Risk Aversion in Sovereign Debt and Default[*]

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Abstract

We study the interaction of risk-sensitive preferences with sovereign default risk. Macro-financial separation, a pervasive property of real business cycles models, breaks in the context of sovereign debt. Risk aversion that is consistent with observed risk premia significantly affects the equilibrium, particularly the distribution of debt and spreads, as well as inference drawn about costs of default. We (re)evaluate the welfare effects of access to capital markets, debt dilution, and post-default negotiations. We also find that convex default costs can become problematic when paired with meaningful risk aversion and show how to amend them in a way that is also more consistent with observation.

JEL Classification E43, E44, F34, G12

Keywords Sovereign debt, default risk, robust control, macro-financial separation

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Introduction

What makes governments repay their debts, thereby sustaining sovereign borrowing? The general consensus points to a combination of direct costs, in terms of utility or foregone output, combined with a period of exclusion from international capital markets. Exclusion is costly as it disrupts consumption smoothing. However, most quantitative studies of sovereign debt and default are specified with constant relative risk aversion (CRRA) for the government's preferences, a feature which renders business-cycle volatility in consumption almost irrelevant (Lucas, 1987).

In this paper we study sovereign default risk under risk-sensitive preferences, which disentangle risk aversion from the elasticity of intertemporal substitution. We find that risk aversion modulates the welfare costs of fluctuations in consumption and thus the strength of the threat of autarky following default. This leads to a failure of macro-financial separation (Tallarini, 2000) and creates a role for risk aversion in the determination of economic outcomes beyond asset prices. We then compare the performance and predictions of this model with the standard CRRA case, both calibrated to the same empirical regularities of emerging-market economies.

We find that meaningful risk aversion affects the equilibrium, especially in the higher order moments of some variables. The model with robustness faces a more potent contradiction when deciding indebtedness. While on the one hand, it really dislikes being exposed to the risk of default, it also wishes to use debt more heavily to smooth income shocks. This results in more pronounced dynamics of debt relative to the default barrier which manifest as more skewness and volatility of spreads. We also find that convex costs of default, a standard feature of models of sovereign default, have a powerful impact on the equilibrium of the model with robustness; and show how to amend this feature to improve the performance of the model, in a way that also happens to be more in line with the data.

Discussion of the Literature Our analysis builds on and extends two branches of the literature: sovereign default and the asset pricing implications of robust control methods and risk-sensitive preferences. First, our study is related to the recent literature on quantitative models of sovereign default that extended the approach developed by **?**, starting with **?** and **?**. Different aspects of sovereign debt dynamics and default have been analyzed in these quantitative studies. Excellent surveys of the literature on sustainable public debt and sovereign default can be found in handbook chapters by **?**, **?**, **?**, and **?**.

Our study also relates to the literature on robust control methods pioneered by Hansen and Sargent (2001); **?**. A growing theoretical macro literature extends canonical models to the case in which the social planner and/or private agents fear model misspecification and search for robust policies under worst-case scenarios (?; ?; ?). In the context of sovereign default, ? and Roch and Roldán (2023) augment the canonical model with international lenders who fear model misspecification. ? show that the introduction of robust lenders improves the quantitative erformance of sovereign default models. Roch and Roldán (2023) show that ambiguity premium can be very large when state-contingent bonds feature the threshold structure observed in recent issuances by emerging markets (e.g., Argentina, 2005; Greece, 2012; Ukraine, 2015), which results in substantial welfare losses and, thus, can account for the little use of these financial instruments and their unfavorable pricing. In this paper, we abstract from robustness on the lenders' side and, instead, study the implications of endowing the government with risk-sensitive preferences.

Layout The remainder of the paper is structured as follows. First, section 2 introduces the quantitative model. Section 3 presents our benchmark calibration. Section 4 contains our main results on the equilibrium effects of assuming different preferences for the government. Section 5 discusses the implications of departing from the baseline model by assuming persistent costs of defaults. Finally, section 6 concludes.

2. Model

We consider a small open economy whose government borrows from competitive international lenders on behalf of its citizens. Debt helps frontload consumption and smooth shocks and takes the form of a long-term, non-contingent, defaultable bond. Except for the choice of the government's (or the representative agent's) preferences, we stay as close as possible to the standard formulation of Chatterjee and Eyigungor (2012).

Resources The economy receives an exogenous tradable endowment y_t whose evolution follows an AR(1) process in logs,

$$z_t = (1 - \rho_z)\mu_z + \rho_z z_{t-1} + \epsilon_t^z$$

where $y_t = \exp(z_t)$ and $\epsilon \overset{iid}{\sim} \mathcal{N}(0, \sigma_z^2)$.

Government The government's objective is to maximize the representative consumer's welfare, given recursively by the following specification of Epstein-Zin preferences

$$\begin{aligned} w_t &= h(c_t, \mathbb{T}\left[w_{t+1}\right]) \\ &= \left[(1-\beta)c^{1-\gamma} + \beta\mathbb{E}_t\left[w_{t+1}^{1-\theta}\right]^{\frac{1-\gamma}{1-\theta}}\right]^{\frac{1}{1-\gamma}} \end{aligned} \tag{1}$$

where the function h (parametrized by γ) determines attitudes towards intertemporal substitution and the operator $\mathbb{T}$ (parametrized by θ) describes attitudes towards risk.[1] Notice that when $\gamma = 1$, this formulation nests the robust *multiplier* preferences of Hansen and Sargent (2001); when $\theta = \gamma$, it nests the standard CRRA case.

Assets The government borrows from international lenders in the form of a defaultable bond which promises to pay a noncontingent stream of geometrically-decaying coupons (Leland, 1998; Hatchondo and Martinez, 2009; Chatterjee and Eyigungor, 2012). A bond issued in period t pays $(1-\rho)^{s-1}\kappa$ units of the good in period $t+s$, which effectively makes a one-period-old bond a perfect substitute of $(1-\rho)$ units of newly-issued debt. The coupon rate $\kappa = r + \rho$, where r is the international risk-free rate, is chosen so that the price of a bond that is expected to never default is $q^\star = 1$.

With this structure, the government's budget constraint dictates resources available for consumption in case of repayment and if new debt $i_t = b'_t - (1-\rho)b_t$ is issued at price q_t

$$c_t + \kappa b_t = y(z_t) + q_t(b'_t - (1-\rho)b_t)$$

Default Each period, the government may choose to default on the debt, which triggers temporary exclusion from international capital markets. As in most models, we assume that while this period of exclusion lasts, the economy's output is reduced by a factor of $\phi(y)$. At the same time, while excluded the government faces a constant hazard ψ of reaching a deal with bondholders, in which case a share $N(b,z)$ of the defaulted bonds become due again. The value of default for the government is then

$$v_D(b,z) = h\left(y(z) - \phi(y(z)),\ \mathbb{T}\left[1_R\mathcal{V}(N(b,z')b,z') + (1-1_R)v_D(b,z') \mid z\right]\right) \tag{2}$$

where 1_R is an indicator function for the event of market reentry and $\mathcal{V}$ is the value attained by the government when it has access to markets.

[1] When convenient, we also write preferences in the Kreps and Porteus (1978) formulation with $h(x,y) = u^{-1}\left((1-\beta)u(x) + \beta u(y)\right)$, $u(x) = x^{1-\gamma}$, and the risk sensitive expectation operator $\mathbb{T}\left[x \mid \mathcal{F}\right] = \mathbb{E}\left[x^{1-\theta} \mid \mathcal{F}\right]^{\frac{1}{1-\theta}}$.

At the beginning of each period in which it has access to markets, the government faces a choice to repay the debt or default, so that

$$\mathcal{V}(b,z) = \max\left\{ v_R(b,z) + \epsilon_R,\ v_D(b,z) + \epsilon_D \right\}$$

where (ϵ_R, ϵ_D) follow independent Type 1 Extreme Value distributions with scale parameter χ. As is well-known (Chatterjee et al., 2018; Dvorkin et al., 2021), this specification leads the distribution of the difference $\epsilon_R - \epsilon_D$ to be logistic and yields the closed forms for the value function and the ex-post probability of default

$$\begin{aligned} \mathcal{V}(b,z) &= \chi \log\left(\exp\left(\frac{1}{\chi} v_R(b,z)\right) + \exp\left(\frac{1}{\chi} v_D(b,z)\right)\right) \\ \mathcal{P}(b,z) &= \frac{\exp\left(\frac{1}{\chi} v_D(b,z)\right)}{\exp\left(\frac{1}{\chi} v_R(b,z)\right) + \exp\left(\frac{1}{\chi} v_D(b,z)\right)} \end{aligned} \tag{3}$$

Since the ϵ shocks are only intended for numerical performance (and hence we keep their variance small), following standard practice in models with preference shocks and risk-sensitive preferences we assume that they are not factored in through the agent's risk attitudes.

Debt issuances While it remains current on its obligations, the government can issue new debt b' on the market[2] and attain a value

$$\begin{aligned} v_R(b,z) = &\max_{b'} h\left(c,\ \mathbb{T}\left[\mathcal{V}(b',z') \mid z\right]\right) \\ \text{subject to} \quad & c + \kappa b = y(z) + q(b',z)(b' - (1-\rho)b) \end{aligned} \tag{4}$$

Debt prices Financing to the small open economy is provided by a continuum of competitive risk-neutral foreign investors with access to funds at a risk-free rate r. To hold the government's debt, creditors must break even in expectation

$$\begin{aligned} q(b',z) &= \frac{1}{1+r}\mathbb{E}\left[(1-1_{\mathcal{D}'})(\kappa + (1-\rho)q(g_b(b',z'),z')) + 1_{\mathcal{D}'} q_D(b',z') \mid z\right] \\ q_D(b,z) &= \frac{1}{1+r}\mathbb{E}\left[(\psi N(b,z')R(N(b,z')b,z')b + (1-\psi)q_D(b,z')) \mid z\right] \end{aligned} \tag{5}$$

where $R(b,z) = (1-1_{\mathcal{D}})(\kappa + (1-\rho)q(g_b(b,z))) + 1_{\mathcal{D}} q_D(b,z)$ is the value of a restructured bond and $g_b(b,z)$ denotes the government's (potentially stochastic) policy function for debt issuance.

[2] In the numerical solution of the model, we discretize the set of choices $\mathcal{B}$ for debt and include Extreme Value Type 1 preference shocks, similarly to the default choice. This helps smooth out the choice of debt by making the probability of choosing level b' proportional to $\exp\left(\frac{1}{\chi_b} h\left(c,\ \mathbb{T}\left[\mathcal{V}(b',z') \mid z\right]\right)\right)$. Similarly to the default decision, we choose χ_b as small as possible to ensure that it does not affect the equilibrium.

3. Calibration

We parametrize our model to match salient features of emerging-market economies. A period in the model refers to a quarter. We use data from Argentina, a common reference for quantitative studies of sovereign default. We set the risk-free interest rate r and the government's discount factor β to standard values in this literature. We set the inverse maturity of debt ρ to obtain an average maturity of 5 years. We assume that any defaults are resolved in about 6 years, which is well in the range of empirical estimates (Cruces and Trebesch, 2013). The parameters governing the exogenous shock process are taken from Roch and Roldán (2023) to match the behavior of output. For the debt restructuring function $N(b, z)$, for the time being we assume zero recovery.

Table 1 summarizes the parameters we set externally.

	Parameter	Value
Sovereign's discount factor	β	0.9627
Income autocorrelation coefficient	ρ_z	0.9484
Standard deviation of y_t	σ_z	0.02
Preference shock scale parameter: default	χ	0.01
Preference shock scale parameter: borrowing	χ_b	0.002
Risk-free interest rate	r	0.01
Duration of debt	ρ	0.05
Reentry probability	ψ	0.0385
Haircut upon default	$\hbar$	1

Table 1: Externally chosen parameters

We set the output costs of default function $\phi(y) = \max\{0, d_1 y + d_2 y^2\}$. These two parameters help match the average levels of debt and spread in the data (Hatchondo and Martinez, 2017).

We consider three main cases, a standard CRRA calibration with $\gamma = 2$ and $\theta = 0$, a 'loglog' benchmark with $\gamma = \theta = 1$, and a robust version with $\gamma = 1$ and $\theta = 3$ (as we show below, this version generates an equity premium of 5-6pp). For each, we calibrate the cost of default parameters (d_1, d_2) to match the average level of debt and spreads in pre-default samples corresponding to Argentina in 1993Q1-2001Q4.

Table 2 contains the values of the parameters that we set by calibration, for the main versions we consider, along with the calibration moments which these choices generate.

	Parameter	$\gamma = 2$	loglog	$\theta = 3$
Sovereign's discount factor	β	0.9627	0.9627	0.9627
Sovereign's risk aversion	θ	1	1	3
Sovereign's EIS	γ	2	1	1
Default output cost: linear	d_1	-0.2833	-0.2836	-0.247
Default output cost: quadratic	d_2	0.3253	0.3228	0.3029
Average spread (bps)	815	754	756	815
Debt-to-GDP ratio (%)	17.4	16.8	16.7	17.4

Table 2: Calibrated parameters

3.1 *Macro-financial separation*

We demonstrate that macro-financial separation breaks in the context of the sovereign debt and default model. For this, first consider a version of the model without default risk (e.g. $d_1 \to 1$, $d_2 = 0$).

Table 3 demonstrates macro-financial separation in the model without default. Starting from the loglog case, we increase risk aversion (keeping the EIS fixed) in the top panel and increase both the risk aversion and EIS parameters in the bottom panel. In addition to the spread and debt average levels, we compute the correlation of net exports and GDP, the relatively volatility of consumption to output, and the correlation between GDP and the government deficit. We also show the average level of the risk or equity premium in the economy, computed as the difference in yields between a Lucas tree (a claim to the economy's output) and a risk-free asset, both priced by the representative household's stochastic discount factor. Finally, we show the value of each allocation to the representative household, measured as the constant amount of consumption that would attain the same value as the equilibrium under consideration.

The top panel of Table 3 shows that by increasing risk aversion, one can generate a substantial equity premium (of about 6pp) with almost no impact on the equilibrium allocation.[3] At the same time, as risk aversion increases, so does the dislike of the household for this allocation in which the volatility of consumption is about 60% larger than that of output. On the other hand, the bottom panel shows that increasing the EIS (along with risk aversion, following the CRRA direction) induces a dramatic change in macroeconomic outcomes, substantially decreasing the volatility of

[3]Positive (but below 1 basis point) spreads reflect the presence of preference shocks which lead to a non-zero but negligible default probability.

	loglog	$\theta = 1$	$\theta = 2$	$\theta = 3$
Average spread (bps)	0.0276	0.031	0.0406	0.138
Corr. NX, y	0.00777	0.00916	0.0114	0.0147
Rel. vol. cons	1.59	1.62	1.65	1.66
Risk premium (p.p.)	0.0769	2.03	3.84	5.44
Debt-to-GDP (%)	29.7	29.5	29.2	28.9
Corr. deficit, y	−0.0119	−0.0141	−0.0177	−0.0231
Welfare	1.034	1.008	0.9867	0.971

	loglog	$\gamma = 2$	$\gamma = 5$	$\gamma = 10$	$\gamma = 20$
Average spread (bps)	0.0276	0.0273	0.0269	0.0271	0.0285
Corr. NX, y	0.00777	0.0154	0.0852	0.397	0.668
Rel. vol. cons	1.59	1.56	1.35	0.965	0.727
Risk premium (p.p.)	0.0769	0.227	0.627	1.02	1.67
Debt-to-GDP (%)	29.7	28.8	25.9	19.3	8.75
Corr. deficit, y	−0.0119	−0.0251	−0.162	−0.605	−0.774
Welfare	1.034	1.03	1.021	1.01	0.9918

Table 3: Macro-financial separation without default

consumption, making exports procyclical and the deficit countercyclical. These changes coexist with a very modest increase in the risk premium.

In contrast, when default is an option, the lack of smoothing while excluded from international capital markets becomes more costly for the household. This opens up a way for risk aversion to have a direct impact on the relative value of default versus repayment. Through it, risk aversion affects default probabilities and, hence, the entire equilibrium.

Table 4 repeats the previous exercise in the main model with the values of (d_1, d_2) at their calibrated levels for the loglog model.

The top panel of Table 4 shows that, with the option of default, risk aversion leads to a similar level for the risk premium but now also affects quantities: debt tolerance decreases as the government sustains much lower levels of debt, the economy becomes a bit less exposed to risk as consumption becomes smoother and net exports and the deficit exhibit a lower correlation with output. At the same time, while the unconditional default frequency is lower, the volatility of spreads is magnified, leading to higher average spreads in pre-default samples.

	loglog	$\theta = 1$	$\theta = 2$	$\theta = 3$
Avg. spread (bps)	731	1,215	1,635	1,505
Corr. NX, y (%)	-0.291	-0.231	-0.167	-0.0692
Rel. vol. cons (%)	1.51	1.4	1.33	1.27
Risk premium (p.p.)	0.657	2.87	4.8	5.93
Debt-to-GDP (%)	16.9	14.5	11.1	7.63
Corr. deficit, y (%)	0.394	0.304	0.213	0.136
Default freq. (%)	4.43	5.79	4.72	2.58
Std. dev. spreads (bps)	369	700	965	1,084

	loglog	$\gamma = 2$	$\gamma = 5$	$\gamma = 10$	$\gamma = 20$
Avg. spread (bps)	731	770	840	851	581
Corr. NX, y (%)	-0.291	-0.305	-0.213	0.0514	0.353
Rel. vol. cons (%)	1.51	1.37	1.19	1.05	0.939
Risk premium (p.p.)	0.657	0.792	1.03	1.3	2.23
Debt-to-GDP (%)	16.9	15.9	12.6	7.8	3.07
Corr. deficit, y (%)	0.394	0.394	0.223	-0.175	-0.549
Default freq. (%)	4.43	4.43	4.18	3.43	2.04
Std. dev. spreads (bps)	369	452	650	834	764

Table 4: No macro-financial separation with default

In the bottom panel, we see that increasing the EIS (along with risk aversion, in the CRRA direction) leads to much less volatility, highly procyclical net exports and countercyclical deficits (in contrast to Cuadra, Sanchez, and Sapriza, 2010, who argue that procyclical deficits arise as a consequence of lack of commitment). Debt tolerance is also significantly reduced and a similar pattern can be found in the default frequency and the volatility of spreads. However, even with a large value of the CRRA parameter, consistent with standard findings, the domestic risk premium remains too low.

3.2 *Calibrations with risk aversion*

TBW

	γ2	loglog	θ3
Avg. spread (bps)	754	757	749
Corr. NX, y (%)	-0.315	-0.288	-0.198
Rel. vol. cons (%)	1.38	1.5	1.36
Risk premium (p.p.)	0.778	0.649	5.91
Debt-to-GDP (%)	16.8	16.7	17.4
Corr. deficit, y (%)	0.406	0.392	0.209
Default freq. (%)	4.21	4.4	1.51
Std. dev. spreads (bps)	500	458	1,622

Table 5: Calibrations with risk aversion

3.3 Asset pricing implications

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4. Quantitative Analysis

Figure 1 shows output and the debt/GDP ratio in a long simulation in blue (conditioning only on having exited the latest default spell at least 2 years prior). The red dots correspond to periods in which a default is declared, and the black dashed line represents the debt level at which the default probability $\mathcal{P}$ crosses 50%.

While standard models based on CRRA preferences stay close to the barrier most of the time (as can be seen in Figure 5 in the Appendix). In contrast, the model with risk-sensitive preferences generates more cautious behavior, the government tries to reduce risk by keeping a distance from the default barrier. At the same time, because it has real smoothing motive, it uses debt to lean against income shocks, which can bring debt back up when negative shocks pile up.

The difference of policies implied by the model with robust and CRRA preferences can also be seen in Figure 2, which plots the ergodic distribution of spreads for all models. While in the pre-default samples used for calibration, all models share roughly the same level of spreads, the ergodic distribution reveal that the model with robustness spends much more time away from the risky area. In this sense, for the model with robustness crises are much more salient events.

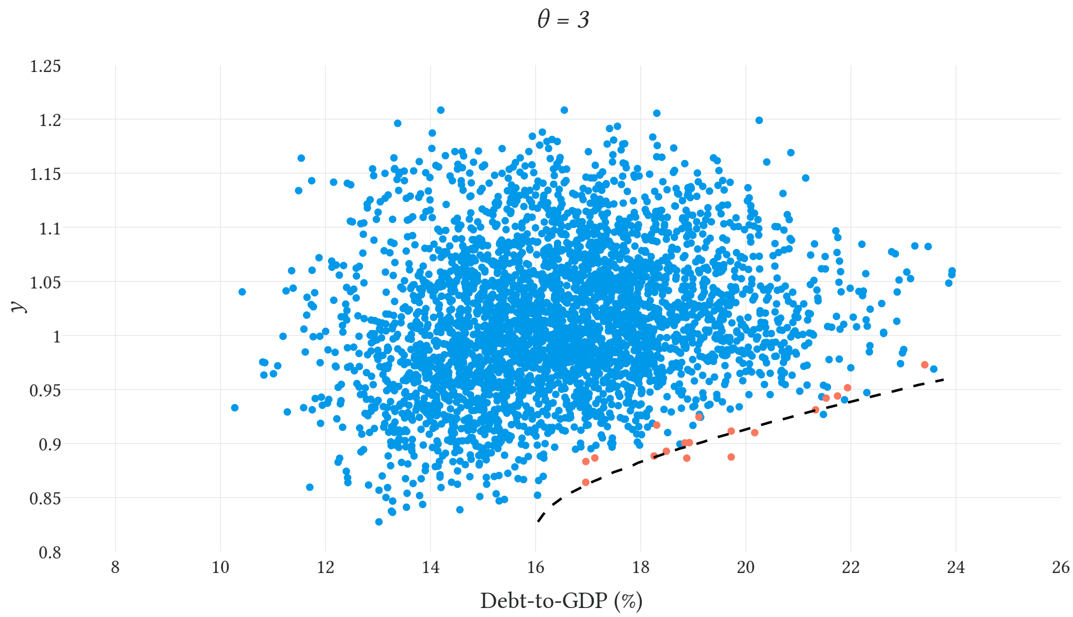

Figure 1: Ergodic distribution for debt in model with robustness

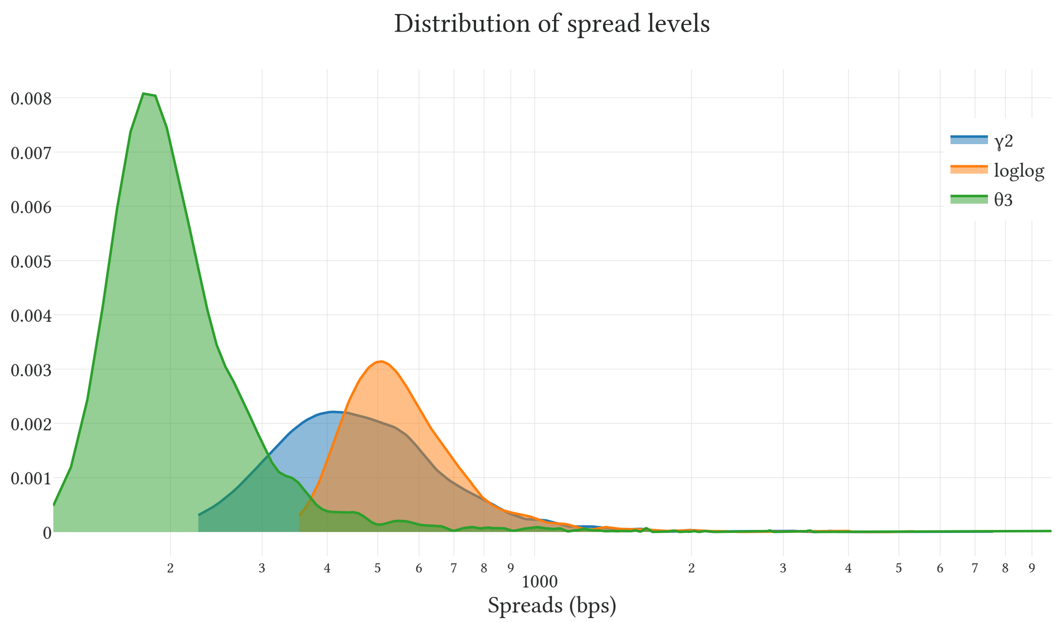

Figure 2: Ergodic distributions for spreads

4.1 *Welfare implications*

Our specification of preferences (1) is such that the value function $\mathcal{V}$ equals the constant level of consumption that would yield the same utility as the equilibrium (in other words, the value of a constant stream of consumption c is c). Therefore, to study the differential welfare implications of policies, we compare the average of the value function averaging across the ergodic distribution $\mu(z)$ for the exogenous state, at 0 debt,

$$c^{\star}(\Theta) = \int \mathcal{V}_{\Theta}(0, z) d\mu(z). \tag{6}$$

4.1.1 Welfare effects of access to markets

Figure 3 shows the welfare gains (6) of moving from autarky (our model with $q(b', z) \equiv 0$) to the benchmark equilibrium, for the three parametrizations we consider.

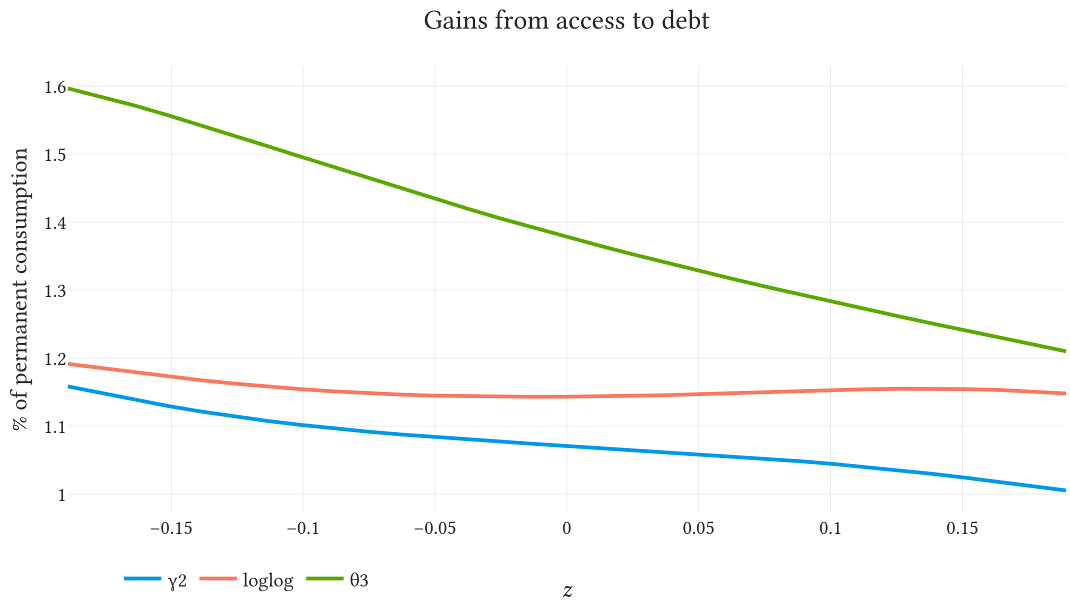

Figure 3: Welfare gains from market access

The version with robustness ($\theta = 3$) displays the largest gains, but also this is the model in which the gains from market access are the most state-dependent. This gradient reflects the insurance benefits that market access provides in the model with robustness. In the model(s) without meaningful risk aversion, debt is mostly used to frontload consumption, and hence the gains are less dependent on the current state.

4.1.2 Welfare effects of sovereign risk

We now turn to the welfare gains of making defaults impossible. Figure 4 shows the gains of moving from the benchmark equilibrium to one in which defaults are banned (e.g. $d_2 = 0$, $d_1 \to 1$).

In this case, the gains are comparable across all models, and the model with robustness is the one for which gains are least dependent on the current state.

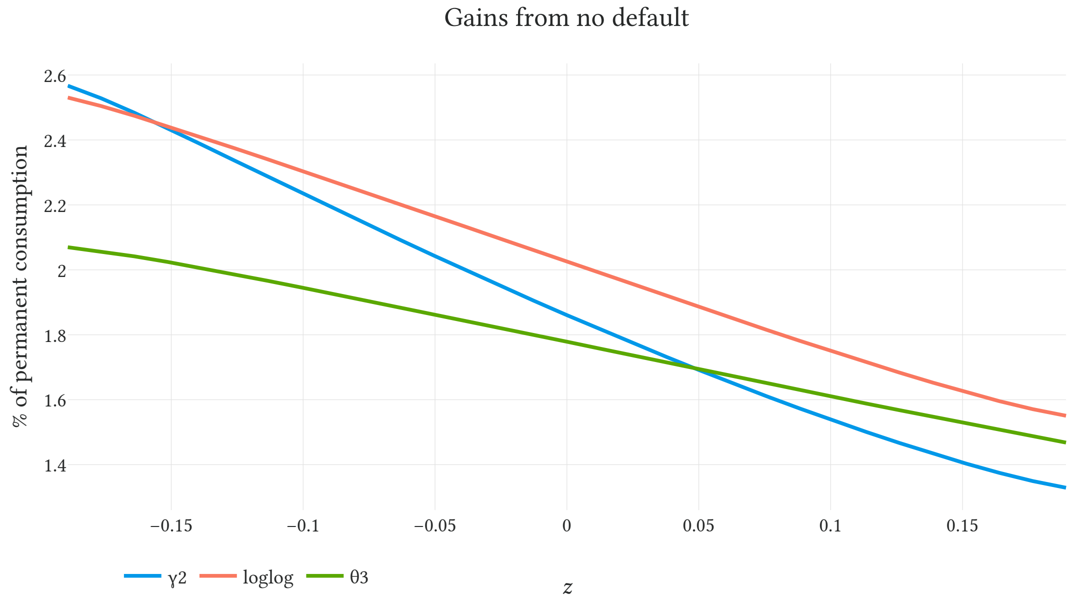

FIGURE 4: WELFARE GAINS FROM BANNING DEFAULTS

4.1.3 Welfare effects of debt dilution

To evaluate debt dilution and its welfare effects, we solve our model with the assumption that the government can commit to state-contingent borrowing plans $b'(b, x, z)$, but must respect the sequential decision-making process for default. We adapt the Marcet and Marimon (2019) approach introduced by Hatchondo et al. (2020).

For comparison, we also solve the model in its original sequential timing, but replacing the fixed-coupon with floating-rate debt, as in Aguiar et al. (2023).

4.2 *The effect of risk aversion on post-default negotiations*

5. A MODEL WITH PERSISTENT COSTS OF DEFAULT

In most models of sovereign default, while the government is excluded from international capital markets, it suffers an output penalty, which we summarize above by the function ϕ. As is well-known, the costs of default must be convex in order to induce defaults in bad time and, hence, countercyclical spreads.

However, an overlooked feature of convex costs as represented by a convex function ϕ is that they mute the volatility of output during the default spell, by disproportionately reducing upside risk. This second prediction is counterfactual can be avoided by simply amending the value function for the default choice as follows

$$\mathcal{V}(b,z) = \max\left\{ v_R(b,z) + \epsilon_R,\, v_D(b, \phi(y(z)), z) + \epsilon_D \right\}$$

$$v_D(b,\varphi,z) = h\left(y(z) - \varphi,\ \mathbb{T}\left[1_R \mathcal{V}(N(b,z')b, z') + (1-1_R) v_D(b,\varphi,z') \mid z\right] \right)$$

so that $\varphi = \phi(y(z))$ at the moment of default.

6. Concluding Remarks

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References

Aguiar, M., M. Amador, and R. Alves Monteiro (2023): "Sovereign Debt Crises and Floating-Rate Bonds," in *Credibility of Emerging Markets, Foreign Investors' Risk Perceptions, and Capital Flows*, Central Bank of Chile, 159–184.

Chatterjee, S., D. Corbae, J.-V. Rios-Rull, and K. Dempsey (2018): "A Theory of Credit Scoring and the Competitive Pricing of Default Risk," 2018 Meeting Papers 550, Society for Economic Dynamics.

Chatterjee, S. and B. Eyigungor (2012): "Maturity, Indebtedness, and Default Risk," *American Economic Review*, 102, 2674–99.

Cruces, J. J. and C. Trebesch (2013): "Sovereign Defaults: The Price of Haircuts," *American Economic Journal: Macroeconomics*, 5, 85–117.

Cuadra, G., J. M. Sanchez, and H. Sapriza (2010): "Fiscal policy and default risk in emerging markets," *Review of Economic Dynamics*, 13, 452–469.

Dvorkin, M., J. M. Sánchez, H. Sapriza, and E. Yurdagul (2021): "Sovereign Debt Restructurings," *American Economic Journal: Macroeconomics*, 13, 26–77.

Hansen, L. P. and T. J. Sargent (2001): "Robust Control and Model Uncertainty," *American Economic Review*, 91, 60–66.

Hatchondo, J. C. and L. Martinez (2009): "Long-duration bonds and sovereign defaults," *Journal of International Economics*, 79, 117–125.

——— (2017): "Calibrating the Cost of Defaulting in Models of Sovereign Defaults," in *Rethinking Fiscal Policy after the Crisis*, Cambridge University Press, 414–440.

Hatchondo, J. C., M. L. Martinez, and M. F. Roch (2020): "Constrained Efficient Borrowing with Sovereign Default Risk," IMF Working Papers 2020/227, International Monetary Fund.

Kreps, D. M. and E. L. Porteus (1978): "Temporal Resolution of Uncertainty and Dynamic Choice Theory," *Econometrica*, 46, 185–200.

Leland, H. E. (1998): "Agency Costs, Risk Management, and Capital Structure," *Journal of Finance*, 53, 1213–1243.

Lucas, R. (1987): *Models of Business Cycles*, Yrjö Jahnsson lectures, Basil Blackwell.

Marcet, A. and R. Marimon (2019): "Recursive Contracts," *Econometrica*, 87, 1589–1631.

Roch, F. and F. Roldán (2023): "Uncertainty Premia, Sovereign Default Risk, and State-Contingent Debt," *Journal of Political Economy Macroeconomics*, 1, 334–370.

Tallarini, T. D. (2000): "Risk-sensitive real business cycles," *Journal of Monetary Economics*, 45, 507–532.

A. More Results

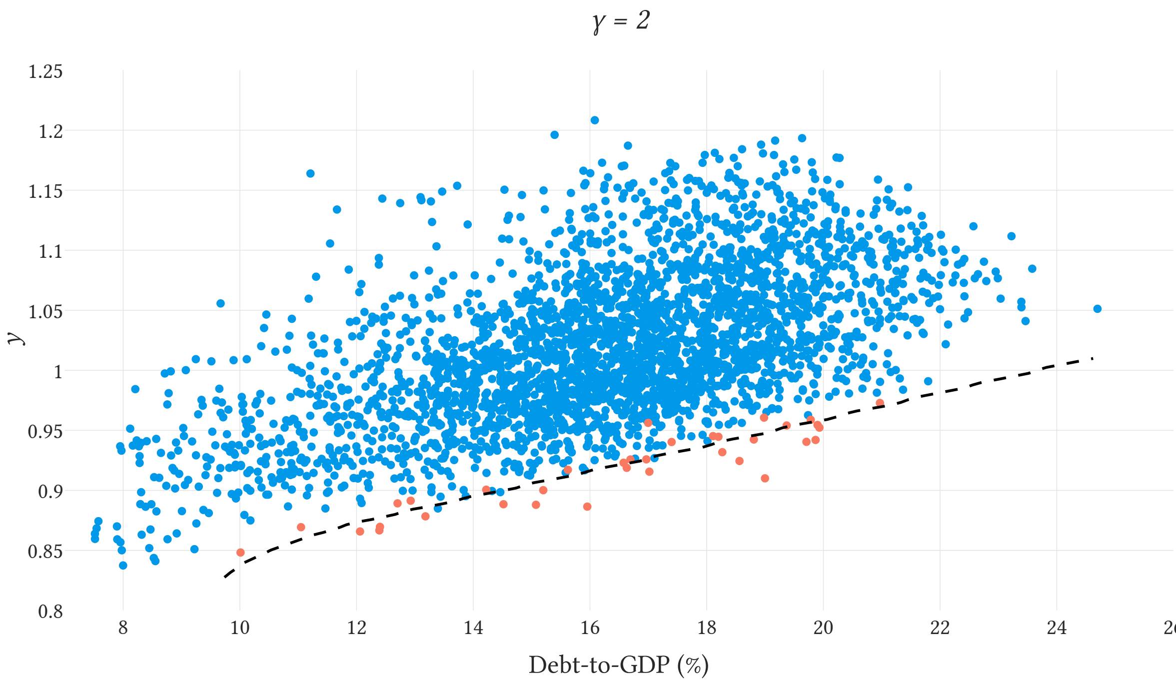

Figure 5: Ergodic distribution for debt in model with CRRA