Everything In Moderation: The Currency-Maturity Composition of Sovereign Debt[*]

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Abstract

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Country	Sample Period	Number of Bonds	FC Share	Weighted Average Maturity
Angola	Nov. 2005 - Dec. 2024	3,053	9.1%	3.8 years
Argentina	Apr. 1990 - Dec. 2024	915	60.8%	9.2 years
Brazil	Sep. 1990 - Oct. 2024	1,056	2.9%	6.5 years
Egypt	Dec. 1993 - Dec. 2024	2,647	8.2%	1.8 years
Hungary	Feb. 1990 - Dec. 2024	2,404	15.8%	5.2 years
Indonesia	Jul. 1990 - Dec. 2024	1,885	15.2%	9.0 years
Jamaica	Sep. 1991 - Dec. 2024	778	55.5%	7.3 years
Jordan	Aug. 1993 - Nov. 2024	1,229	17.8%	4.3 years
Malaysia	Mar. 1990 - Nov. 2024	1,684	7.3%	9.6 years
Mexico	Mar. 1990 - Dec. 2024	2,467	7.2%	4.9 years
Philippines	May. 1990 - Dec. 2024	2,066	12.9%	6.5 years
Poland	Dec. 1993 - Nov. 2024	1,242	13.7%	6.4 years
Romania	Jun. 1997 - Dec. 2024	888	38.0%	6.9 years
Russia	May. 1993 - Dec. 2021	561	13.5%	7.8 years
Türkiye	Mar. 1990 - Dec. 2024	992	15.8%	4.1 years
Ukraine	Mar. 1995 - Dec. 2024	1,756	47.2%	6.1 years
Venezuela	Dec. 1990 - Nov. 2018	1,926	35.0%	7.7 years

Table 1: Country-level bond data description

I Introduction

The rest of the paper is as follows. I present novel empirical evidence that emerging market economies' domestic currency debt is consistently of significantly lower maturity than their foreign currency debt in section II. The quantitative model is then outlined in section III. I discuss the economic forces that drive the sovereign's optimal debt portfolio in section IV. section V contains the quantitative analysis, and section VI concludes.

II Empirical Analysis

In this section, I analyze individual issuance-level data on sovereign bonds issued in international financial markets across 15 emerging market economies. I robustly find that sovereign debt denominated in a country's domestic currency tends to be of significantly shorter maturity than debt denominated in a foreign currency.

II.A Data Description

I collect data on individual sovereign bonds issued by 18 emerging market economies from 1990 to 2024 from Bloomberg.[1] As there is no formal definition of whether a country is con-

[1] Bloomberg data only became available from 1990 onwards.

sidered a developing or developed economy, I try to keep my sample of countries as consistent with Ottonello and Perez (2019)'s sample as possible.[2] I exclude advanced economies from my analysis as all their debt is denominated in their own domestic currency and only need to optimize their debt portolio with respect to its maturity composition.

Data on each bond issued includes the institutional name of the debtor, the issue date, the amount borrowed, maturity, currency denomination, coupon rate, the price at issue, and yield at issue. I use data on debt issuance rather than debt stocks because there there is no publicly available data that is granular enough to decompose debt by currency denomination and maturity simultaneously. Arslanalp and Tsuda (2012) includes quarterly data on foreign holdings of sovereign debt but does not provide a breakdown by maturity.

There are two drawbacks of Bloomberg data. Firstly, there is no data on nationality of the creditor and thus whether they are a domestic or an international investor. Since I only consider bonds issued in international financial markets, I follow Gürkaynak et al. (2007) and Ottonello and Perez (2019) by removing all bonds issued by a country's central bank and bonds that mature in less than 3 months from issuance since they are typically only bought by domestic investors. Secondly, Bloomberg data also includes sub-national (or municipal) bonds. Since sub-national bonds have different risk profiles to national bonds,[3] I also remove them.[4] I am left with 27,549 bonds in total.

II.B Bond Issuance: Average Maturity by Currency

I report the average maturity of issued sovereign debt by currency denomination for each country in my empirical sample in Table 2. Columns 1 and 2 shows the weighted average of each country's domestic and foreign currency debt respectively, where each bond is weighted by the amount issued. Columns 3 and 4 show the unweighted average maturity.

Table 2 shows that across countries, the foreign currency debt that they issue is consistently of much longer maturity than the debt that is denominated in their own currency. This stylized fact holds across most countries, with Jamaica and Malaysia being the only exceptions and only when the weighted average is considered. Across all bond in my data, the weighted mean maturity of domestic currency debt is 5.1 years whereas it is over twice as long for foreign currency debt at 11.7 years.

Moreover, this empirical pattern is also consistent across time. I plot the time series of the weighted average maturities of domestic and foreign currency debt in Figure 1. Apart from 1991, foreign currency debt has been of longer maturity than domestic currency debt in 34 of

[2] I omit Lithuania because it officially adopted the Euro as its national currency in 2015 and has since denominated all its debt in Euros. I also do not include China and India since both countries's debt is almost entirely denominated in their domestic currencies. By amount issued, the FC share of China and India's sovereign debt is only 1.50% and 0.19%, respectively. Furthermore, India only started issuing non-rupee-denominated sovereign bonds in June 2019.

[3] Schwert (2017) finds that municipal bonds pay an oversized risk premium for default risk relative to comparable bonds at the national level.

[4] I filter out all municipal bonds, bonds issued from to finance local projects, and bonds issued by state-owned companies. I consider a bond to be from a state-owned company if the issuer name contains the words 'Ltd.' or 'Corp.'

Country	Weighted		Unweighted	
	DC	FC	DC	FC
Angola	3.2 years	10.5 years	2.1 years	5.1 years
Argentina	4.9 years	11.9 years	3.1 years	7.7 years
Brazil	6.2 years	15.9 years	2.7 years	10.2 years
Egypt	1.5 years	4.6 years	1.5 years	3.9 years
Hungary	4.4 years	9.5 years	2.2 years	7.4 years
Indonesia	8.5 years	11.3 years	3.3 years	5.9 years
Jamaica	8.8 years	6.1 years	6.4 years	7.9 years
Jordan	3.7 years	6.8 years	3.3 years	7.0 years
Malaysia	10.1 years	3.0 years	3.1 years	2.2 years
Mexico	3.8 years	18.3 years	3.0 years	11.7 years
Philippines	5.2 years	14.9 years	2.5 years	12.1 years
Poland	5.6 years	11.6 years	2.3 years	11.5 years
Romania	4.8 years	10.2 years	1.7 years	8.6 years
Russia	6.3 years	17.5 years	5.6 years	11.4 years
Türkiye	3.5 years	7.5 years	3.0 years	6.0 years
Ukraine	5.3 years	7.0 years	3.2 years	4.1 years
Venezuela	2.7 years	17.2 years	1.7 years	15.8 years
Average	5.2 years	10.8 years	3.0 years	8.1 years
Median	4.9 years	10.5 years	3.0 years	7.7 years
Standard Deviation	2.3 years	4.7 years	1.5 years	3.6 years

Notes: Country-level statistics (rows 1–17) are computed across bond issuances within their respective country. Moments (rows 18–20) are calculated across countries.

Table 2: Average Maturity of External Sovereign Debt by Currency

the 35 years across my sample.[5]

Lastly, I present the distribution of maturities of domestic and foreign currency debt across all bonds in Figure 2. While foreign currency debt of shorter maturity (less than 3 years) and domestic currency debt of longer maturity (greater than 10 years) do get issued by countries, the overwhelming majority of long-term debt is denominated in foreign currency.

II.C Summary

In summary, I use microdata on sovereign bond issuance to robustly show that among emerging market economies, sovereign debt denominated in a country's domestic currency tends to be of much shorter maturity than its debt denominated in a foreign currency. The consistency of this stylized fact across both time and countries suggests that this is a fundamental feature of sovereign debt markets, and that sovereigns do consider both currency and maturity

[5] In 1991, the average maturity of domestic and foreign currency debt was 11.6 and 9.6 years, respectively.

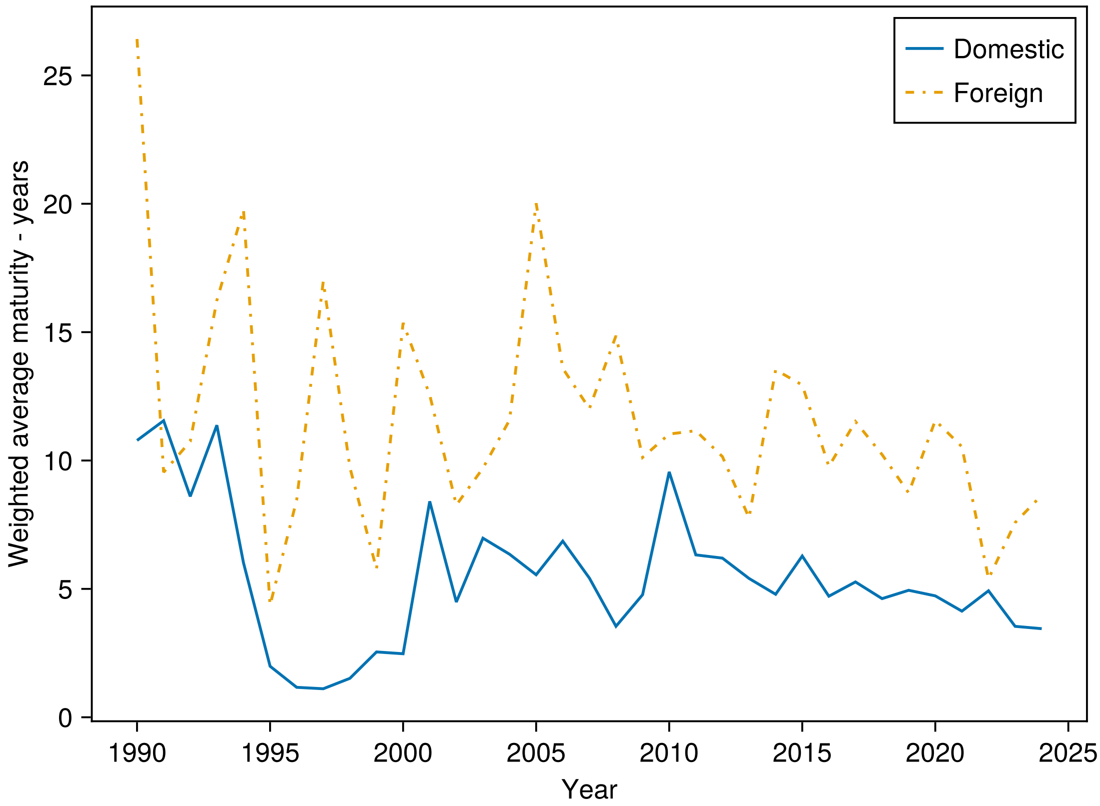


Figure 1: Time Series of Weighted Average Maturity by Currency

margins jointly when making their issuance decisions.

III Model

In this section, I present a dynamic, small open economy model of defaultable debt that includes bonds with different maturities and currency denomination. There are two types of agents. Firstly, there is a benevolent sovereign borrower who cannot commit to repaying its debts in future periods, nor its future choices over borrowing and monetary policy. Secondly, there is a unit-mass of perfectly competitive and risk-neutral international investors, and they are the sovereign's only source of financing.

III.A Environment

The sovereign is subject to two exogenous shocks: its endowment ($\mathcal{Y}_t$) and the real exchange rate ($\mathcal{E}_t$). I define $\mathcal{E}_t$ as the price of foreign currency in units of domestic currency.[6] Both shocks follow the following process:

$$\begin{pmatrix} \log(\mathcal{Y}_t) \\ \log(\mathcal{E}_t) \end{pmatrix} = \begin{pmatrix} \rho_y & 0 \\ 0 & \rho_e \end{pmatrix} \begin{pmatrix} \log(\mathcal{Y}_{t-1}) \\ \log(\mathcal{E}_{t-1}) \end{pmatrix} + \begin{pmatrix} \varepsilon_t^y \\ \varepsilon_t^e \end{pmatrix} \quad \text{where} \quad \begin{pmatrix} \varepsilon_t^y \\ \varepsilon_t^e \end{pmatrix} \sim N\left(0, \begin{pmatrix} \sigma_y^2 & \rho_{y,e}\sigma_y\sigma_e \\ \rho_{y,e}\sigma_y\sigma_e & \sigma_e^2 \end{pmatrix}\right).$$

[6] $\mathcal{E}_t$ increasing corresponds to the domestic currency depreciating.

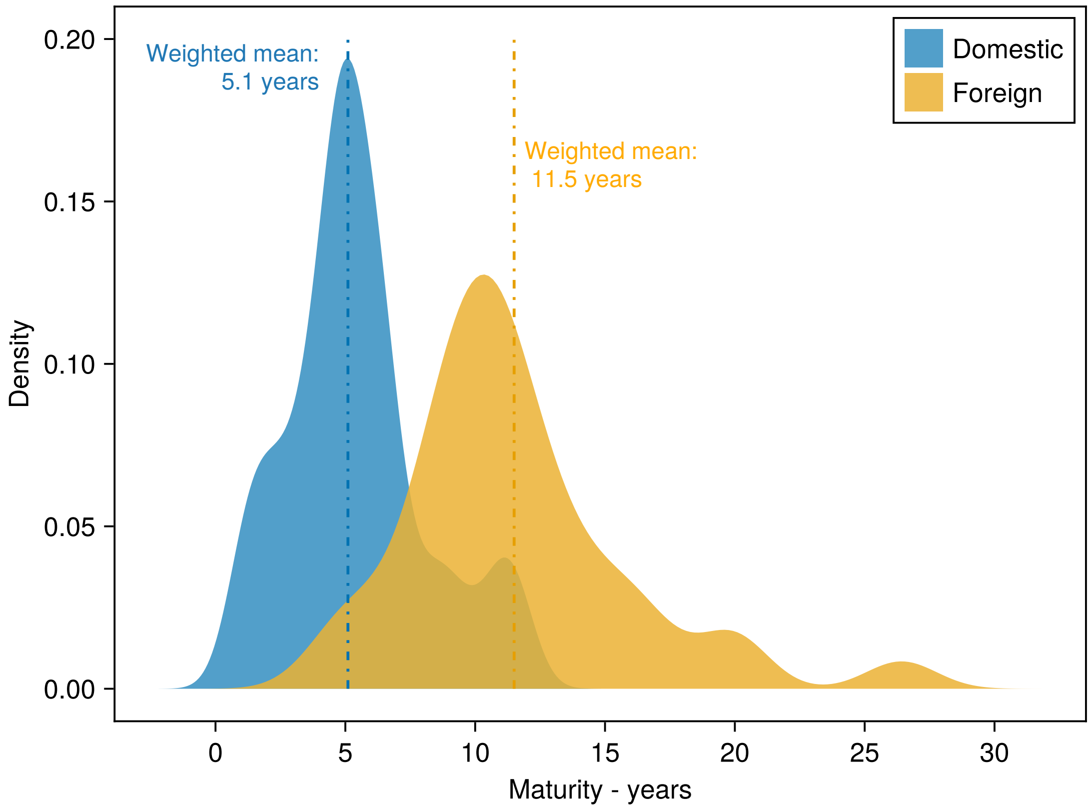


Figure 2: Distribution of Maturity by Currency

ρ_y and ρ_e are the persistence parameters of the endowment and real exchange rate respectively, while σ_y and σ_e denote the volatility of the two shocks. Finally, $\rho_{y,e}$ is the correlation between the two shocks, which is typically negative for emerging market economies.[7]

III.B Sovereign Borrower

As is standard in the literature, I focus on Markov-perfect equilibria and represent the sovereign's infinite-horizon decision problem as a recursive dynamic programming problem.

Every period, the sovereign observes the realized value of its endowment and real exchange rate. It then computes the the value of repaying all its debt obligations and defaulting on them, and chooses the option that provides it the most value. For notational convenience, $\mathbb{B}_t = (\{b_t^{SD}, b_t^{SF}, b_t^{LD}, b_t^{LF}\})$ denotes the vector of period t debt obligations for each type of bond, and $\mathbb{X}_t = (\mathcal{E}_t, \mathcal{Y}_t)$ denotes the vector of all exogenous state variables at time t.

The sovereign's value function is given by:

$$V(\mathbb{B}_t, \mathbb{X}_t) = \max_{\{D,R\}} \left\{ V^D(\mathbb{X}_t), V^R(\mathbb{B}_t, \mathbb{X}_t) \right\}. \tag{1}$$

[7] I present a stationary version of the model where the price level and nominal value of domestic currency debt are detrended by the previous period's price level.

I define the sovereign's policy function for defaulting with the indicator function:

$$d(\mathbb{B}_t, \mathbb{X}_t) = \mathbb{1}\Big\{V^R(\mathbb{B}_t, \mathbb{X}_t) < V^D(\mathbb{X}_t)\Big\}. \tag{2}$$

III.B.1 Value of Defaulting

If the sovereign defaults, then all its debt obligations are permanently erased from its resource constraint.[8] However, defaulting comes at two costs. Firstly, the sovereign will suffer output costs given by $h(\mathcal{Y}_t.)$ Secondly, the sovereign will be excluded from international financial markets and will be able to borrow from international investors. It will only regain access with i.i.d. probability θ. Once the sovereign regains access to financial markets, it does so with zero outstanding debt.

Together, the value of defaulting is given by:

$$V^D(\mathbb{X}_t) = u(h(\mathcal{Y}_t)) + \mathbb{E}_{\mathbb{X}_{t+1}|\mathbb{X}_t}\Big[\theta V(\mathbf{0}, \mathbb{X}_{t+1}) + (1-\theta)V^D(\mathbb{X}_{t+1})\Big]. \tag{3}$$

III.B.2 Value of Repaying

The sovereign's value of repaying its debt obligations is given as follows:

$$V^R(\mathbb{B}_t, \mathbb{X}_t) = \max_{\{\mathbb{B}_{t+1}, \Pi_t\}}\Big\{u(C_t) - l(\Pi_t - \Pi^*) + \beta \mathbb{E}_{\mathbb{X}_{t+1}|\mathbb{X}_t}\left[V(\mathbb{B}_{t+1}, \mathbb{X}_t)\right]\Big\} \tag{4}$$

subject to the resource constraint (in domestic currency):

$$\begin{aligned} C_t + \mathcal{E}_t\Big[\kappa^S b_t^{SF} + \kappa^L b_t^{LF}\Big] + \frac{\kappa^S b_t^{SD} + \kappa^L b_t^{LD}}{\Pi_t} &= q^{SD}(\mathbb{B}_{t+1}, \mathbb{X}_t) b_{t+1}^{SD} + q^{LD}(\mathbb{B}_{t+1}, \mathbb{X}_t)\left[b_{t+1}^{LD} - (1-\delta)\frac{b_t^{LD}}{\Pi_t}\right] \\ &\quad + \mathcal{E}_t\Big[q^{SF}(\mathbb{B}_{t+1}, \mathbb{X}_t) b_{t+1}^{SF} + q^{LF}(\mathbb{B}_{t+1}, \mathbb{X}_t)\Big[b_{t+1}^{LF} - (1-\delta) b_t^{LF}\Big]\Big] + \mathcal{Y}_t \end{aligned} \tag{5}$$

The sovereign has time separable preferences over consumption, C_t, and gross inflation Π_t, and discounts the future at the constant rate $\beta \in (0,1)$. As is standard, $u : \mathbb{R}_+ \to \mathbb{R}$ is strictly increasing and concave. To capture the distortional real effects of inflation, I assume that the sovereign suffers disutility from inflation, $l(\Pi_t - \Pi^*)$, where Π^* is the sovereign's target inflation rate and $l : \mathbb{R}_+ \to \mathbb{R}$ is strictly increasing and convex.[9]

To finance consumption and honour its debt obligations, the sovereign can use a combination of (i) inflation to dilute the real cost of its debts denominated in its domestic currency, and (ii) issuing new debt. The sovereign can issue four types of bonds - short-term domestic currency (b_{t+1}^{SD}) and foreign currency (b_{t+1}^{SF}) bonds, and long-term domestic currency (b_{t+1}^{LD}) bonds and foreign currency (b_{t+1}^{LF}) bonds. Both short-term contracts specify prices q^{SD} and q^{SF}, and respective face values b_{t+1}^{SD} and b_{t+1}^{SF}, such that the sovereign receives $q^{SD} b_{t+1}^{SD}$ and $\mathcal{E}_t q^{SF} b_{t+1}^{SF}$ in domestic currency today, and pays $\frac{b_{t+1}^{SD}}{\Pi_{t+1}}$ and $\mathcal{E}_{t+1} b_{t+1}^{SF}$ in domestic currency the next period (conditional on not defaulting).

[8] I do not allow the sovereign to selectively default on only some of its debt obligations.

[9] The economy I present in the main text is stationary as I de-trend all domestic currency variables by dividing it by the previous period's price level.

I model each bond's maturity in the same manner as Chatterjee and Eyigungor (2012), where for each unit of debt, fraction $\delta \in (0,1]$ matures and a coupon of κ is paid. Short-term debt matures in 1 period and corresponds to $\delta = 1$. The real value of debt denominated in the sovereign's domestic currency can be altered via inflation, whereas the real value of foreign currency bonds is exogenous to the sovereign and increases with $\mathcal{E}_t$.

III.C Foreign Investors

Investors are risk-neutral and perfectly competitive and can access a riskless security that yields a constant gross interest rate of R^*. Hence, investors break even in expectation, yielding the following pricing functions for each type of bond:

$$q^{SF}(\mathbb{B}_{t+1}, \mathbb{X}_t) = \frac{1}{R^*} \mathbb{E}_{\mathbb{X}_{t+1}|\mathbb{X}_t} \left[d(\mathbb{B}_{t+1}, \mathbb{X}_{t+1}) \times \kappa^S \right], \tag{6}$$

$$q^{LF}(\mathbb{B}_{t+1}, \mathbb{X}_t) = \frac{1}{R^*} \mathbb{E}_{\mathbb{X}_{t+1}|\mathbb{X}_t} \left[d(\mathbb{B}_{t+1}, \mathbb{X}_{t+1}) \times \left[\kappa^L + (1-\delta) q^{LF}(\mathbb{B}_{t+2}, \mathbb{X}_{t+1}) \right] \right], \tag{7}$$

$$q^{SD}(\mathbb{B}_{t+1}, \mathbb{X}_t) = \frac{1}{R^*} \mathbb{E}_{\mathbb{X}_{t+1}|\mathbb{X}_t} \left[d(\mathbb{B}_{t+1}, \mathbb{X}_{t+1}) \times \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} \times \frac{1}{\Pi_{t+1}} \times \kappa^S \right], \tag{8}$$

$$q^{LD}(\mathbb{B}_{t+1}, \mathbb{X}_t) = \frac{1}{R^*} \mathbb{E}_{\mathbb{X}_{t+1}|\mathbb{X}_t} \left[d(\mathbb{B}_{t+1}, \mathbb{X}_{t+1}) \times \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} \times \frac{1}{\Pi_{t+1}} \times \left[\kappa^L + (1-\delta) q^{LD}(\mathbb{B}_{t+2}, \mathbb{X}_{t+1}) \right] \right]. \tag{9}$$

For lenders, all bonds are subject to default risk as given by the sovereign's default policy function $d(\mathbb{B}_{t+1}, \mathbb{X}_{t+1})$. Moreover, bonds denominated in the sovereign's domestic currency entail two additional sources of risk for investors relative to their foreign currency counterparts. Firstly, holding domestic curency bonds exposes investors to fluctuations in the real exchange rate. Secondly, since the sovereign can manipuate the real value of its domestic currency debt via inflation, lenders also need to account for expected inflation in the next period.

Meanwhile, since long-term bonds are repaid to investors over multiple periods, holding them exposes investors to an additional source of risk relative to short-term bonds (holding denominated currency constant), which is dilution risk. Due to the sovereign's inability to commit to future borrowing (and monetary policy), investors are concerned that the sovereign may issue new debt in the future, which would dilute the real value of their existing debt holdings.

All together, the short-term foreign currency bond only needs to compensate investors for default risk, while on the other extreme, the long-term, domestic currency bond needs to compensate investors for risks arising from default, exchange rate fluctuations, inflation, and dilution.

III.D Equilibrium

Definition 1 (Markov Perfect Equilibrium)**.** *A Markov-perfect recursive equilibrium for this economy consists of a set of:*

(i) value functions $\left\{ V(\mathbb{B}_t, \mathbb{X}_t), V^D(\mathbb{X}_t), V^R(\mathbb{B}_t, \mathbb{X}_t) \right\}$,

(ii) pricing functions $\left\{ q^{SF}(\mathbb{B}_{t+1}, \mathbb{X}_t), q^{LF}(\mathbb{B}_{t+1}, \mathbb{X}_t), q^{SD}(\mathbb{B}_{t+1}, \mathbb{X}_t), q^{LD}(\mathbb{B}_{t+1}, \mathbb{X}_t) \right\}$*, and*

(iii) policy functions $\left\{\hat{b}^{LD}(\mathbb{B}_t,\mathbb{X}_t),\hat{b}^{LF}(\mathbb{B}_t,\mathbb{X}_t),\hat{b}^{SD}(\mathbb{B}_t,\mathbb{X}_t),\hat{b}^{SF}(\mathbb{B}_t,\mathbb{X}_t),\hat{\Pi}_{t+1}(\mathbb{B}_t,\mathbb{X}_t)\right\}$

such that the following conditions hold:

1. *Taking the bond price functions as given, the sovereign's policy functions and value functions solve the sovereign's dynamic programming problem, and*

2. *The bond price functions* $q^{SF}(\mathbb{B}_{t+1},\mathbb{X}_t), q^{LF}(\mathbb{B}_{t+1},\mathbb{X}_t), q^{SD}(\mathbb{B}_{t+1},\mathbb{X}_t), q^{LD}(\mathbb{B}_{t+1},\mathbb{X}_t)$ *satisfy* (6), (7), (8), *and* (9) *respectively.*

IV Optimality Conditions

In this section, I discuss the economic trade-offs associated with the sovereign's optimal debt portfolio. Ultimately, I argue that the short-term, foreign currency bond offers the most disciplining benefits out of all four bonds, but at the cost of having no hedging benefits. Meanwhile, a bond being longer-term or being denominated in domestic currency offers hedging benefits, but at the cost of having weaker disciplining benefits. This culminates in the long-term domestic currency bond having the most hedging benefits, but at the cost of the worst incentive costs.

This section is organized as follows. I first present the inter-temporal optimality condition of each bond corresponding to the full problem. Then, in order to show the trade-offs between each bond more transparently, I use the short-term, foreign currency bond as a baseline since it is the simplest and most understood, and I vary one margin at a time. The first margin I vary is currency denomination, which I discuss in subsection IV.A. Then, I only consider foreign currency bonds and vary the maturity of the bond in subsection IV.B. Finally, I vary both margins simultaneously by comparing the short-term, foreign currency bond against the long-term, domestic currency bond in subsection IV.C. To ease the notational burden, I set $\kappa^S = \kappa^L = 1$ without loss of generality.

Let $R(\mathbb{B}_t)$ denote the set of $\{\mathcal{E}_t,\mathcal{Y}_t\}$ realizations for which the sovereign chooses to repay their debts:

$$R(\mathbb{B}_t) = \left\{\mathcal{E}_t,\mathcal{Y}_t : V^R(\mathbb{B}_t,\mathbb{X}_t) \geq V^D(\mathbb{X}_t)\right\} \tag{10}$$

Assuming repayment, the first order necessary conditions for the sovereign's optimal portfolio choice are given by the following four equations, which correspond to the first-order conditions of (4) with respect to each bond's issuance decision.

$$u_C(C_t)\left[q^{SF} + \frac{\partial q^{SF}}{\partial b^{SF}_{t+1}} b^{SF}_{t+1} + \frac{\partial q^{LF}}{\partial b^{SF}_{t+1}}\left[b^{LF}_{t+1} - (1-\delta)b^{LF}_{t+1}\right] + \frac{\partial q^{SD}}{\partial b^{SF}_{t+1}} b^{SD}_{t+1} + \frac{\partial q^{LD}}{\partial b^{SF}_{t+1}}\left[b^{LD}_{t+1} - (1-\delta)\frac{b^{LD}_t}{\Pi_t}\right]\right] \tag{11}$$

$$= \beta \int_{R_{t+1}} u_C(C_{t+1})\mathcal{E}_{t+1} f(\mathbb{X}_t,\mathbb{X}_{t+1}) d\mathbb{X}_{t+1}$$

$$u_C(C_t)\left[q^{SD}+\frac{\partial q^{SF}}{\partial b^{SD}_{t+1}}b^{SF}_{t+1}+\frac{\partial q^{LF}}{\partial b^{SD}_{t+1}}\left[b^{LF}_{t+1}-(1-\delta)b^{LF}_t\right]+\frac{\partial q^{SD}}{\partial b^{SD}_{t+1}}b^{SD}_{t+1}+\frac{\partial q^{LD}}{\partial b^{SD}_{t+1}}\left[b^{LD}_{t+1}-(1-\delta)\frac{b^{LD}_t}{\Pi_t}\right]\right] \tag{12}$$
$$=\beta\int_{R_{t+1}}u_C(C_{t+1})\frac{1}{\Pi_{t+1}}f(\mathbb{X}_t,\mathbb{X}_{t+1})d\mathbb{X}_{t+1}$$

$$u_C(C_t)\left[q^{LF}+\frac{\partial q^{SF}}{\partial b^{LF}_{t+1}}b^{SF}_{t+1}+\frac{\partial q^{LF}}{\partial b^{LF}_{t+1}}\left[b^{LF}_{t+1}-(1-\delta)b^{LF}_{t+1}\right]+\frac{\partial q^{SD}}{\partial b^{LF}_{t+1}}b^{SD}_{t+1}+\frac{\partial q^{LD}}{\partial b^{LF}_{t+1}}\left[b^{LD}_{t+1}-(1-\delta)\frac{b^{LD}_t}{\Pi_t}\right]\right] \tag{13}$$
$$=\beta\int_{R_{t+1}}u_C(C_{t+1})\left[1+(1-\delta)q^{LF}_{t+1}\right]\mathcal{E}_{t+1}f(\mathbb{X}_t,\mathbb{X}_{t+1})d\mathbb{X}_{t+1}$$

$$u_C(C_t)\left[q^{LD}+\frac{\partial q^{SF}}{\partial b^{SD}_{t+1}}b^{SF}_{t+1}+\frac{\partial q^{LF}}{\partial b^{SD}_{t+1}}\left[b^{LF}_{t+1}-(1-\delta)b^{LF}_t\right]+\frac{\partial q^{SD}}{\partial b^{SD}_{t+1}}b^{SD}_{t+1}+\frac{\partial q^{LD}}{\partial b^{SD}_{t+1}}\left[b^{LD}_{t+1}-(1-\delta)\frac{b^{LD}_t}{\Pi_t}\right]\right] \tag{14}$$
$$=\beta\int_{R_{t+1}}u_C(C_{t+1})\times\frac{1}{\Pi_{t+1}}\times\left[1+(1-\delta)q^{LD}_{t+1}\right]f(\mathbb{X}_t,\mathbb{X}_{t+1})d\mathbb{X}_{t+1}$$

The left-hand side of each equation corresponds to the marginal benefit of issuing an additional unit of that bond, while the right-hand side corresponds to the marginal cost of issuing an additional unit of that bond. The marginal benefit is given by the marginal utility of consumption multiplied by the bond's price and its sensitivity to changes in issuance. The terms in the square bracket capture the marginal revenue from issuing an additional unit of that bond, which includes the direct effect of the bond's price and the indirect effect of the bond's price on all other bond prices. Since the incentive to default and inflate next period is increasing with all debt issuance, all bond prices are decreasing with respect to issuance. Meanwhile, the marginal cost is given by the discounted expected marginal utility of consumption in the next period, adjusted for inflation and any future bond prices.

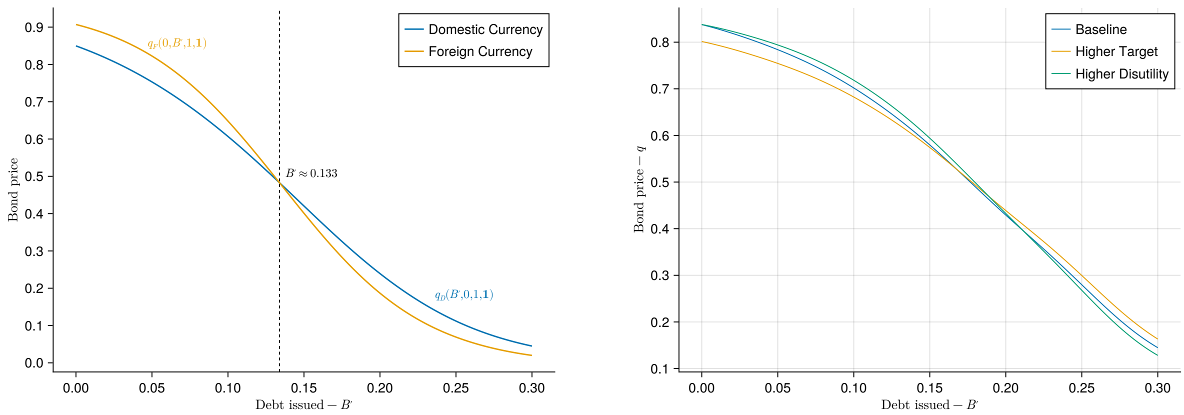
IV.A Margin 1: Currency

In this subsection, I highlight the economic trade-offs between domestic and foreign currency debt.

IV.A.1 Domestic Currency's Incentive Costs

I first argue that foregin currency debt has discipilning benefits for the sovererign relative to domestic currency debt (hodling maturity constant). This can be seen in Figure 3a, where I show the equilibrium pricing functions for domestic and foreign currency debt as a function of the corresponding amount of debt issued while holding the other bond constant at zero. There are two noteworthy aspects.

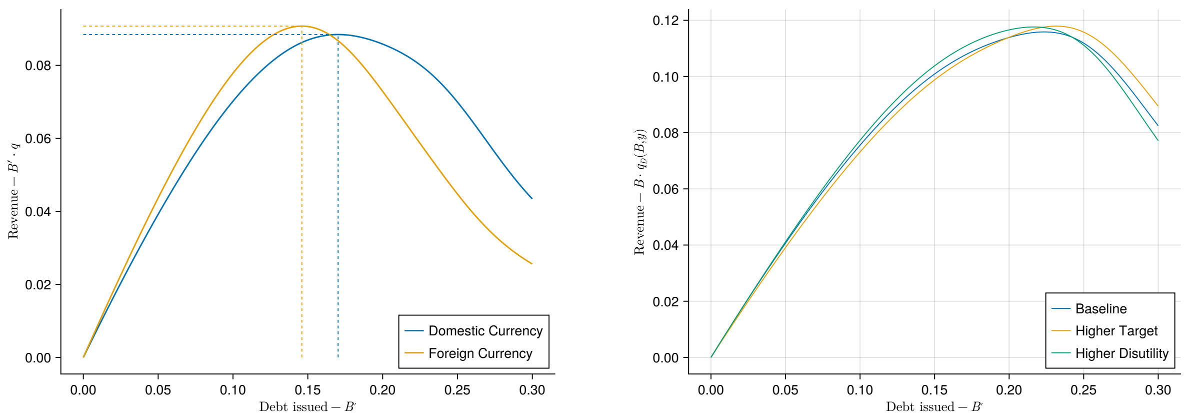
Firstly, as long as the sovereign's target inflation rate is strictly positive, then investors will anticipate that that holding any amount of domestic currency debt will result in its real value



(a) Pricing Functions: Currency Choice

(b) Comparative Statics: Currency Choice

Figure 3: Pricing Functions of Domestic and Foreign Currency Debt



(a) Revenue Curves: Currency Choice

(b) Comparative Statics: Currency Choice

Figure 4: Revenue Curves of Domestic and Foreign Currency Debt

being eroded by at least the target inflation rate next period. Meanwhile, the foreign currency bond's real value is not eroded by domestic inflation.

Secondly, the foreign currency bond pricing function is steeper than the domestic currency bond. As reflected in the decreasing slope of the pricing functions, the sovereign's incentive to default rises with the amount of debt issued, irrespective of currency denomination. However, default risk rises more quickly with respect to foreign currency than domestic currency debt. This is because as long as the sovereign targets a strictly positive net inflation rate, then can costly (from a utility perspective) reduce its domestic currency burden, which translates to the sovereign being able to owe a higher amount of domestic currency debt for which it would find it optimal to repay in equilibrium. Thus, while issuing mroe domestic currency debt increases the sovereign's incentive to default and engage in costly inflation, these incentives costs grow slower with domestic currency debt issuance than foreign currency debt issuance, and the initial premium the sovereign pays from the target inflation rate overtakes the foreign currency bond's higher default risk at $B' = 0.133$.

Figure 3b shows the equilibrium domestic currency pricing function for different values of the sovereign's target inflation rate and inflation disutility parameter. When the target rate increases, the inital wedge grows, while a high inflation disutility parameter renders the pricing function initially less steep. This is because the more disutility the sovereign incurs from inflation, the less domestic currency debt it can hold before it would find it optimal to default.

The relative incentive benefits of foreign currency debt over domestic currency debt can further be seen in the revenue curves in Figure 4a. I vary the amount of domestic and foreign currency debt issued along the x-axis (while holding the other bond constant at zero), and plot the corresponding revenue generated from issuing that debt along the y-axis. Revenue initially increases with debt issuance. However, due to the decreasing slope of the pricing function, the revenue eventually peaks and then decreases with further debt issuance since the negative price effects dominate. Not only can the sovereign raise more revenue from issuing foreign currency debt than domestic currency debt, but it is also able to accomplish that higher level of reveunue with a lower amount of debt issued and thus owed next period.

Note that the revenue functions and pricing functions simply reflect the sovereign's choice set for a given state of the world. In other words, it reflects what options the sovereign can choose among, but which portfolio it ultimately chooses from that menu in equilibrium is further determined by the sovereign's debt burden.

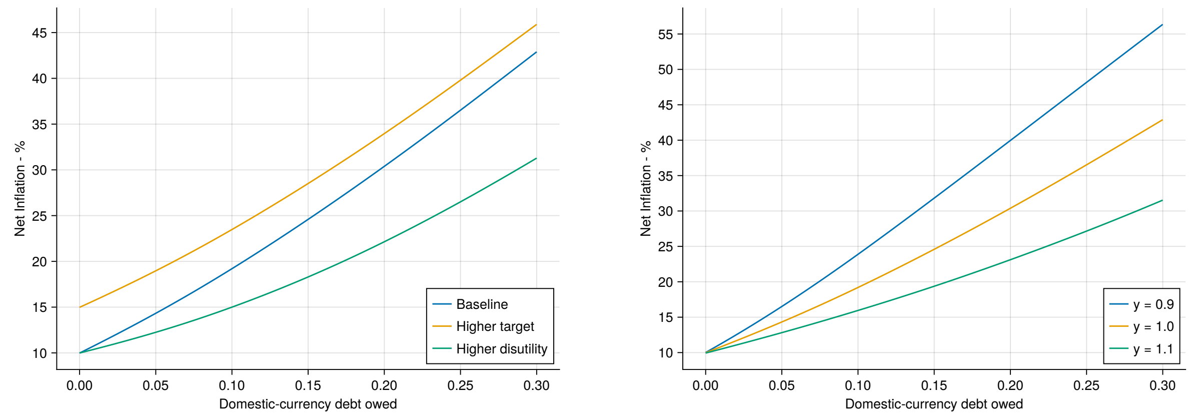
Lastly, the role of the sovereign's target inflation rate and inflation disutility parameter on revenue generation are shown in Figure 4b. When the target inflation rate increases, the sovereign needs to issue more domestic currency debt to attain its maximum, while increasing the inflation disutility parameter lowers the required amount of debt issuance. Meanwhile, how varying the two parameters affects the maximum revenue further depends on the sovereign's value function for defaulting, and especially the output costs from defaulting.

In this example, the sovereign's output costs from defaulting are relatively low, so default risk increases faster with debt issued, resulting in the flatter pricing function from the higher inflation target dominating the initial wedge. However, if the sovereign's output costs from defaulting were higher, the default risk would grow more slowly, and a higher target inflation rate may result in a lower maximized revenue.

IV.A.2 Domestic Currency's Hedging Benefits

I now show that on the other hand, domestic currency debt provides the sovereign with hedging benefits. The marginal cost of foreign and domestic currency debt is given by the right hand side of (11) and (12). This is where the real exchange rate being negatively correlated with real endowment becomes crucial. In such a world, the sovereign's marginal utility of consuimption would covary positively with the real cost of repaying foreign currency debt. In other words, repaying foreign currency debt is more costly when the sovereign is in a bad state with low endowment.

Meanwhile, domestic currency debt would have insurance properties if the inverse of next period's inflation co-moved negatively with the marginal utility of consumption. In a currency-choice problem where all debt is short-term, the sovereign's static optimality condi-



(a) Inflation policy function

(b) Inflation policy function comparative statics

Figure 5: Policy function for inflation

tion for inflation is:

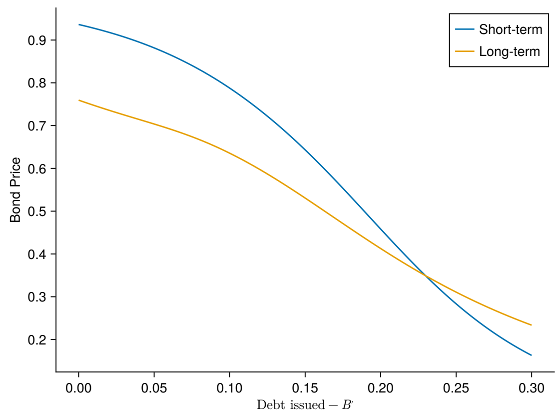
$$u_C(C_t)\left[\frac{1}{\Pi_t^2}\right]\left[b_t^{SD}\right] = l_\Pi(\Pi_t - \Pi^*). \tag{15}$$

I present the equilibrium policy function for inflation as the amount of domestic currency debt owed increases in Figure 5a. As long as any strictly positive amount of domestic currency debt is owed, then the sovereign is able to use inflation to relax its real resource constraint via diluting the real cost of repaying its domestic currency debt, thereby enjoying higher consumption. Optimal inflation equates the marginal utility gain from higher consumption with the marginal disutility from deviating from the target inflation rate.

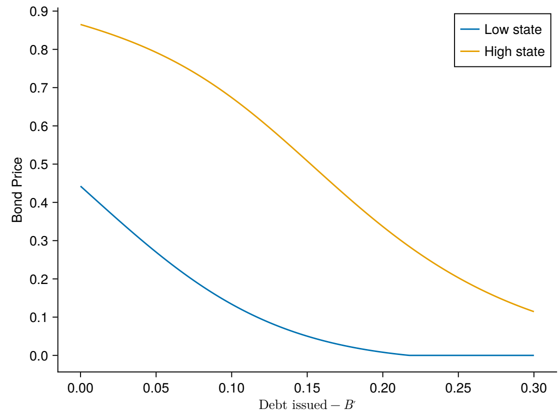
In order to understand the economic role of the sovereign's target inflation rate, Π^*, and disutility parameter, ψ, I plot the different inflation policy functions across different parameter values (holding the state constant) in Figure 5a. When the sovereign's target inflation rate is higher, then the sovereign is able set a higher level of inflation without incurring any disutility. However, note that the policy function does not shift linearly with the change in the target inflation rate as for $b_t^{SD} > 0$. This is because as the target inflation rate increases, the marginal utility gain from higher consumption increases more slowly with domestic currency debt owed, resulting in a steeper policy function.

If the sovereign's disutility parameter is higher, optimal inflation at $b_t^{SD} = 0$ is unchanged since the sovereign is not able to use inflation to relax its real resource constraint. However, as the amount of domestic currency debt owed increases, the marginal disutility from inflation increases faster, resulting in a flatter policy function with respect to domestic currency debt obligations.

Finally, Figure 5b shows that holding the amount of domestic debt constant, optimal inflation is decreasing with respect to endowment. If the sovereign is suffering a recession where GDP is low, then the its marginal utility of consumption is higher, and the marginal benefit of relaxing the resource constraint via inflation is larger, resulting in higher inflation.

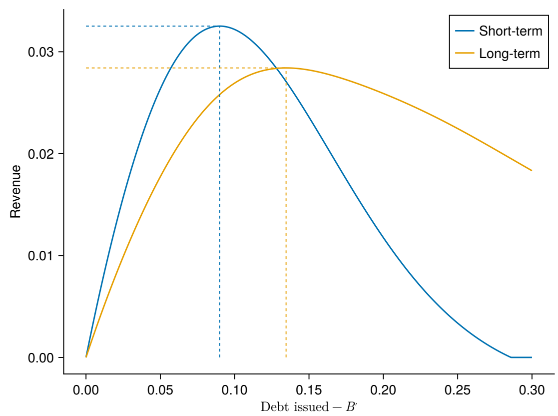


(a) Pricing Functions: Maturity Choice

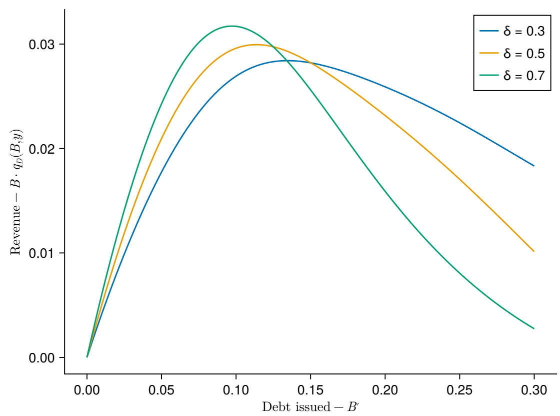


(b) Comparative Statics: Maturity Choice

Figure 6: Pricing Functions of Short and Long Term Debt



(a) Revenue Curves: Maturity Choice



(b) Comparative Statics: Maturity Choice

Figure 7: Revenue Curves of Short and Long Term Debt

IV.B Margin 2: Maturity

Now, I highlight the hedging-incentive trade-offs that arise when the sovereign chooses between short-term and long-term debt. Since the margin of adjustment is now maturity, the analysis in this subsection assumes that all debt is denominated in foreign currency, and that the real exchange rate is constant at unity.

IV.B.1 Long Term Debt's Incentive Costs

Issuing long-term debt is costly from a disciplining perspective because the sovereign lacks commitment in its future actions. While the sovereign may choose a b_{t+1}^{LF} such that default risk next period is low, it cannot promise that it will will not choose a b_{t+2}^{LF} that increases default risk in the subsequent period. This dilutes the market value of the unmatured long-term debt.

Forward-looking investors anticipate this dilutionary incentive and factor it into their pricing, resulting in the pricing functions in Figure 6a. This translates to the revenue curves in

Figure 7. Figure 7a displays the revenue curves for the short-term and long-term debt separately, showing that short-term debt is both able to generate higher revenue at lower levels of debt issuance compared to long-term debt. I further plot the equilibrium revenue curves as I vary the maturity of the long-term bond in Figure 7b. As δ decreases (or the maturity of the long-term bond increases), the more pronounced the relative incentive disadvantage of long-term debt over short-term debt.

IV.B.2 Long Term Debt's Hedging Benefits

While long-term debt is costly relatively to short-term debt, it provides the sovereign hedging benefits. This can be seen by comparing the right hand side of (11) and (13) - the real cost of repaying the short-term bond is invariant to the sovereign's state of the world, while the real cost of repaying the long-term bond would covary negatively with the sovereign's marginal utility of consumption if q^{LF} decreased with $\mathcal{Y}_t$.

This is indeed the case, as shown in Figure 6b, which shows q^{LF} for a low-endowment and high-endowment state. In bad states of the world, the market value of the unmatured long-term debt is lower as future default risk is heightened. This means that conditional on repayment, the cost of serving the long-term debt is lower in bad states of the world.

IV.C Both Margins

Lastly, I now compare the short-term, foreign currency bond against the long-term, domestic currency bond. In the full problem, the sovereign's intra-optimality condition for inflation is:

$$u_C(C_t)\left[\frac{1}{\Pi_t^2}\right]\left[b_t^{LD} + b_t^{SD} + q^{LD}(1-\delta)b_t^{LD}\right] = l_\Pi(\Pi_t - \Pi^*). \tag{16}$$

There are two important differences between (16) and (15), which is the optimality condition for inflation when all debt is short-term. First, holding the amount of domestic currency debt constant, optimal inflation is increasing in the share of that debt that is long-term. In other words, one unit of long-term domestic debt increases optimal inflation more than one unit of short-term domestic debt. Second, holding all else constant, the optimal inflation is increasing with respect to the maturity of the long-term domestic currency bond.

These two forces only arise when both currency and maturity are examined simultaneously. When the domestic currency debt is long term, the sovereign can use inflation to reduce the real value of its debt over time. Inflation not only erodes the real value of the fraction that is due today, but also theunmatured fraction that is due in the future. The longer-term the domestic currency bond (the lower δ is), the greater the sovereign is able to use inflation to reduce its real value over time.

These two forces are shown in Figure 8, where I plot the optimal inflation rate while varing the share of domestic currency debt that is long-term (while holding the total amount of domestic currency debt constant). I then also vary the maturity of the long-term domestic currency bond relative to the short-term domestic currency bond. The longer-term the bond is, the greater the sovereign is incentivized to inflate to erode future debt obligations as well.

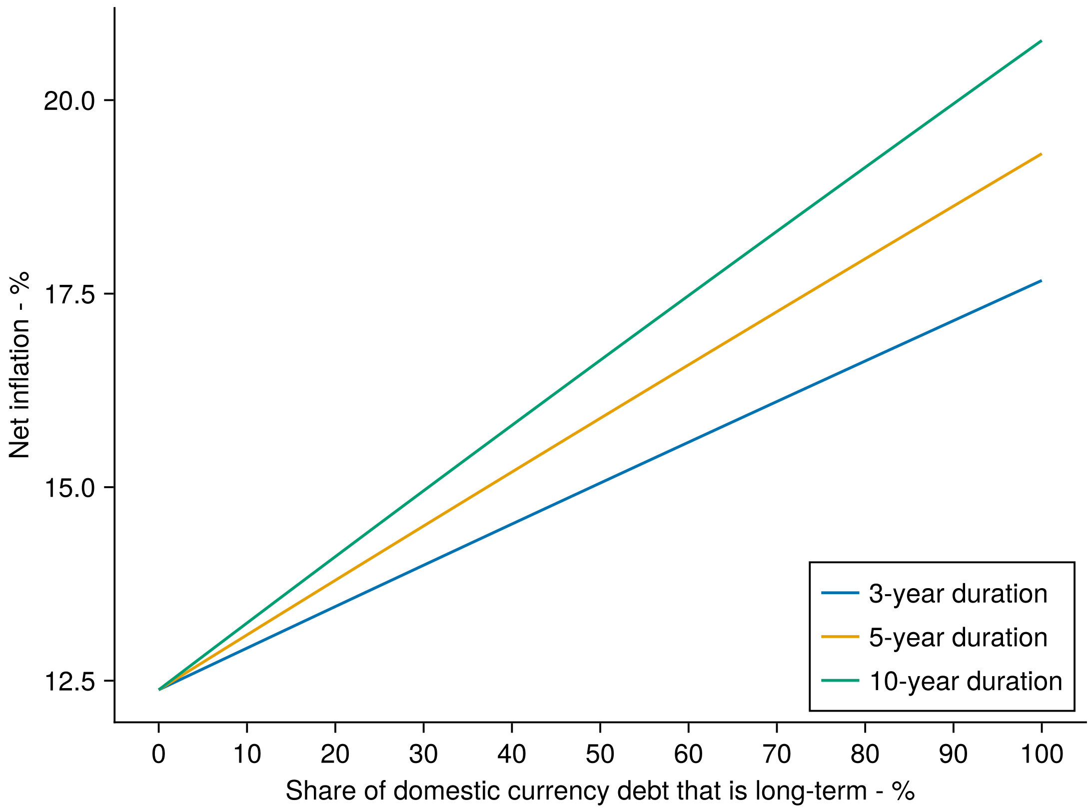


Figure 8: Maturity's effects on optimal inflation

Thus, issuing a unit of the long-term domestic currency bond increases investors' expectations of future inflation more than an equivalent unit of short-term domestic currency debt. When coupled with the aforementioned dilution risk present in all long-term debt as shown in subsection IV.B, they culminate in the long-term domestic currency bond having the worst incentive costs of all four bonds.

On the other hand, the individual insurance benefits of domestic currency and long-term debt also compound to give the long-term domestic currency bond the most hedging benefits of all four bonds. As the right hand side of (14) shows, in bad states of the world where the marginal utility of consumption is high, the real cost of repaying the long-term domestic currency bond decreases due to both inflation and the lower market value of the unmatured long-term domestic currency bond.

V Quantitative Analysis

I solve the model numerically via value function iteration to evaluate its quantitative predictions on the sovereign's dynamic portfolio choice of debt issuance.

As shown in Chatterjee and Eyigungor (2012), sovereign debt models with long-term debt are notoriously difficult to solve without some form of randomization. To facilitate convergence, I follow Mateos-Planas et al. (2026) by assuming that the sovereign is subject to additive

Type-1 (Gumbel) distributed taste shocks to its discrete default-repayment decision.[10] Hence, the sovereign's value function ex-ante of taste shocks is:

$$\begin{aligned} V^O(\mathbb{B}_t, \mathbb{X}_t) &= \mathbb{E}_{\varepsilon_t^D, \varepsilon_t^R}\left[V^D(\mathbb{X}_t) + \varepsilon_t^D, V^R(\mathbb{B}_t, \mathbb{X}_t + \varepsilon_t^R)\right] \\ &= \alpha \log\left[\exp\left(\frac{V^D(\mathbb{X}_t)}{\alpha}\right) + \exp\left(\frac{V^R(\mathbb{B}_t, \mathbb{X}_t)}{\alpha}\right)\right] \end{aligned} \tag{17}$$

This assumption replaces the sovereign's pure strategy for whether to repay or default with a mixed strategy, which smooths the bond pricing functions and yields a closed-form expression for the ex-ante probability of repayment (before observing the taste-shock realization):

$$P(d_t = 0|\mathbb{B}_t, \mathbb{X}_t) = \frac{\exp\left(\frac{V^R(\mathbb{B}_t, \mathbb{X}_t)}{\alpha}\right)}{\exp\left(\frac{V^D(\mathbb{X}_t)}{\alpha}\right) + \exp\left(\frac{V^R(\mathbb{B}_t, \mathbb{X}_t)}{\alpha}\right)} \tag{18}$$

Two further numerical challenges arise when solving the model. Firstly, the the state space is six-dimensional, rendering conventional discrete-choice grid based methods computationally infeasible due to the curse of dimensionality. Secondly, the state-space over which the policy functions for bond issuance are well-defined is irregular. To overcome these challenges, I approximate the equilibrium functions in my model via Gaussian process regression. I provide details of my numerical algorithm in Appendix A.

V.A Calibration

I discipline my model by calibrating it to the Turkish economy over the period 2002-2018. I begin in 2002,

I summarize parameter values that were selected directly in Table 3 and parameters that were selected by matching moments in Table 4.

One period in my model corresponds to 1 year. I impose the following functional form for sovereign's period utility function, which is separable in consumption and inflation:

$$u(C_t) - l(\Pi_t - \Pi^*) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{\psi}{2}(\Pi_t - \Pi^*)^2, \tag{19}$$

where σ is the sovereign's coefficient of relative risk aversion, ψ is the dis-utility of inflation, and Π^* is the inflation target. Following Chatterjee and Eyigungor (2012), I assume that the output costs of default are given by:

$$h(\mathcal{Y}_t) = \mathcal{Y}_t - \max\left\{0, \lambda_0 \mathcal{Y}_t + \lambda_1^2 \mathcal{Y}_t\right\}. \tag{20}$$

Following Mihalache (2020), I set the coupon of short-term and long-term debt to $\kappa^S = R^*$ and $\kappa^L = \delta + R^* - 1$, respectively. This has the convenient property of normalizing the risk-free price of both foreign currency bonds to 1, which facilitates easier comparison of bond prices across different maturities.[11]

VI Conclusion

[10] I do not assume that the sovereign is also subject to taste shocks to its portfolio choice or inflation.

[11] The risk-free price of a foreign currency bond with decay parameter δ is given by $\frac{\kappa}{\delta + R^* - 1}$.

Parameter	Description	Value	Source
σ	risk aversion	4	standard value
R^*	risk-free rate	1.04	1-year US Treasury yield
δ	perpetuity decay factor	0.09	10 year debt maturity
κ^S	ST coupon payments	1.04	Normalization
κ^L	LT coupon payments	0.13	Normalization
θ	re-entry probability	0.17	6-year exclusion
ρ_y	output persistence	0.882	data
σ_y	output volatility	0.020	data
ρ_e	real exchange rate persistence	0.944	data
σ_e	real exchange rate volatility	0.074	data
$\rho_{y,e}$	shock correlation	-0.402	data
α	taste shock variance	0.05	numerical convergence

Table 3: Parameters Selected Directly

Parameter	Description	Value	Target
β	discount factor		MSM
ψ	inflation dis-utility		MSM
Π^*	inflation target		MSM
λ_0	default cost - linear		MSM
λ_1	default cost - quadratic		MSM

Table 4: Parameters Selected By Matching Moments

References

Arslanalp, Serkan and Takahiro Tsuda, "Tracking Global Demand for Advanced Economy Sovereign Debt," *IMF Working Papers*, 2012, *12* (284), 1.

Chatterjee, Satyajit and Burcu Eyigungor, "Maturity, Indebtedness, and Default Risk," *American Economic Review*, May 2012, *102* (6), 2674–2699.

Gu, Grace Weishi and Zachary R. Stangebye, "Costly Information and Sovereign Risk," *International Economic Review*, November 2023, *64* (4), 1397–1429.

Gürkaynak, Refet S., Brian Sack, and Jonathan H. Wright, "The U.S. Treasury yield curve: 1961 to the present," *Journal of Monetary Economics*, November 2007, *54* (8), 2291–2304.

Mateos-Planas, Xavier, Sean McCrary, Jose-Vıctor Rıos-Rull, and Adrien Wicht, "The Generalized Euler Equation and the Bankruptcy-Sovereign Default Problem," Technical Report June 2026.

Mihalache, Gabriel, "Sovereign default resolution through maturity extension," *Journal of International Economics*, July 2020, *125*, 103326.

Ottonello, Pablo and Diego J. Perez, "The Currency Composition of Sovereign Debt," *American Economic Journal: Macroeconomics*, July 2019, *11* (3), 174–208.

Schwert, Michael, "Municipal Bond Liquidity and Default Risk," *The Journal of Finance*, August 2017, *72* (4), 1683–1722.

A Solution Method

I solve the model with value function iteration, where I approximate all equilibrium functions as Gaussian processes.

Due to the high dimensionality of the state space, discrete-choice methods quickly run into the curse of dimensionality, necessitating continuous methods. However, approximating the desired equilibrium functions with traditional sparse grid methods proved to be insufficient for two main reasons. Firstly, although considerably fewer than a standard tensor product grid, Smolyak's sparse grid method still requires a impractically large number of grid points. Due to the large number of control variables, multi-start optimization is required to portfolios that are only locally optimal, making solving the Bellman equation at each grid point particularly computationally expensive.

Secondly and most importantly, Smolyak grids inherently require surrendering control over the placement of grid points over a hypercube. This inflexibility is particularly fatal for accurate approximations of the policy functions because the domain over which they map to a unique maximizer is irregular. In points which correspond to defaulting in equilibrium, the sovereign is indifferent about their portfolio choice since it is going to default regardless of what portfolio it chooses. Due to the non-uniqueness of the value-maximizing portfolio at grid points which correspond to defaulting, the portfolio that the numerical optimizer is numerical noise.

Smolyak's method particularly struggles with this issue because it interpolates between points with Chebyshev polynomials which are global, meaning that the policies evaluated at the default points may contaminate the approximation of the policy functions even at points which correspond to repayment. Adaptive sparse grids are more robust to issue since the interpolant is constructed with linear hierarchical basis functions which are local. However, they will keep adding points in the default region until the maximum depth is reached since the policy functions are so noisy there. This quickly and needlessly renders the number of grid points upon which the costly maximization routine is used computationally impractical.

Gaussian process regression circumvents these issues by being grid-less, giving the user the flexibility to train the policy functions with points that are strategically placed only in the repayment region. This not only economizes the number of required points, but also leads to a more accurate and well-behaved approximation of the policy functions in region of the state space that matter.

I adapt my algorithm from Gu and Stangebye (2023).

1. **Initialization**

(a) I create a level $\mu = 3$ isotropic Smolyak sparse grid corresponding to piecewise linear approximation,[12] which yields 389 points in 6 dimensions. This places grid points at the edge of the hypercube, which mitigates Gaussian Process Regression's tendency to extrapolate poorly. I then add an additional 311 points via Bayesian Active Learning.

(b) I set my initial guess to correspond to the terminal period of a finite-horizon problem corresponding to a full debt buy-back of all unmatured long-term debt.
Set initial guesses:

$$V_T^D(\mathbb{X}_T) = u(h(\mathcal{Y}_T))$$
$$V_T^R(\mathbb{B}, \mathbb{X}) = \max_{\Pi_T} \{u(C_T) - l(\Pi_T - \Pi^*)\}$$

subject to:

$$C_T = \mathcal{Y}_T - \frac{\kappa^S b_T^{SD} + \kappa^L b_T^{LD}}{\Pi_T} - \mathcal{E}_T \left[\kappa_S b_T^{SF} + \kappa_L b_T^{LF}\right] - \overbrace{\mathcal{E}_T q_T^{LF}(1-\delta) b_T^{LF}}^{\text{unmatured LF buybck}} - \overbrace{q_T^{LD} \frac{1-\delta}{\Pi_T} b_T^{LD}}^{\text{unmatured LD buyback}}$$

where

$$q_T^{LF} = \frac{\kappa^L}{1 + 2r + \delta}$$

which is the fixed point to:

$$q^* = \frac{1}{1+r} \times \frac{1}{2} \times \left[\kappa^L + (1-\delta) q^*\right]$$

and $q_T^{LD}(\mathcal{E}_T)$ will be the numerical fixed point:

$$q^*(\mathcal{E}_T) = \frac{1}{1+r} \mathbb{E}_T \left[\frac{1}{2} \times \frac{1}{\bar{\Pi}} \times \frac{\mathcal{E}_T}{\mathcal{E}_{T+1}} \times \left[\kappa^L + (1-\delta) q^*(\mathcal{E}_{T+1})\right]\right]$$

2. **Update**

(a) Use V_T^R and V_T^D to approximate V_{T-1}^D.

(b) Use V_T^R, V_T^D, $\hat{\Pi}_T$, q_T^{LF} and q_T^{LD} to approximate $q_{T-1}^{SF}, q_{T-1}^{LF}, q_{T-1}^{SD}, q_{T-1}^{LD}$.

(c) Use the period $T-1$ pricing functions and V_T^R, V_T^D to approximate V_{T-1}^R and all policy functions.

3. **Convergence Check**

(a) Evaluate $q_{T-1}^{SF}, q_{T-1}^{LF}, q_{T-1}^{SD}, q_{T-1}^{LD}$ and V_{T-1}^R at a fixed set of 10,000 grid points throughout the state space

(b) Compute the sup-norm difference.

(c) If the difference is below the tolerance threshold, stop. Otherwise, set $T = T-1$ and return to step 2 until stationarity.

I use Gauss-Hermite quadrature with 81 nodes (9 nodes per shock) to compute expected values.

[12] The equidistant nodes are allocated according to the Clenshaw-Curtis grid structure.