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 smooth the costs of taxation across states of the world. If deadweight costs are higher during recessions, either due to risk aversion or distortionary taxes (Barro, 1979), it is optimal to issue bonds that require low repayments in recessions and higher repayments in expansions (Bohn, 1990; Barro, 1997). For a country, where the beta of nominal government bonds with respect to the local stock market is positive, the real value of nominal debt falls exactly in the worst states of the world. Issuing nominal debt should therefore be highly attractive. In contrast with this prediction, 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

While the empirical finding in Figure 1 appears puzzling from a hedging perspective, we show that it is consistent with a model where monetary policy credibility drives both bond return cyclicality and sovereign debt portfolios. In that sense, documenting the downward-sloping relation between nominal debt shares and bond return cyclicality provides a sharp distinction between two key potential drivers of nominal debt issuance: first, the incentive to

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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.
smooth debt repayments across states of the world, and, second, the credibility of monetary policy. In our model, negative bond betas reflect the monetary policy authority’s credibility in signaling inflation, as in Campbell, Pflueger, and Viceira (2015), and governments with credible monetary policy choose to issue debt denominated in their own currency.

We begin by documenting significant cross-country heterogeneity in inflation cyclicality and 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. Since nominal bonds depreciate when inflation expectations increase, and stock returns are pro-cyclical, positive bond-stock betas should coincide with countercyclical inflation or stagflationary recessions. We find a strongly negative relation between bond-stock betas and inflation cyclicality, consistent with inflation expectations being a key driver of the hedging properties of nominal bonds. We can measure inflation cyclicality either as the beta of inflation expectations with respect to output expectations or as the beta of realized inflation with respect to industrial production.

Our second set of stylized facts documents the relationship 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. These relations are robust to controlling for GDP-per-capita and the foreign exchange rate regime.

We explain these stylized facts in a model that integrates the government’s portfolio choice between nominal local currency debt and real foreign currency debt with a New Keynesian model of inflation dynamics. 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. Our modeling of credibility builds on the idea of loose commitment as in Debortoli and Nunes (2010).

The government’s trade-off between LC and FC debt can be very different depending on the monetary policy authority’s inflation credibility. Next-period’s 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 authority issues a higher share of FC debt, because FC debt reduces the incentive to inflate next period. The commitment benefits of FC debt are counteracted by benefits of LC debt, which we model as an increasing quadratic function of the LC debt share. Flexibility of LC debt during crises provides a set of micro-foundations for the benefits of LC debt. Alternatively, the benefits of LC debt may be interpreted more broadly as encompassing reduced expected default costs, and reduced short-term volatility of debt service costs.

On the monetary policy side, we build on a standard New Keynesian model with imperfectly competitive firms and staggered (Calvo, 1983) price-setting. The model gives rise to a log-linearized New Keynesian Phillips Curve, thereby linking monetary policy with inflation and output dynamics. We keep the model tractable by assuming that bonds are priced by a continuum of risk-neutral international investors, purchasing power parity, and that inflation and output return to steady-state after two periods. The second-order expansion to consumer welfare combines the standard New Keynesian objective of smoothing inflation and the output gap with the costs of transferring resources to bond investors. The marginal cost of debt service increases in states with adverse technology shocks, providing an additional incentive to reduce debt service through surprise inflation.

We solve the model analytically in a special case, where consumers are risk-neutral, real debt repayments can be well approximated by a linear function in log inflation, a zero target output gap, and no technology shocks. We prove that an increase in monetary policy credibility decreases average inflation, increases the beta of inflation expectations with respect to
output expectations, and increases the share of nominal local currency debt. A high credibility government mitigates recessionary and inflationary cost-push shocks by strengthening its commitment to low future inflation, thereby lowering inflation expectations during a recession. In contrast, a low credibility government can only partially offset cost-push shocks, leading to counter-cyclical inflation expectations and positive bond-stock betas. We solve the full model numerically in a calibration based on Galí (2008) and Smets and Wouters (2007) and show that these predictions continue to hold using the more general welfare function.

Finally, we present additional empirical support linking nominal risk with the credibility of monetary policy. First, we show that the nominal debt share, inflation, inflation expectations, bond-stock betas, expected inflation-output betas, and bond-CDS betas are strongly correlated across countries with model consistent-signs. The absolute bivariate correlation of each measure with the first principal component is at least 52%. Second, we construct a new measure of de-facto 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-stock betas across countries, consistent with model predictions. Third, we construct an inflation credibility gap as the average difference between official inflation targets and survey inflation expectations. Low inflation credibility should be reflected in a high inflation target gap. We show that the inflation credibility gap is 57% correlated with nominal bond-stock betas across countries, rendering further support that the bond-stock beta contains valuable information about inflation credibility.

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; Daví, 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. In simultaneous work, Ottonello and Perez (2016) and Engel and Park (2016) also explain the currency composition of sovereign debt by emphasizing the time-consistency problem in monetary policy. Compared to these two papers, we make empirical contributions by documenting a new stylized fact on the cross-country relationship between the cyclicality of nominal risks and the sovereign bond portfolio and linking it to new de-facto measures of monetary policy credibility. On the theoretical side, the New-Keynesian structure of our model microfounds the connection between inflation and output dynamics, allowing us to endogenously generate varying degrees of nominal risk 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 relation between the cyclicality of nominal bond risk and shares of nominal debt in sovereign portfolios. In Section 3, we present a stylized model, where debt portfolio choice is driven by the desire to smooth debt repayments across states of the world. Section 4 presents a New Keynesian model with government debt portfolio choice and imperfect monetary policy credibility, and solves a simple case of the model analytically. Section 5 solves the full model numerically. Section 6 tests additional implications of the model explanations based on a principal component analysis and presents our monetary policy credibility measure based on newspaper counts and the inflation credibility gap. Section 7 concludes.

2 Empirical Evidence

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

2.1 Data and Variable Construction

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

For LC bond yields, we use primarily Bloomberg fair value (BFV) curves. BFV curves are estimated using individual LC sovereign bond prices traded in secondary markets. Since
sufficient numbers of bonds spanning different maturities are needed for yield curve estimation, the availability of the BFV curve is a good indicator for the overall development of the LC nominal bond market. Countries such as Argentina, Uruguay and Venezuela only have a handful of fixed-rate bonds and hence do not have a BFV curve. As for most emerging markets in our sample BFV curves are available starting in the mid-2000s, we focus on the period 2005-2014 to maintain a balanced panel.

To measure 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.\(^3\)

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.

### 2.1.1 Nominal Bond Risks: Bond-Stock and Bond-CDS Betas

Asset markets incorporate investors’ forward-looking information at much higher frequency than surveys and can therefore provide additional proxies for inflation cyclicality, that are potentially less subject to measurement error. Nominal bond-stock betas and bond-CDS serve as asset-market based proxies of inflation expectations cyclicality. We expect bond-stock betas to be inversely related to the cyclicality of inflation expectations and bond-CDS betas to be positively related to the cyclicality of inflation expectations.

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

\(^3\)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.
The log holding period return on the bond is given by

\[ r_{n,t+\Delta t}^b \approx D_n y_{nt} - (D_n - \Delta t) y_{n-1,t+\Delta t}, \]

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

\[ r_x^{b,n,t+\Delta t} = r_{n,t+\Delta t}^b - y_{t1}. \]

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

\[ r_x^{b,n,t+\Delta t} = \left[ r_{n,t+\Delta t}^b - (y_{t1} - y_{t1}^*) \right] - y_{t1}. \]

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:

\[ r_x^{m,n,t+\Delta t} = (p_{t+\Delta t}^m - p_{t}^m) - y_{t1}, \]

where \( p_t^m \) denotes the log benchmark equity return index at time \( t \). Country subscripts are suppressed to keep the notation concise. We then compute the local bond-stock beta \( \beta_{b,s} \) by
regressing LC bond excess returns $r x_{t+\Delta t}^b$ on local equity excess returns $r x_{t+\Delta t}^s$:

$$r x_{t+\Delta t}^b = \alpha + \beta_{b,s} r x_{t+\Delta t}^s + \epsilon_t.$$ 

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:

$$r x_{t+\Delta t}^b = \alpha + \beta_{b,cds} \Delta cds_{t+\Delta t} + \epsilon_t.$$ 

2.1.2 Cyclicality of Inflation Expectations: Forecast Beta

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

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

where $t$ indicates the date of the forecast revision. 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 $\beta_{\tilde{\pi},\tilde{gdp}}$ measures the cyclicity 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 Cyclicality of Realized Inflation: Realized Inflation-Output Beta

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

\[ \Delta \pi_t = \beta_0 + \beta^{\pi,IP} \Delta ip_t + \epsilon_t, \]  

(2)

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

2.1.4 Nominal Debt Shares

For developed countries, we construct the share of nominal debt based on the OECD Central Government Debt Statistics and supplement this data with hand-collected statistics from individual central banks.\(^4\) Central banks typically directly report the instrument composition of debt securities outstanding issued by the central government.

\(^4\)The OECD Central Bank Debt Statistics was discontinued in 2010. We collected the statistics between 2010-2014 from individual central banks.
using the BIS Debt Securities Statistics, supplemented with statistics from individual central banks. Table 16C of the Debt Securities Statistics reports the instrument composition for outstanding domestic bonds and notes issued by the central government ($D_{t}^{Dom}$) starting in 1995. Table 12E of the Debt Securities Statistics reports total international debt securities outstanding issued by the general government ($D_{t}^{Int}$). For emerging markets, as the vast majority of international sovereign debt is denominated in foreign currency, and local governments rarely tap international debt markets, $D_{t}^{Int}$ offers a very good proxy for central government foreign currency debt outstanding. Data for developed countries are from individual central banks or the OECD. The share of nominal debt is computed as the ratio of the fixed-coupon domestic sovereign debt outstanding ($D_{t}^{Int}$) over the sum of domestic and international government debt:

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

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, nominal bond yields, bond-stocks betas, bond-CDS betas, inflation-output forecast betas, realized inflation-output betas, CDS spreads, and nominal debt shares by developed and emerging market groups. Emerging market realized inflation is 2.4 percentage points higher and survey-based expected inflation is 2.0 percentage points higher. In addition, expected inflation and realized inflation are less pro-cyclical in emerging markets than in developed countries.

For 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 developed markets, as evident from negative bond-stock betas and positive bond-CDS betas. By contrast, nominal bond returns are pro-cyclical in emerging markets. Compared with
developed markets, emerging market CDS spreads are 91 basis points higher on average, indicating greater fiscal distress. Finally, the share of nominal debt in total debt portfolios is 26 percentage points higher in developed than in emerging markets.

2.3 Comovement among Nominal Risk Measures

Figure 2 shows the strong co-movement between bond-stock betas and bond-CDS betas in Panel (A), between bond-stock betas and inflation forecast betas in Panel (B), and between bond-stock betas and realized inflation-output betas in Panel (C). 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. Panel (A) shows 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.

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.

The correlation between the bond-stock beta and realized inflation cyclicality is confirmed in Panel (C). Countries with lower bond-stock betas tend to have higher realized inflation cyclicality with respect to output. Both realized and expected inflation are more countercyclical in emerging markets than in developed markets.
2.4 Relation between Nominal Risk Betas and Sovereign Debt Portfolios

Figure 3 adds to the evidence in Figure 1 on the relation between bond return cyclicality and the share of nominal debt in sovereign debt portfolios. In particular, we find that countries with higher bond-stock betas, lower bond-CDS betas, lower inflation forecast betas and lower inflation-output betas tend to have lower shares of nominal sovereign 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.

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

The cross-sectional relationship between nominal risk betas and nominal debt shares is robust to measuring the nominal debt share only in long-term debt. This is important, because Missale and Blanchard (1994) argue that a shorter debt maturity can reduce the incentive to inflate away debt. We obtain all historical individual sovereign bond issuance data from Bloomberg for 14 emerging markets.\footnote{These sample countries are the same as the ones used in Du and Schreger (2015b).} We focus on bonds with remaining maturity equal or greater than 5 years and estimate outstanding amounts of long-term LC and FC bonds. Figure 4 shows that countries with higher nominal bond-stock betas tend to have lower shares of long-term debt denominated in their local currencies.

\footnote{These sample countries are the same as the ones used in Du and Schreger (2015b).}
3 A Simple Consumption Smoothing Model

This section presents a simple baseline model to establish the main empirical puzzle: A standard consumption smoothing approach suggests that a country with counter-cyclical inflation should issue LC debt, which is exactly the opposite of the empirical relation documented in section 2.4.

In this simple model, the trade-off between nominal and real debt is driven by the government’s desire to smooth consumption across states of the world. Curvature in the utility function makes debt repayments costlier when output is already low. Alternatively, we could have assumed that tax distortions increase in low output states to obtain similar implications (Barro, 1979; Bohn, 1990).

The model has two periods. The government’s debt portfolio choice decision takes place in period 1 and debt is repaid in period 2. Log output and inflation in period 2 are distributed

$$\begin{pmatrix} y_2 \\ \pi_2 \end{pmatrix} \sim N \left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_y^2 & \sigma_{y,\pi} \\ \sigma_{y,\pi} & \sigma_{\pi}^2 \end{pmatrix} \right).$$

(3)

The inflation-output covariance in (3) could arise from a combination of supply, demand, and commodity shocks, or from a monetary policy rule that is exogenous to fiscal policy.

3.1 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.

Assuming that the government never defaults outright, international investors are risk-
neutral with discount rate $\beta$, and purchasing power parity, bond prices are:

$$q_1^{FC} = \beta,$$  \hspace{1cm} (4)  

$$q_1^{LC} = \beta E_1 \exp(-\pi_2).$$  \hspace{1cm} (5)

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 budget constraint

$$q_1^{FC} D_1^{FC} + q_1^{LC} D_1^{LC} = V.$$  \hspace{1cm} (6)

Assumption (6) 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). We define

$$s_1 = D_1^{LC} E_1 \exp(-\pi_2).$$  \hspace{1cm} (7)

The variable $s_1$ summarizes the government’s debt issuance decision and equals the expected payout on LC debt. In an abuse of notation, we refer to it as the “local currency debt share”.

### 3.2 Government Objective Function

Assuming no inflation costs for now, the government seeks to maximize the local representative consumer’s welfare. We assume that the representative consumer’s welfare can be
represented by a quadratic utility function of the form

\[ U_2 = C_2 - \frac{\gamma}{2} C_2^2, \]  

(8)

\[ C_2 = \exp(y_2) - (D_1^{FC} + D_1^{LC} \exp(-\pi_2)). \]  

(9)

The quadratic utility function (8) could arise as a second-order expansion of a more general utility function.

### 3.3 Irrelevance in Risk-Neutral Case

If the representative consumer is risk-neutral, we have the special case \( \gamma = 0 \). Substituting bond prices (4) and (5) into the budget constraint (6), expected utility becomes

\[ E_1 U_2 = E_1 \exp(y_2) - \beta^{-1} V. \]  

(10)

With risk neutrality, expected utility (10) is independent of the LC debt share. Higher expected inflation depresses the price of LC debt, making the issuance of LC debt less attractive. However, higher inflation expectations also reduce the real resources needed to repay a given face value of nominal debt, making LC debt more attractive. The two effects cancel exactly, leaving the government indifferent between issuing LC and FC debt.

The government’s indifference in this example is a result of a specific loss function that is linear in real debt service and does not depend on inflation. Next, we break this irrelevance by making the aggregate consumer risk-averse.
3.4 Optimal Debt Portfolio Choice with Utility Curvature

For simplicity, we now log-linearize period 2 output and inflation

\[ \exp(y_2) \approx 1 + y_2, \quad (11) \]
\[ \exp(-\pi_2) \approx 1 - \pi_2. \quad (12) \]

The government maximizes

\[ E_1 U_2 = E_1 (1 + y_2) - \beta V - \frac{\gamma}{2} E_1 (1 + y_2 - (\beta V - D_1^{LC} \pi_2)^2), \quad (13) \]

giving the first-order-condition

\[ D_1^{LC} = -\frac{\sigma_{y,\pi}}{\sigma_\pi^2}. \quad (14) \]

With utility curvature, the marginal cost of transferring resources to foreign bond holders is highest in recessions, so the government optimally shifts debt repayments towards good states of the world. A negative inflation-output beta implies that LC debt depreciates in high marginal utility states, thereby making nominal debt an attractive way of borrowing. Prediction (14) implies that countries with a positive inflation-output betas, such as Turkey or Brazil, should primarily borrow in local currency. This prediction is clearly in contrast with the empirical evidence in section 2.

4 New-Keynesian Model with Imperfect Credibility

This section presents a model resolving the puzzling relation between nominal risk betas and sovereign debt portfolios. We add two new features to a standard New Keynesian 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 varies
the probability that the government implements its promised future policy or implements discretionary policy.

In addition to setting short-term nominal interest rate policy, the government also decides in which currency to borrow. 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 inflation.

4.1 Setup and Timing

The government’s debt issuance decision is identical to section 3.1. Debt is held by foreign investors, who do not enter into the government’s welfare function, and the government services debt using lump-sum taxes. Foreign investors consume the same consumption bundle as domestic consumers and experience no inflation, so real debt and foreign currency debt are identical.

The model has two time periods, as illustrated in Figure 5. 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, as a function of period 2 cost-push and technology shocks.

We follow the literature on loose commitment (Calvo and Guidotti, 1993; Debortoli and Nunes, 2010) in assuming that the monetary policy authority will be able to implement this plan only with probability $p$, and will be replaced by a myopic policy maker with probability $1 - p$. 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 overcoming the incentive problems often faced by central banks, as in Persson and Tabellini (1993). Finally, at the end of the period the benefits of LC debt are realized,
reflecting the expected benefits of flexibility in a very low probability crisis.

4.2 Macroeconomic Dynamics and Welfare


4.2.1 Production

Let $Y_t$ denote aggregate output, $C_t$ consumption, and $D_t$ debt repayments to foreigners. Aggregate output is a Dixit-Stiglitz aggregate of differentiated goods $y_t(i)$

$$
Y_t \equiv \left[ \int_0^1 y_t(i)^{(\theta_t-1)/\theta_t} \frac{1}{\theta_t} \right]^{\theta_t/(\theta_t-1)}.
$$

(15)

Firms face downward-sloping demand of the form

$$
y_t(i) = Y_t \left( \frac{p_t(i)}{P_t} \right)^{-\theta_t}.
$$

(16)

Here, sector $i$ uses labor $h_t(i)$ to produce according to the Cobb-Douglas production function

$$
y_t(i) = A_t f(h_t(i)),
$$

(17)

$$
f(h) = h^{1-\kappa}.
$$

(18)

where $A_t$ is the level of technology, and $\kappa$ is the capital share in the economy.

4.2.2 Utility

The representative agent derives utility from consumption

$$
u(C) = \frac{C^{1-\gamma}}{1-\gamma}.
$$

(19)
and disutility from labor

\[ v(h) = \frac{h^{1+\phi}}{1+\phi}, \quad (20) \]

where \( \gamma \) is risk aversion and \( \phi \) is the Frisch elasticity of labor supply. The natural welfare criterion in the model is the representative agent’s expected utility

\[ E \left\{ \sum_{t=0}^{\infty} \beta U_t \right\}, \quad (21) \]

\[ U_t = u(C_t) - \int_0^1 v(h_t(i)) \, di. \quad (22) \]

Letting \( D_t \) denote real debt repayments, aggregate consumption satisfies the resource constraint

\[ C_t = Y_t - D_t. \quad (23) \]

### 4.2.3 Steady State and Output Gap

The real marginal cost of production is given by

\[ s(y, Y, D; A) = \frac{1 + \omega}{1 + \phi} A^{-(1+\omega)} y^\omega (Y - D)^\gamma, \quad (24) \]

where

\[ \omega = \frac{1 + \phi}{1 - \kappa} - 1 \quad (25) \]

is the elasticity of disutility of labor with respect to output.

In equilibrium, each firm wishes to charge a markup \( \mu_t \) over real marginal costs

\[ \mu_t \equiv \frac{\theta_t}{\theta_t - 1}. \quad (26) \]
In the case of fully flexible prices, each firm produces the natural rate of output $Y^n_t$ given by

$$s(Y^n_t, Y^n_t, D_t; A_t) = \mu_t^{-1}. \quad (27)$$

We will log-linearize around the steady-state level of output $\bar{Y}_t$, which is the level of output that would obtain with flexible prices, steady-state markups and no debt service

$$s(\bar{Y}_t, \bar{Y}_t, 0; A_t) = \bar{\mu}^{-1}. \quad (28)$$

In deriving a second-order Taylor expansion for welfare, we will need $Y^*_t$ and $Y^e_t$, defined as

$$s(Y^*_t, Y^*_t, 0; A_t) = 1, \quad (29)$$

$$s(Y^e_t, Y^e_t, D_t; A_t) = 1. \quad (30)$$

$Y^*_t$ denotes the efficient level of output with no debt service, while $Y^e_t$ is the efficient level of output with debt service. We can solve for the steady-state rate of output $\bar{Y}_t$ and for $Y^*_t$ as

$$\bar{Y}_t = \left( \frac{1 + \phi}{1 + \omega} \frac{\mu^{-1}}{A_t^{\omega+1}} \right)^{\frac{1}{1+\gamma}} A_t^{\omega+1}, \quad (31)$$

$$Y^*_t = \left( \frac{1 + \phi}{1 + \omega} \right)^{\frac{1}{1+\gamma}} A_t^{\frac{\omega+1}{1+\gamma}}. \quad (32)$$

Note that steady-state output depends only on the technology shock, but not on debt service or markup shocks. The reason for defining $\bar{Y}_t$ as a function of $A_t$ is that we can log-linearize around steady-state markups, without log-linearizing $A_t$. With log utility ($\gamma = 1$), steady-state output rises one-for-one with the technology factor.

The welfare relevant output gap is defined as the gap between log output and log efficient
output relative to its steady-state

\[ x_t = \log(Y_t) - \log(Y_t^e) + x^*, \]  
(33)

where the target output gap is equal to

\[ x^* = \log(Y_t^* / \bar{Y}_t). \]  
(34)

### 4.2.4 Log Deviations

Next, we log-linearize macroeconomic dynamics and derive a second-order Taylor expansion for welfare around \( \dot{Y}_t = 0, d_t = 0, \) and \( \dot{\mu}_t = \bar{\mu}, \) where

\[ \dot{Y}_t \equiv \log\left(\frac{Y_t}{\bar{Y}_t}\right), \]  
(35)

\[ d_t = \frac{D_t}{\bar{Y}_t} \]  
(36)

\[ \dot{\mu}_t = \log(\mu_t / \bar{\mu}). \]  
(37)

Similarly to Woodford (2003), we consider the case where \( \log \bar{\mu} \) approaches zero.

### 4.2.5 Price-Setting

We assume staggered price-setting in the manner of Calvo (1983), where a fraction \( \alpha \) of prices remain unchanged each period, with each firm equally likely to adjust prices. This assumption gives the standard log-linearized aggregate supply relation

\[ \pi_t = \lambda x_t + \beta E_t \pi_{t+1} + u_t, \]  
(38)

where the slope coefficient is given by

\[ \lambda \equiv \frac{(1 - \alpha)(1 - \alpha \beta)}{\alpha} \gamma + \omega \frac{1 + \omega \theta}{1 + \omega \theta} > 0, \]  
(39)
and the cost-push shock is given by

\[ u_t = \frac{\lambda}{\omega + \sigma^{-1}} \hat{\mu}_t. \] (40)

### 4.2.6 Euler Equation

Letting \( r_t \) be the real short-term interest rate, the log-linearized Euler equation becomes

\[
r_t = \gamma \left[ E_t \left( \hat{Y}_{t+1} - d_{t+1} \right) - \left( \hat{Y}_t - d_t \right) \right] + \gamma E_t \left( \log \bar{Y}_{t+1} - \log \bar{Y}_t \right),
\]

\[ = \gamma \left[ E_t \left( \hat{Y}_{t+1} - d_{t+1} \right) - \left( \hat{Y}_t - d_t \right) \right] + \frac{\omega + 1}{\omega + \gamma} E_t (a_{t+1} - a_t). \] (42)

Importantly, the government can achieve any output gap and inflation along the Phillips Curve (38) by choosing \( r_t \) to equate (42). Optimal monetary policy can hence be represented as a contingent plan for log inflation and the output gap, that does not depend on the specific terms in the Euler equation.

### 4.2.7 Shocks

We assume a particularly simple structure for shocks, consistent with the two-period nature of the government’s borrowing problem. Both periods 1 and 2 are subject to cost-push shocks distributed according to

\[
\begin{pmatrix}
    u_1 \\
    u_2
\end{pmatrix}
\sim
N
\begin{pmatrix}
    \begin{pmatrix}
        0 \\
        0
    \end{pmatrix}, \sigma_u^2 \begin{pmatrix}
        1 & \rho \\
        \rho & 1
    \end{pmatrix}
\end{pmatrix}
\]

(43)

We assume that the technology factor in period 1 is known in advance and that technology growth from period 1 to period 2 is distributed as

\[
a_2 - a_1 \sim N \left( \mu_a, \sigma_a^2 \right).
\] (44)
To more clearly exhibit the mechanism at work, we assume that from period 3 onwards, inflation and the output gap are at their steady-states and there are no debt repayments

\[
\pi_t = 0 \quad \forall \quad t \geq 3, \quad (45)
\]
\[
x_t = x^* \quad \forall \quad t \geq 3. \quad (46)
\]

The conditions (45) and (46) could arise from a sequence of cost-push shocks that return the output gap and inflation to their steady-state from period 3 onwards. Besides clarifying the exposition, the assumption (45) is plausible if a partially credible government controls policy over the medium run, but takes long-run inflation as given.

With assumptions (45) and (46), we can solve recursively to find the unique equilibrium macroeconomic dynamics and optimal debt portfolios. While a unique solution exists for our given set of assumptions, we do not resolve the well-known issues of equilibrium multiplicity and sunspots of infinite-period New Keynesian models (Evans, 1985; Uhlig, 1999; Cochrane, 2011).

### 4.3 Consumer Welfare

**Proposition 1** Define the loss function as the negative of consumer utility \( L_t = -U_t \). Then

\[
L_t = \bar{\lambda}_{t}^{1-\gamma} (\alpha^x (x_t - x^*)^2 + \alpha^\pi \pi_t^2 + d_t + \alpha^d d_t^2) + \mathcal{O} \left( \| \hat{y}_t, \pi_t, \log \bar{\mu}, \hat{\mu}_t, d_t \|^3 \right), \quad (47)
\]

where

\[
\alpha^x = \frac{\omega + \gamma}{2} \frac{1}{1 - x^* \gamma}, \quad (48)
\]
\[
\alpha^d = \frac{\gamma}{2} \left( \frac{\omega}{\omega + \gamma} \right) \frac{1}{1 - x^* \gamma}, \quad (49)
\]
\[
\alpha^\pi = \frac{\theta}{\lambda} \alpha^x. \quad (50)
\]
Three comments are in order. First, the loss function nests the welfare function derived
in Woodford (2003) and commonly used in the literature on optimal monetary policy,
\( \alpha^x (x_t - x^*)^2 + \alpha^\pi \pi_t^2 \), where the log output gap relative to target and log inflation both
enter quadratically. Here, these squared terms appear pre-multiplied by \( \bar{Y}_t^{1-\gamma} \), reflecting the
marginal utility of consumption at steady-state output.

Second, the loss function (50) simplifies in the case when \( \gamma = 0 \) and consumers are risk-
neutral. In that case \( \alpha^d = 0 \) and loss increases linearly in debt service. Assuming that
\( x^* \gamma < 1 \) and \( \gamma > 0 \), we have \( \alpha^d > 0 \). Loss increases convexly in debt service, because of
utility curvature. Intuitively, when debt service is already high, the marginal disutility of
transferring another unit of resources is also high.

Third, note that \( d_t \) is defined as debt service relative to potential output. When potential
output is high, the utility cost of a given real transfer to investors is lower than when potential
output is low, due to the curvature of the utility function. The interaction of potential output
and real debt service pushes the government to minimize debt repayments in states of the
world when potential output is low, similarly to the intuition in section 3.

4.4 Policy Objective

The government chooses monetary policy and debt issuance to minimize the expected dis-
counted sum of losses, subject to incentive compatibility in the no-commitment state in period
2. Real debt service is linked to inflation and the debt portfolio composition. A second-order
expansion for real debt service in terms of log inflation gives

\[
D_t = \beta^{-1} V + s_1 \left( - (\pi_2 - E_1 \pi_2) + \frac{1}{2} (\pi_2 - E_1 \pi_2)^2 - \frac{1}{2} Var_1 \pi_2 \right) + O (\|\pi_t\|^3) . \quad (51)
\]
Next, we normalize $Y_1 = 1$, log-linearize the loss function around $\log Y_2 = 0$, and substitute in (51). To second order, the expected sum of period 1 and period 2 losses then equals

$$E_1 (L_1 + L_2) = \alpha^x (x_1 - x^*)^2 + \alpha^\pi \pi_1^2,$$

$$+ \beta E_1 \left( \alpha^x (x_2 - x^*)^2 + \alpha^\pi \pi_2^2 \right)$$

$$+ \beta s_1 \omega + \frac{1}{\omega + \gamma} \left( \gamma + (1 + \gamma) 2 \alpha^d \beta^{-1} V \right) Cov_1 (a_2, \pi_2)$$

$$+ \beta \alpha^d s_1^2 E_1 (\pi_2 - E_1 \pi_2)^2. \quad (52)$$

Note that the productivity shock $a_2$ enters into expected loss (54) through its covariance with inflation. When productivity and inflation are positively correlated, real debt service on LC debt is low during good times and high during bad times. Utility curvature makes debt repayments during bad states of the world costlier, so a positive inflation-technology shock covariance increases expected loss. Expected losses are more sensitive to the technology-inflation covariance when the LC debt share is high. The interaction between productivity shocks and squared debt repayments is third order and drops out of (52).

Abstracting for a moment from technology shocks, (52) suggests that all countries should prefer to issue real debt. Since expected debt repayments are pinned down by the budget constraint (6), it is optimal to minimize variance of debt repayments. Similarly, we can minimize the last term in (52) by setting the nominal debt share $s_1$ to zero. To generate a trade-off between nominal and real debt, the next subsection introduces crisis benefits of nominal debt.

### 4.5 Crisis Costs and Nominal Debt

Nominal debt plausibly provides benefits during crises, either by allowing the government to lower real debt repayments or even reducing default costs. Fisher (1983) argued that “The best of all possible worlds, if governments acted optimally, might be one in which governments had the option of imposing a capital levy in this way (through inflating) in
emergencies, like wars.”

We model crisis costs of LC debt as a quadratic decreasing function of the LC debt share

\[ \text{Cost}_1 = -Cs_1 + Ds_1^2. \]  

(53)

Hence, the costs of a crisis decrease in the share of LC debt, but they do so concavely. A country that is mostly financed with FC debt obtains substantial benefits from a marginal increase in the LC debt share. However, a country that is mostly financed with LC debt obtains little benefit from a further increase in the LC debt share. Assuming that \( C > 0 \) implies that a government that is unconstrained in terms of monetary policy credibility, has an incentive to issue debt in local currency. Assuming \( D > 0 \) implies that volatility in the LC debt share is costly, thereby making variation in the LC debt share an imperfect substitute for credible variation in the inflation target.

We provide a microfoundation for the functional form (53) in Appendix B, based on LC debt allowing the government to reduce the debt burden through inflation in rare crisis states. A crisis probability approaching zero leaves inflation and output gap expectations unchanged. However, if utility costs in a crisis are high, crises may contribute to expected losses. During a crisis, the marginal utility of consumption is high and very sensitive to debt repayments, so expected crisis losses are dominated by the quadratic costs of debt repayment. Expected crisis losses are decreasing and convex in \( s_1 \), because LC debt provides debt relief in states of low potential output. However, due to utility curvature the first dollar of debt relief is more valuable than the last dollar of debt relief, so the marginal benefit of \( s_1 \) decreases with \( s_1 \).
The policy objective function incorporating both crisis and non-crisis costs then becomes

\[ \mathcal{L} = E_1(L_1 + L_2) + Cost_1, \]

\[ = \alpha^x(x_1 - x^*)^2 + \alpha^\pi \pi_1^2, \]

\[ + \beta E_1 \left( \alpha^x(x_2 - x^*)^2 + \alpha^\pi \pi_2^2 \right) \]

\[ + \beta s_1 \frac{\omega + 1}{\omega + \gamma} \left( \gamma + (1 + \gamma)2\alpha^d \beta^{-1} V \right) Cov_1 (a_2, \pi_2) \]

\[ + \beta \alpha^d s_1^2 E_1 (\pi_2 - E_1 \pi_2)^2 - Cs_1 + Ds_1^2. \]  

(54)

4.6 Analytic Case

Valuable intuition can be gained from analyzing a special case, where a tractable analytic solution is available. This case consists of four assumptions, all of which will be relaxed in the next section.

**Assumption 1:** Consumers are close to risk neutral. \((\gamma \approx 0)\)

**Assumption 2:** We use a first-order expansion for real debt service

\[ D_t = \beta^{-1} V - s_1 (\pi_2 - E_1 \pi_2). \]  

(55)

**Assumption 3:** The target output gap \(x^*\) equals zero.

**Assumption 4:** No technology shocks. \((\sigma_a = 0)\)

Assumption 1 implies that \(\alpha^d\) is small, allowing us to ignore the term \(\beta \alpha^d s_1^2 E_1 (\pi_2 - E_1 \pi_2)^2\) in the objective function (54), because it is now third order. With consumers close to risk neutral, debt repayments enter linearly into utility.

Assumption 2 retains only the first-order terms of realized debt repayment, thereby greatly simplifying the solution in the no-commitment case. To first order, debt repay-
ments decline with period 2 surprise inflation and more so when the LC debt share \( s_1 \) is higher. Second order terms in log inflation appear in (51) to reflect a Jensen’s inequality effect. In our numerical work, we find that the effect of assumption 2 on the solution is small. Assumption 3 is in no way crucial to our results, but simplifies the analytic expressions. Assumption 4 is to highlight the novel force in our model and to abstract from consumption smoothing motives.

4.6.1 No-Commitment Regime Solution

Let \( \pi_{2}^{nc} \) and \( x_{2}^{nc} \) denote period 2 inflation and the output gap in the no-commitment regime. In the no-commitment state in period 2, the government behaves myopically and minimizes the loss function

\[
L_2 = \alpha^x (x_{2}^{nc})^2 + \alpha^\pi (\pi_{2}^{nc})^2 + \beta^{-1} V - s_1 (\pi_{2}^{nc} - E_1 \pi_2),
\]

subject to the Phillips Curve

\[
\pi_{2}^{nc} = \lambda x_{2}^{nc} + u_2.
\]

The first-order condition with respect to inflation gives

\[
\pi_{2}^{nc} = \frac{\lambda^2 s_1 + 2\alpha^x u_2}{2(\alpha^x + \lambda^2 \alpha^\pi)}.
\]

Clearly, no-commitment inflation increases with the LC debt share \( s_1 \) and the period 2 cost-push shock. Intuitively, issuing a higher share of LC debt increases the incentive to devalue through inflation. Up to an exogenous component that does not affect policy, the expected weighted sum of output gap and inflation distortions then takes the particularly simple form

\[
E_1 (\alpha^x (x_{2}^{nc})^2 + \alpha^\pi (\pi_{2}^{nc})^2) = \frac{\lambda^2 s_1^2}{4(\alpha^\pi \lambda^2 + \alpha^x)}.
\]
Welfare losses in the no-commitment case increase quadratically in the LC debt share $s_1$, because a higher LC debt share leads to distortionary inflation.

4.6.2 Commitment Policy

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

$$
\mathcal{L} = \underset{\text{Inflation and Output Distortions Commitment Regime}}{\alpha^x x_1^2 + \alpha^\pi \pi_1^2 + \beta p E_1 \left[ \alpha^x (x_2^c)^2 + \alpha^\pi (\pi_2^c)^2 \right]} + \beta (1 - p) \frac{\lambda^2 s_1^2}{4(\alpha^\pi \lambda^2 + \alpha^x)} \quad (60)
$$

$$
\underset{\text{Inflation and Output Distortions No-Commitment Regime}}{-\beta C s_1 + \beta D s_1^2} \quad (61)
$$

$$
\underset{\text{Crisis Costs}}{\phi_1 \left[ \pi_1 - \lambda x_1 - \beta p E_1 \pi_2^c - \beta (1 - p) \frac{\lambda^2 s_1 + 2 \alpha^x \rho u_1}{2(\alpha^\pi \lambda^2 + \alpha^x)} - u_1 \right]} \quad (62)
$$

$$
\phi_2 \left[ \pi_2^c - \lambda x_2^c - u_2 \right]. \quad (63)
$$

Expected period 2 inflation enters into the period 1 PC as a weighted sum of commitment and no-commitment regimes. 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 cost-push shocks. Expected debt repayments satisfy the budget constraint (6) and hence drop out of the Lagrangian (60) through (64).
The first-order condition with respect to the LC share is

\[ s_1 = \frac{c}{\lambda^2(1-p) + d} + 2\alpha^x \frac{\lambda(1-p)}{\lambda^2(1-p) + d} x_1, \tag{65} \]
\[ c = 2C(\alpha^\pi \lambda^2 + \alpha^x), \tag{66} \]
\[ d = 4D(\alpha^\pi \lambda^2 + \alpha^x). \tag{67} \]

An increase in the LC debt share \( s_1 \) is costly, because it increases inflation expectations. Inflation expectations enter into the government’s objective function through no-commitment inflation and output distortions (61) and the period 1 PC (63). These costs are offset by the crisis benefits of LC debt, as captured by (62). The optimal LC share equates marginal benefits and marginal costs. An increase in credibility \( p \) increases the intercept in (65). Intuitively, if credibility is high, it is unlikely that the government will inflate away the debt, and hence LC debt is less costly.

Next, we need to solve for period 1 inflation and the contingent plan for period 2 inflation for the commitment regime. The first-order conditions are given by

\[ \pi_1 = -\frac{\alpha^x}{\lambda \alpha^\pi} x_1, \tag{68} \]
\[ \pi_2^c = -\frac{\alpha^x}{\lambda \alpha^\pi} (x_2^c - x_1). \tag{69} \]

The welfare weights \( \alpha^x \) and \( \alpha^\pi \), combined with the PC slope coefficient \( \lambda \) determine the optimal trade-off between inflation and the output gap in period 1. The first-order-condition (69) 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. The government seeks to anchor inflation expectations in bad states of the world, using low inflation expectations to offset a positive shock \( u_1 \) to the PC (38).

When credibility is high, consumers and investors form inflation expectations largely based on \( \pi_2^c \) 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 $\pi_2$ 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.

### 4.6.3 Special Case: $p = 1$

Now, solving for the special case of perfect credibility $p = 1$ gives

\[
\begin{align*}
\pi_1 &= u_1 \frac{\alpha^x (\alpha^x \lambda^2 + \alpha^x + \alpha^x \beta \rho)}{\alpha^x + \alpha^x \lambda^2)^2 + \alpha^x \alpha^x \beta \lambda^2} \\
E_1 \pi_2 &= E_1 \pi_2^c \\
&= u_1 \frac{\alpha^x ((\alpha^x + \alpha^x \lambda^2) \rho - \alpha^x \lambda^2)}{(\alpha^x + \alpha^x \lambda^2)^2 + \alpha^x \alpha^x \beta \lambda^2} \\
E_1 x_2 &= E_1 x_2^c \\
&= -u_1 \frac{\alpha^x \lambda ((\alpha^x + \alpha^x \lambda^2) \rho + \alpha^x (1 + \beta \rho))}{(\alpha^x + \alpha^x \lambda^2)^2 + \alpha^x \alpha^x \beta \lambda^2} \\
s_1 &= \frac{c}{d} \\
Beta(E_1 \pi_2, E_1 x_2) &= -\frac{\alpha^x}{\alpha^x \lambda} \frac{\rho (\alpha^x + \alpha^x \lambda^2) - \alpha^x \lambda}{\rho (\alpha^x + \alpha^x \lambda^2) + \alpha^x (1 + \beta \rho)}
\end{align*}
\]

Expression (72) shows that with perfect credibility, the expected output gap declines with the period 1 cost-push shock. However, (71) shows that expected inflation may either increase or decrease with the period 1 cost-push shock. If cost-push shocks are highly persistent, expected inflation increases with the cost-push shock. If cost-push shocks are not persistent, expected inflation decreases with the period 1 cost-push shock. The expected inflation-output beta (74) can be positive if the persistence of cost-push shocks is sufficiently low.
4.6.4 Special Case \( p = 0 \)

Next, we solve for the second special case of no credibility \( p = 0 \). This gives

\[
\pi_1 = \frac{\alpha^x}{2(\alpha^x + \alpha^x \lambda^2)^2 + b \alpha^x \beta \lambda^2} \left( a \beta \lambda^2 + 2 u_1 \left( \alpha^x + \alpha^x \lambda^2 + \alpha^x \beta \rho \right) \right) \quad (75)
\]

\[
E_1 \pi_2 = E_1 \pi_2^{nc}, \quad (76)
\]

\[
E_1 x_2 = E_1 x_2^{nc}, \quad (77)
\]

\[
s_1 = a \left( \frac{2(\alpha^x + \alpha^x \lambda^2)^2}{2(\alpha^x + \alpha^x \lambda^2)^2 + b \alpha^x \beta \lambda^2} \right) - u_1 \frac{2 \alpha^x (\alpha^x \lambda^2 + \alpha^x \beta \rho)}{2(\alpha^x + \alpha^x \lambda^2)^2 + b \alpha^x \beta \lambda^2}, \quad (78)
\]

\[
\text{Beta}(E_1 \pi_2, E_1 x_2) = \frac{-\alpha^x}{\lambda \alpha^x \rho (\alpha^x + \alpha^x \lambda^2)} - \frac{b}{2 \alpha^x \alpha^x (1 + \beta \rho)} \quad (79)
\]

\[
a = \frac{c \lambda^2 + d}{\lambda^2 + d} \quad (80)
\]

\[
b = 2 \alpha^x \frac{\lambda^2}{\lambda^2 + d} \quad (81)
\]

4.6.5 Comparing \( p = 0 \) and \( p = 1 \)

Now, clearly \( E(\pi_1 | p = 0) > 0 = E(\pi_1 | p = 1) \) and \( E(\pi_2 | p = 0) > 0 = E(\pi_2 | p = 1) \). Average period 1 and period 2 inflation decrease as we go from zero credibility to full credibility.

As we go from full credibility to no credibility, the average LC debt share decreases.

\[
E(s_1 | p = 0) = a \left( \frac{2(\alpha^x + \alpha^x \lambda^2)^2}{2(\alpha^x + \alpha^x \lambda^2)^2 + b \alpha^x \beta \lambda^2} \right) < c = E(s_1 | p = 1). \quad (82)
\]

Next, we compare betas across the \( p = 0 \) and \( p = 1 \) cases. A rational function of the form \( \frac{1-c_1 X}{1+c_2 X} \) with \( c_1, c_2 > 0 \) is strictly decreasing in \( X \) over its region of continuity. Applying this
to \( X = \frac{b}{2\alpha^x} < 1 \) shows that

\[
\text{Beta}(E_1\pi_2, E_1x_2 | p = 0) = -\frac{\alpha^x}{\lambda\alpha^x} \frac{\rho(\alpha^x + \alpha^\pi\lambda^2) - \frac{b}{2\alpha^x} \alpha^\pi\lambda^2}{\rho(\alpha^x + \alpha^\pi\lambda^2) + \frac{b}{2\alpha^x} \alpha^x(1 + \beta\rho)},
\]

(85)

\[
< -\frac{\alpha^x}{\lambda\alpha^x} \frac{\rho(\alpha^x + \alpha^\pi\lambda^2) - \alpha^\pi\lambda^2}{\rho(\alpha^x + \alpha^\pi\lambda^2) + \alpha^x(1 + \beta\rho)},
\]

(86)

\[
= \text{Beta}(E_1\pi_2, E_1x_2 | p = 1).
\]

(87)

Hence, as we move from no credibility to full credibility, the expected inflation-output gap beta increases.

### 4.6.6 Predictions

We can derive several testable model predictions for inflation and output dynamics, and the sovereign debt portfolio. The proof is provided in the appendix and relies on the two special cases of \( p = 0 \) and \( p = 1 \) and showing strict monotonicity on the interval \( p \in [0, 1] \).

**Implication 1** The unconditional expected LC debt share \( E_s_1 \) is strictly increasing in \( p \) for \( p \in [0, 1] \).

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.

**Implication 2** Unconditional expected period 1 inflation \( E\pi_1 \) and unconditional period 2 inflation \( E\pi_2 \) are both strictly decreasing in \( p \) for \( p \in [0, 1] \).

When monetary policy is credible, it is unlikely that the government will inflate away LC debt, lowering inflation expectations. This effect is mitigated, but never fully reversed, by credible governments issuing more LC debt.

**Implication 3** The expected inflation-output beta \( \text{Beta}(E_1\pi_2, E_1x_2) \) is strictly increasing in
When credibility is low, cost-push shocks simultaneously decrease the output gap and increase inflation. The non-credible central bank trades off output against inflation through the PC, but it can never reverse the sign of the initial shock. A credible central bank can credibly signal future policy, or engage in forward guidance. Following a positive cost-push shock, a credible central bank mitigates the increase in inflation and decrease in the output gap by committing to lower future inflation, potentially generating a positive correlation between inflation and output gap expectations.

5 Numerical Analysis and Key Mechanisms

In the previous section, we made a number of simplifying assumptions to derive analytical results. In this section, we relax those assumptions and solve the model numerically to illustrate additional predictions from risk aversion and a non-zero target output gap. We solve the model using the full loss function in equation (54) with risk-averse consumers, technology shocks, a non-zero target output gap, and a second-order expansion for real debt service. We also require that the amounts of LC and FC debt are both non-negative.

With technology shocks and risk aversion, LC debt can offer the benefit of consumption-smoothing, similarly to the illustrative model in section 3. A government with nominal debt has an incentive to choose higher inflation following an adverse technology shock to raise consumption in low output states. The second order approximation to real debt service matters only in terms of the accuracy of the solution but does not qualitatively change any of the results.

A non-zero target output gap introduces an additional important force to the model. Equation (58) shows that with $x^* = 0$ inflation in the no-commitment state increases in the LC debt share and the realization of the cost-push shock. However, with a zero target output gap and all real debt, the no-commitment government has no incentive to inflate on average.
This can be seen by substituting $s_1 = 0$ into (58) and taking the expectation over $u_1$. A positive target output gap generates an additional incentive to inflate when commitment fails, leading to time-inconsistent monetary policy as in Barro and Gordon (1983).

5.1 Calibration

In Table 3, we report parameter values for a preliminary benchmark calibration. As reported in the table, most parameters come directly from Galí (2008) and Smets and Wouters (2007). The parameters relating to the government’s borrowing decision and monetary policy credibility are new in our model and warrant a discussion. We set the government’s borrowing need to 10% debt/GDP. This is around the average share of external sovereign debt in emerging markets and is roughly half the average amount of external debt in developed countries.\footnote{For emerging markets, we use data on the international debt/gross national income ratio from the World Bank International Debt Statistics Database. For developed countries, we use the amount of sovereign debt owned by non-residents as a share of GDP from Merler and Pisani-Ferry (2012). More details are in the appendix.}

To calibrate the monetary policy credibility parameter $p$, we combine survey forecasts with announced central bank inflation targets. We define the “Credibility Gap” as the greater of the average difference between the central bank inflation target and survey inflation expectations and zero. Interpreting the government’s announced inflation target as average commitment inflation $E(\pi^c)$ and survey inflation as average unconditional inflation $E(\pi)$, we can back out $p$ from

$$Credibility\ Gap = E(\pi) - E(\pi^c) = (1 - p) (E(\pi_{nc}) - E(\pi^c))$$

We hand-collect annual announced inflation targets from central bank websites for 22 of our 30 sample countries, with an average starting date of 2005. Average credibility gaps range from zero for some developed countries to 1.5% for emerging markets. To back out credibility
$p$, the unknown parameter is the inflation level conditional on losing commitment. For no-commitment inflation consistent with high but not hyper-inflation in the range of 10\%-20\%, we obtain credibility levels for developed countries between 0.97 and 0.99 and for emerging countries between 0.88 and 0.95. We therefore solve the model for a range of different values for $p$ between 0.8 and 0.99.

5.2 Key Mechanisms

In Figure 6, we plot the equilibrium mean amount of LC debt issued by governments of different credibility levels. Varying the credibility from 0.8 to around 0.9 causes the share of debt issued by the sovereign to go from being entirely in FC to entirely in LC, consistent with the analytical results. Interestingly, there is only a narrow range of the parameter space where the sovereign chooses to have some debt in both LC and FC. This is quite similar to the data, where a large share of developed countries, and now some EMs, borrow entirely in LC, but many countries, such as Argentina and Venezuela, have historically borrowed entirely in FC.

In Figure 6, we see that average equilibrium second period inflation falls monotonically with credibility, in spite of the fact that higher credibility governments borrow more in LC. This figure matches the empirical fact that lower inflation governments borrow more in LC. The kink in LC debt issuance and mean inflation at around $p = 0.9$ occurs when the amount of FC borrowing hits zero.

While the model generates a negative relation between unconditional average inflation and the LC debt share, conditional on the no-commitment state the relation between inflation and LC debt is positive. This is shown in Figure 7, which generalizes the first-order condition (58). Figure 7 shows the optimal no-commitment policy conditional on all shocks and period 1 inflation expectations being zero. The blue line shows that the no-commitment inflation policy function increases with LC debt in the benchmark case. For the red line, we show the no-commitment policy function for a negative technology shock. We see that with a
negative technology shock, inflation increases more sharply with the amount of LC debt outstanding. This is a difference with the analytic case where the households are assumed to be risk-neutral and captures the fact that the benefit of higher inflation is larger the lower is consumption. The yellow lines makes this point even more starkly, leaving output as low as in the red line but increasing the coefficient of relative risk aversion to 5.

Figure 8 plots the distribution of realized inflation for three different calibrations in order to highlight the importance of the temptation to inflate in the absence of LC debt. The top panel sets the target output gap to 0, as in the analytic case in section 4.6. The middle panel sets the target output gap to the level consistent with average markups ($x^* = 0.067$). The bottom panel chooses an extremely large value of $x^* = 0.5$ for illustrative purposes, corresponding to a strong desire to push output above potential in the government’s objective function. All three panels set $p = 0.9$.

Figure 8 shows that we obtain a two-peaked distribution for realized period 2 inflation, with the right peak corresponding to inflation conditional on realizing the no-commitment state. The top panel in Figure 8 shows that with a zero output gap target, the inflation rate in the no-commitment state is small. However, as the target output gap increases, no-commitment inflation increases, reaching 7% in the bottom panel.

6 Testing Additional Empirical Implications

The model presented in the previous two sections highlights the importance of monetary policy credibility in explaining the level and cyclicality of nominal risk and sovereign debt portfolios across countries. In this section, we use three de-facto measures to shed light on the varying degree of monetary policy credibility across countries, providing direct evidence in support of our proposed mechanism.\footnote{We prefer de-facto measures of central bank credibility, because recent measures of legal central bank independence have been found to be uncorrelated with average inflation (Crowe and Meade, 2007).}
6.1 Principal Component Analysis

First, we construct the first principal component (PC) of all nominal risk measures as a proxy for the degree of monetary policy credibility across countries. Table 4 reports cross-country correlations between measures of inflation, inflation expectations, bond-stock betas, expected and realized inflation-output betas, nominal bond yields, and bond-CDS betas. The last row of Table 4 reports the correlation between the first PC and each of the seven individual risk measures. Countries with high first PC scores are associated with high inflation 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 4 confirms the key model predictions. All proxies have an absolute bivariate correlation with the first principal component of at least 52% and the signs are consistent with the model, supporting a unifying explanation bond risks and sovereign debt portfolios.

6.2 News Counts

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

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

We count the number of articles containing both keywords and the country name and divide them by the geometric average of the articles that contain one of the keywords combined
with the country name. Consistent with the model, Panel (A) in Figure 9 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 the proposed mechanism.

6.3 Announced Inflation Targets

Another way to gauge cross-country differences in monetary policy credibility is from the gap between announced inflation targets and survey expectations. In countries with low monetary policy credibility, we expect survey inflation to exceed announced inflation targets.

Figure 9 Panel B shows the credibility gap, defined in section 5.1, against the bond-stock beta since 2005. We find a strongly positive correlation between bond-stock betas and average credibility gaps of 57%, providing further support that bond-stock betas are linked to monetary policy credibility. Over the past decade, on average, the emerging markets in the sample have a mean credibility gap of 0.6 percent, whereas the developed markets in the sample have a mean credibility gap of 0.1 percent.

7 Conclusion

This paper argues that differences in monetary policy credibility explains the relation 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 type (Backus and Driffill, 1985; Barro, 1986), policy uncertainty might be reflected in asset prices (Pastor and Veronesi, 2012, 2013).
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Figure 1: Nominal Debt Shares and Nominal Bond Betas

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 Measures

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

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

(C) Bond-Stock Betas v.s. Realized Inflation-Output Betas

Note: Panel (A) plots nominal bond-stock betas on the y-axis and nominal bond-CDS betas on the x-axis. Panel (B) plots nominal bond-stock betas on the y-axis and expected inflation-output betas on the x-axis. Panel (C) plots nominal bond-stock betas on the y-axis and realized 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 Measures

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

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

(C) Nominal Debt Share v.s. Realized Inflation-Output Beta

Note: Panels (A), (B) and (C) plot the share of nominal debt in the sovereign debt portfolio on the y-axis against bond-CDS betas, expected inflation-output betas and realized 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: LC Debt Share in Long-Term Debt versus Bond-Stock Beta

Notes: This figure plots the bond-stock beta on the x-axis and the share of LC debt in all outstanding long-term debt on the y-axis. Long-term debt is defined as having a remaining time to maturity of five or more years. The share of LC debt in long-term debt is estimated from individual bond issuance data from Bloomberg.
Figure 5: 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 $u_2$
- Observe technology shock $a_2$
- Probability $p$: Obey contingent plan
- Probability $1-p$: Myopic monetary policy
- Benefits of LC debt realized
Figure 6: Credibility, LC Debt, and Inflation

(A) LC Debt Issuance and Credibility

(B) Mean Inflation and Credibility

Notes: The left panel plots equilibrium LC debt issuance (relative to GDP) at a zero realized period 1 cost-push shock as a function of credibility $p$. The right panel plots the mean second period inflation rate in equilibrium as a function of credibility $p$. 
Notes: This figure plots the inflation policy function in the absence of shocks in the no-commitment state as a function of the amount of LC debt issued by the government. “Benchmark” uses the calibration in Table 3. “Low Output” sets the log technology shock to $a_2 - a_1 = -0.1$. “Low Output, High Risk Aversion” sets $a_2 - a_1 = -0.1$ and $\gamma = 5$. 

Figure 7: Inflation in No-Commitment State
Figure 8: Target Output Gap and Inflation

Notes: This figure shows histograms of realized period 2 inflation. The top panel uses a zero target output gap. The middle panel targets the target output gap implied by steady-state markups. In the bottom panel, the targets a large and output gap of $x^* = 0.5$. Each calibration is simulated 20,000 times.
Figure 9: Bond-Stock Betas and Measures of Monetary Policy Credibility

(A) News Counts

(B) Inflation Credibility Gap

Note: Panel (A) 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. Panel (B) shows bond-stock betas against the inflation credibility gap, measured as the mean difference between the survey inflation expectations from Consensus Economics and the announced inflation target since 2005.
Table 1: Summary Statistics for Developed and Emerging Markets (2005-2014)

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<th>(2)</th>
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<th>(5)</th>
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Note: This table reports summary statistics for the cross-sectional mean of eight variables for developed and emerging market groups. The variables include (1) π, realized inflation (%), (2) Survey π, survey inflation (%), (3) βπ,gdp, inflation-output forecast beta, (4) βπ,IP, realized inflation-output beta, (5) y, five-year nominal LC bond yield, (6) βh,s, bond-stock beta, (7) βh,cds, bond-CDS beta, (8) CDS, five-year sovereign credit default swap spreads in percentage points, and (9) αNom, 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-Sectional Regression of Nominal Debt Shares on Nominal Risk Betas

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<td>0.317</td>
<td>0.322</td>
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</tbody>
</table>

Notes: This table shows the cross-country regression results of the nominal debt share, $\alpha_{Nom}$ (between 0 and 1), on measures of inflation cyclicality. The independent variables in the first four columns are the bond-stock beta ($\beta^{b,s}$), the bond-CDS beta ($\beta^{b,cds}$), the inflation forecast beta ($\beta^{\pi,\hat{gdp}}$) and the realized inflation output beta ($\beta^{\pi,IP}$), respectively. In Column 5, we control for the mean log per capita GDP level between 2005 and 2014, log(GDP). In Column 6, we control for the average exchange rate classification used in Reinhart and Rogoff (2004), FX regime. More details on variable definitions can be found in Section 2.1. Robust standard errors are used in all regressions with the significance level indicated by *** p<0.01, ** p<0.05, * p<0.1.
Table 3: Calibration

Panel A: Fundamental Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Aversion</td>
<td>$\gamma$</td>
<td>1</td>
<td>Galí (2008)</td>
</tr>
<tr>
<td>Frisch Elasticity of Labor Supply</td>
<td>$\phi$</td>
<td>1</td>
<td>Galí (2008)</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>$\beta$</td>
<td>0.96</td>
<td>Galí (2008)</td>
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<tr>
<td><strong>Firms</strong></td>
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</tr>
<tr>
<td>Technology Growth</td>
<td>$\mu_A$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fraction of firms that leave prices unchanged</td>
<td>$\alpha$</td>
<td>0.19</td>
<td>Galí (2008)*</td>
</tr>
<tr>
<td>Capital Share of Production</td>
<td>$\kappa$</td>
<td>0.33</td>
<td>Galí (2008)</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debt/GDP</td>
<td>$V$</td>
<td>0.1</td>
<td>See text.</td>
</tr>
<tr>
<td>Credibility</td>
<td>$p$</td>
<td>0.8-0.99</td>
<td>See text.</td>
</tr>
<tr>
<td><strong>Shocks</strong></td>
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</tr>
<tr>
<td>Std. Cost-Push Shock</td>
<td>$\sigma_u$</td>
<td>0.28</td>
<td>Smets and Wouters (2007)*</td>
</tr>
<tr>
<td>Std. Technology Shock</td>
<td>$\sigma_a$</td>
<td>0.90</td>
<td>Smets and Wouters (2007)*</td>
</tr>
<tr>
<td>Autocorrelation Cost-Push Shock</td>
<td>$\rho$</td>
<td>0.81</td>
<td>Smets and Wouters (2007)*</td>
</tr>
<tr>
<td><strong>Crisis</strong></td>
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<td></td>
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<tr>
<td>Crisis Probability</td>
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<td>0.02</td>
<td>Barro (2006)</td>
</tr>
<tr>
<td>Crisis Output Drop</td>
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<td>0.29</td>
<td>Barro (2006)</td>
</tr>
<tr>
<td>Crisis Inflation</td>
<td></td>
<td>0.07</td>
<td>Barro and Ursúa (2008)</td>
</tr>
</tbody>
</table>

Panel B: Implied Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggregate Supply</strong></td>
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<tr>
<td>Elasticity Disutility of Labor to Output</td>
<td>$\omega$</td>
<td>1.99</td>
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<tr>
<td>Slope Phillips Curve</td>
<td>$\lambda$</td>
<td>0.81</td>
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<tr>
<td><strong>Loss Function</strong></td>
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<tr>
<td>Output Weight</td>
<td>$\alpha_x$</td>
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<tr>
<td>Inflation Weight</td>
<td>$\alpha_\pi$</td>
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<tr>
<td>Debt Weight</td>
<td>$\alpha_d$</td>
<td>0.33</td>
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<tr>
<td><strong>Crisis Benefits of LC Debt</strong></td>
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</tr>
<tr>
<td>Target Output Gap</td>
<td>$x^*$</td>
<td>0.067</td>
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<tr>
<td>Linear</td>
<td>$C$</td>
<td>0.0016</td>
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<tr>
<td>Quadratic</td>
<td>$D$</td>
<td>0.00005</td>
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</tbody>
</table>

Notes: *indicates that we annualized quarterly estimates.
Table 4: Cross-Country Correlations for 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>
<tbody>
<tr>
<td>$\pi$</td>
<td>1.00</td>
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<tr>
<td>Survey $\pi$</td>
<td>0.99</td>
<td>1.00</td>
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<tr>
<td>$\beta_{\pi,\text{gdp}}$</td>
<td>-0.63</td>
<td>-0.61</td>
<td>1.00</td>
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<tr>
<td>$\beta_{\pi,\text{IP}}$</td>
<td>-0.41</td>
<td>-0.38</td>
<td>0.47</td>
<td>1.00</td>
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<tr>
<td>$y$</td>
<td>0.86</td>
<td>0.86</td>
<td>-0.66</td>
<td>-0.37</td>
<td>1.00</td>
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<tr>
<td>$\beta_{b,s}$</td>
<td>0.72</td>
<td>0.72</td>
<td>-0.61</td>
<td>-0.43</td>
<td>0.77</td>
<td>1.00</td>
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</tr>
<tr>
<td>$\beta_{b,cds}$</td>
<td>-0.62</td>
<td>-0.62</td>
<td>0.49</td>
<td>0.25</td>
<td>-0.68</td>
<td>-0.84</td>
<td>1.00</td>
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<tr>
<td>$\alpha^{\text{Nom}}$</td>
<td>-0.51</td>
<td>-0.49</td>
<td>0.58</td>
<td>0.30</td>
<td>-0.67</td>
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<tr>
<td>First PC</td>
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<td>0.92</td>
<td>-0.76</td>
<td>-0.52</td>
<td>0.92</td>
<td>0.89</td>
<td>-0.79</td>
<td>-0.64</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) $\pi$, realized inflation (%), (2) Survey $\pi$, survey inflation (%), (3) $\beta_{\pi,\text{gdp}}$, inflation-output forecast beta, (4) $\beta_{\pi,\text{IP}}$, realized inflation-output beta, (5) $y$, five-year nominal LC bond yield, (6) $\beta_{b,s}$, bond-stock beta, (7) $\beta_{b,cds}$, bond-CDS beta, (8) $\alpha^{\text{Nom}}$, nominal debt share, and (9) First PC, the first principal component of the first seven nominal risk measures.