alpha^\pi}{\alpha^x} (\pi_2^c + \pi_1) + (1 - p)x_2^{nc} \right] \right).$$

(70)

Now, we can relate $x_2^{nc}$ to $\pi_2^{nc}$ and $\pi_t$ via

$$E_1 - E_0) x_2^{nc} = (E_1 - E_0) \left[ \frac{-\lambda \alpha^\pi}{\alpha^x} \pi_2^{nc} + \lambda \frac{1}{2\alpha^x} \pi s_1 \right],$$

$$= -\lambda \alpha^\pi \frac{1}{\alpha^x} (E_1 - E_0) \left[ \pi_2^{nc} - \frac{1}{2\alpha^x} \pi s_1 \right],$$

$$= -\lambda \alpha^\pi \frac{1}{\alpha^x} (E_1 - E_0) (\pi_2^{nc} + \pi_1)$$

(73)

(74)

(75)

Substituting back in, it follows that

$$r_1^e - E_0r_1^e = -\lambda \alpha^\pi \frac{1}{\alpha^x} \delta (1 - \rho) (E_1 - E_0) ((1 + \rho w) \pi_1 + \rho E_1 \pi_2),$$

$$= -\lambda \alpha^\pi \frac{1}{\alpha^x} \delta (1 - \rho) (E_1 - E_0) ((1 + \rho w) \pi_1 + \rho \pi_1 E_1 \pi_2),$$

(76)

(77)

Bond returns are given by

$$r_1^{LC} - E_0r_1^{LC} = -(E_1 - E_0) (\pi_2 - \log(1 - P_2^d)),$$

$$\approx -(E_1 - E_0) (\pi_2 - (\theta^{FC} - \theta^{LC}) \pi_1)),$$

$$= \left( \frac{\alpha^\pi \lambda^2}{\alpha^x \lambda^2 + \alpha^x} - 2v(\theta^{FC} - \theta^{LC}) \alpha^\pi \right) (E_1 - E_0) \pi_1$$

(78)

(79)

When inflation is unexpectedly high, the government issues more FC debt, which leads to a drop in bond prices.

The beta of LC bond returns with respect to stock returns is then equal to

$$\text{Beta}(r_1^{LC}, r_1^c) = \frac{-\frac{\alpha^\pi \lambda^2}{\alpha^x \lambda^2 + \alpha^x} + 2v(\theta^{FC} - \theta^{LC}) \alpha^\pi}{\lambda \alpha^\pi \delta (1 - \rho) \left(1 + \rho w \frac{\alpha^\pi}{\alpha^x \lambda^2 + \alpha^x}\right)}$$

(80)

Now,

$$\frac{2v(\theta^{FC} - \theta^{LC}) \alpha^\pi}{\lambda \alpha^\pi \delta (1 - \rho) \left(1 + \rho w \frac{\alpha^\pi}{\alpha^x \lambda^2 + \alpha^x}\right)}$$

(81)
decreases in $p$, because the numerator is positive and decreases in $p$ and the denominator is positive and increases in $p$. Since higher credibility means less time-variation in credit risk, the credit component of LC bond betas decreases with credibility.

In addition
\[
\frac{-w}{\alpha^x \lambda^2 + \alpha^x} \frac{\lambda_\pi \delta (1 - \rho) (1 + \rho w \alpha^x \lambda^2 + \alpha^x)}{2 (\theta FC - \theta LC) \alpha^x v} - 1.
\]

The default risk beta of LC bonds hence decreases in $p$.

We can also compute the beta of long-run average inflation $E_1 (\pi_1 + \pi_2)$ with respect to the expected output gap over the same time period $E_1 (x_1 + x_2)$. This is given by
\[
\text{Beta}_0 (E_1 (\pi_1 + \pi_2), E_1 (x_1 + x_2)) = \frac{\alpha^x \alpha^x \lambda^2 w - (\alpha^x \lambda^2 + \alpha^x)}{\alpha^x w + (\alpha^x \lambda^2 + \alpha^x)},
\]

which increases in $w$ and hence in $p$.

Now, the beta of expected period 2 inflation with respect to expected period 2 output is
\[
\text{Beta}_0 (E_1 \pi_2, E_2 x_2) = \frac{-w}{\alpha^x \lambda^2 + \alpha^x} \frac{-\alpha^x}{\alpha^x w \alpha^x \lambda^2 + \alpha^x}.
\]

Now, the different expressions (69), (84) and (86) show that the timing convention of inflation and output expectations is quite important. The beta of inflation expectations with respect to the current output gap is an important driver of how bond betas change with credibility.

### C An Alternative Model with Exogenous Inflation and Output Dynamics

This appendix section considers an alternative model of government debt portfolio choice. The purpose of this model is to derive the implications for LC and FC debt issuance, when countries face exogenous differences in inflation and output dynamics. For instance, some countries might be more exposed to commodity shocks, which could give rise to stagflationary recessions.

The model in this section implies that for countries with countercyclical inflation, LC
debt service is lowest during recessions. Such countries should therefore prefer LC debt to minimize default costs. However, empirically we see that countercyclical inflation expectations go along with FC borrowing. We therefore conclude that the choice between FC and LC debt is not primarily a function of country exposures to inflation and business cycle shocks.

C.1 Model Setup

The government again borrows a fixed real $V$ in period 1. Let $D^{FC}$ and $D^{LC}$ denote the face values of the two types of debt outstanding and $q^{FC}$ and $q^{LC}$ the corresponding prices per unit of face value. Log real output $x = \log(X)$ and log inflation $\pi = \log(\Pi)$ in period 2 are jointly conditionally lognormal with

$$
\begin{bmatrix}
  x \\
  \pi
\end{bmatrix} \sim N \left( \begin{bmatrix}
  \mu_x \\
  \mu_p
\end{bmatrix}, \begin{bmatrix}
  \sigma_x^2 & \sigma_{xp} \\
  \sigma_{xp} & \sigma_p^2
\end{bmatrix} \right). \tag{87}
$$

Sovereign default is costly and a fraction $(1 - \theta)$ of total real output is lost in default. In case of default, bond holders receive nothing, and all remaining output is consumed within the country.

The government defaults when the real face value of debt exceeds the cost from defaulting, similarly to Merton (1974). The government defaults if and only if

$$(1 - \theta)\exp(x) < D^{FC} + D^{LC}\exp(-\pi). \tag{88}$$

Condition (88) shows that the government chooses to default when output is low or the real face value of debt is high. Since the real face value of LC debt decreases with inflation, the government is less likely to default when inflation is high.

C.2 Bond Prices

Investors are risk neutral and discount future cash flows at a constant discount factor $\beta$, just like the government. FC and LC bond prices are given by

$$q^{FC} = \beta \left( 1 - E \left[ I_{(1-\theta)\exp(x)-D^{LC}\exp(-\pi)-D^{FC}<0} \right] \right), \tag{89}$$

$$q^{LC} = \beta E \left[ \exp(-\pi) \left( 1 - I_{(1-\theta)\exp(x)-D^{LC}\exp(-\pi)-D^{FC}<0} \right) \right]. \tag{90}$$

Here $I$ denotes an indicator function that equals one if the argument is true and zero otherwise.
C.3 Government Objective Function

The government maximizes expected output net of debt repayment costs, discounted at a constant discount factor $\beta$. The government’s problem hence is

$$\max_{D^F, D^L} \beta E \left[ \max \left( \exp(x) - D^F - D^L \exp(-\pi), \theta \exp(x) \right) \right],$$

(91)

subject to the constraint

$$V = q^F D^F + q^L D^L.$$  

(92)

Substituting (89), (90), and (92) into the objective function (91)

$$\exp \left( \mu_x + \frac{1}{2} \sigma_x^2 \right) - \left(1 - \theta\right) E \left[ \exp(x) I(1-\theta)\exp(x) - D^L \exp(-\pi) - D^F < 0 \right] \quad \beta^{-1} V.$$  

(93)

Since the government and investors are risk-neutral, expected bond cash flows equal $\beta^{-1} V$. Total expected output available for consumption is expected output less default costs. Expression (93) shows that the government’s objective is equivalent to minimizing expected default costs.

C.4 Approximate Analytic Solution

Next, we obtain an intuitive approximate solution, based on approximating a linear combination of lognormal distributions as lognormal (Campbell and Viceira, 2002). We find that this approximation works well for reasonable parameter values. Countries in our sample have 5-year CDS spreads of less than 5%. We therefore derive an approximate solution for the empirically relevant case with small default probabilities. For a default probability close to zero, the budget constraint is approximated by

$$V = \beta D^F + \beta \exp \left( -\mu_p + \frac{1}{2} \sigma_p^2 \right) D^L.$$  

(94)

Next, we use Girsanov’s theorem to rewrite the expected default cost as

$$(1 - \theta) E \left[ \exp(x) I(1-\theta)\exp(x) - D^L \exp(-\pi) - D^F < 0 \right]$$

(95)

$$= (1 - \theta) \exp(\mu_x + \frac{1}{2} \sigma_x^2) \times P \left[ (1 - \theta) \exp(\sigma_x^2 + x) - D^L \exp(-\sigma_x - \pi) - D^F < 0 \right].$$  

(96)

But now with (94)

$$E[(1 - \theta) \exp(\sigma_x^2 + x) - D^L \exp(-\sigma_x - \pi) - D^F]$$

(97)

$$= (1 - \theta) \exp \left( \frac{3}{2} \sigma_x^2 + \mu_x \right) - D^L \exp \left( -\mu_p + \frac{1}{2} \sigma_p^2 \right) \left[ \exp(-\sigma_x) - 1 \right] - \beta^{-1} V.$$  

(98)
When $\sigma_{xp} \approx 0$, the expectation (98) is close to independent of $D^{LC}$ and hence the government’s debt portfolio choice.

Letting $\tilde{x} = x - \mu_x$ and $\tilde{\pi} = \pi - \mu_{\pi}$, we use a loglinear approximation to obtain the variance

$$\text{Var} \left[ (1 - \theta)e^{\sigma_x^2 + x} - D^{LC}e^{(-\sigma_{xp} - \pi) - D^{FC}} \right]$$

$$\approx \text{Var} \left[ (1 - \theta)e^{\mu_x + \sigma_x^2}\tilde{x} + D^{LC}e^{(-\mu_p - \sigma_{xp})\tilde{\pi}} \right]$$

$$= (1 - \theta)^2 e^{\mu_x + \sigma_x^2} (1 - \theta)^2 e^{\mu_p + \sigma_{xp}^2} + (D^{LC})^2 e^{(-\mu_p - \sigma_{xp})^2 \sigma_p^2} + 2(1 - \theta)D^{LC}e^{\mu_x + \sigma_x^2} e^{(-\mu_p - \sigma_{xp})\sigma_{xp}}.$$  

If the random variable $(1 - \theta)e^{\sigma_x^2 + x} - D^{LC}e^{(-\sigma_{xp} - \pi) - D^{FC}}$ is close to normal, the probability of a negative realization depends only on its mean and variance. Its mean is approximately independent of $D^{LC}$, so the government’s portfolio choice problem reduces to minimizing the variance of the difference between default costs and debt payouts (102). Together with the assumption that local currency debt issuance cannot be negative, this gives the solution

$$D^{LC} \approx \max \left( -\frac{\sigma_{xp}}{\sigma_p^2} (1 - \theta)e^{\mu_x + \sigma_x^2 + \mu_p + \sigma_{xp}}, 0 \right).$$

The approximate solution (103) clearly decreases in the output-inflation covariance. The intuition is that when the output-inflation covariance is positive borrowing in local currency increases debt repayments exactly when output is low. Since the government is faced with high real debt repayments and low output and tax revenues at the same time, it is likely to default. Seeking to minimize expected default costs ex-ante a government with a positive inflation-output covariance therefore borrows in foreign currency in this model.

### C.5 Numerical Evaluation of Analytic Solution

We obtained the approximate solution (103) as a loglinear approximation. We now compare it to an exact simulated solution for a particular set of parameter values. We use $\theta = 0.8$, $\sigma_x = 0.05$, $\sigma_p = 0.1$, $\mu_x = 0.05$, $\mu_p = 0.10$, $\beta = 0.98$, and $V = 0.18$. We plot the optimal debt portfolio against the output-inflation correlation, which we vary from $-1$ to $1$. The simulated solution uses 100,000 draws for $x$ and $\pi$ and minimizes the objective function over 10,000 randomly chosen values for $D^{FC}$ and $D^{LC}$.

Figure C2 plots the solutions for $D^{FC}$ and $D^{LC}$ against the output-inflation correlation $\rho_{xp} = \frac{\sigma_{xp}}{\sigma_x \sigma_p}$. Up to simulation noise, the simulated and normal solutions are indistinguishable. We can see that the face value of local currency debt decreases and the face value of foreign currency debt increases with $\rho_{xp}$.
This figure plots the analytic approximate solution (103) for the face value of local currency debt, $D_{LC,n}$, and the face value of foreign currency debt, $D_{FC,n}$ against the output-inflation correlation. The corresponding simulated solutions are denoted by $D_{LC,sim}^{LC}$ and $D_{FC,sim}^{FC}$. All parameter values are as listed in section C.5.