Sovereign Defaults and Banking Crises*

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Abstract

Episodes of sovereign default feature three key empirical regularities in connection with the banking systems of the countries where they occur: (i) sovereign defaults and banking crises tend to happen together, (ii) commercial banks have substantial holdings of government debt, and (iii) sovereign defaults result in major contractions in bank credit and production. This paper provides a rationale for these phenomena by extending the traditional sovereign default framework to incorporate bankers who lend to both the government and the corporate sector. When these bankers are highly exposed to government debt, a default triggers a banking crisis, which leads to a corporate credit collapse and subsequently to an output decline. When calibrated to the 2001-02 Argentine default episode, the model is able to produce default in equilibrium at observed frequencies, and when defaults occur credit contracts sharply, generating output drops of 6% below trend, on average. Moreover, the model matches several moments of the data on macroeconomic aggregates, sovereign borrowing, and fiscal policy. The framework presented can also be useful for studying the optimality of fractional defaults and the political economy of domestic debt repudiation.

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1 Introduction

Sovereign defaults and banking crises have been recurrent events in emerging economies. Recent default episodes (e.g., Russia 1998, Argentina 2001-02) have shown that whenever the sovereign decides to default on its debt there is an adverse impact on the domestic economy, largely through disruptions of the domestic financial systems. Why does this happen? Both in the Argentine and Russian cases (and also in others discussed below), the banking sectors were highly exposed to government debt. In this way a government default directly decreased the value of the banking sector's assets. This forced banks to reduce credit to the domestic economy (a *credit crunch*), which in turn generated a decline in economic activity.

The ongoing debt crisis in Europe also highlights the relationship between sovereign defaults, banking crises, and economic activity. In early 2012, most of the concerns around Greece's possible default (or unfavorable restructuring) were related to the level of exposure that banking sectors in Greece and other European countries had to Greek debt. The concerns were not only about losing what had been invested in Greek bonds, but also, and mostly, over how this shock to banks' assets would undermine their lending ability and ultimately the economic activity as a whole. [1]

This leads to the realization that sovereign default episodes can no longer be understood as events in which the defaulting country suffers mainly from international financial exclusion and trade punishments. The motivation above, the empirical evidence we present later on, and the policy discussions (e.g., IMF, 2002, Lane, 2012) all suggest shifting the attention to domestic financial sectors and how they channel the adverse effects of a default into the rest of the economy.

The contribution of this paper is twofold. Firstly, it quantifies the impact of a sovereign default on the domestic banks' balance sheets, their lending ability and economy-wide activity. To do so, we build on the work of Brutti (2011), Sandleris (2012), and Gennaioli et al. (2014b)

[1] Another related and current policy debate concerns the necessary improvements to regulatory policy for European banks and the ways in which they value their holdings of sovereign debt. Different proposals have been put forward aimed at lowering the fragility of the banking sector and its exposure to sovereign risk, like the implementation of Eurobonds (see. Favero and Missale, 2012), or the creation of European Safe Bonds (see Brunnermeier et al., 2011), among others. These proposals highlight how important it is for policy-making to have a better understanding of the dynamic relation between sovereign borrowing, bank fragility, and economic activity, and to have reliable quantifications of the impact of different government policies. Our paper provides both a theory of the dynamics and a quantification of the impact.

to extend a theory of the transition mechanism of sovereign defaults. The existing literature on quantitative models of sovereign default has been mostly silent about the relationship between sovereign debt, defaults and banking sector performance. Secondly, on a methodological note, this paper presents a mechanism for endogenizing the output cost of defaults: a sovereign default triggers a credit crunch, and this credit crunch generates output declines. Ours is the first quantitative paper to endogenize the output cost of default as a function of the repudiated debt. This makes our framework a natural starting point to study the optimality of fractional defaults.

Based on three key empirical regularities, namely that (i) defaults and banking crises tend to happen together, (ii) banks are highly exposed to government debt, and (iii) crisis episodes are costly in terms of credit and output, we build a theoretical framework that links defaults, banking sector performance, and economic activity. This paper rationalizes these phenomena extending a traditional sovereign default framework (in the spirit of Eaton and Gersovitz, 1981) to include bankers who lend to both the government and the corporate sector. When these bankers are highly exposed to government debt, a default triggers a banking crisis which leads to a corporate credit collapse and consequently to an output decline.

These dynamics that characterize a default and a banking crisis are obtained as the optimal response of a benevolent planner: faced with a level of spending that needs to be financed, and having only two instruments at hand (debt and taxes), the planner may find it optimal to default on its debt even at the expense of decreased output and consumption. The planner balances the costs and benefits of a default: the benefit is the lower taxation needed to finance spending (lower than would otherwise have been necessary), and the cost is the reduced credit availability and the subsequently decreased output. Quantitative analysis of a version of the model calibrated to the 2001-02 Argentine default yields the following main findings: (1) default on equilibrium, (2) v-shaped behavior of output and credit around crises episodes, (3) mean output decline in default episodes of approximately 6%, and (4) overall quantitative performance of the model is in line with the business cycle regularities observed in Argentina and other emerging economies.

Quantitative models of sovereign default have received increased attention since the contributions of Aguiar and Gopinath (2006) and Arellano (2008). These papers extended the seminal framework of Eaton and Gersovitz (1981) to account for business cycle regularities in emerging economies. A large literature has emerged following this approach and several interesting aspects of the dynamics of sovereign debt have recently been studied.[2] The optimal default decision examined in most models in this literature comes from weighing the costs and benefits of default. The majority of the literature has assumed an exogenous cost-of-default structure.[3] This paper proposes a channel to endogenize these costs via the role of government debt in the domestic credit market.

Mendoza and Yue (2012) were the first to introduce endogenous costs of default. They assume that a sovereign default not only excludes the government from the international markets but also prevents private sector firms from accessing foreign markets. In this way, a sovereign default forces the productive sector to use less efficient resources and hence generates an output cost. This paper departs from Mendoza and Yue (2012) in two relevant ways. First, it presents a model economy flexible enough to accommodate both external and domestic debt: when debt is at least partially domestically held, defaulting is a less attractive option (domestic residents' assets become worthless) and therefore makes *default-on-equilibrium* a more challenging outcome. Secondly, it acknowledges the prevalence of government debt in banks' balance sheets and illustrates how a sovereign default diminishes the availability of credit in the economy.

Other researchers have recently and independently noticed the exposure of the domestic banking sector to government debt and have asked different questions about this phenomenon. Gennaioli et al. (2014b) construct a stylized model of domestic and external sovereign debt in which domestic debt weakens the balance sheets of banks. This potential damage suffered by the banking sector represents in itself a 'signaling' device that attracts more foreign lenders.[4] They interpret the banks' exposure as a measure of the quality of the financial institutions in the economy and derive a number of testable implications that they investigate empirically. In a related paper, Brutti (2011) studies a sovereign debt model in a three-period economy in which public debt is a source of liquidity and a default generates a liquidity crises. Both papers find that the presence of financial frictions allows the emergence of public debt even in

[2]Among others, Yue (2010) studies debt defaults and renegotiations, D'Erasmo (2011) incorporates government reputation and endogenous default resolutions, Hatchondo and Martinez (2009) extend the model to incorporate long duration bonds, and Hatchondo et al. (Forthcoming) study the effects of debt dilution. Stähler (2013) presents a thorough account of recent developments in this literature.

[3]See, for example, Chatterjee and Eyigungor (2012).

[4]Basu (2009) develops a similar model that features domestic and foreign creditors and in which domestic economic fragility allows the sovereign to borrow from international markets. Alessandro (2009) presents a related model in which the sovereign default increases the borrowing costs to domestic firms.

the absence of typical default penalties. [5] Our analysis relates to Gennaioli et al. (2014b) and Brutti (2011) in that it also identifies the damage that financial institutions suffer when there are defaults. We identify this reduced credit as the endogenous mechanism generating output costs of defaults and also analyze the benefits side: how distortionary taxation can be reduced when defaults occur. Additionally, our dynamic stochastic general equilibrium model allows us to quantify the importance of the "balance-sheet channel" while also been able to account for a number of empirical regularities in emerging economies. [6]

Bolton and Jeanne (2011) study sovereign defaults and bank fragility in a model of contagion between financially integrated economies. Using a stylized three-period model, they show that financial integration without fiscal integration may result in an inefficient (from a global perspective) supply of government debt. Like theirs, this paper both highlights the exposure of the banking sector to government debt and shows that sovereign defaults generate contractions in private credit. Unlike Bolton and Jeanne (2011), whose focus is mostly on advanced economies and contagion among them, our paper focuses more on emerging economies. This study also differs in the optimal policy treatment of the default decision and the quantitative analysis of the business cycle behavior of models of sovereign defaults and banking.[7]

This paper is also related to the optimal taxation literature. The closest paper to ours in this literature is Pouzo and Presno (2014). They build on the work of Aiyagari et al. (2002) to analyze the optimal taxation problem of a planner in a closed economy with defaultable debt. This paper differs from Pouzo and Presno (2014) in three crucial aspects: first, Pouzo and Presno (2014) rely on an exogenous cost of default, whereas we propose an endogenous structure; secondly, Pouzo and Presno (2014) restrict the analysis to a closed economy setting (and therefore to domestic debt), whereas the environment to be studied here is flexible enough to accommodate both domestic and external debt; and thirdly (on a more technical note), Pouzo and Presno (2014) solve for an equilibrium in which the government has commitment to a certain tax schedule but not to a repayment policy, whereas our analysis assumes no

[5] Niemann and Pichler (2013) study a related infinite horizon economy where government debt provides collateral and liquidity services, and find that typical (i.e., contemporaneous and reputational) default costs are essential for obtaining empirically plausible predictions.

[6] Our analysis is also consistent with Sandleris (2012), who finds that the main costs of default come through the effects on the agents' balance sheets and expectations.

[7] Another related paper is the one by Livshits and Schoors (2009). They argue that defaults generate banking crises because of a prudential regulation which is inadequate in failing to recognize the riskiness of the debt.

commitment on the part of the government.[8]

The rest of the manuscript is structured as follows. Section 2 presents stylized facts on sovereign defaults, banking crises, and output and credit drops around defaults. Section 3 lays out the model and defines the equilibrium. Section 4 presents details of the calibration and the numerical solution. Section 5 contains the main results, and Section 6 presents the results of robustness exercises. Section 7 concludes and describes avenues for future research. All tables and graphs are in the appendices.

2 Stylized Facts

This section documents the stylized facts that motivate the theoretical and quantitative analysis presented in the rest of the paper. It begins by describing the time clustering of default crises and banking crises. Next, it examines the exposure of the emerging economies' banking sectors to government debt. Finally, it presents the output and credit behavior around default episodes.

Default and Banking crises tend to happen together. We follow the classification in Reinhart and Rogoff (2009) in order to identify banking crises that occurred in the temporal vicinity of a sovereign default. Of the 82 banking crises episodes documented in Reinhart (2010), 70 accompanied default crises.[9] From those 70 episodes, we only consider crises after 1970 (due to data limitations), and we identify those in which the sovereign default either preceded or coincided with the banking crisis: Table I shows that this occurred in 25 out of 39 post-1970 events.[10]

The relationship between banking crises and default episodes has been the subject of previous empirical studies. In particular, the question of whether a default causes a banking crisis

[8]This paper is also related to the literature on optimal public policy without commitment. Papers in this literature (like ours) solve for Markov-perfect (and therefore, time-consistent) optimal policies. See Klein et al. (2008) and the references therein.

[9]Reinhart and Rogoff (2009) follow Demirgüç-Kunt and Detragiache (1998) in defining as a banking crisis any episode in which at least one of the following criteria is true: (1) the ratio of non-performing assets to total assets in the banking system exceeds 10 percent, (2) the cost of the rescue operation was at least 2 percent of GDP, (3) banking sector problems resulted in a large-scale nationalization of banks, (4) extensive bank runs took place or emergency measures (e.g., deposit freezes, prolonged bank holidays, generalized deposit guarantees) were enacted by the government. The mechanism highlighted in this paper is closely related to (1).

[10] This timing of events, with the banking crisis occurring after or at the same time as the default event, is consistent with the one that we will assume in the model presented in the next section. Thus, the significance of documenting that this was the timing observed in about 2/3 of the actual twin default/banking crises.

or vice versa has recently been addressed by Borensztein and Panizza (2009). They construct an index of banking crises that includes 149 countries for the period 1975-2000. In this sample, they identify 111 banking crises (implying an unconditional probability of having a crisis equal to 2.9%) and 85 default episodes (unconditional default probability of 2.2%). Their results are reproduced in Table II.

When conditioned on a sovereign default episode, the probability of a banking crisis increases by a factor of 5 and this conditional probability is statistically significantly higher than the unconditional one (as denoted by a 0.0 p-value).

Nevertheless, it could be argued that a banking crisis can generate additional government spending (e.g., in the form of bailouts) that would make the sovereign more prone to a default. It is then imperative to examine the probability of having a default conditional on experiencing a banking crisis: this probability is only 2 percentage points higher than the unconditional probability and it is not statistically significantly higher than the unconditional one (at either 1% or 5% confidence levels).[11]

Although these results should be considered with caution, they suggest that a default is much more likely to increase the probability of a banking crisis than a banking crisis is to increase the likelihood of a default. Overall, the evidence presented provides support for the assumed timing in the model.

The banking sector exposure to government debt. In this subsection, we examine the degree of exposure of domestic commercial banks to government debt.[12] To do this, we follow Kumhof and Tanner (2005) and define an *exposure ratio* in the following way:

$$\frac{\text{Financial Institutions' net credit to the gov't}}{\text{Financial Institutions' net total assets}}$$

As Figure I documents, this exposure ratio averages 22% when all countries are considered, 24% for developing economies, and 16% for advanced economies. What is even more compelling is

[11] A more recent empirical study on banking crises and sovereign defaults is the one by Balteanu et al. (2011). Using the dates of sovereign debt crises provided by Standard & Poor's and the systemic banking crises identified in Laeven and Valencia (2008), they end up with a sample including 121 sovereign defaults and 131 banking crises for 117 emerging and developing countries from 1975 to 2007. Among these, they identify 36 "twin crises" (defaults and banking crises): in 19 of them a sovereign default preceded the banking crisis and in 17 the reverse was true.

[12] In Argentina, between 2001 and 2002, considerations of the eventual harm to the banking system were at the forefront of the discussions that eventually led to the default decision. See Perry and Servén (2003) and Kumhof (2004).

that for countries that actually defaulted, this percentage was even higher (e.g., Argentina: 33%, Russia: 39%).[13]

Crisis episodes are episodes of decreased output and credit. It has been documented that output falls sharply in the event of a sovereign default (see, e.g., Sturzenegger and Zettelmeyer, 2005). Figure II makes the same point visually. If the level of GDP three years prior a default is normalized to 100, then Figure II shows that GDP falls (on average) 3% in the default year. Moreover, we observe a v-shape behavior of GDP in the temporal vicinity of defaults.

Defaults and banking crises are also characterized by decreased credit to the private sector. To document this fact, we use the Financial Structure Dataset constructed by Beck et al. (2009) to look at the behavior of *Private credit by deposit money banks and other financial institutions* around defaults and banking crises. Figure III plots this measure as a percentage of GDP. If the Private Credit (as a percentage of GDP) three years prior a default is normalized to 100, then Figure III shows that Private Credit falls (on average) 8% in the default year. We also see that when there is a default, private credit shrinks and remains low for the subsequent periods. [14]

To summarize the set of facts just reviewed: (1) defaults and banking crises tend to happen together (with 64% of banking crises coinciding with or immediately following a default), (2) the banking sector is highly exposed to government debt (with the banking sectors in emerging economies holding on average 24% of their assets in government bonds), and (3) crisis episodes are episodes of decreased output and credit.

3 Model

Time is discrete and goes on forever. There are four players in this economy: households, firms, bankers, and the government. In this framework, the households do not have any inter-temporal choice, so they make only two decisions: how much to consume and how much to work (i.e.,

[13] Figure I was constructed for the period 1998-2002 in order to facilitate comparison with Kumhof and Tanner (2005). Details on the dataset used can be found in Appendix C.

[14] Details on the dataset used to construct Figures II and III can be found in Appendix C.

this is just a consumption/leisure problem from the households' point of view). The production in the economy is conducted by standard neo-classical firms that face only a working capital constraint: they have to pay a fraction of the wage bill up-front; hence their need for external financing.

The bankers lend to both firms and government from a pool of funds available to them during each period. These bankers start the period with two assets: A and b. A represents an exogenous endowment, which the bankers receive each period.[15] b represents the level of sovereign debt owned by the bankers at the beginning of the period (which was optimally chosen in the previous period).

Finally, the government is a benevolent one (i.e., it tries to maximize the residents' utility). It faces a stream of spending that must be financed and it has three instruments for this purpose: labor income taxation, borrowing, and default. We do not assume that the government has available to it any kind of commitment technology, and this means that in each period, the government can default on its debt. This default decision is taken at the beginning of the period and it influences the other economic decisions. Accordingly, the following subsections examine how this economy works under both default and no-default, and ultimately how the sovereign optimally chooses its tax, debt, and default policies.

3.1 Timing of events

The timing of events for a government that starts period t in good credit standing (i.e., is not excluded from the credit market) is illustrated in Figure IV and it proceeds as follows (where *primed* variables represent next-period values):

- The government makes the default decision: $d \in \{0, 1\}$

  1. if default is chosen ($d = 1$), we move to the lower branch of the tree and the following happens:

[15] There are a number of ways to interpret this endowment, A. One alternative is to model deposit dynamics; then A is composed of fresh deposits received by the bankers in period t. An alternative interpretation is that bankers are part of the household, and they are the only ones capable of conducting financial transactions; then it is optimal for the household (at the beginning of the period) to give this endowment A to those members of the household who will use it best: the bankers. Yet another interpretation is to think of the bankers as "international banks": A represents a flow of funds from the parent bank to its subsidiary.

(a) the government gets excluded and the credit market consists of only the (intra-period) private loan market: firms borrow to meet the working capital constraint and bankers lend (l^s) up to the level of their endowment (A).

(b) firms produce and then repay principal plus interest ($l^s(1+r)$), and all other markets (labor and goods) clear.

(c) taxation (τ) and consumption take place.

(d) at the end of period t a re-access *coin* is tossed: with probability ϕ the government will re-access in the next period and get a fresh start (in node Ⓐ and with $b' = 0$), and with probability $1-\phi$ the government will remain excluded and will start next period in node Ⓑ.

2. if repayment is chosen ($d = 0$) we move to the upper branch of the tree and the following occurs:

(a) the credit market now consists of two markets: the market for working capital loans to firms and the market for government bonds. The bankers serve first the working capital market (l^s) up to the sum of their endowment and the repaid government debt that they own ($A + b$).

(b) firms produce and repay principal plus interests ($l^s(1+r)$). The (intra-period) working-capital loan market closes.

(c) bankers now serve the sovereign bonds market. Each bond is traded at a price of q and bankers can lend (qb') only up to the total of their resources ($l^s r + A + b$).

(d) all other markets (labor and goods) clear, and taxation and consumption take place.

- Period t+1 arrives

3.2 Decision problems

In this section, we describe the problems faced by each of the four economic agents in the economy. The variable d stands for the default decision and can take only two values: 0 (no default) or 1 (default).

3.2.1 Households' problem

As indicated above, the only decisions of the households are the labor supply and consumption levels. Therefore, the problem faced by the households can be expressed as:

$$\max_{\{c_t,n_t\}_0^\infty} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t, n_t) \tag{1}$$

$$\text{s.t. } c_t + m = (1-\tau_t)w_t n_t + \Pi_t^F \tag{2}$$

where $\mathbb{E}$ is the expectation operator, $U(c,n)$ is the period utility function, c_t stands for consumption, n_t denotes labor supply, w_t is the wage rate, τ_t is the labor-income tax rate, Π_t^F represents the firms' profits, and m is a constant spending level aiming to capture the sum of investment and net exports.[16]

Plugging equation (2) into equation (1), the households' problem can be rewritten as:

$$\max_{\{n_t\}_0^\infty} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U((1-\tau_t)w_t n_t + \Pi_t^F - m, n_t)$$

and the period-t first-order condition reads as:

$$-\frac{U_n}{U_c} = (1-\tau_t)w_t \tag{3}$$

Equation (3) is the usual intra-temporal optimality condition equating the marginal rate of substitution between leisure and consumption to the after-tax wage rate. Therefore, the optimality conditions from the households' problem are equations (2) and (3).

3.2.2 Firms' problem

The firms in this economy demand labor to produce the consumption good. They face a working capital constraint that requires them to pay up-front a certain fraction of the wage bill. In order to do so, firms will take out intra-period loans from bankers. Given these features, the firms' problem can be expressed as:

$$\max_{\{N_t,l_t^d\}} \Pi_t^F = z_t F(N_t) - w_t N_t + l_t^d - (1+r_t)l_t^d \tag{4}$$

$$\text{s.t. } \gamma w_t N_t \leq l_t^d \tag{5}$$

[16]The constant m is added only for calibration purposes so that the model can correctly match the consumption-to-output ratio. See section 4.2.

where z is an aggregate productivity shock, $F(N)$ is the production function, l_t^d is the demand for working capital loans, r_t is the interest rate charged for these loans, and γ is the fraction of the wage bill that must be paid up-front.

The working capital constraint is captured by equation (5). This equation will always hold with equality because firms do not need loans for anything else but paying $\gamma w_t N_t$; thus any borrowing over and above $\gamma w_t N_t$ would be sub-optimal. Taking this into account and plugging the constraint into the objective function, we obtain:

$$\max_{\{N_t\}} \Pi_t^F = z_t F(N_t) - (1 + \gamma r_t) w_t N_t$$

The period-t first-order condition is:

$$z_t F_N = (1 + \gamma r_t) w_t \tag{6}$$

Condition (6) equates the marginal product of labor to the marginal cost of hiring labor once the financing cost is factored in. Therefore, the optimality conditions from the firms' problem are represented by equation (6) and equation (5), evaluated with equality.

3.2.3 Bankers' problem

Bankers are assumed to be risk-neutral agents. In each period, they participate in two different credit markets: the loan market and the sovereign bond market. The working assumption is that they participate in these markets sequentially.[17]

The problem of the bankers can be written in recursive form as:

$$W(b, z) = \max_{\{x, l^s, b'\}} \{x + \delta\, \mathbb{E} W(b', z')\} \tag{7}$$

$$s.t.\ x = A + (1-d)b + l^s r - (1-d)qb' \tag{8}$$

$$A + (1-d)b \geq l^s \tag{9}$$

where $\mathbb{E}$ is the expectation operator, l^s stands for working capital loans supply, b' represents government bonds demand, A is the bankers' endowment, r is the interest rate on the working capital loans, and q is the price per sovereign bond. x is the end-of-period consumption of the banker, and δ stands for the discount factor.

[17] The assumption of sequential banking is no different from the day-market/ night-market or the decentralized-market/ centralized-market assumption commonly used in the money-search literature (e.g., Lagos and Wright, 2005).

Equation (9) captures the timing of the banking sector: the maximum the banker can lend to the firms is the sum of the endowment and the repayment of government debt. We can rewrite (7) - (9) as follows:

$$W(b,z) = \max_{\{l^s, b', \mu\}} \left\{ A + (1-d)b + l^s r - (1-d)qb' + \delta\, \mathbb{E}W(b',z') + \mu[A + (1-d)b - l^s] \right\}.$$

Assuming differentiability of $W(b,z)$, the first-order conditions are:

$$l^s \quad : \quad r - \mu = 0 \tag{10}$$

$$b' \quad : \quad -q(1-d) + \delta\, \mathbb{E}W_b(b',z') = 0 \tag{11}$$

$$\mu \quad : \quad A + (1-d)b - l^s \geq 0 \;\; \& \;\; \mu[A + (1-d)b - l^s] = 0 \tag{12}$$

The envelope condition reads as:

$$W_b(b,z) = (1+\mu)(1-d) \tag{13}$$

Combining equations (10), (11), and (13) updated one period, and focusing on the case of $d = 0$ (when government is not excluded and debt is actually traded), we obtain:

$$q = \delta\, \mathbb{E}\left\{(1-d')(1+r')\right\} \tag{14}$$

We can rewrite the next period's payoff of the sovereign bond as:

$$\vartheta' = (1-d')(1+r') \tag{15}$$

This expression shows that in the case of a default in the next period, ($d' = 1$) the lender loses not only its original investment in sovereign bonds but also the future gains that those bonds would have created had they been repaid. These gains are captured by r'.

Combining (14) and (15), we obtain the following standard asset-pricing equation:

$$q = \begin{cases} \delta\, \mathbb{E}\{\vartheta'\} & \text{if } d = 0 \\ 0 & \text{if } d = 1 \end{cases} \tag{16}$$

Equation (16) is the condition pinning down the price of debt subject to default risk in this model. It is similar to the one typically found in models of sovereign default with risk-neutral foreign lenders, where δ is replaced by the (inverse of the) world's risk-free rate, which represents the lenders' opportunity cost of funds.

3.2.4 Government Budget Constraint

The government has access to labor income taxation and (in case it is not excluded from credit markets) debt issuance in order to finance a stream of public spending and (in case it has not defaulted) debt obligations. Its flow budget constraint can be expressed as follows:

$$g + (1 - d_t)B_t = \tau_t w_t n_t + (1 - d_t)B_{t+1}q_t \tag{17}$$

where B_t stands for debt (with positive values meaning higher indebtedness), g is an exogenous level of government spending, τ_t is the labor income tax rate, w_t is the wage rate, and n_t stands for labor.

3.3 Competitive Equilibrium given Government Policies

Definition 1 *A Competitive Equilibrium given Government Policies is a sequence of allocations* $\{c_t, x_t, n_t, N_t, l_t^d, l_t^s, b_{t+1}\}_{t=0}^{\infty}$ *and prices* $\{r_t, w_t, \Pi_t^F\}_{t=0}^{\infty}$*, such that given sovereign bond prices* $\{q_t\}_{t=0}^{\infty}$*, government policies* $\{\tau_t, d_t, B_{t+1}\}_{t=0}^{\infty}$*, and shocks* $\{m, g, z_t\}_{t=0}^{\infty}$*, the following holds:*

1. $\{c_t, n_t\}_{t=0}^{\infty}$ *solve the households' problem in (1) - (2).*

2. $\{N_t, l_t^d\}_{t=0}^{\infty}$ *solve the firms' problem in (4) - (5).*

3. $\{x_t, l_t^s, b_{t+1}\}_{t=0}^{\infty}$ *solve the bankers' problem in (7) - (9).*

4. *Markets clear:*

$$n_t = N_t, \;\; b_t = B_t, \;\; l_t^d = l_t^s$$

and the Aggregate Resources Constraint holds:

$$c_t + x_t + g + m = zF(n_t) + A$$

3.3.1 Loan Market Characterization

A central aim of this model is to highlight how a sovereign default generates a credit crunch, which translates into an increase in borrowing costs for the corporate sector (firms) and a subsequent economic slowdown. This mechanism puts the financial sector in the spotlight and

Figure V shows how the private credit market reacts to a sovereign default. Both the demand for loans (l^d) and the supply for loans (l^s) can be obtained from the partial equilibrium conditions coming from the firms' and bankers' optimization problems.

Given that the intra-period working capital loan is always risk-free (because firms are assumed to never default on the loans), the bankers will supply inelastically the maximum amount that they can. This inelastic supply curve is affected by a default: when the government defaults, bankers' holdings of government debt become non-performing and thus cannot be used in the private credit market. This is graphed as a shift to left of the l^s curve in Figure V. All this ends up in firms facing higher borrowing costs ($r^*_{d=1} > r^*_{d=0}$) and lower private credit in equilibrium. The planner (whose problem is defined in the following subsection) takes into account how a default will disrupt this market.

3.4 Determination of Government Policies

We focus on Markov-perfect equilibria in which government policies are functions of payoff-relevant state variables: the level of public debt and the productivity shock.

The benevolent planner wants to maximize the welfare of the residents. To do so it has three policy tools: taxation, debt, and default. But it is subject to two constraints: (1) the allocations that emerge from the government policies should represent a competitive equilibrium, and (2) the government budget constraint must hold.

The governments optimization problem can be written recursively as:

$$\mathcal{V}(b,z) = \max_{d\in\{0,1\}} \left\{(1-d)\mathcal{V}^{nd} + d\mathcal{V}^{d}\right\} \tag{18}$$

where $\mathcal{V}^{nd}$ ($\mathcal{V}^{d}$) is the value of repaying (defaulting).

Given that there are two types of residents (households and bankers), the overall objective function of the planner is a convex combination of the value functions of the two types of residents. Then:

$$\mathcal{V}^i(b,z) = \theta V^i(b,z) + (1-\theta)W^i(b,z),$$

where $i = \{nd, d\}$ and θ is the weight assigned to the households' *happiness* in the planner's objective function. The parameter θ gives the model a certain flexibility. Letting θ be equal to one implies that the planner will not take into account the welfare of bankers, placing the environment closer to the traditional Eaton and Gersovitz (1981) approach, where the lenders are foreigners and thus do not enter into the planner's objective function. Moving θ to zero implies that the planner will only care about bankers.

Following (7), $W^i(b,z)$ represents the banker's value function. The household's value function, on the other hand, is defined as: $V^i = U(c,n) + \beta \mathbb{E} V^i(b',z')$.

Therefore, the value of no default is:

$$\mathcal{V}^{nd}(b,z) = \max_{\{n,c,b',x\}} \left\{ \theta V^{nd}(b,z) + (1-\theta) W^{nd}(b,z) \right\}$$

subject to:

$$\begin{aligned}
V^{nd}(b,z) &= U(c,n) + \beta\, \mathbb{E} V^{nd}(b',z') \\
W^{nd}(b,z) &= x + \delta\, \mathbb{E} W^{nd}(b',z') \\
g + b &= \tau w n + b' q && \text{(gov't b.c.)} \\
c + x + g + m &= zF(n) + A && \text{(resources const.)} \\
&\left.\begin{aligned}
x &= (A+b)(1+r) - qb' \\
r &= \tfrac{znF_n}{b+A} - \tfrac{1}{\gamma} \\
-\tfrac{U_n}{U_c} &= (1-\tau) w \\
w &= \tfrac{zF_n}{(1+\gamma r)} \\
q &= \delta\, \mathbb{E}\left\{(1-d')(1+r')\right\}
\end{aligned}\right\} && \text{(comp. eq. conditions)}
\end{aligned}$$

where $V^{nd}(\cdot,\cdot)$ and $W^{nd}(\cdot,\cdot)$ represent the values of the household and the banker, respectively, under no-default.

In case the sovereign decides to default, it is excluded from the credit market in that period. There is a probability ϕ that the government will regain access to the financial market, in which case its debt will be forgiven (i.e., it gets a *fresh start*). Then, the value of default can be written as:

$$\mathcal{V}^{d}(z) = \max_{n,c,x} \left\{ \theta V^{d}(z) + (1-\theta) W^{d}(z) \right\}$$

subject to:

$$V^d(z) = U(c,n) + \beta\,\mathbb{E}\left\{\phi V^{nd}(0,z') + (1-\phi)V^d(z')\right\}$$

$$W^d(z) = x + \delta\,\mathbb{E}\left\{\phi W^{nd}(0,z') + (1-\phi)W^d(z')\right\}$$

$$g = \tau w n \qquad \text{(gov't b.c.)}$$

$$c + x + g + m = zF(n) + A \qquad \text{(resources const.)}$$

$$\left.\begin{aligned} x &= A(1+r) \\ r &= \tfrac{znF_n}{A} - \tfrac{1}{\gamma} \\ -\tfrac{U_n}{U_c} &= (1-\tau)w \\ w &= \tfrac{zF_n}{(1+\gamma r)} \end{aligned}\right\} \qquad \text{(comp. eq. conditions)}$$

3.4.1 Recursive Competitive Equilibrium

Definition 2 *The Markov-perfect Equilibrium for this economy is (i) a borrowing rule $b'(b,z)$, and a default rule $d(b,z)$ with associated value functions $\{\mathcal{V}(b,z), \mathcal{V}^{nd}(b,z), \mathcal{V}^d(z)\}$, consumption(s) and labor rules $\{c(b,z), x(b,z), n(b,z)\}$, and taxation rule $\tau(b,z)$, and (ii) an equilibrium pricing function for the sovereign bond $q(b',z)$, such that:*

1. *Given the price $q(b',z)$, the borrowing and default rules solve the sovereign's maximization problem in (18)*
2. *Given the price $q(b',z)$ and the borrowing and default rules, the consumption and labor plans $\{c(b,z), x(b,z), n(b,z)\}$ are consistent with competitive equilibrium.*
3. *Given the price $q(b',z)$ and the borrowing and default rules, the taxation rule $\tau(b,z)$ satisfies the government budget constraint.*
4. *The equilibrium price function satisfies equation (16)*

4 Numerical Solution

We solve the model using value function iteration with a discrete state space.[18] As discussed by Krusell and Smith (2003), there may be a problem of multiplicity of Markov-perfect equilibria in infinite-horizon economies. In order to avoid this problem, we solve for the equilibrium

[18] The algorithm computes and iterates on four value functions: V^{nd}, V^d, W^{nd} and W^d. Convergence in the equilibrium price function q is also assured.

of the finite-horizon version of our economy, and we increase the number of periods of the finite-horizon economy until value functions and bond prices for the first and second periods of this economy are sufficiently close. We then use the first-period equilibrium objects as the infinite-horizon-economy equilibrium objects.

4.1 Functional Forms and Stochastic Processes

The period utility function of the households is:

$$U(c,n) = \frac{\left(c - \frac{n^{\omega}}{\omega}\right)^{1-\sigma_c}}{1-\sigma_c}$$

where σ_c controls the degree of risk aversion and ω governs the wage elasticity of the labor supply. The above preferences (called GHH after Greenwood et al., 1988) have traditionally been used in the Small Open Economy - Real Business Cycle literature (e.g. Mendoza, 1991). These preferences shut off the wealth effect on labor supply and thus help in avoiding the potentially undesirable effect of having a counter-factual increase of output in default periods.[19]

The production function available to the firms is:

$$F(N) = N^{\alpha}$$

The only source of exogenous uncertainty in this economy is a productivity shock z_t. This shock follows an AR(1) process:

$$\log z_t = \rho \log z_{t-1} + \varepsilon_t \tag{19}$$

where ε_t is an *i.i.d.* $N(0, \sigma_{\varepsilon}^2)$.

4.2 Calibration

The model is calibrated to an annual frequency using data for Argentina from the period 1980-2005. Table III contains the parameter values.

The parameters *above the line* are either set to independently match moments from the data or are parameters that take common values in the literature. The labor share in output

[19] Using GHH preferences, the marginal rate of substitution between consumption and labor does not depend on consumption, and thus the labor supply is not affected by wealth effects. For a study of how important GHH preferences are in generating output drops in the Sudden Stops literature, see Chakraborty (2009).

(α) and the risk aversion parameter for the households (σ_c) are set to 0.7 and 2 respectively, which are standard values in the quantitative macroeconomics literature. The working capital requirement parameter (γ) is taken directly from the Argentine data. In the model γ is equal to the ratio of private credit to wage payments and the data shows that for Argentina this ratio was 52% (for the period 1993-2007).[20] We use TFP estimates from the ARKLEMS team in order to estimate ρ and σ_ε.[21]

The discount factor for the bankers (δ) takes a usual value in RBC models with an annual frequency, 0.96. It is important to realize that the exact value of δ is crucial not in itself but in how it compares with the households discount factor (discussed below). The weight that households' utility receives on the planner's overall objective function (θ) is set in the benchmark calibration to 0.5 in order to give all the residents (bankers and households) the same weight. Note that if θ takes the value of one, then the model features 'international banks' and hence facilitates comparison with previous literature focusing on external debt and default. This exercise is performed below as part of a sensitivity analysis.[22]

There are two more *above the line* parameters to discuss: the curvature of labor disutility (ω) and the probability of financial redemption (ϕ). The value of ω is typically chosen to match empirical evidence of the Frisch wage elasticity, $1/(\omega-1)$. The estimates for this elasticity vary considerably: Greenwood et al. (1988) cite estimates from previous studies ranging from 0.3 to 2.2, while González and Sala Lorda (Forthcoming) find estimates ranging from -13.1 to 12.8 for Mercosur countries. Here we take $\omega = 2.5$ as the benchmark scenario, implying a Frisch wage elasticity of 0.67, a value in the middle range of the estimates.

The probability of financial redemption is governed by the parameter ϕ. The evidence collected by Gelos et al. (2011) is that emerging economies remain excluded for, on average, 4 years after a default. This finding applies only to external defaults. It can be argued that governments have additional mechanisms (regulatory measures, moral suasion, etc.) for placing their debt in domestic markets, making domestic exclusion shorter than external exclusion.

[20] In order to construct this ratio, we took data for Private Credit from IMF's International Financial Statistics, and data for Total Wage-Earners Remuneration from INDEC (Argentina's Census and Statistics Office). The latter time series is not available prior to 1993.

[21] All the data used in the calibration exercise is further explained in Appendix C.

[22] Setting $\theta = 1$ features international banks but does not make our model collapse into those in Aguiar and Gopinath (2006) and Arellano (2008). The reason is that in our model these international banks do not have deep pockets, and they are only able to lend up to $A + (1-d)b$.

Therefore, the benchmark calibration will be $\phi = 0.5$, which, given the annual frequency of the calibration, implies a mean exclusion of 2 years. Alternative values for ϕ are considered in the sensitivity analysis section.

The parameters *below the line* $\{\beta, A, g, m\}$ are simultaneously determined in order to match a set of meaningful moments of the data. The value of the exogenous spending level (g) is set to 0.0934 to match the ratio of General Government Expenditures to GDP for Argentina in the period 1991-2001 of 11.37% (from the World Bank's World Development Indicators). Parameter m is meant to capture the level of investment (I) plus net exports (NX) and it is set to 0.1357 so that the ratio (I+NX)/GDP generated by the model is equal to the observed ratio, 16.52%.

The remaining parameters are set so that the model matches a default frequency and the exposure ratio observed in Argentina. According to Reinhart and Rogoff (2009), Argentina has defaulted on its domestic debt 5 times since its independence in 1816, implying a default probability of 2.5%, which is our calibration target. As documented in section 2, the banking sector of virtually every emerging economy is highly exposed to government debt. The average *exposure ratio* (defined in section 2) in Argentina was 26.47% for the period 1991-2001.

5 Results

First, we show the ability of the benchmark calibration of the model to account for salient features of business cycle dynamics in Argentina. Secondly, we study the dynamics of output around sovereign default episodes. Thirdly, we discuss properties of the endogenous costs of defaults generated by our model. Fourthly, we analyze the "benefit" side of defaults, a reduction in distortionary taxation. Fifthly, we examine the dynamics in the sovereign debt market.

5.1 Business cycle moments

Table IV reports moments in the data and in our simulations. As in previous studies, we report results for pre-default simulation samples. The exceptions are the default rate (which we compute using all simulation periods) and the credit and output drop surrounding a default (which we compute for a window of 11 years before and 4 years after a default). We simulate the model for a sufficiently large number of periods, allowing us to extract 1,000 samples of 11 consecutive years before and 4 consecutive years after a default. [23]

Overall, the benchmark calibration of the model is able to account for several salient facts of the Argentine economy, as well as to approximate reasonably well the moments used as targets. As in the data, in simulations of the model consumption and output are positively and highly correlated, and the consumption volatility is higher than the output volatility.[24] None of these moments were targeted by the calibration process, but they are all, nonetheless, reproduced in the model.

The benchmark calibration also approximates well the dynamics of employment. The model is able to produce employment time series that are pro-cyclical and at the same time less volatile than output. As found in the data, the model features a negative correlation between employment and sovereign spreads. [25]

The model generates an output drop at default that is endogenous. Data from the World Development Indicators (WDI) indicate that in the 2001-02 Argentine default episode, real GDP per capita fell 10.64 percentage points below its trend. The benchmark calibration delivers an average decrease of 5.77 percent. The sovereign default triggers a credit crunch in the model and this in turn generates an output collapse. This collapse is due to reduced access to the labor input, which is the only variable input in the economy. The inability of the economy to resort to a substitute input generates a sharp output decline. It is important to keep in mind that the mean output drop was not among the targeted moments in the calibration strategy, which is why the mechanism presented in the paper is able to account for 54% of the observed output drop.

The credit drop that drives the endogenous cost of default is the main mechanism of the model. The benchmark calibration is able to produce a mean credit drop (measured as Private Credit/GDP) of 0.34% below trend, which accounts for 26% of the actual credit drop observed

[23] We focus our quantitative analysis on the 2001-02 Argentine default. To do this, we choose a time window that is restricted to 11 years pre-default and 4 years post-default (i.e., 1991-2006 in the data), in order to be consistent with previous studies that report statistics for no-default periods and also to be consistent with Reinhart and Rogoff (2011), who identify Argentina as falling into domestic default both in 1990 and 2007, on top of the aforementioned 2001-02 episode.

[24] These facts also characterize many other emerging economies, as documented by Neumeyer and Perri (2005), Uribe and Yue (2006) and Fernández-Villaverde et al. (2011), among others.

[25] The data for the correlation between employment and sovereign spreads is from Neumeyer and Perri (2005), while all the other employment data in Table IV comes from Li (2011).

in the 2001-02 Argentine default.[26]

Given that the model features debt holders who are domestic, the correct debt-to-output ratio to look at in the data is Domestic Debt to GDP. To do so we take the ratio of Total Debt to Output from Reinhart and Rogoff (2010) and extract only its Domestic Debt part by using the share of Domestic Debt to Total Debt from Reinhart and Rogoff (2011).

$$\underbrace{\frac{TD}{Y}}_{\text{from Reinhart and Rogoff (2010)}} \times \underbrace{\frac{DD}{TD}}_{\text{from Reinhart and Rogoff (2011)}} = \underbrace{\frac{DD}{Y}}_{\text{relevant debt ratio}}$$

This exercise gives a mean Domestic Debt to GDP ratio of 11.32% for the period 1991-2001. As shown in Table IV, the benchmark calibration of the model features a debt-to-output ratio of 12.99%, which is in line with its data counterpart.

The level, cyclicality, and volatility of sovereign spreads were also not among the targeted moments, and they are closely reproduced by the model. The same is true for the correlation between the tax-rate and output: as in the data, the model exhibits a negative correlation.[27] This result has been dubbed "optimal procyclical fiscal policy" for emerging economies, in the sense that the fiscal policy (in this case the tax rate) amplifies the cycle. Why is the tax rate "procyclical" in our model? Because when output is high, it is cheaper to borrow and postpone taxation, whereas when output is low, the reverse is true. Thus, we expect periods of high output to be associated with lower tax rates and vice versa. Moreover, when the government defaults it is left with only taxation in order to finance spending, which leads to even more fiscal procyclicality. [28]

5.2 Output dynamics around defaults

One contribution of this paper is to provide a framework able to deliver endogenous output declines in default periods. Figure VI is constructed from the model simulations as follows: first, we identify the simulation periods when defaults happen; secondly, we construct a time series of 11 years before and 4 years after each default and compute deviations from trend;

[26] Both the real GDP per capita and the Private Credit/GDP series are taken from WDI, and their respective trends are computed using annual data from 1991 to 2006.

[27] The data for $\rho(\tau, y)$ in Table IV comes from Talvi and Végh (2005).

[28] This result is by no means new in the literature and it is in fact a consequence of more general capital market imperfections. See Cuadra et al. (2010) and Riascos and Végh (2003).

thirdly, we average across default episodes to construct a series of the mean output deviations from trend around defaults; fourthly, we plot deviations from trend generated by the model and those observed in the data for the $t-3$ to $t+3$ time window, with t denoting the default year.

As is clear from Figure VI, the model features an output decline (and a consequent consumption decline) in the default period. The size of the output drop (measured in deviations from trend) accounts for 54% of the observed credit drop in the data.

The model also produces a v-shape behavior of output around defaults. Argentina's output dynamics before and after the default event mostly lie within the 99% confidence bands of the model simulations. As in Mendoza and Yue (2012), the v-shaped recovery of output after a default event is driven by two forces: TFP and re-access to credit. TFP is mean-reverting and thus very likely to recover after defaults. Also, when the sovereign regains access to credit markets, then the output recovery is even faster (see the following subsection for further discussion of the effects of market re-access).

5.3 Endogenous costs of defaults: credit contractions

Why does a default generate such a sharp output decline? This paper gives a *credit crunch* explanation: given that bankers hold government debt as part of their assets, when a default comes a considerable fraction of those assets losses value; thus, the bankers' lending ability decreases and as a consequence credit to the private sector contracts. Given that the productive sector is in need of external financing, a credit crunch translates into an output decline.[29]

Figure VII presents the behavior of the Private Credit/GDP simulated series around defaults. It is constructed in the same way as Figure VI. It demonstrates that credit to the private sector (as a fraction of output) falls in the default period and continues falling in the subsequent period. The magnitude of the credit drop (measured in deviations from trend) accounts for 26% of the observed credit drop in the data; in other words, credit plays a more important role in the model economy than in the data.

Figure VIII shows how a credit crunch looks in the model. The benchmark calibration of the model features a collapse in the private sector credit (i.e., working capital loans to firms,

[29] Bolton and Jeanne (2011) identify this phenomenon as banks becoming *illiquid*.

in the model). In the two panels of Figure VIII we can see the workings of a credit crunch: as firms are in need of external financing, when loanable funds shrink, output shrinks along with them.

We can also see the effect of exclusion from financial markets: if the government remains excluded, the private credit reduces (and remains low) and the output decline becomes more protracted. On the other hand, an immediate re-access to the credit market implies a rapid recovery in both credit and output.

5.3.1 Two properties of the output cost of defaults

As already explained, our paper provides a mechanism for endogenizing the output costs of default via a credit crunch. Here we analyze two properties of these costs: that they are increasing in the level of TFP and that they are increasing also in the *size* of the default (i.e. the level of outstanding debt that is repudiated).

Using the numerical solution of the model we are able to compute the effect of defaults on output. Figure IX shows the percent decline of output as a function of the TFP shock (z) when computed for the mean debt level observed in the model simulations. [30] As the figure shows, the cost increases with the level of TFP. This property (referred to as "asymmetric cost of defaults" in the literature) is shared by other papers with endogenous cost-of-default structure (e.g. Mendoza and Yue, 2012) and has been proven to be critical to match the counter-cyclicality of sovereign spreads: in good times (high TFP) defaulting is too costly, investors understand this and assign a low probability to observing a default event, this translates into low spreads; on the contrary, during bad times (low TFP) default is less costly (and therefore a more attractive policy choice), defaults are more likely and spreads are consequently higher. [31]

A second property of the cost of defaults is that they are an increasing function of the level of outstanding debt. This has a clear intuition: the more debt a government repudiates, the higher the cost of repudiation. Our framework is to our knowledge the first quantitative model

[30] The shaded area in Figure IX represents the "default region," which are the levels of TFP shock at which the country decides to default when facing the mean debt level observed in the simulations.

[31] Chatterjee and Eyigungor (2012) provide a detail discussion about the asymmetric nature of default costs. They use an ad hoc cost-of-default function (in an endowment-economy model) and their calibration implies the same asymmetry that our model delivers endogenously.

that endogenously delivers this behavior (which is supported by the data, see Arellano et al., 2013). Figure X was constructed in a similar manner as the previous figure, and it shows how the output cost of defaults increases with the level of outstanding debt, when the economy received the mean realization of the TFP shock. [32] This happens because sovereign debt plays a "liquidity" role in our economy: the more debt is repaid, the more funds can be lent in the private credit market, and the lower is the equilibrium interest rate paid by the private sector. As explained above, a credit crunch translates into an output decline, and the larger is the stock of repudiated debt, the larger the credit crunch. [33]

5.4 Benefit of defaults: reduced taxation

As argued in the introduction, the optimal default decision comes from balancing costs and benefits of defaults. The costs of default are discussed above: output declines because of a credit contraction. The benefits on the other hand come from reduced taxation. Figure XI shows the behavior of the labor income tax rate around defaults: we plot the equilibrium tax rate and also the "counterfactual" tax rate that would have been necessary if instead of defaulting the government had repaid its debt.

The reduced taxation is precisely the difference between the counterfactual repayment rate and the equilibrium tax rate: for the benchmark calibration this difference is of 8 percentage points on average. This tax decline represents a benefit of defaulting because households dislike increases in distortionary taxes. In other words, a default allows the government to *afford* a tax cut.

This subsection and the previous one show that the planner finds a strategic default to be the optimal *crisis resolution mechanism*: due to worsening economic conditions, the sovereign finds it optimal to default on its obligations (and assume the associated costs) instead of increasing the tax revenues required for repayment. [34]

[32] The shaded area in Figure X represents the "default region," which (in this case) are levels of outstanding debt for which the country decides to default when facing the mean TFP level.

[33] The liquidity role of government debt has been highlighted by Bolton and Jeanne (2011), Brutti (2011) and Sandleris (2012).

[34] On related work, Adam and Grill (2012) study optimal sovereign defaults in a Ramsey setup with full commitment. They find that Ramsey optimal policies ocassionally involve defaults, even when those defaults imply large costs.

5.5 Sovereign bonds market

In this section we analyze the behavior of the government bonds market. To this end, we show a set of plots that are often used in the sovereign default literature. As discussed above, the model performs quite well with respect to the sovereign bond market dynamics: it produces defaults in bad times and therefore countercyclical spreads.

Figure XII shows the equilibrium default region (in the left panel) and the combinations of spreads and indebtedness levels from which the sovereign can choose (in the right panel). With respect to the left panel, the white area represents the repayment area: it is increasing with the level of productivity and decreasing with the level of indebtedness. The right panel presents the spreads schedule that the government faces. As expected, the spreads that the government can choose from increase with the level of indebtedness and decrease with the level of productivity.

Next we turn to the behavior of spreads in the run-up to a default. Figure XIII shows that the spreads generated by the model mimic the behavior of the Argentine spreads, in that they are relatively flat until the year previous to a default, when they spike. On the other hand, the mean spreads are higher than the observed ones away from default and lower than the data in the period immediately before the default. The spreads dynamics in the run-up to a default are well within the 1 standard error bands of the model simulations.

6 Robustness

In this section we study the robustness of our results to a number of modifications. Firstly, we re-calibrate the model so that the exposure of the banking sector to sovereign debt is roughly 14% (in line with recent evidence from Gennaioli et al., 2014a). We show that the main results are robust to a calibration featuring a lower exposure ratio. Secondly, we perform a sensitivity analysis with respect to the main parameters of the model, in order to illustrate how each of them affect the mechanisms in the model. Thirdly, we provide a general discussion about the relevance of the main simplifying assumption and how relaxing them affects the results.

6.1 Calibration to a lower exposure ratio

In a recent paper, Gennaioli et al. (2014a) report an average exposure ratio of 9.28% when using the entire Bankscope dataset (which includes banks from both advanced and developing countries). When they focus only on defaulting countries, they find an exposure ratio that is on average between 13.51% (in non-defaulting years) and 14.49% (in defaulting years). In this subsection we take an exposure ratio of 14% (as representative of defaulting countries in this richer dataset) and re-calibrate our model using this target. We refer to this calibration as the "low-exposure" economy. [35]

Table V shows selected moments of the data, the benchmark economy and the low-exposure economy. We can see that the dynamics of the sovereign debt market remain mostly unchanged. At a virtually identical default frequency (which was a targeted moment), the low-exposure economy has a mean debt-to-output ratio of 6.05% (which represents 47% of the ratio obtained in the benchmark economy and 53% of the observed ratio). The lenders understand that, with a higher A (i.e. a higher bankers' endowment), debt is less important for the functioning of private credit markets and therefore the planner has higher temptation to default on it, therefore they reduce sovereign lending. They equilibrium spread is almost identical across the two simulated economies, but more volatile for the low-exposure calibration. [36]

As the theory predicts, an economy with lower debt-to-output ratio has a lower exposure ratio, should experience a smaller credit crunch and consequently exhibit milder output drop at defaults. Along these lines, we see from Table V that the low-exposure calibration can explain only 42% of the output decline at defaults (4.46% below trend versus the observed 10.66% below trend).

We can also see from Table V that even though credit declines during a default, this decline is not big enough to make the average time series of Private Credit/ GDP to fall below trend on impact. When we look at the same time series at its trough (which consistently occurs in the period following the default, both in the model simulations and in the data), we see that indeed there is a credit drop (as predicted by our theory) although it is quite mild (0.1% versus

[35]The parameter values for the low-exposure calibration are the same as the benchmark calibration with the exception of the households' discount factor (β, which now is 0.99) and the level of bankers' endowment (A, which now takes the value of 0.2625).

[36]Other non-targeted business cycle moments (not reported in Table V), like relative volatilities and correlations with output, are in line with the data.

the 1.3% generated by the benchmark economy versus the 3.4% observed in the data).

The main difference between this low-exposure economy and the benchmark economy is quantitative: the lower exposure ratio implies (in line with the theory) that the credit and output drops are smaller. However, the main mechanisms are still present qualitatively and in some dimensions even quantitatively.

6.2 Sensitivity analysis

In this section we vary the value of some key parameters in order to get an insight on how each of them affect the dynamics. Note that parameter values are changed one at a time (i.e. keeping the values of all other parameters unchanged). Table VI summarizes the findings of this exercise. [37]

Let us first consider how the model economy reacts to changes in the re-entry probability (ϕ). When the government can re-access credit markets immediately after a default ($\phi = 1$), the overall costs of a default (exclusion from credit markets being among them) are reduced. A lower default cost renders repudiation more attractive, so we see that for $\phi = 1$ default is more frequent. Consequently, the government can sustain less debt in equilibrium and has to pay higher spreads. If, on the other hand, we lower ϕ (making re-access to credit markets less frequent), then the exclusion cost of default is larger, default is chosen less frequently, and the government is able to sustain higher debt ratios while paying lower spreads.

Next, let us examine how the model behaves with different values of γ. This parameter governs the tightness of the working capital constraint, $\gamma \in (0, 1]$. A high (low) value of γ means that firms need to pay up-front a higher (lower) proportion of their wage bill; this means that private credit in the form of working capital loans is more (less) important for production. We can see that the model performs as expected: for lower values of γ (cases in which private credit is not so important for production), default is not very costly. Consequently, the government is tempted to default too often. Creditors, understanding this, reduce lending in the government bonds market. Along those lines, we see that for values of $\gamma \leq .30$ the mean debt ratio is zero and the observed default rate is also zero. On the other hand, high values of γ make

[37] While columns 1 to 5 have self-explanatory headings, columns 6 and 7 warrant a minor clarification: they report output drops and credit drops on impact (i.e. at default events) measured in percent deviations from trend, respectively.

defaults very costly. This raises the observed debt ratios and lowers the observed default rates. In these less frequent (i.e., rarer than the benchmark) defaults, the costs in terms of output and credit drops are considerable larger than in the benchmark calibration (precisely because higher exposure ratios bring higher output and credit drops during defaults). These dynamics imply a non-monotonic behavior of the default rate as we increase the value of γ. This leads to (for example) having two scenarios with a zero default rate and with zero spreads that are very different: on the one hand, low enough values of γ, for which there is no lending (default temptation is too high), and on the other hand, sufficiently large values of γ, for which there are large debt and exposure ratios (default costs are too large).

Bankers' endowment A is a crucial parameter for the workings of the credit crunch. Basically a higher level of A makes government debt less important for the private credit market. The planner understands this and is more tempted to default when A is larger. Lenders anticipate this behavior and refrain from lending to the government. This again renders a non-monotonic equilibrium default rate. For low enough levels of A (e.g. $A = 0.1$), default is too costly for the firms and thus the government decides to never default. In this way, it is able to sustain large debt ratios. Conversely, for large enough levels of A (e.g. $A = 0.3$), defaults are less costly for the private credit market and thus the government is more tempted to default (we observe larger default rates) and is also able to sustain lower debt ratios. For even larger levels of A, agents understand that public debt is not very important for the credit markets and that governments will be tempted to default on it whenever they have the chance; consequently, lending is nil. At the same time, we observe (as the theory predicts) that there is a positive correlation between debt ratios and exposure ratios, and between debt ratios and output drops.

Finally, we examine the role of θ, the weight that households receive in the planner's objective function. If $\theta = 1$, it means that either the planner cares only about households, or that the bankers are not residents but international agents, who do not enter into the planner's objective function. When this is the case, we can compare the model against other models of external sovereign debt and default. In this case, the model has mixed results: it obtains a reasonable default probability (2.19%, which is in line with the typical low default frequencies targeted in most studies on external sovereign default), but it achieves an external debt-to-output ratio that accounts for 48% of the observed ratio (12.64% produced by the model simulations, 26.41% observed in the Argentine data for the period 1991-2001). In terms of the default rate, changing the value of θ has the expected results: for lower values, the planner places more weight on the welfare of bankers, and thus default is less frequent (in the extreme case of $\theta = 0$, the default rate is zero and the government is able to sustain larger debt ratios). The case of $\theta = 1$ is a more interesting extreme: even though the planner places zero weight on the welfare of the lenders (i.e., the bankers), it nonetheless refrains from defaulting too often. The reason for this behavior is that even when the planner cares only about households, it understands that defaulting brings associated costs that are only sometimes, not always, outweighed by gains.

6.3 Discussion of the assumptions

The model described in Section 3 involved a series of simplifying assumptions that were made in order to isolate the effect that a sovereign default has on the banking and productive sectors of the economy. In this subsection we discuss ways to relax these assumptions and the implications of doing so.

Constant government spending. In order to simplify the optimal fiscal policy planning, we have assumed a constant level of government expenditures, g. While this is a useful first approximation, relaxing this assumption could improve the model's quantitative performance. A commonly used alternative is to render g valuable by including it in the agents' preferences. In this case, g becomes an extra fiscal policy instrument: the planner understands that a higher g implies either higher taxation or higher indebtedness, but also takes into account the agents' preferences for g. Then, when the country defaults and consumption declines, the planner will find it optimal to decrease g as well in order to satisfy the intra-temporal optimality condition relating private and public consumption. Thus, if we were to "endogenize" g in this way, the model would be able to account for the observed pro-cyclicality of government spending (see Cuadra et al., 2010).

Another alternative is to follow the tradition of Lucas and Stokey (1983) and have g follow an exogenously given stochastic process. Extending in this way the model presented in Section 3, "good times" and "bad times" will now be indexed by the realizations of both the TFP process and the "expenditure" shock. We consider that, while enriching the environment, this second alternative does not add any new insights to better understand the dynamics of sovereign debt, bank lending, and defaults. [38]

Financial autarky. The benchmark version of our model can be understood as a closed economy in which government debt is held by domestic bankers. While this is an attractive environment for studying the implications of a sovereign default on the domestic financial sector, it comes at the expense of having an unrealistically closed capital account. If we let the government borrow from abroad as well as from domestic bankers, then the model becomes one of domestic and external sovereign debt, a missing piece in the quantitative literature on sovereign defaults. This extension would bring other forces into play. In principle, the possibility of selective defaults can mitigate the negative effect of a sovereign default on the domestic economy, as, by defaulting on foreign lenders, the government can afford to treat domestic lenders better.

Another consequence of a closed capital account in the benchmark version of our model, is that the private sector can only borrow from domestic lenders. Allowing the private sector to borrow from abroad as well will decrease the relevance of the domestic credit market for domestic production and potentially weaken the channel highlighted in the model. However, as long as a fraction of the domestic firms need to borrow from domestic sources (probably because not every firm in the economy is capable of tapping international markets), the mechanism proposed in the model will still play a central role in our understanding of the dynamics of macroeconomic aggregates and the incentives to default on sovereign debt.

Constant A**.** Assuming that bankers receive a constant endowment in every period allows us to fix ideas and focus on the asset side of the bankers' balance sheet and how it responds to a sovereign default. Relaxing this assumption is clearly a desirable step, as it will bring the model closer to the data. Allowing (for example) for deposits from households will capture another salient feature of crises in emerging economies: bank runs. Anticipating the possibility of a sovereign default and fearing that banks will not be able to fully repay the deposits, households may engage in a run on the banks, and thus put more pressure on the availability of loanable funds. Along this line of thought, we understand that allowing for bank runs could have an

[38] The computational challenge of adding an "expenditure" shock, as in Lucas and Stokey (1983) (or (Aiyagari et al., 2002)), boils down to adding an extra exogenous state variable, which increases the state space but keeps the algorithm and solution method otherwise unchanged.

amplifying effect on the dynamics already captured by our model and is therefore a candidate extension that could help close the gap between the observed output decline and the 54% explained by the benchmark calibration of our model.

Total defaults. The model economy in this paper is based on the assumption that sovereigns can either repay in full or default in full. This is an assumption shared by most of the papers in the quantitative literature on sovereign debt and default. In models à la Eaton and Gersovitz (1981), this assumption is easily justified by making the cost of the default independent of its size: if a country is to suffer the costs of defaulting, it had better obtain all the possible gains thereof, which implies a full repudiation. In our environment, the cost of a default (i.e., the output decline) is not independent but actually a function of the amount of debt repudiated. The very nature of the model renders it a suitable laboratory for studying the extent to which sovereigns would like to conduct partial defaults, and also for analyzing the dynamics of such defaults.

Recent work by Arellano et al. (2013) has incorporated the option for sovereigns in models of this type to partially default on their debts. One advantage of our framework over Arellano et al. (2013)'s is that in our environment incentives to default on fractions of the debt arise endogenously rather than by assuming an ad hoc "cost-of-default" function that depends on the amount of defaulted debt. Studying the reasons why countries may partially default on their debts is nonetheless beyond the scope of this paper.

7 Conclusions

The prevalence of defaults and banking crises is a defining feature of emerging economies. Three facts are noteworthy about these episodes: *i*- defaults and banking crises tend to happen together (with 64% of banking crises coinciding with or immediately following a default), *ii*- the banking sector is highly exposed to government debt (with the banking sector in emerging economies holding on average 24% of their assets in government bonds), and *iii*- crisis episodes involve decreased output and credit.

In this paper, we have provided a rationale for these phenomena. Bankers who are exposed to government debt suffer from a sovereign default that reduces the value of their assets (i.e., a banking crisis). This forces the bankers to decrease the credit they offer to the productive private sector. This *credit crunch* translates into reduced and more costly financing for the productive sector, which generates an endogenous output decline.

The benchmark calibration of the model produces a close fit with the Argentine business cycle moments. When calibrated to target the observed default frequency and exposure ratio, the model generates sovereign spreads that compare well with the data, in terms of both levels and volatility. Furthermore, the model features a v-shaped behavior for both credit and output around defaults, which is consistent with the data. The mechanism proposed in the paper is able to account for 54% of the observed GDP drop and 26% of the observed credit drop, in default periods.

This paper quantifies the impact of a sovereign default on the domestic banks' balance sheets, their lending ability and economy-wide activity. Its chief methodological contribution is that it presents an endogenous default cost that works through a general-equilibrium effect of the government's default decision on the economy's working-capital interest rate. Additionally, ours is the first quantitative paper to endogenize the output cost of default as a function of repudiated debt. This makes our framework a natural starting point for further research on the optimality of fractional defaults.

The theory and quantitative analysis presented in this paper can also be applied to the study of the political economy of sovereign defaults. Given that a default in our model implies a redistribution from bankers (lenders) to households (taxpayers), it is a useful framework for studying the politico-economic equilibrium that would arise if agents were allowed to vote on the default policies. We leave this for future research.

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A Tables

Table I: Timing of Defaults and Banking Crises.

	Default in period t
Banking Crises in:	
$t-2$ or $t-1$	14 (36%)
t	13 (33%)
$t+1$ or $t+2$	12 (31%)

Source: Author's calculations from Reinhart and Rogoff (2009) and Reinhart (2010) data. Details in Appendix C.

Table II: Probabilities of Defaults and Banking Crises.

Unconditional Prob. of a banking crisis	2.9
Prob. of banking crisis conditional on default	14.1
p-value on the test: $prob(bc/def) > prob(bc)$	0.0
Unconditional Prob. of a sovereign default	2.2
Prob. of default conditional on banking crisis	4.5
p-value on the test: $prob(def/bc) > prob(def)$	0.1

Source: Borensztein and Panizza (2009)

Table III: Benchmark Calibration.

Curvature of labor disutility	ω	2.5	Frisch wage elasticity
Labor share in output	α	0.70	Standard value
Household risk aversion	σ_c	2	Standard value
Banker's discount factor	δ	0.96	Standard value
Probability of redemption	ϕ	0.50	Mean exclusion spell = 2 years
Working capital requirement	γ	0.52	Private credit/ Wage bill = 52%
TFP auto-correlation coefficient	ρ	0.7631	TFP autocorrelation
Std. dev. of innovations	σ_ε	2.62%	TFP std. dev.
Weight of hh. in planner's obj. function	θ	0.5	Equal weight
Government Spending	g	0.0934	Gov't Spending/GDP $\approx$ 11%
Investment + Net Exports	m	0.1357	$(I + NX)$/GDP $\approx$ 17%
Household's discount factor	β	0.80	Default rate $\approx$ 2.5%
Banker's endowment	A	0.24875	Mean exposure ratio $\approx$ 26%

Table IV: Simulated Moments and Data.

	Data	Model
$\sigma(c)/\sigma(y)$	1.59	1.55
$\sigma(n)/\sigma(y)$	0.57	0.74
$corr(c, y)$	0.72	0.99
$corr(n, y)$	0.52	0.98
$corr(\tau, y)$	-0.69	-0.74
$corr(R_s, y)$	-0.62	-0.60
$corr(R_s, n)$	-0.58	-0.50
$E(R_s)$ (in %)	7.44	7.30
$\sigma(R_s)$ (in %)	2.51	2.64
$E(b/y)$(in %)	11.32	12.99
Mean output drop (in %)	10.66	5.77
Mean credit drop (in %)	1.30	0.34
Default rate (in %)	2.5	2.5
Gov't Spending/ output (in %)	11.4	11.6
Mean Exposure Ratio (in %)	26.5	26.3

Note: The mean and the standard deviation of a variable x are denoted by $E(x)$ and $\sigma(x)$, respectively. All variables are logged (except those that are ratios) and then de-trended using the Hodrick-Prescott filter, with a smoothing parameter of 6.25, as suggested by Ravn and Uhlig (2002). We report deviations from the trend.
R_s stands for bond spread. The data for sovereign spreads is taken from J.P. Morgan's EMBI, which represents the difference in yields between an Argentine bond and a US bond of similar maturity. The spreads obtained in the simulations are computed as the difference between the interest rate paid by the government and that paid by the private sector. Results are robust to using an ad hoc constant risk-free rate.

Table V: Selected Moments: Data, Benchmark Economy and Low-Exposure Economy.

	Data	Benchmark Economy	Low-Exposure Economy
$E(R_s)$ (in %)	7.44	7.30	7.28
$\sigma(R_s)$ (in %)	2.51	2.64	4.70
$E(b/y)$(in %)	11.32	12.99	6.05
Mean output drop (in %)	10.66	5.77	4.46
Mean credit drop on impact (in %)	1.30	0.34	-0.20
Mean credit drop at trough (in %)	3.4	1.3	0.1
Default rate (in %)	2.5	2.5	2.6
Gov't Spending/ output (in %)	11.4	11.6	11.5
Mean Exposure Ratio (in %)	26.5	26.3	14.3

Note: The mean and the standard deviation of a variable x are denoted by $E(x)$ and $\sigma(x)$, respectively. All variables are logged (except those that are ratios) and then de-trended using the Hodrick-Prescott filter, with a smoothing parameter of 6.25, as suggested by Ravn and Uhlig (2002). We report deviations from the trend.
R_s stands for bond spread. The data for sovereign spreads is taken from J.P. Morgan's EMBI, which represents the difference in yields between an Argentine bond and a US bond of similar maturity. The spreads obtained in the simulations are computed as the difference between the interest rate paid by the government and that paid by the private sector. Results are robust to using an ad hoc constant risk-free rate.

Table VI: Sensitivity Analysis.

	Moments (in %)					
	Default rate	$E\{b/y\}$	$E\{R_s\}$	Exposure	$y \downarrow$	Credit $\downarrow$
Data	2.5	11.32	7.44	26.5	10.66	1.30
Benchmark	2.5	12.99	7.30	26.3	5.77	0.34
re-entry (benchmark: $\phi = 0.5$)						
$\phi = 0.10$	0.97	24.38	4.72	38.33	5.39	0.01
$\phi = 0.25$	1.76	18.27	6.59	33.36	5.41	0.19
$\phi = 0.75$	2.86	10.70	7.60	22.68	5.93	0.42
$\phi = 1$	3.31	9.70	7.91	21.00	6.10	0.53
w-k constraint (benchmark: $\gamma = 0.52$)						
$\gamma = 0.3$	0	0	0	0	n.a.	n.a.
$\gamma = 0.45$	18.58	3.64	34.05	10.33	2.70	0.06
$\gamma = 0.65$	0.38	56.35	4.49	55.03	12.17	2.23
$\gamma = 1$	0	101.87	0	59.21	n.a.	n.a.
Banker's endowment (benchmark: $A = 0.24875$)						
$A = 0.1$	0	101.87	0	73.62	n.a.	n.a.
$A = 0.2$	0.41	54.32	4.51	59.51	11.97	1.75
$A = 0.3$	21.34	0.84	71.29	2.17	0.40	−0.02
$A = 0.4$	0	0	0	0	n.a.	n.a.
HH weight on $\mathcal{V}(b, z)$ (benchmark: $\theta = 0.5$)						
$\theta = 0$	0	38.75	0	21.64	n.a.	n.a.
$\theta = 0.25$	3.16	13.77	8.08	27.39	5.73	0.43
$\theta = 0.75$	2.22	12.68	7.07	25.79	5.75	0.28
$\theta = 1$	2.19	12.64	7.06	25.72	5.74	0.28

B Figures

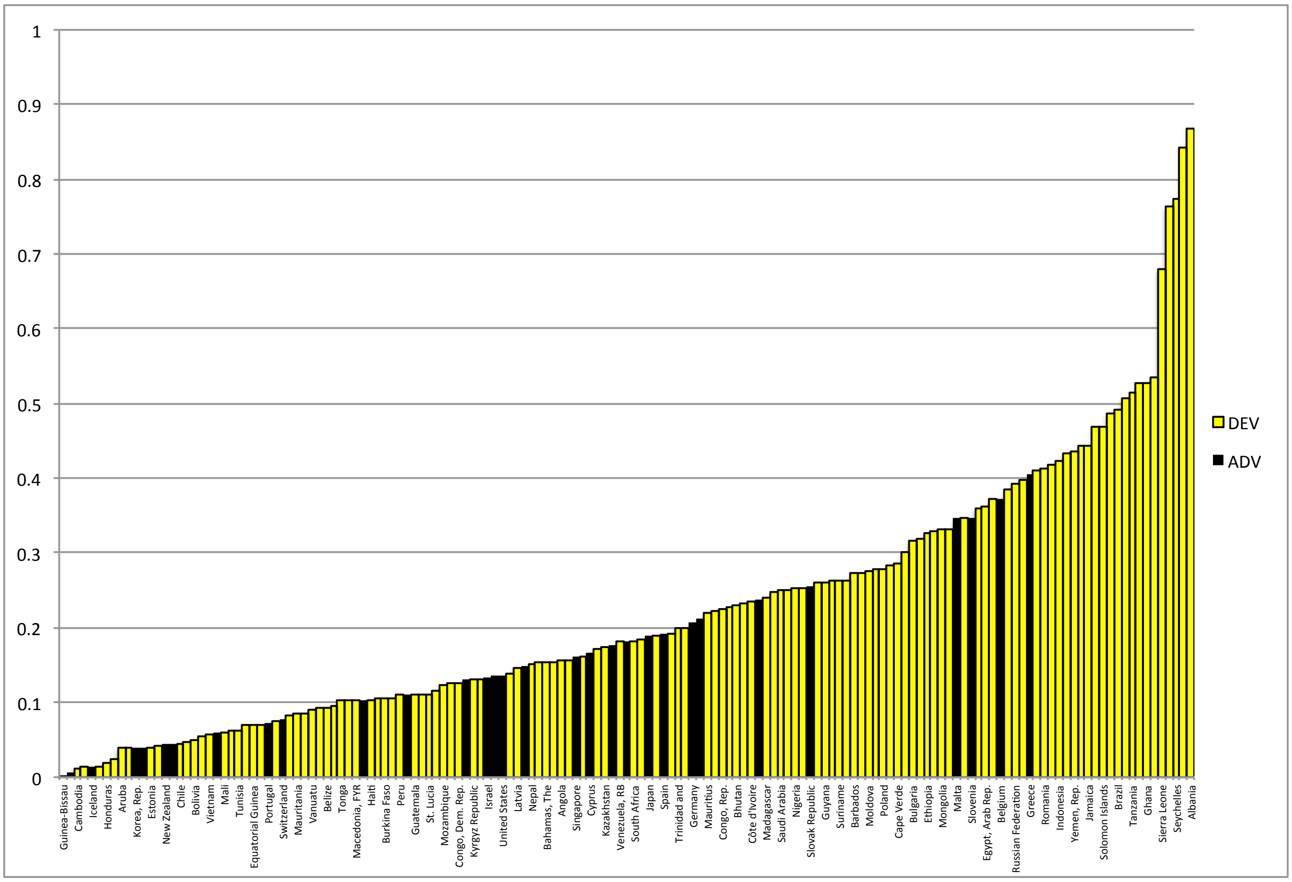

Figure I: Banking Sector Exposure to Government Debt.

Note: Author's calculations from Financial Structure Database 2009. Period coverage: 1998–2002. Details in Appendix C.

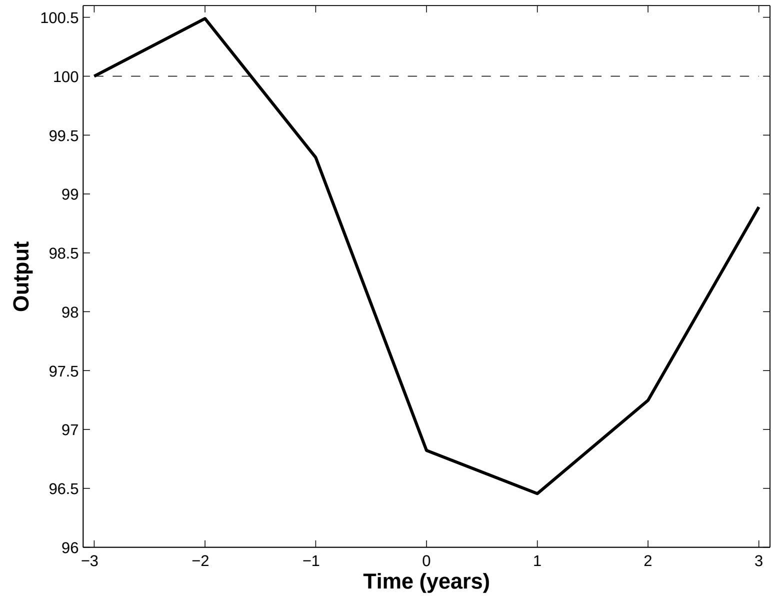

Figure II: Costly Defaults and Banking Crises.

Note: Series is normalized so that $T-3=100$. We report sample means.
Source: Author's calculations from the Maddison Project Database. Details in Appendix C.

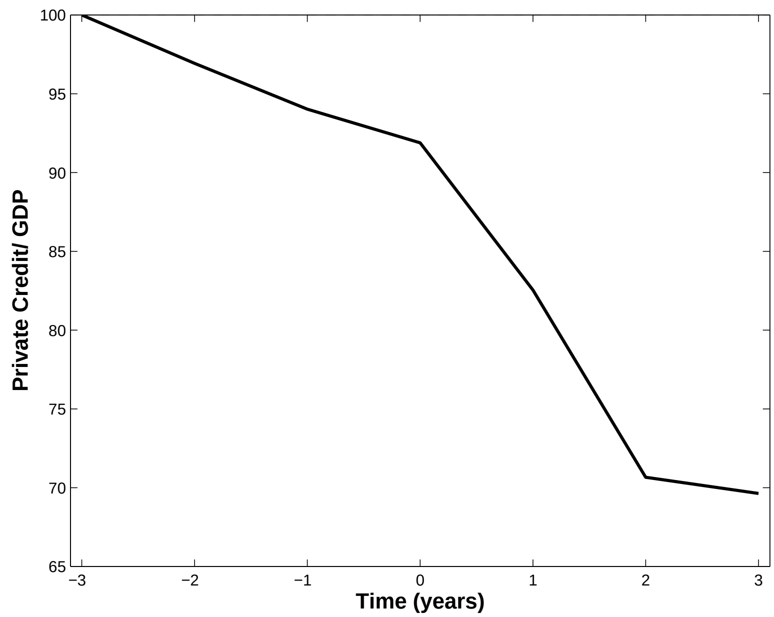

Figure III: Private Credit.

Note: Series is normalized so that $T-3=100$. We report sample means.
Source: Author's calculations from the Financial Structure Database 2009. Details in Appendix C.

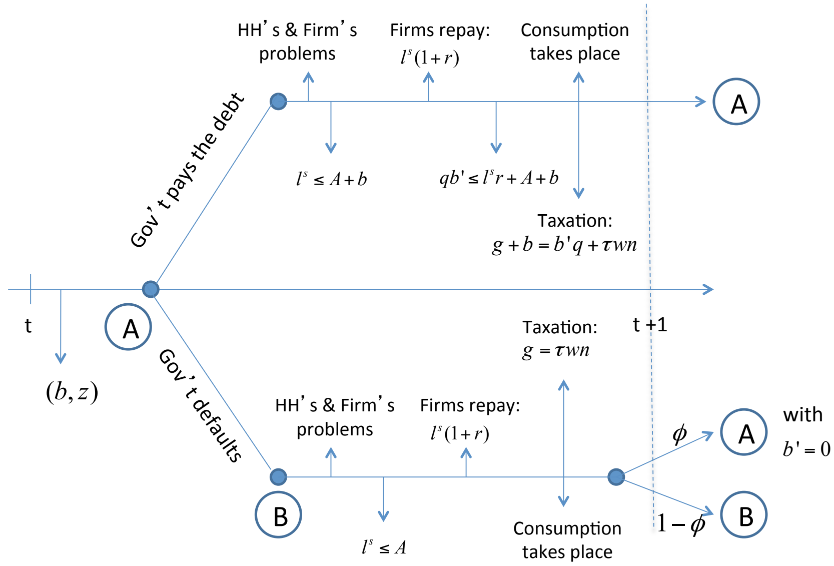

Figure IV: Timing of Events.

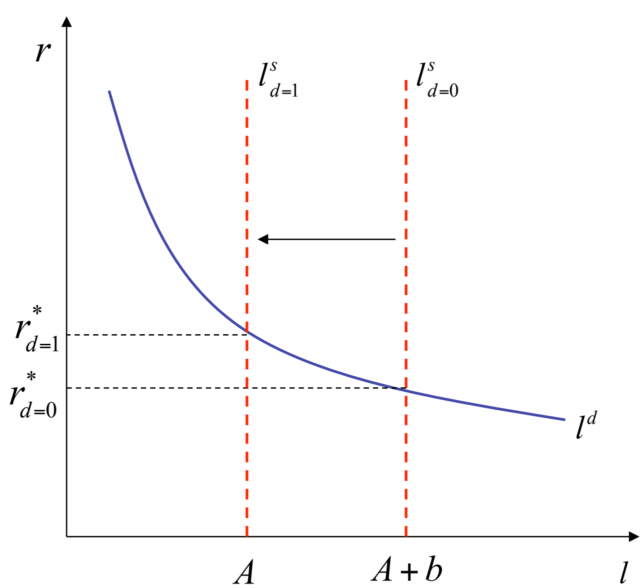

Figure V: Loan Market in Period t.

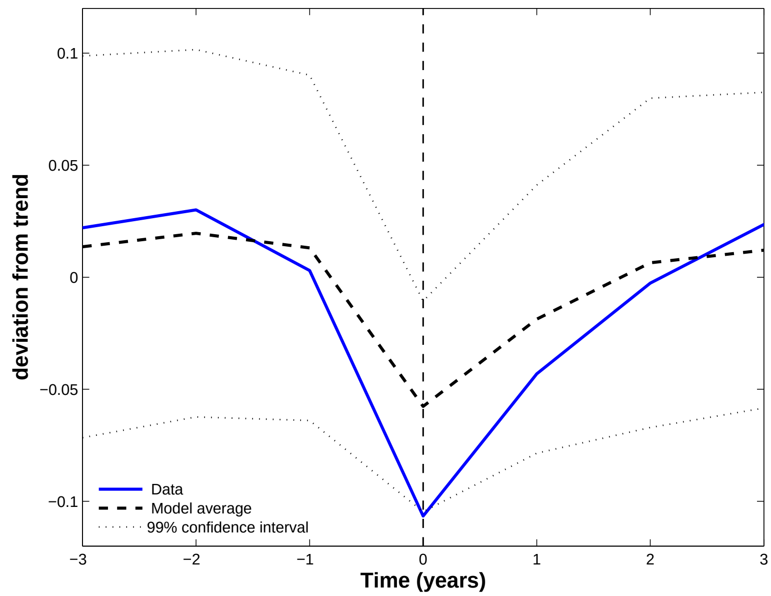

Figure VI: Output around Defaults.

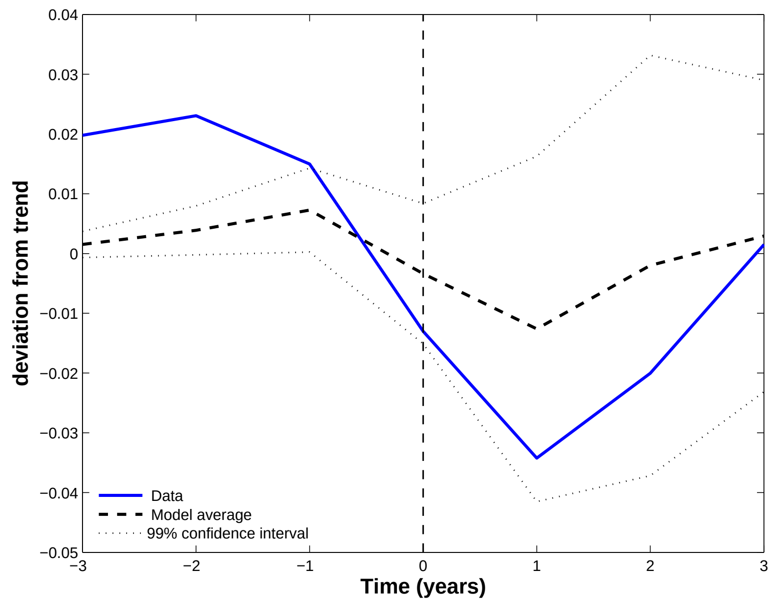

Figure VII: Private Credit/ GDP around Defaults.

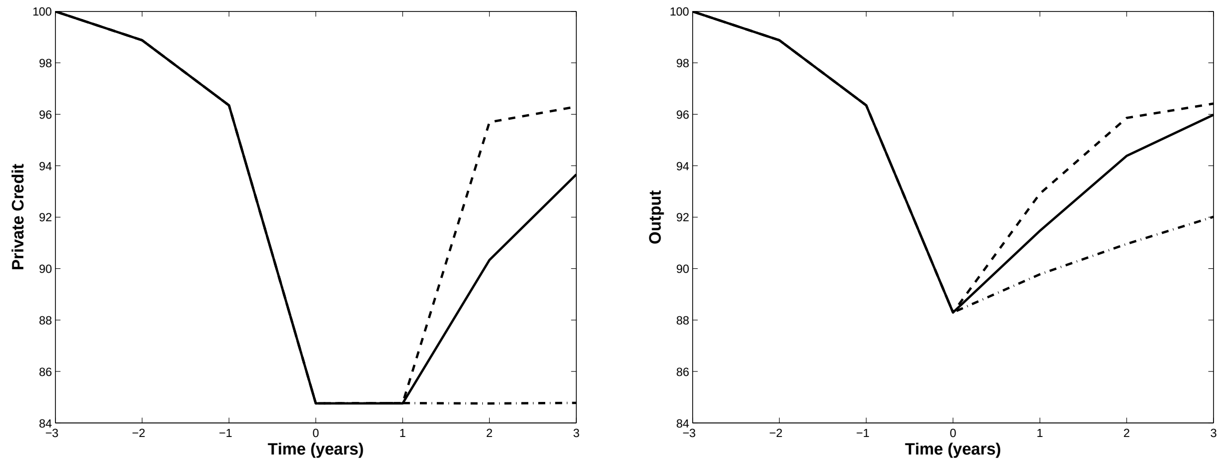

Figure VIII: Private Credit, Output, and Financial Exclusion. The left panel corresponds to Private Credit. The right panel corresponds to Output. Both series are normalized so that $T-3=100$. The solid line (—) is for the model average, the dashed line (– – –) is for the case of immediate re-access, and the dashed-dotted line (– · –) is for the no re-access case.

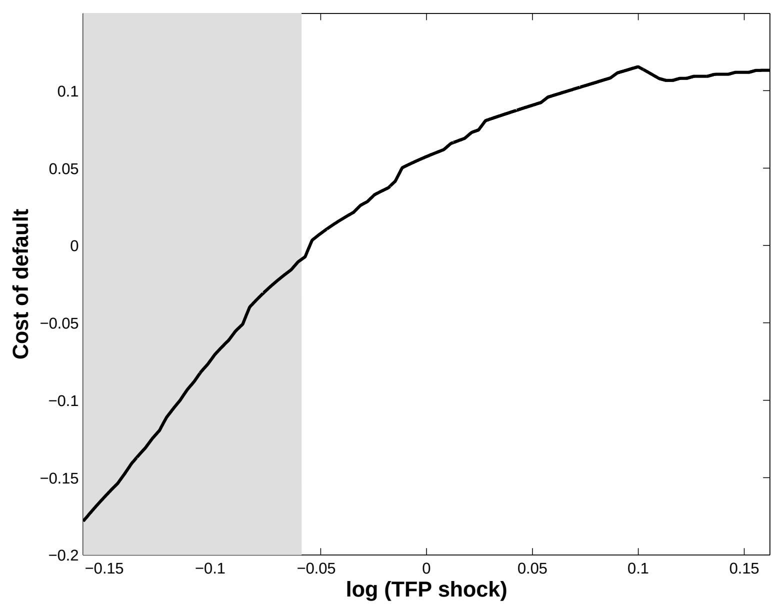

Figure IX: Cost of Default as a function of TFP shock. The figure is constructed for the mean debt level observed in the simulations. The solid line represents the percent output cost of a default, $1 - y_{d=1}/y_{d=0}$. The shaded area is the "default region": TFP levels for which default is optimal given that the country has the mean indebtedness level.

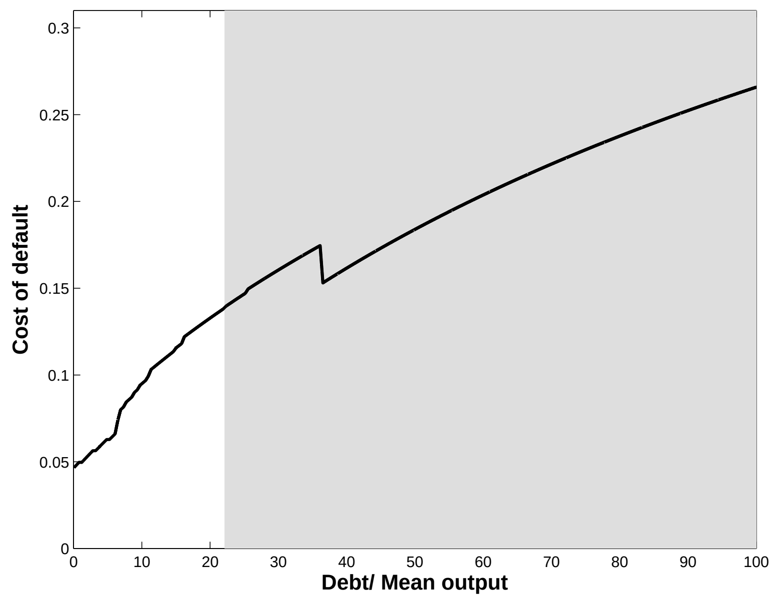

Figure X: Cost of Default as a function of outstanding debt. The figure is constructed for the mean realization of the TFP shock. The solid line represents the percent output cost of a default, $1 - y_{d=1}/y_{d=0}$. The shaded area is the "default region": debt levels for which default is optimal given that the country has received the mean realization of the TFP shock.

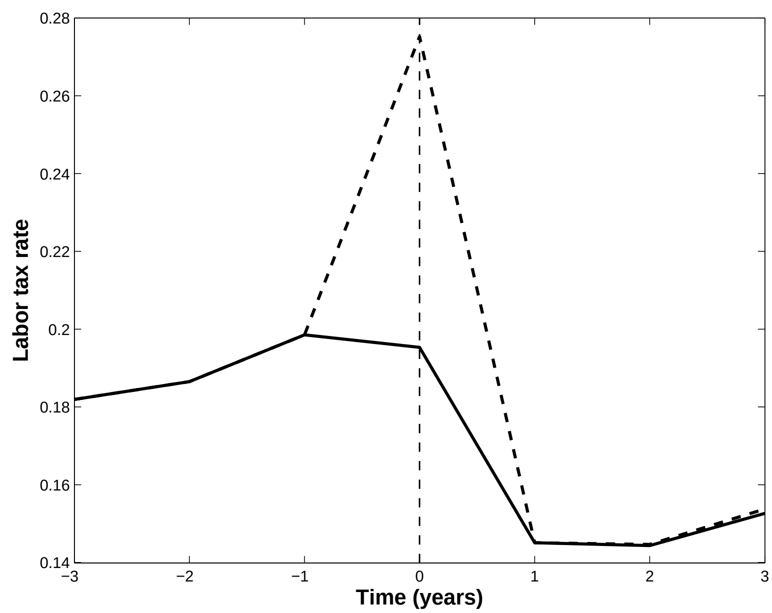

Figure XI: Labor-Income Tax Rate around Defaults. The solid line (—) is for the equilibrium tax rate and the dashed line (– – –) is for the counterfactual repayment tax rate.

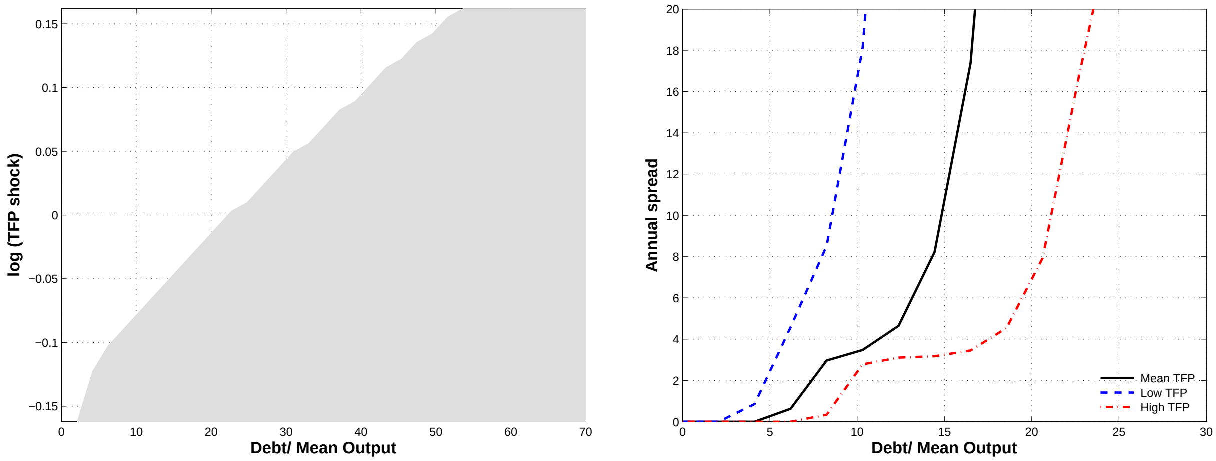

Figure XII: Default Region and Spreads-Borrowing Menu. The left panel shows the default region, where the shaded area represents combinations of debt levels and TFP realizations for which default is optimal. The right panel corresponds to the combinations of spreads and borrowing that the government can choose from. The solid line (—) is for the average TFP level, the dashed line (– – –) is for a TFP realization 1 standard deviation below mean, and the dashed-dotted line (– · –) is for a TFP realization 1 standard deviation above the mean.

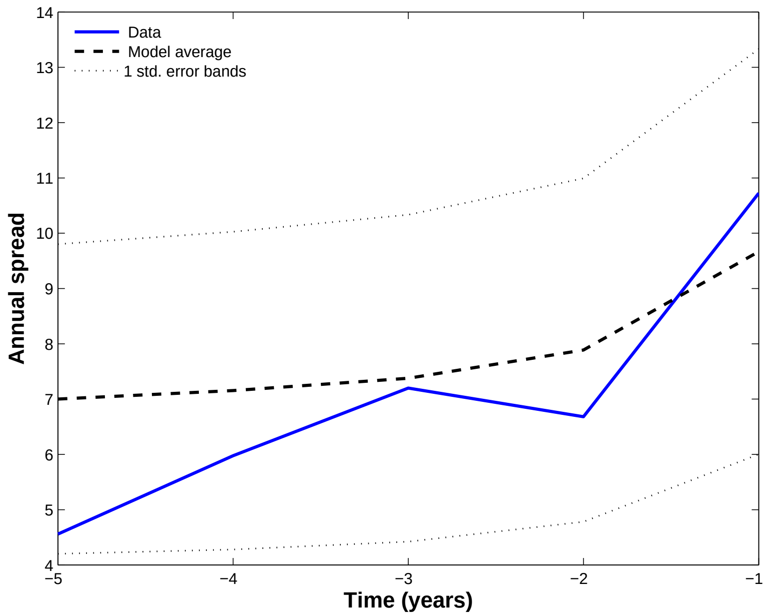

Figure XIII: Spreads in the Run-up to a Default.

C Data Appendix (for online publication)

Cross-country data. [39]

1. Real GDP growth around defaults. Default dates are from Reinhart and Rogoff (2009) and GDP growth is from the Maddison Project Database (see Bolt and van Zanden (2013)). Data was kindly shared by Carmen Reinhart.

2. Private Credit as a % of GDP. Series is from FinStructure Database 2009 (a database that is itself constructed mainly from the International Monetary Fund's International Financial Statistics). The most recent version of the database can be accessed here.

3. Exposure Ratio. It is constructed using series from FinStructure Database 2009. The ratio is constructed as:
$$Exp\_Ratio = 1 - \frac{Private\_Credit}{Assets\_Fin\_Sector},$$
where $Private\_Credit$ is "Private Credit by Deposit Money Banks and Other Financial Institutions as Percent of GDP" (pcrdbofgdp) and $Assets\_Fin\_Sector$ is the sum of "Deposit Money Banks Assets as Percent of GDP" (dbagdp) plus "Other Financial Institutions Assets as Percent of GDP" (ofagdp).

4. Sovereign Default and Banking Crises episodes. We follow Reinhart and Rogoff (2009)'s classification of banking crises to identify those in the temporal vicinity of a sovereign default. Reinhart (2010) identifies 82 banking crises episodes, and 70 of those are coupled with default crises. Table I focuses on those 'twin events' post-1970.

Argentine data. [40]

1. Sovereign Spreads. Series is from J.P. Morgan's Emerging Markets Bond Iindex (EMBI).

2. Debt Ratios. Series for DD/TD and for TD/GDP are from Reinhart and Rogoff (2011) and Reinhart and Rogoff (2010), respectively. Some of this data is also available from Carmen Reinhart's website.

3. Wages. Data on Total Wage-Earners Remuneration is from INDEC (Argentina's Census and Statistics Office).

4. Aggregate Demand. Series for Private Consumption, Government Consumption, Trade Balance, and Investment are from World Development Indicators.

5. TFP. The series that we use is the one reported as "Strict TFP" by the ARKLEMS team.

   Raw data available at: http://arklems.org/datos/. Documentation available at:

   http://arklems.files.wordpress.com/2011/05/paper-wordklems.pdf

[39] A file with all cross-country data and replication of Figures I, II, and III can be found here.

[40] A file with all Argentina-specific data used for calibration purposes can be found here.