

On the Welfare Losses from External Sovereign Borrowing*

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Abstract

This paper studies the losses to the citizenry when the private agents discount the future at different rates than their government. In the presence of such a disagreement, the private sector may prefer an environment in which the government is in financial autarky. Using a sequence of sovereign debt models, the paper quantifies the potential welfare losses that citizens suffer from the government's access to international bond markets.

1 Introduction

The fact that Argentina is experiencing a fiscal crisis only two years after coming to terms with bondholders from the previous default is just the latest reminder that governments frequently borrow to the point of default. Reinhart and Rogoff (2004) refer to this phenomenon as “serial default.” Rationalizing this pattern typically begins with modeling governments, and the politicians that run them, as impatient.¹ In particular, the government's discount rate is higher than that of

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¹A well established political economy literature has provided several models that generate impatient policy makers.

international lenders. This is a pervasive feature of the political economy literature as well as the quantitative sovereign debt models.

While the government may be relatively impatient viz-a-viz the world interest rate, the sovereign debt literature is often silent on the discount rates of domestic private agents. We explore how sensitive is private sector welfare to disagreement in discount rates between politicians and their constituents. We do so by asking a simple but stark question: at what level of disagreement would the private sector be better off if the government had zero access to international debt markets.

In this paper, we identify three potential costs that arise when an impatient government can access international sovereign debt markets:

1. *Front-loading of expenditures*: from the perspective of a more patient household, an impatient government shifts too much spending towards the present.
2. *Excess-variability of expenditures*: by borrowing more in good endowment states than in bad, the government may introduce additional variability to the spending allocation.
3. *Default costs*: By borrowing, the government exposes the country to a future default and its associated costs.

To explore and quantify these potential channels, the analysis begins with a simple benchmark. Suppose that the government borrowed to an exogenous debt limit in a deterministic environment. The debt limit is assumed to be such that the government does not default. Hence, the only distortion relative to the household optimal path of spending is the front-loading of consumption. We show that this tilting of consumption in the absence of default has minimal welfare consequences: households strictly prefer that their government borrows (unless their discount factor is very close to the interest rate). Hence, this simple model does not make a strong case for banning sovereign borrowing unless the households are very patient.

The simple model however ignores two important elements: uncertainty and the possibility of default in equilibrium. To assess the implications of these, we turn to the quantitative sovereign debt models popular in the literature. In these models, which are based on an earlier contribution by Eaton and Gersovitz (1981), the government faces uncertainty with respect to its revenue or endowment, and borrows with an uncontingent bond. However, the government may choose to default, in which case it suffers a period of reduced output and no access to international financial markets. We begin with the early contributions of Aguiar and Gopinath (2006) and Arellano (2008).

The Aguiar-Gopinath (AG) model with transitory shocks hews closely to the original Eaton and Gersovitz (1981) model. The major difference is adding a proportional drop in the endowment while the country is in default. We show that this model generates results strikingly similar to the

back-of-the-envelope benchmark described above. The reason is primarily due to the infrequent default under this calibration, a feature of the model emphasized in the original AG paper.

Arellano (2008) introduces a richer notion of default costs. In particular, Arellano assumes a non-linear decline in the endowment in default, with no losses for low output realizations and large declines for high output realizations. The fact that equilibrium default occurs in low-endowment states implies negligible deadweight losses as well as a higher frequency of default relative to AG. Despite the frequency of default, the fact that deadweight losses are minimal generates welfare losses similar in magnitude to AG and the benchmark calculation. More accurately, compared to AG, the losses are relatively sensitive to the differences in discount factors, but the magnitude is only on the order of 0.2% of consumption.

We then turn to the richer environments explored by Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012). These papers introduced long-term bonds and flagged that the incentive to dilute existing bondholders plays an important role in debt dynamics and the frequency of default. We first provide a theoretical result: despite the incentive to dilute and the potential beneficial role for fiscal rules (See Hatchondo, Roch and Martinez, 2012), the government strictly prefers access to bond markets over financial autarky. The rule of zero access to sovereign markets is too costly: a government will never voluntarily shut itself out of sovereign debt markets. The private agents, on the other hand, are a different story.

Using the calibration of Chatterjee and Eyigungor (CE), we find large welfare losses at relatively small levels of discount rate disagreement. The reason for the sharp difference is that the simulated economy spends a significant fraction of time in the default state. Given the endowment costs due to default, this generates a large deadweight loss. The presence of default costs in equilibrium significantly strengthen the case for banning international sovereign debt borrowing.

Related Literature

For a comprehensive review of the sovereign debt literature, we refer to Aguiar and Amador (2014a) and Aguiar, Chatterjee, Cole and Stangebye (2016). That some countries seem to be serial defaulters was first documented in Reinhart and Rogoff (2004).² The quantitative sovereign debt literature is based on the model of Eaton and Gersovitz (1981), which assumes the government is a benevolent social planner that decides on the expenditures and the amount to borrow externally, but it is unable to commit not to default on its debt. With one-period bonds, there is no benefit for the government to commit to fiscal rules that restrict its future borrowing and spending decisions. When the government has time-inconsistent preferences, Alfaro and Kanczuk (2017) discuss the role for fiscal rules within such an environment. They also analyze the case where the govern-

²See also Amador and Phelan (2018) for a model as well as other references.

ment has standard exponentially discounted preferences, but its discount factor differs from the citizen's. With longer-duration bonds, there are potentially benefits of committing to fiscal rules even for a benevolent government, a point explored in detail in Hatchondo et al. (2012). That paper also discusses the case for fiscal rules when the private agents have a different discount factor from the government. Our contribution, in relation to the last two papers, is to provide a simple benchmark exercise to quantify the losses from market access, as well as to investigate the magnitudes and the degree of disagreement across several calibrations and environments. In addition, rather than exploring different fiscal rules, we focus on the simpler question of whether the citizens would prefer that their government had no access to external debt markets.³

2 A Simple Model of Inter-Temporal Disagreement

In this section we set the stage for our quantitative analysis by considering a simple model that admits closed form solutions. In addition to providing a useful reference, it allows a back-of-the-envelope calculation that demonstrates that inter-temporal disagreement in a default-free environment has limited welfare consequences.

Consider a simple deterministic consumption-savings problem in which a potentially impatient government decides how much to consume and borrow from international financial markets. Time is infinite and continuous. There is a small open economy (SOE) which is endowed with a constant endowment flow, y . At every instant, the government decides the consumption of the representative consumer, c_t , and finances it with the endowment plus issuing bonds with face value b_t to international financial markets. International financial markets are willing to lend to the government at a constant interest rate r up to a borrowing limit, \bar{b} .

The budget constraint for the SOE is:

$$\dot{b}_t = c_t + rb_t - y, \tag{1}$$

which states that the change in debt equals consumption plus interest rate payments on the debt minus the endowment.

³For other models where fiscal rules are useful, see Dovis and Kirpalani (2018) and the work of Halac and Yared (2018).

2.1 The Government's Value

The government's preferences over consumption sequences are given by:

$$U = \int_0^{\infty} e^{-\rho_G t} u(c_t) dt.$$

We impose that $\rho_G > r$, so that this government is more impatient than the market interest rate, and, as a result, ends up borrowing to the maximum \bar{b} .

A useful case, which we pursue throughout, is that of power utility: $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ for $\sigma > 0$ and $\sigma \neq 1$ and $u(c) = \log(c)$ for $\sigma = 1$. The parameter $\sigma = \frac{u'(c)}{-cu''(c)}$ is the inter-temporal elasticity of substitution (IES).

The solution to the government's problem is straightforward. The fact that $\rho_G > r$ implies that the government borrows up to the limit. The speed at which it does this is governed by the degree of impatience and the inter-temporal elasticity of substitution (IES). In particular, while $b_t < \bar{b}$, consumption obeys the Euler Equation:

$$\frac{\dot{c}}{c} = \frac{u'(c)}{-cu''(c)} (\rho_G - r).$$

Once $b_t = \bar{b}$, then $c = y - r\bar{b}$.

With constant IES, the solution has a closed form. Specifically, starting from $b_0 = 0$, let T denote the first time $b_t = \bar{b}$. We have

$$c_t = \begin{cases} e^{\frac{\rho_G - r}{\sigma}(T-t)}(y - r\bar{b}) & ; t \in [0, T] \\ y - r\bar{b} & ; t > T \end{cases} \quad (2)$$

where T is such that

$$1 - r\frac{\bar{b}}{y} = \frac{e^{rT}}{1 - r\frac{\sigma}{\rho_G - r(1-\sigma)} \left(1 - e^{\frac{T(\rho_G - r(1-\sigma))}{\sigma}}\right)}.$$

Let V_0 denote the associated value of the government, where the subscript zero reminds us that the initial debt is zero. For convenience, let us define the value of autarky for the government:

$$V^A = \frac{u(y)}{\rho_G},$$

which represents the value to the government if it could not borrow nor save internationally (in which case, it is constrained to equalize its expenditures to the endowment).

Given that the government can always choose not to borrow, it follows that $V_0 \geq u(y)/\rho_G$. It is also straightforward to argue that if $\rho_G > r$ and $\bar{b} > 0$, $V_0 > u(y)/\rho_G$. Hence, such a government

finds it beneficial to have access to international markets. As we will see below, this result survives the presence of uncertainty, potential default, and the introduction of debt dilution into the model.

The question of interest relates to the benefits of access to international financial markets from the perspective of the households of the SOE, to which we now turn.

2.2 The Households' Value

We assume that, in addition to the government, the SOE also contains a representative household. This household cannot borrow or save internationally, and values the expenditure flows generated by the government using the same utility flow function as the government, u . Importantly, we assume the household uses a different inter-temporal discount factor, ρ_H . Clearly, when $\rho_H = \rho_G$, the government is benevolent and agrees with the household ranking of consumption paths. However, when $\rho_H < \rho_G$, then we say the *government is impatient* with respect to the households. In this case, the households ranking of consumption paths disagrees from the government's.

Let W_0 denote the welfare of the household under the consumption plan chosen by the government in 2 and constant IES preferences:

$$W_0 = \begin{cases} e^{-T\rho_H} \left(\frac{1}{\rho_H} + \frac{e^{T(\frac{\rho_G-r}{\sigma}(1-\sigma)+\rho_H)} - 1}{\frac{\rho_G-r}{\sigma}(1-\sigma)+\rho_H} \right) \frac{(y-r\bar{b})^{1-\sigma}}{1-\sigma} & ; \text{if } \sigma \neq 1 \\ \frac{\rho_G-r}{\rho_H} \left(\frac{e^{-T\rho_H}-1}{\rho_H} + T \log(y-r\bar{b}) \right) & ; \text{if } \sigma = 1 \end{cases}$$

The representative household's autarkic value is:

$$W^A = \frac{u(y)}{\rho_H}$$

Note that if $\rho_H = r$, then autarky is the optimal consumption plan from the perspective of the household. That is, if $\rho_H = r$, then $W_0 < W^A$ for any $\rho_G > r$ and $\bar{b} > 0$.

In this simple environment, if the household's discount rate equals the foreign interest rates, then giving the government access to international financial markets unambiguously reduces household's welfare. The intuition is straight-forward: with no access to international financial markets, consumption equals the constant endowment, which corresponds to the best allocation from the household perspective. Allowing the government the ability to distort consumption inter-temporally away from this benchmark induces a reduction of household welfare.

The Welfare Costs of Financial Market Access: A Simple Calculation

To assess the welfare costs of market access when the household and the government disagree on inter-temporal trade-offs, define λ as the percentage increase in the autarky consumption path

that would make a household indifferent between this allocation and the allocation where the government follows its optimal borrowing plan. That is:

$$\lambda \equiv \begin{cases} \left(\frac{W_0}{W^A} \right)^{\frac{1}{1-\sigma}} - 1 & ; \text{if } \sigma \neq 1 \\ e^{\rho_H(W_0 - W^A)} - 1 & ; \text{if } \sigma = 1, \end{cases}$$

where λ captures the *welfare gains from international financial market access*.

Using the previous calculations, we obtain the following result:

Lemma 1. For $\bar{b} > 0$ and $\rho_G > r$, the welfare gains from international financial market access are strictly increasing in ρ_H , and given by

$$\lambda = \begin{cases} \frac{e^{rT}(\rho_G - r(1-\sigma))}{\rho_G - r \left(1 - \sigma e^{T \frac{\rho_G - r(1-\sigma)}{\sigma}} \right)} \left(\frac{\rho_H \sigma e^{T(1-\sigma) \frac{\rho_G - r}{\sigma}} + e^{-T\rho_H}(\rho_G - r)(1-\sigma)}{(\rho_G - r)(1-\sigma) + \rho_H \sigma} \right)^{\frac{1}{1-\sigma}} - 1 & ; \text{if } \sigma \neq 1 \\ \frac{\rho_G}{\rho_G - r(1 - r e^{\rho_G T})} e^{(\rho_G - r) \frac{e^{-T\rho_H} - 1}{\rho_H} + \rho_G T} & ; \text{if } \sigma = 1 \end{cases} \quad (3)$$

Proof. In the appendix. □

As stated in the lemma, the welfare gains are strictly increasing in ρ_H : a more *impatient* household values more the ability that its government can borrow internationally,

At the other end, when the households are infinitely patient, that is, when $\rho_H \rightarrow 0$, λ converges to :

$$\lim_{\rho_H \rightarrow 0} \lambda = -r \frac{\bar{b}}{y}$$

This result is quite intuitive: in the limit, consumption converges to $y - r\bar{b}$, and hence, an infinitely patient households needs to be positively compensated with respect to its endowment path by exactly $r\bar{b}/y$. It follows as well that this value is the maximum possible loss, as λ is strictly increasing in ρ_H .

The question that concerns us is quantitative: how large are the potential losses from financial market access? And how are they related to the difference in discount factors between the households and the government?

Towards this goal, let us make the following parametric assumptions, which lie within the ballpark of the assumptions made in the quantitative sovereign debt literature. We set $\sigma = 2$, and let $r = 0.04$, representing a 4% real annual rate of return on a safe external asset. We let $\bar{b}/y = 0.25$, representing a 25% percent of external debt over the annual GDP.

In our first exercise, we vary ρ_G and calculate the value of ρ_H that makes the household indifferent between market access or autarky, that is, the value of ρ_H such that $\lambda = 0$. The results

of this exercise are summarized in Figure 1.

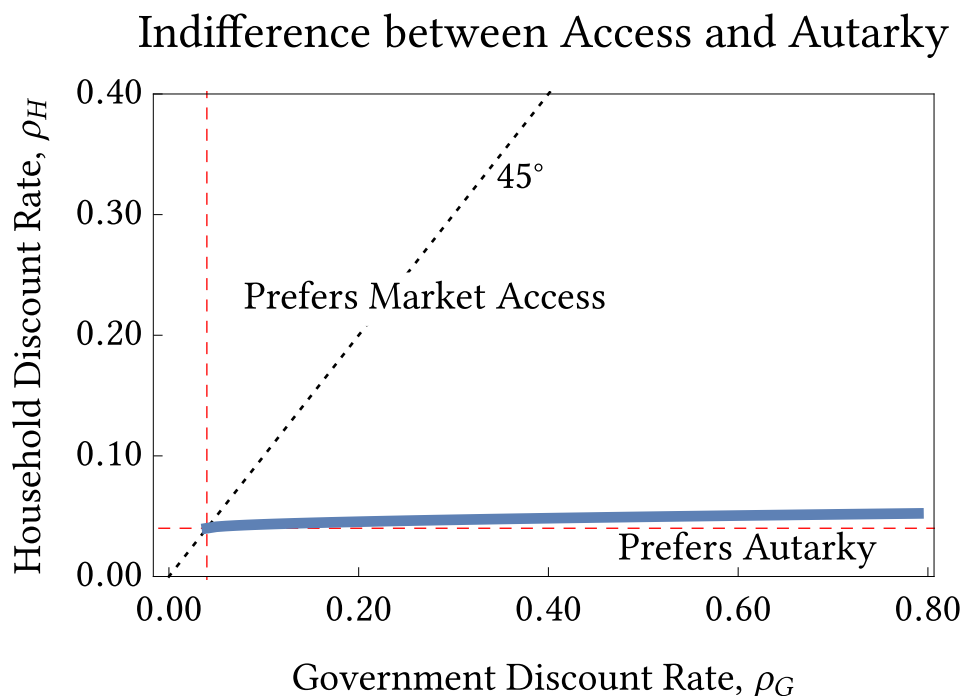


Figure 1: Values of ρ_H above the solid thick line represent values for which the households strictly prefer access to financial markets over autarky. Values below are those where the opposite is preferred. The indifference points are captured by the solid thick line. The dashed lines represent the market discount rate. The dotted line is the 45° line.

Figure 1 shows that the discount rate that makes households indifferent between autarky and financial market access is (i) very close to the world interest rate, and (ii) almost insensitive to the the discount rate of the government. Even when the discount rate of the government is 0.80 (which is equivalent to an annual discount factor of 0.45), a household with a discount rate higher than 0.0524 (that is, a discount factor below 0.95) strictly prefers financial market access to autarky.⁴

The second exercise highlights the magnitudes of the gain/losses. For this, we let $\rho_G = 0.20$, a value commonly used in the quantitative literature (which we discuss below). We then compute λ using the previous parameter values, while varying ρ_H .

Figure 2 shows the associated values of λ as a function of ρ_H . Note that when ρ_H is close to zero, the welfare gains are negative (that is, the households prefer autarky) and close to $-\bar{r}b/y = -0.01$, as expected. That is, for ρ_H close to zero, the households would be willing to reduce their consumption by 1% in order for the government not to access international financial markets. Note also that very close to the market discount rate, the welfare gains turn positive and become

⁴To compute the implicit annual discount factor we compound the annual discount rate for one unit of time: $\beta_G = e^{-\rho_G}$.

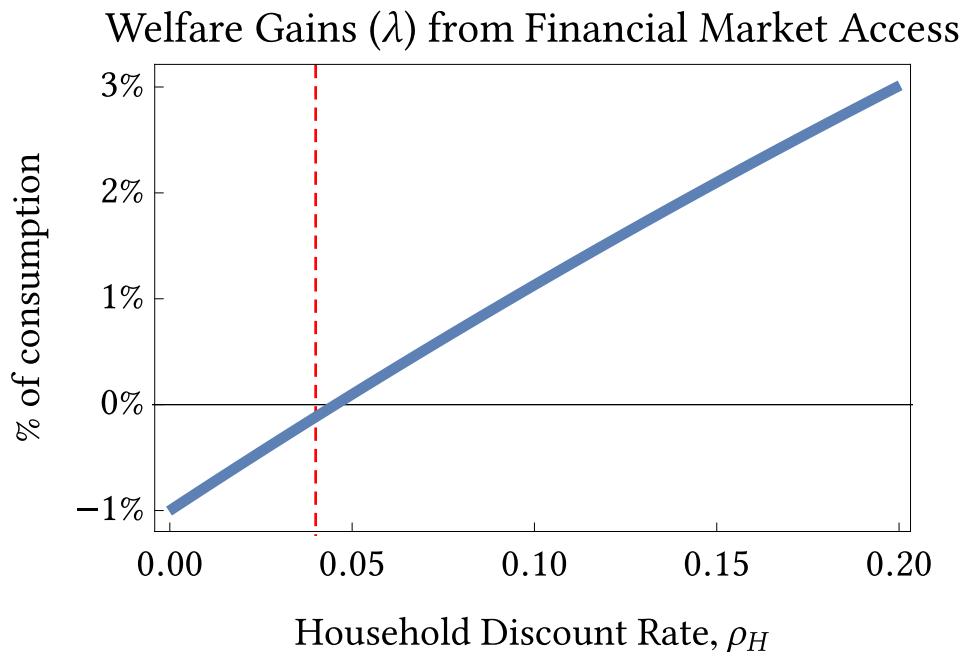


Figure 2: The solid thick line represents the value of λ (y-axis) as a function of the household discount rates ρ_H (x-axis) assuming $\rho_G = 0.20$. The vertical dashed line represents the market discount rate, $r = 0.04$. The horizontal solid line represents $\lambda = 0$.

large. For example, for a household discount rate of 10%, the welfare gains are above 1% of consumption.

Let us now briefly summarize the results of the simple benchmark exercise. First, the welfare costs of financial market access are bounded above by $r\bar{b}/y$. Second, for parameter values close to those typically assumed in the quantitative sovereign debt literature, the discount rate that keeps households indifferent between financial market access and autarky remains numerically close to the market risk-free interest rate. As a result, households which are only slightly more impatient than the markets strictly prefer that their governments maintain financial market access in order to front-load consumption and borrow the maximum amount. Finally, the welfare gains from having access to financial markets can be potentially large, as the household discount rate increases above the market rate.

Our simple back of the envelope exercise suggests that allowing governments to borrow internationally is beneficial for their citizens, even when such governments may be extremely impatient. However, this exercise has ignored the role of shocks, the possibility of not paying the international debts, and the potential costs of default. We now show that incorporating such elements makes the case for banning international financial market access much stronger.

3 The Canonical Sovereign Debt Model

The quantitative sovereign debt literature is based around the model of Eaton and Gersovitz (1981).⁵ The models in this area incorporate stochastic endowment shocks, defaultable but otherwise non-contingent bonds, the possibility of default occurring in equilibrium, the existence of default costs, and the possibility re-entry to financial markets after a default.⁶

We now introduce the benchmark environment. Time is discrete. There is a small open economy, with a government that can access international financial markets. Let $s \in S$ denote the exogenous state, and s^t represent the history of the state realizations. The state evolves according to a probability function given by $\pi(s'|s)$. At every period, the country receives an endowment, $y(s)$, in units of the single consumption good.

As long as it has access to international credit markets, the government can issue bonds, each of which is a promise to deliver an exponentially declining coupon, δ^t , t periods from its issuance date.⁷ Note that this implies, absent issuances or repurchases, that bonds at time t promise a stream of payments that are equivalent to δ times that of bonds at time $t - 1$. Hence, if b_t is the face value of bonds at time t , net issuances are $b_t - \delta b_{t-1}$.

The government can, at any time, choose to default. In such case, the outstanding bonds lose all value and the government enters a (temporary) exclusion period. While excluded from credit markets, the government cannot issue bonds or save, and the economy's endowment is reduced to $y^D(s) \leq y(s)$. Once in financial autarky, the government may re-enter the financial markets (starting with zero debt) at which point the endowment process reverts back to $y(s)$ and the government regains its ability to trade financial instruments. This re-entry after a default occurs with a constant Poisson probability θ .

In every period, the government decides whether to default or not, how much debt to issue (if it has access to financial markets), and the level of its expenditures. We assume that the government has preferences given by

$$\mathbb{E} \sum_{t=0}^{\infty} (\beta^G)^t u(c_t),$$

where $\beta^G \equiv e^{-\rho_G}$ and the expectation is over the Markov process s conditional on the initial state.

As usual in the literature, we narrow attention to Markov perfect equilibria. The payoff relevant state variables are s , whether the government is in autarky or not, and its current level of

⁵Early contributions to the quantitative literature are Aguiar and Gopinath (2006), Arellano (2008), Hamann (2002), and Yue (2010). See the handbook chapters by Aguiar and Amador (2014b) and Aguiar et al. (2016) for additional references.

⁶The model has also been extended to incorporate bargaining among creditors and the sovereign after a default, production, and risk-averse lenders.

⁷This follows Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012).

outstanding debt.

For the case of a government that enters the period in good credit standing, and decides to repay its debts, its value is given by the solution to the following problem:

$$V(b, s) = \max_{b'} \left\{ u(c) + \beta^G \sum_{s'|s} \pi(s'|s) \max\{V(b', s'), \underline{V}(s')\} \right\}$$

subject to:

$$c = y(s) - b + q(b', s)(b' - \delta b)$$

where b denotes the current level of outstanding debt; $q(b', s)$, the price of the bonds; and $\underline{V}(s')$, the value of default. Note that we have incorporated next period default decision into the government problem. We let $\mathcal{B}(b, s)$ denote the policy function that solves this problem.

In case of default, the payoff to the government is:

$$\underline{V}(s) = u(y^D(s)) + \beta^G \sum_{s'|s} \pi(s'|s) (\theta V(0, s') + (1 - \theta) \underline{V}(s'))$$

Finally, we need to specify how the financial markets value the bonds. We assume for now that the financial markets are risk-neutral, and discount inter-temporal flows at a rate R . The bond price is then:

$$q(b, s) = \frac{1}{R} \sum_{s'|s} \pi(s'|s) \mathbb{1}_{\{V(b, s') \geq \underline{V}(s')\}} (1 + \delta q(\mathcal{B}(b, s'), s'))$$

where $\mathbb{1}_{\{x\}}$ is an indicator function that x is true and $\mathcal{B}(b, s')$ was defined above to be the government's debt-issuance policy function.

Definition 1. A Markov equilibrium is then set of functions $V, \underline{V}, q, \mathcal{B}$ such that (i) V and \underline{V} are fixed points of the government's Bellman equations; (ii) \mathcal{B} is a solution of the government's repayment problem; and (iii) q satisfies the break-even condition for the financial markets.

4 The Welfare Gains and Losses of Financial Market Access

We now assess the potential welfare gains and losses due to financial market access. We do this under a sequence of calibrations popular in the quantitative literature.

The reference allocation is autarky. An alternative reference would be to allow the government to save but not borrow. Doing this in principle will raise the value of financial constraints from the perspective of the households, biasing our current results against finding welfare gains

from financial market access. We define the autarky welfare (starting from zero debt) for the government and representative household, respectively, as:

$$V^A(s) = u(y(s)) + \beta^G \sum_{s'|s} \pi(s'|s) V^A(s')$$

$$W^A(s) = u(y(s)) + \beta^H \sum_{s'|s} \pi(s'|s) V^A(s').$$

As before, the disagreement arises when $\beta^G \neq \beta^H = e^{-\rho_H}$.

Given an equilibrium policy function \mathcal{B} and associated equilibrium prices, we can compute the welfare of the representative household:

$$W(b, s) = u\left(y(s) - b + q(\mathcal{B}(b, s), s)(\mathcal{B}(b, s) - \delta b)\right) + \quad (4)$$

$$\beta^H \sum_{s'|s} \pi(s'|s) \left[\mathbb{1}_{(V(\mathcal{B}(b, s), s') \geq \underline{V}(s'))} W(\mathcal{B}(b, s), s') + \mathbb{1}_{(V(\mathcal{B}(b, s), s') < \underline{V}(s'))} \underline{W}(s') \right] \quad (5)$$

$$\underline{W}(s) = u(y^D(s)) + \beta^H \sum_{s'|s} \pi(s'|s) (\theta W(0, s') + (1 - \theta) \underline{W}(s')) \quad (6)$$

where $V, \underline{V}, q, \mathcal{B}$ represents the components of a Markov equilibrium of the economy when the government has access to sovereign debt markets.

Just as we did before, we can then compute the welfare gains of having financial market access. With CRRA utility, we have:

$$\lambda = \begin{cases} \mathbb{E}_s \left[e^{\{(1-\beta^H)(W(0,s)-W^A(s))\}} \right] - 1 & ; \text{if } \sigma = 1 \\ \mathbb{E}_s \left[\frac{W(0,s)}{W^A(s)} \right]^{\frac{1}{1-\sigma}} - 1 & ; \text{if } \sigma \neq 1 \end{cases}$$

where the expectation operator is taken over the ergodic distribution of the Markov process s .

With long-term bonds and the risk of default, it is not obvious that the government may not itself prefer autarky. Hatchondo et al. (2012) show that with long-duration bonds, the introduction of fiscal or debt limits can be beneficial from the perspective of the government.⁸ Such constraints limit the negative incentive effects to dilute initial bondholders and alter equilibrium prices.

Nevertheless, one can show that even though a government may benefit from self-imposed debt limits, a debt limit of 0 would never be optimal from its perspective:

Lemma 2. *In any Markov equilibrium, and for any maturity δ , $V(0, s) \geq V^A(s)$ for all $s \in S$.*

Proof. In the appendix. □

⁸See Aguiar, Amador, Hopenhayn and Werning (Forthcoming) for a discussion of maturity choice under lack of commitment.

Table 1: Parameter Specifications Used (Quarterly Values)

Parameter	AG	Arellano	CE
δ	1.000	1.000	0.9500
β^G	0.800	0.953	0.9540
θ	0.100	0.282	0.0385
r	0.010	0.017	0.0100
$\tilde{y}^D(s)$	$0.98\tilde{y}(s)$	$\min\{0.969\mathbb{E}\tilde{y}(s), \tilde{y}(s)\}$	$\tilde{y}(s) - \max\{-0.188\tilde{y}(s) + 0.246\tilde{y}(s)^2, 0\}$

Note: The value of $\tilde{y}(s)$ and $\tilde{y}^D(s)$ refer to the permanent component of the output process. See footnote 9 for an explanation.

The lemma establishes that *a government will never choose to shut itself out of sovereign debt markets completely.*

4.1 Welfare Losses Across Different Models

In what follows, we will narrow attention to three different calibrations of the Eaton and Gersovitz (1981) model. All the simulations are done with a period equal to a quarter. To keep the results of each of these calibrations consistent, we will set certain parameters the same across them. In particular, in all of the simulations below, the utility parameter σ is set to a value of 2 (which corresponds to the value used in each of the papers we focus on). The income process in all of the exercises is set to one that approximates the quarterly income process for Argentina.⁹ However, we adjust the maturity parameter δ ; re-entry parameter θ ; the default cost process, $\{y^D(s)\}$; the discount factor of the government, β^G ; and the risk-free real interest rate, R , across the alternative simulations. The parameter values used are described in Table 1. Some key moments from the simulations are shown in 2.

The first two calibrations consider an environment with one-period bonds, so $\delta = 1$ in each of them. Critically, the default cost process and the government discount factor are different in both of them.

⁹Our specification of the income process is the same as the specification in Chatterjee and Eyigungor (2012), including both a persistent component and a transitory component. In all the simulations we perform, we similarly set the transitory endowment component to its lowest value in a period where a default occurs. The transitory component is small and needed to facilitate the convergence of the numerical computations in the long term bond case. Its presence is not necessary for the one-period bond calculations (and its effects there are not significant). We refer the reader to Chatterjee and Eyigungor (2012) for more details.

Table 2: Model Statistics (Annualized Values)

Statistic	AG	Arellano	CE
Ergodic Default Frequency	0.30%	2.86%	5.62%
Ergodic Default Mass	0.74%	2.49%	27.02%
Mean Ergodic Debt/GDP	6.02%	0.97%	19.78%
Limiting Mean Debt/GDP on Paths w/o Default	6.02%	1.10%	22.13%
Conditional Mean Default Cost/Persistent GDP	2.00%	0.50%	4.73%
Unconditional Mean Default Cost/Persistent GDP	0.01%	0.01%	1.27%

Note: The debt to output ratio in CE is computed following the transformation described in footnote 13 and the definition in equation (7). The "Limiting Mean Debt/GDP on Paths Without Default" is the mean debt to output ratio that the economy converges to conditional on equilibrium paths where default does not occur, starting from zero debt and from the ergodic endowment distribution. The mean default costs are computed conditional on being in default (the row labelled "Conditional Mean Default Cost/Persistent GDP) and unconditional on default status. The latter is the former multiplied by the fraction of periods spent in default (the row labelled "Ergodic Default Mass").

4.2 Losses in Aguiar and Gopinath (2006)'s Calibration

We start with the transitory-shock version of Aguiar and Gopinath (2006), henceforth AG, which is the closest to the original EG framework. The primary difference is that AG introduce a linear cost of default, which is necessary to support non-trivial amounts of debt in equilibrium.

Following AG, we set the international risk-free (quarterly) gross interest rate to $R = 1.01$ and the (quarterly) re-entry parameter to $\theta = 0.10$. The (quarterly) discount factor of the government equals $\beta^G = 0.8$, which generates an annual discount rate of $\rho_G = 0.89$. The endowment process under default is reduced in each state by 2%, that is, $y^D(s) = 0.98y(s)$.

With these parameter values, we solve for the Markov Equilibrium numerically. The model's debt to (annual) output ratio converges (conditional on no default) to an average level of 0.06, a number very closed to the 0.0625 obtained in Aguiar and Gopinath (2006).¹⁰

Given the simulation results, we compute the counterpart to Figure 2, which is presented in Figure 3. The figure shows the consumption equivalent gains of a household with an annual discount rate ρ_H of giving market access to the government. This is shown in the solid line. The dashed line in the figure is the prediction from the deterministic model using the formula (3), where we used annualized parameters corresponding to the ones in the calibration. Accordingly, we set $r = 4 \log(R) = 0.04$, $\rho_G = -4 \log(\beta^G) = 0.89$, and $\bar{b}/y = 0.06$.

A surprising finding is how well our previous back-of-the-envelope exercise, without un-

¹⁰We compare our results to Aguiar and Gopinath (2006)'s transitory shocks model (Model I). They obtained a 0.25 (quarterly) debt to output ratio. The only difference between our numerical exercise and their transitory shocks model is the specification of output process.

Welfare Gains (λ) from Financial Market Access

Aguiar Gopinath (2008)

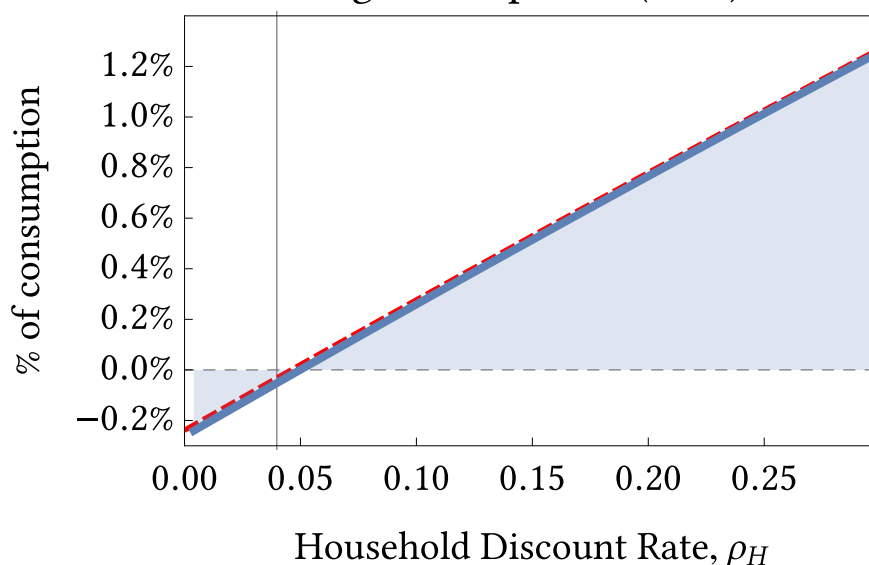


Figure 3: The x-axis is the annualized household discount rate. The y-axis represents the welfare gains in percentage points of consumption. The solid line is the results from the Aguiar and Gopinath (2006) calibration. The dashed line is the result from using formula (3). The vertical line corresponds to the (annualized) international interest rate.

certainty or the possibility of default, is able to very accurately capture the welfare losses from market access in this calibration. The dashed line in Figure 3 is right on top of the solid line. Hence, the calibration seems to confirm the general message of the back of the envelope exercise: For a large range of discount factors for the households, the households are better-off under a regime where the government has access to international financial markets, even when the inter-temporal disagreement between the household and its government is large. As can be seen from Figure 3, it is only when the household discount rate approaches the international discount rate that financial autarky becomes an attractive choice. And even for values close to the market discount rate (but higher), the losses generated by financial market access are quite small – achieving its highest value of 0.053% of consumption for $\rho_H = r$.

This calibration however misses on one particular key dimension. The default probability that arises is quite small (on the order of a 0.3 % annual rate of transiting from a good credit standing to the default state). As stressed in the original AG paper, defaults in this calibration are rare events. As we explore in the next subsections, the presence of uncertainty coupled with a significant risk of default *in equilibrium* can significantly alter the balance between market access and financial autarky, tilting towards the second.

4.3 Losses in Arellano (2008)'s Calibration

The Arellano (2008) builds on the same EG platform as AG, but has a richer model of default. Arellano's major departure from EG and AG is the introduction of a *non-linear* state-dependent default cost. In particular, let

$$y^D(s) = \min\{y(s), \hat{y}\}$$

The asymmetry in this default cost turns out to have significant quantitative implications. The asymmetry implies that for low endowment realizations, that is, for $y(s) < \hat{y}$, defaulting generates no immediate additional drop in output. The only deadweight costs arise from the lack of access to borrowing and saving (which are quantitatively small, as demonstrated by a simple calculation in AG), and the possibility of a future output costs if the endowment transits to a higher level in the future prior to re-entry (which is also mitigated by the persistence in the endowment process).

For $y(s) > \hat{y}$, the output costs equal $y(s) - \hat{y}$. Hence, default in high-endowment states is punished much more harshly. As discussed in Arellano (2008), this specification of default costs allows the model to generate a high default probability in equilibrium.

The introduction of this flexible default specification reduces the government discount rate needed to match the data. We set the (quarterly) discount factor to $\beta^G = 0.953$, the value obtained in Arellano (2008). Similarly to that paper, we set the risk-free (quarterly) interest rate to $R = 1.017$, the re-entry probability to $\theta = 0.282$ (quarterly) and let critical income cutoff be given by $\hat{y} = 0.969\mathbb{E}y(s)$, where $\mathbb{E}y(s)$ represents the ergodic mean of the output process.

Figure 4 presents the computation of the welfare gains, λ , as a function of the household discount rate for this calibration. As before, the solid line is the calibration results; while the dashed line are the gains obtained directly from (3). For the latter, we set $r = 4 \log(R) = 0.067$, $\rho_G = -4 \log(\beta^G) = 0.193$, and $\bar{b}/y = 0.011$, the equivalent annualized parameter values. Again, similarly to the results in the previous model, our back of the envelope calculation does a good job at capturing the order of magnitude of losses generated by financial market access.

Interestingly, and different from the previous calibration, the balance has tilted towards financial autarky. As show in Figure 4, for annual discount rates below 0.13, the household would strictly prefer that the government has no access to international financial markets. Given that a 13% annual discount rate is above the discount rate usually assumed for households in economic models, Figure 4 makes a stronger case for eliminating access to external borrowing than the previous calibration.

We conjecture that the main reason for the difference is that this calibration generates substantial default risk in equilibrium. In the ergodic distribution, the probability of switching from a good credit standing to a default state is around an annual rate of 2.8%, a much higher number

Welfare Gains (λ) from Financial Market Access Arellano (2008)

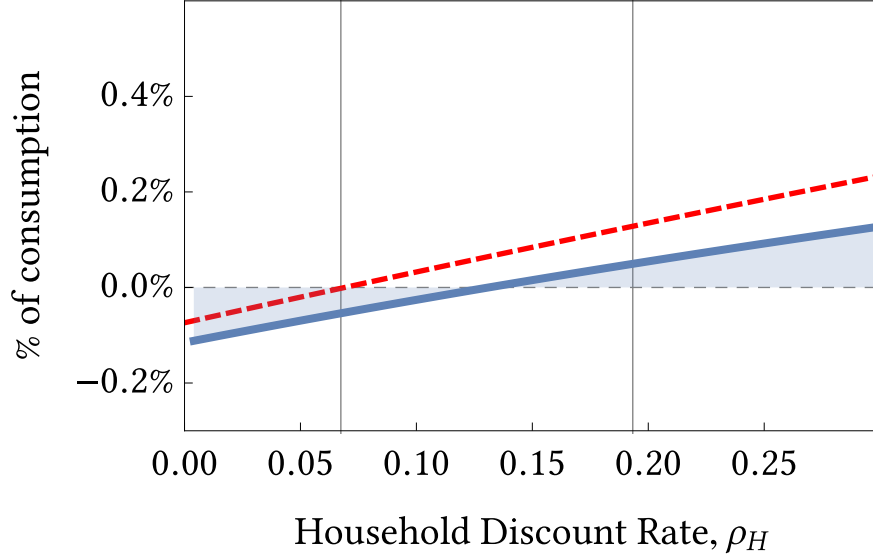


Figure 4: The x-axis is the annualized household discount rate. The y-axis represents the welfare gains in percentage points of consumption. The solid line is the results from the Arellano (2008) calibration. The dashed line is the result from using formula (3). The two vertical lines corresponds to the (annualized) international interest rate and the government discount rate.

than in the previous one. Part of the reason this occurs has to do with the flexible default cost function, which allows for default to occur at a much lower cost in certain endowment states.

To analyze the role that default costs play in this result, we perform the following exercise. Let us define the following altered household value functions, \hat{W} and $\underline{\hat{W}}$:

$$\begin{aligned}\hat{W}(b, s) &= u\left(y(s) - b + q(\mathcal{B}(b, s), s)(\mathcal{B}(b, s) - \delta b)\right) + \\ &\quad \beta^H \sum_{s'|s} \pi(s'|s) \left[\mathbb{1}_{(V(\mathcal{B}(b, s), s') \geq \underline{V}(s'))} \hat{W}(\mathcal{B}(b, s), s') + \mathbb{1}_{(V(\mathcal{B}(b, s), s') < \underline{V}(s'))} \underline{\hat{W}}(s') \right] \\ \underline{\hat{W}}(s) &= u(y(s)) + \beta^H \sum_{s'|s} \pi(s'|s) \left(\theta \hat{W}(0, s') + (1 - \theta) \underline{\hat{W}}(s') \right)\end{aligned}$$

where V , \underline{V} , q , \mathcal{B} are taken as given from the solution to the Markov equilibrium. The main difference between \hat{W} , $\underline{\hat{W}}$ and the specification used in (4) is that we are eliminating the default penalty from the calculations. As can be seen, we have replaced $y^D(s)$ by $y(s)$ in the second equation. \hat{W} captures the welfare of a household that is bound by the default and borrowing choices that the government decides, but faces no output losses when default eventually occurs. We then use this

altered value function and compute the welfare losses from accessing financial markets.¹¹ This is shown in Figure 5.

Welfare Gains (λ) from Financial Market Access Arellano (2008) (Without Default Costs)

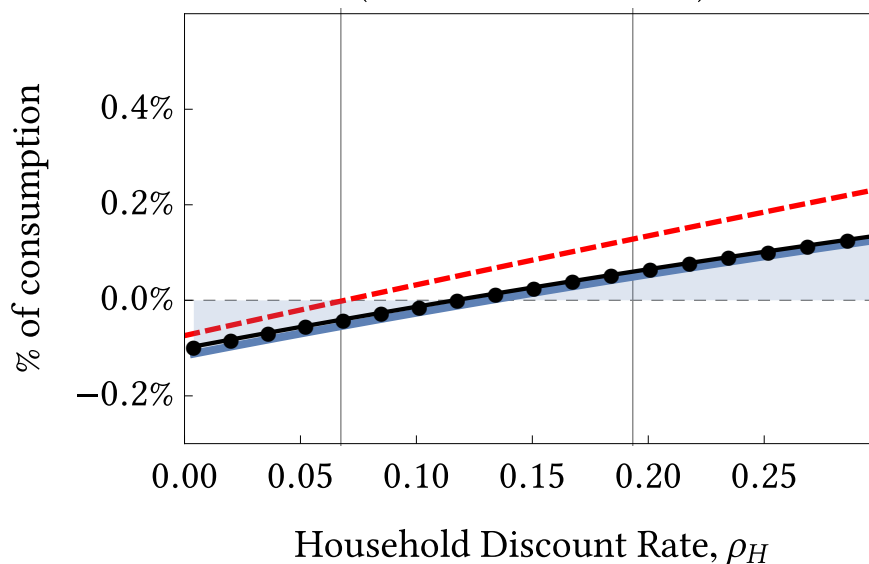


Figure 5: The x-axis is the annualized household discount rate. The y-axis represents the welfare gains in percentage points of consumption. The solid line is the results from the Arellano (2008) calibration. The dashed line is the result from using formula (3). The solid line with markers represents the welfare calculation eliminating the default costs. The two vertical lines corresponds to the (annualized) international interest rate and the government discount rate.

From Figure 5 we can see that it does not matter for the welfare loss calculation whether we include the default costs or not in the household’s welfare computation. A potential explanation for this is that default, in this environment, is occurring mostly in states where default is not too costly. Most of the difference between the prediction of our back of the envelope exercise and the calibration arises from the fact that the presence of default risk in equilibrium has generated an increase in consumption risk, a point we explore in more detail in Appendix C.

As a final comment, note that although Figure 4 strengthens the case against external borrowing, the welfare magnitudes involved remain small. The welfare losses from financial market access at $\rho_G = r$ equal 0.054% of consumption (this is the highest possible number for discount rates weakly above the interest rate). Our back of the envelope exercise suggests that this is

¹¹For this calculation, we have removed both the default costs associated with the permanent component of the endowment, as well as the one associated with the transitory one during the first period of default. This latter however has no impact on the results.

mainly due to the fact that this calibration does not generate significant amounts of sovereign lending.

In order to deal with the short-comings of one-period bond models, the literature has incorporated long-duration bonds into the environment. The presence of long-term debt allows the model to match a higher external debt to output ratio (closer to those observed in emerging markets). They also introduce an additional inefficiency due to debt dilution. As we will show next, these forces significantly strengthen the case against external government borrowing.

4.4 Long Duration Bonds

Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012), henceforth CE, were the first to extend the quantitative EG model to an environment with long-term bonds. We follow the parameter values used in Chatterjee and Eyigungor (2012). The (quarterly) value of the maturity parameter is set to $\delta = 0.95$, which generates an average bond maturity of 5 years. The (quarterly) real interest rate is set to $R = 1.01$. The re-entry parameter is set to a (quarterly) value of $\theta = 0.0385$ (which generates a longer exclusion period than the previous two exercises). Following Arellano (2008), CE use a non-linear cost of default; specifically, the output process during exclusion is given by the following specification:

$$y^D(s) = y(s) - \max\{0, d_0\tilde{y}(s) + d_1\tilde{y}(s)^2\}$$

where $\tilde{y}(s)$ refers to the persistent component of the output process, and where $d_0 = -0.18819$ and $d_1 = 0.24558$.¹²

The (quarterly) discount factor of the government is $\beta = 0.954$, implying an annual government discount rate of $\rho_G = 0.188$. To calculate the debt to output ratio to be used in our back of the envelope exercise, consider the following. Suppose that the bond was risk free, in this case, its price would be $q^* \equiv \frac{1}{1+r-\delta}$. Now, let us calculate the budgetary cost of rolling-over the debt forever. That is setting $b' = b$, from the budget constraint we get that

$$\begin{aligned} c - y(s) &= -b + q^*(b' - \delta b) = -b + q^*(1 - \delta)b \\ &= r \frac{b}{1 + r - \delta} \end{aligned}$$

Thus, servicing an amount b of long duration bonds is equivalent to servicing an amount $b/(1 +$

¹²In Chatterjee and Eyigungor (2012), the output process is the sum of two components: $y(s) = \tilde{y}(s) + m(s)$, where $\tilde{y}(s)$ follows a persistent Markov chain, and $m(s)$ is an i.i.d. process. In the period where default is triggered, the transitory component is set to its lowest level in the support, while it reverts back to its normal stochastic process in subsequent periods. See the related discussion in footnote 9.

$r - \delta$) of one period bonds (under risk-free pricing). We thus use

$$\frac{\text{debt}}{y} \equiv \frac{b/y}{1 + r - \delta} \quad (7)$$

as our equivalent debt to output ratio in our back of the envelope exercise. Conditional on no default, this value converges in the simulation to an annual debt to output ratio of 0.221.¹³

Figure 6 shows the corresponding values of λ for this calibration. First, the welfare gains from denying access are now an order of magnitude larger. Part of the reason is that the debt to output ratio that this model generates is also larger than the previous ones.

The disagreement about the value of financial market access exists for a large range of discount rates for the households. Different from the prediction of the back of the envelope exercise, households with an annual discount rate less than 0.10 would strictly prefer that their government have no access to financial markets. The welfare losses now reach 1.1% of consumption when the household discount rate equals the market interest rate.

This calibration of the model delivers a higher debt to output ratio, and also a higher probability of default. In this calibration, the annual probability of default is 5.7%.

To understand why the welfare magnitudes and the range of disagreement is much larger in the calibration than in the back of the envelope calculation, we perform the same exercise as in the previous section, where we compute household welfare eliminating the output costs.

Figure 7 shows the result of this exercise for this calibration. Eliminating the drop in output generated by default events *comes quantitatively close to eliminating all disagreement* with respect to market access. For annual discount rates above 0.0473, the household strictly prefers the government to have access to international markets. Moreover, the losses when the households discount at the market interest rate equal 0.087% of consumption. Without default costs, slightly impatient households would already strictly prefer their impatient government to have access to international financial markets. Even when they would prefer the opposite, the losses are an order of magnitude smaller than those found when the default costs are taken into account.

As a final exercise, we now replicate Figure 1 in the context of the CE calibration. That is,

¹³ Chatterjee and Eyigungor (2012) use a different specification for the long-term bond. They assume that a given bond matures with an idiosyncratic probability λ , in which case it pays a unit to its holder. If the bond does not mature, it pays a coupon z . The budget constraint (using hats to represent these alternative bonds) is now

$$c = y(s) - (\lambda + (1 - \lambda)z)\hat{b} - \hat{q}(s, b')(\hat{b}' - (1 - \lambda)\hat{b})$$

and the pricing equation

$$\hat{q} = \mathbb{E} \left[1(\text{No default}) \frac{\lambda + (1 - \lambda)(z + \hat{q}')}{R} \right]$$

This is equivalent to our formulation with the following change in variables: $q = \hat{q}/(\lambda + (1 - \lambda)z)$, $b = (\lambda + (1 - \lambda)z)\hat{b}$, $\delta = 1 - \lambda$.

Welfare Gains (λ) from Financial Market Access Chatterjee and Eyigungor (2012)

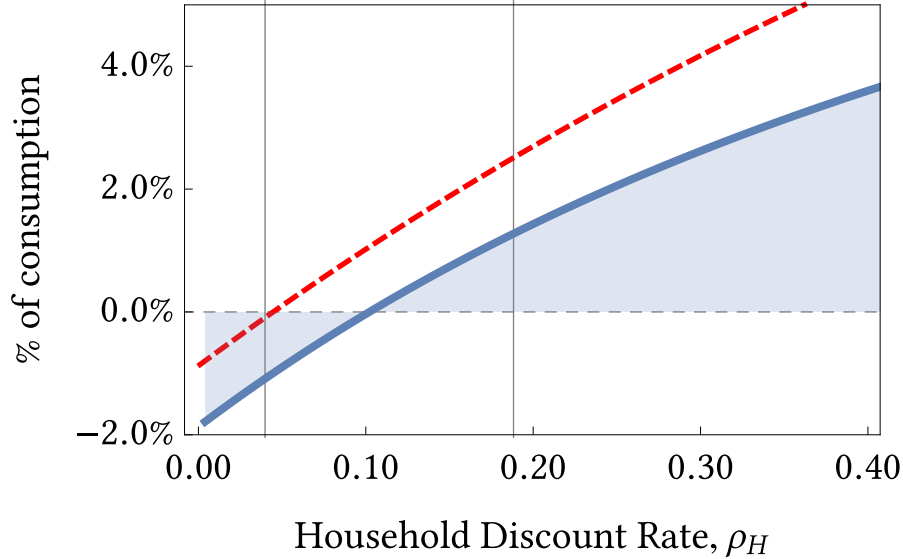


Figure 6: The x-axis is the annualized household discount rate. The y-axis represents the welfare gains in percentage points of consumption. The solid line is the results from the Chatterjee and Eyigungor (2012) calibration. The dashed line is the result from using formula (3). The two vertical lines corresponds to the (annualized) international interest rate and the government discount rate.

keeping all other parameters constant, we compute, for different values of the government discount rate ρ_G , the household discount rate, ρ_H , that will make the household indifferent between market access or not. Recall from Figure 1 that the back of the envelope calibration suggested that such household discount rate would barely change and would remain close to the market interest rate. For the CE calibration, the results are quite different.

Figure 8 shows the indifference calculation performed for the CE calibration. As can be seen, the indifference line is much steeper than that of Figure 1. There is a wider range of household discounts factors that disagree with the government access to external sovereign debt markets. Even more, such disagreement quantitatively increases as the government becomes more impatience (that is, as its discount rate increases).¹⁴

¹⁴It is important to note however, that this indifference line does not fully corresponds to that of Figure 1. In that figure, the debt to output ratio was kept constant. In Figure 8, as we change the government discount factor, the debt to output ratio in equilibrium changes.

Welfare Gains (λ) from Financial Market Access
 Chatterjee and Eyigungor (2012)
 (Without Default Costs)

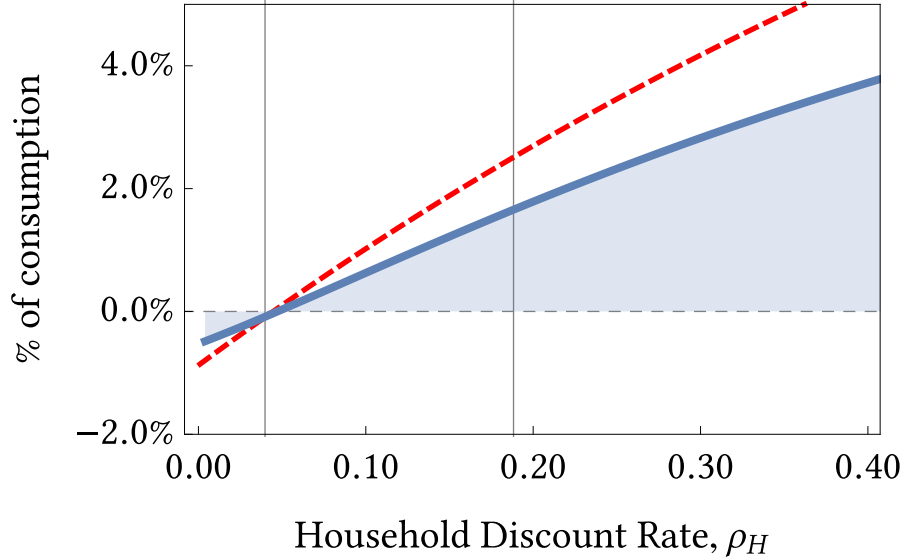


Figure 7: The x-axis is the annualized household discount rate. The y-axis represents the welfare gains in percentage points of consumption. The solid line is the results from the Chatterjee and Eyigungor (2012) calibration. The dashed line is the result from using formula (3). The two vertical lines corresponds to the (annualized) international interest rate and the government discount rate.

5 Conclusion

In this paper we have gathered some lessons from the quantitative sovereign debt literature regarding the costs of external sovereign borrowing. Our back of the envelope exercise turns out to be a very good predictor of the welfare gains from having access to financial markets in the model of Section 4.2, where the default probability is small. We showed that the inter-temporal distortion in spending is not quantitatively large enough to generate a significant level of disagreement between the households and the government regarding access to external borrowing in this case. And, in addition, the welfare magnitudes involved are not large, a fact generated by the low amount of external debt involved.

The introduction of a significant level of default risk matters for this result. In Section 4.3, when default risk is high, but the default costs generated in equilibrium are low, the additional expenditure risk that access to external markets generates is sufficient to drive a disagreement between households and its government with regards to market access. However, the welfare magnitudes involved remain small, as the amount of debt is not large, and default, although it occurs in equilibrium, it generates small deadweight losses.

Indifference between Access and Autarky

Chatterjee Eyigungor (12)

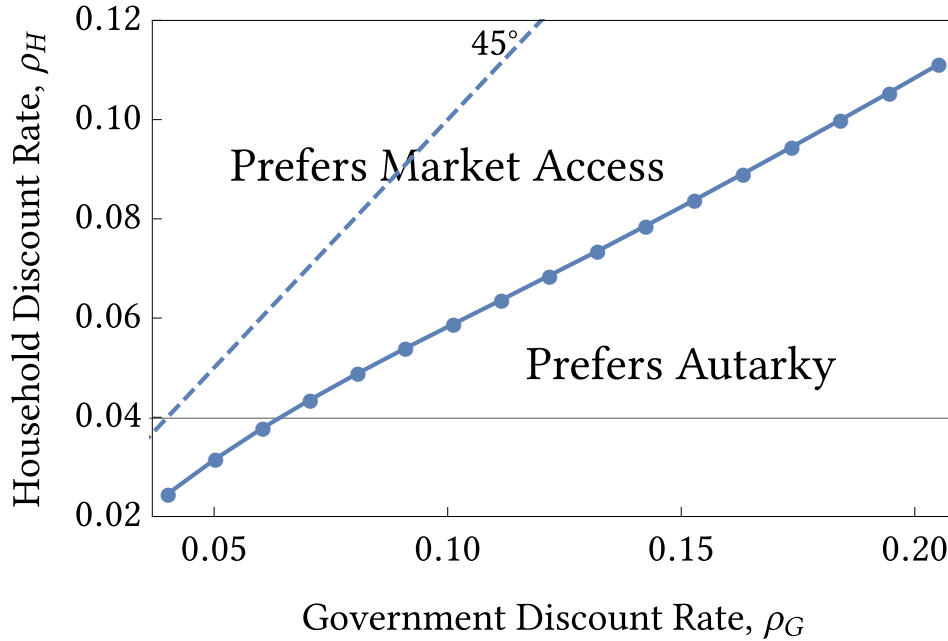


Figure 8: The solid line represents the (annualized) household discount rate (y-axis) that keeps a household indifferent between market access or not, for different (annualized) government discount rates (x-axis). The rest of the parameters are as in the CE calibration.

However, using the latest cohort of sovereign debt models, which include long-term bonds as well as a more flexible specification of the output costs, we find that the level of disagreement is large. Relatively impatient households living in this model will prefer a situation where their government cannot access external sovereign markets. And the magnitudes of the welfare gains that such a market shutdown would generate is significant. We showed that this result is mostly driven by the default costs that in equilibrium the government generates from its excess borrowing and associated defaults.

Our conclusion is that the market structure of the debt (whether it is long or short maturity), as well as the shape of the default costs, are critical to evaluate the benefits of sovereign debt market access. We can observe very well the first one. But there is greater uncertainty regarding the second, as the costs of default are usually inferred from other calibration targets. But the existence of default costs, that occur in equilibrium, can significantly strengthen the case against access to external sovereign debt markets.

A Proof of Lemma 1

The functional form describe in equation (3) arises from the solutions to the welfare functions obtained in the text. To see that this expression is strictly increasing in ρ_G , consider the case where $\rho \neq 1$.

First note that $\bar{b} > 0$ and $\rho_G > r$ implies that $T > 0$.

Let $\kappa \equiv (\rho_G - r)^{\frac{1-\sigma}{\sigma}} \neq 0$. Note that $\rho_G > r$ implies that κ inherits the sign of $1 - \sigma$, given $\sigma > 0$. Whether λ increases with ρ_H then depends on whether

$$\frac{\rho_H e^{\kappa T} + e^{-T\rho_H} \kappa}{\kappa + \rho_H}$$

strictly increases when $0 < \sigma < 1$ ($\kappa > 0$) and decreases when $\sigma > 1$ ($\kappa < 0$).

The derivative with respect to ρ_H is

$$-\kappa \frac{e^{-T\rho_H}(1 - e^{T(\kappa+\rho_H)} + T(\kappa + \rho_H))}{(\kappa + \rho_H)^2}$$

Note that this derivative is continuous for all $\rho_H > 0$, equating $\kappa \frac{1}{2} e^{T\kappa} T^2$ at $\rho_H = -\kappa$. Hence the derivative at $\rho_H = -\kappa$ is non-zero (as $T > 0$) and inherits the sign of κ .

It suffices to check that

$$1 - e^{T(\kappa+\rho_H)} + T(\kappa + \rho_H) < 0$$

for the rest of the domain, $\rho_H \neq -\kappa$. But this follows as the above is a strictly concave function of ρ_H (given $T > 0$), with a maximum of 0 at $\rho_H = -\kappa$.

The proof for the case of $\sigma = 1$ is simpler, and left to the reader.

B Proof of Lemma 2

From the value function of government, starting from any s where $b = 0$, it follows that it is feasible to set $b' = 0$ (independently of the price). In that case, such a strategy provides a lower bound to the value, and thus:

$$\begin{aligned} V(0, s) &\geq u(y(s)) + \beta^G \sum_{s'|s} \pi(s'|s) \max\{V(0, s'), \underline{V}(s')\} \\ &\geq u(y^D(s)) + \beta^G \sum_{s'|s} \pi(s'|s) (\theta \{V(0, s') + (1 - \theta)\underline{V}(s')\}) = \underline{V}(s) \end{aligned}$$

where the second inequality follows from $y^D(s) \leq y(s)$. Thus $V(0, s) \geq \underline{V}(s)$, and

$$V(0, s) \geq u(y(s)) + \beta^G \sum_{s'|s} \pi(s'|s)V(0, s')$$

Solving this recursion yields that

$$V(0, s) \geq V^A(s).$$

C Accounting for Excess Variability

To account for the excess variability of expenditures, we propose the following exercise. Consider the Arellano (2008) calibration, and let \bar{c}_t be the (deterministic) average path of consumption implied by the Arellano (2008) calibration starting from the ergodic distribution of the endowment and zero debt, *once we have removed the default costs*. Note that that the budget constraint and the actuarially fair prices imply that the present value of this deterministic path of consumption equals the present value of a path for the endowment that equals its ergodic mean (without the default costs).

We can then re-do the welfare gains exercise, assuming that the consumption path is deterministic and, at time t equals to its time t average value, \bar{c}_t . With this, we have both removed the default costs as well as the variability of consumption around its mean path as a concern for welfare.

The welfare gains are shown in Figure 9. The result is interesting: once we have removed the default costs and the risk that arises from the variability of consumption; the benchmark exercise captures extremely well the welfare implications. That is, the solid line with markers closely corresponds to the welfare gains inferred from the back of the envelope exercise.

Given that the default costs did not play a role for the welfare gains, it follows that the variability of spending (around its average path) is the reason for the disagreement and the welfare results in this calibration.

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Welfare Gains (λ) from Financial Market Access

Arellano (2008)

(Without Default Costs and Risk)

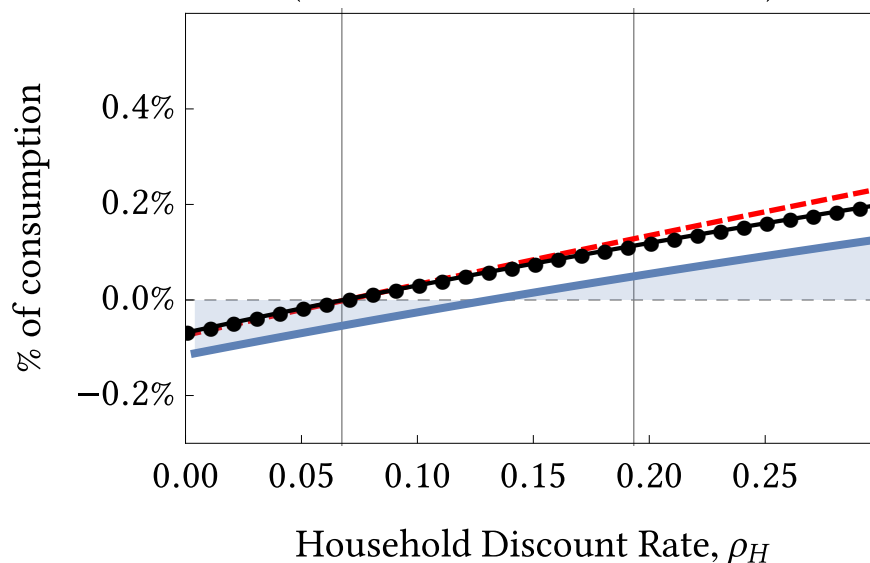


Figure 9: The x-axis is the annualized household discount rate. The y-axis represents the welfare gains in percentage points of consumption. The solid line is the results from the Arellano (2008) calibration. The dashed line is the result from using formula (3). The solid line with markers represents the welfare calculation eliminating both the default costs and risk. The two vertical lines corresponds to the (annualized) international interest rate and the government discount rate.

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