

# 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 that 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 Argentina's 2001 default episode the model produces default on equilibrium with a frequency in line with actual default frequencies, and when it happens credit experiences a sharp contraction which generates an output drop similar in magnitude to the one observed in the data. Moreover, the model also matches several moments of the cyclical dynamics of macroeconomic aggregates.

JEL codes: F34, E62

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# 1 Introduction

Sovereign defaults and Banking Crises have been recurrent in emerging economies. Recent default episodes (e.g. Russia 1998, Argentina 2001) have shown that whenever the sovereign decides to default on its debt there is an adverse impact on the domestic economy to a large extent through disruptions to the domestic financial systems. Why does this happen? Both in the Argentine and Russian experiences (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*) and in turn generated a decline in economic activity.

The current 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 on losing what had been invested in Greek bonds but mostly on how this shock to banks assets would undermine their lending ability and ultimately the economic activity as a whole.

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 exclusion and trade punishments. The motivation above, the empirical evidence presented later on and the policy discussions (e.g. IMF (2002)) all hint towards shifting the attention to domestic financial sectors and how they channel the adverse effects of a default to the rest of the economy.

The contribution of this paper is two-folded. Firstly, it presents a theory of the transmission mechanism of sovereign defaults to the banking sector and the rest of the economy. The existing literature on quantitative models of sovereign defaults has remained silent about the relationship between sovereign debt, default and banking sector performance, this paper fills this gap. Secondly, on a methodological note, this paper presents a novel mechanism to endogenize the costs of sovereign defaults: a sovereign default generates a credit crunch, and this credit crunch generates output declines.

Grounded on three key regularities, namely that (i) defaults and banking crises tend to

happen together, (ii) banks are highly exposed to government debt, and (iii) crises episodes are costly in terms of credit and output; we construct a theory that links defaults, banking sector performance and economic activity. This paper rationalizes these phenomena by extending a traditional sovereign default framework to incorporate bankers that 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 (i.e. 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), the cost is the reduced credit availability and the subsequently decreased output. Quantitative analysis of a version of the model calibrated to Argentina's 2001 default yields the following main findings: (1) default in equilibrium, (2) v-shaped behavior of output and credit around crises episodes, (3) mean output decline in default episodes of approximately 8%, and (4) overall qualitative behavior 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 been studied recently.<sup>1</sup> 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.<sup>2</sup> This paper

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<sup>1</sup>Yue (2010) studies debt defaults and renegotiations, D'Erasmus (2011) incorporates government reputation and endogenous default resolutions, Hatchondo and Martinez (2009) extend the model to incorporate long duration bonds, Hatchondo et al. (2011) study the effects of debt dilution, among others. Stahler (2011) presents a thorough account of the recent developments in this literature.

<sup>2</sup>See, for example, Chatterjee and Eyigungor (2011).

proposes a channel to endogenize these costs via the role of government debt in the domestic credit market.

Mendoza and Yue (forthcoming) 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 the private sector firms from tapping 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 (forthcoming) 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 default is a less attractive option (domestic residents' assets become worthless) and therefore makes *default-on-equilibrium* a more challenging outcome. Second, it acknowledges the high prevalence of government debt in banks' balance sheets and illustrates how a sovereign default diminishes credit availability 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. (2010) construct a stylized model of domestic and external sovereign debt where domestic debt weakens the balance sheet of banks. This potential damage suffered by the banking sector represents in itself a 'signaling' device that attracts more foreign lenders.<sup>3</sup> They interpret the banks' exposure as a measure of financial institutions quality in the economy and derive a number of testable implications that they investigate empirically. Our analysis relates to Gennaioli et al. (2010) in that it also identifies the damage that financial institutions suffer when defaults come. We identify this reduced credit as the endogenous mechanism generating costs of defaults and also analyze the benefits side: how distortionary taxation changes when defaults happen. Additionally we develop a stochastic dynamic general equilibrium model that is able to account for a number of empirical regularities in emerging economies.

Bolton and Jeanne (2011) have an interesting paper on sovereign defaults and bank fragility in a model of contagion between financially integrated economies. With a stylized three-period

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<sup>3</sup>Basu (2009) develops a similar model that features domestic and foreign creditors and where 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.

model they show that financial integration without fiscal integration may result in an inefficient (from a global perspective) supply of government debt. This paper relates to them in that both highlight the exposure of the banking sector to government debt and that sovereign defaults generate contractions in private credit. We depart from Bolton and Jeanne (2011) in that their focus is mostly on advanced economies and contagion among them, whereas our paper focuses on emerging economies. This study also differs on the optimal policy treatment of the default decision and the quantitative analysis of the business cycle behavior of models of sovereign defaults and banking.<sup>4</sup>

This paper is also related to the optimal taxation literature. The closest paper to ours in this literature is Pouzo (2008). He builds 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 (2008) in three crucial aspects: first, Pouzo (2008) relies on an exogenous cost of default whereas we propose an endogenous structure; second, Pouzo (2008) restricts 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 third (on a more technical note), Pouzo (2008) solves 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 commitment on the side of the government.<sup>5</sup>

The rest of the manuscript is structured as follows. Section 2 presents stylized facts on sovereign defaults, banking crises and output and credit drops. Section 3 lays out the model and defines the equilibrium. Section 4 contains the numerical solution and the main results of the paper. Section 5 has a conclusion and describes avenues for future research.

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<sup>4</sup>Yet another related work is the one by Livshits and Schoors (2009). They argue that defaults generate banking crises because of an inadequate prudential regulation which does not recognize the riskiness of the debt.

<sup>5</sup>This paper is also related to the literature on optimal public policy without commitment. These papers solve for Markov-Perfect (and therefore, time-consistent) optimal policies. See Klein et al. (2008) and references therein.

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

Table 1: Timing of Defaults and Banking Crises. Source: Author’s calculations from Reinhart and Rogoff (2010) data.

## 2 Stylized Facts

This section documents the stylized facts that motivate the theoretical/quantitative analysis presented in the rest of the paper. It begins by describing the time clustering of default crises and banking crises. Then, 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 Reinhart and Rogoff (2009) classification of banking crises to identify those crises that occurred in the temporal vicinity of a sovereign default. Of the 82 banking crises episodes documented in Reinhart (2010), 70 were coupled with default crises.<sup>6</sup> 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 2 shows that this occurred in 25 out of 39 post 1970 events.<sup>7</sup>

The relationship between Banking crises and Default episodes has been previously studied in the empirical literature. In particular, the question of whether a default causes a banking crisis or viceversa has been recently addressed by Borensztein and Panizza (2008). They construct

<sup>6</sup>They 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 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).

<sup>7</sup>This timing of events, with the banking crisis occurring after or at the same time as the default event is consistent with the one we will assume in the model of the next Section, and hence the significance of documenting that this was the timing observed in about 2/3 of the actual twin default/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

Table 2: Probabilities of Defaults and Banking Crises. Source: Borensztein and Panizza (2008)

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 summarized in the Table 3.

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

It can be argued that a banking crises can generate additional government spending (for example 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 significant (at either the 1% and the 5% confidence levels) from the unconditional one.<sup>8</sup>

Even tough these results should be taken with a grain of salt, they suggest that a default may increase the probability of a banking crisis much more then the other way around. Overall, the evidence presented provides support for the assumed timing in the model.

**The banking sector exposure to government debt.** In this section we take a look at

<sup>8</sup>A more recent empirical study on banking crises and sovereign defaults is the one by Balteanu et al. (2011). Using the date 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 containing 121 sovereign defaults and 131 banking crises for 117 emerging and developing countries from 1975 to 2007. Among them they identify 36 "twin crises" (defaults and banking crises): in 17 of them a banking crisis preceded the sovereign default and in 19 the reverse was true.

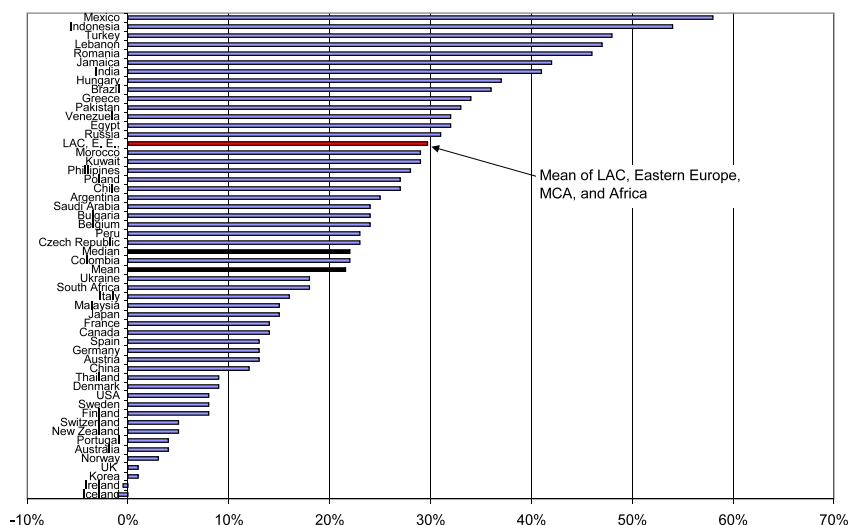


Figure 1: Banking Sector exposure to Gov't debt. Source: Author's calculations from Kumhof and Tanner (2005) and IMF IFS data.

the degree of exposure of banks to government debt.<sup>9</sup> 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 1 documents, this exposure ratio averages 30% for emerging economies. What is even more compelling is that for countries that actually defaulted (like Russia and Pakistan) this percentage was even higher.

**Crises episodes are episodes of decreased output and credit.** It has been documented that output falls sharply in the event of a sovereign default (see for example Sturzenegger and Zettelmeyer (2005)). Figure 2 makes the same point in a visual way. We observe a v-shape behavior of GDP in the temporal vicinity of defaults.

Default 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)

<sup>9</sup>Between 2001 and 2002 in Argentina, considerations on the harm the banking system would take were in the front row of the discussions that eventually lead to the default decision. See Perry and Servén (2003) and Kumhof (2004).



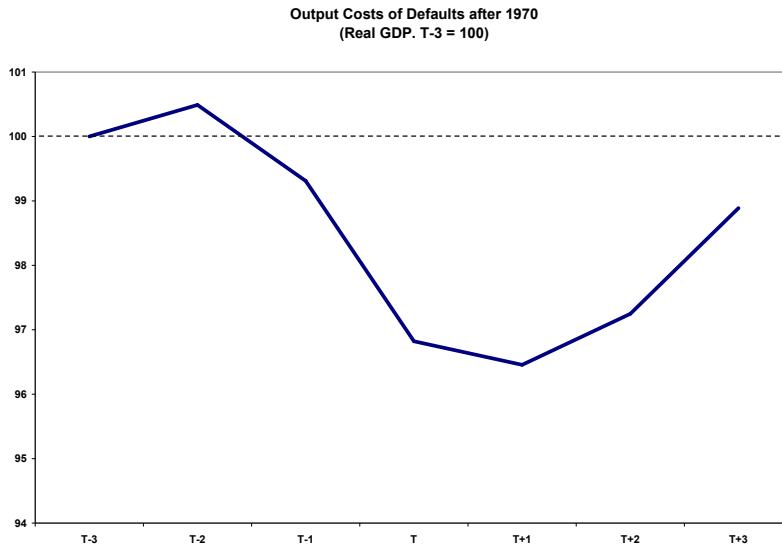


Figure 2: Costly Defaults and Banking Crises. Source: Author's calculations from IMF IFS data.

to look at the behavior of *Private credit by deposit money banks and other financial institutions* around defaults and banking crises. Figure 3 plots this measure as a percentage of GDP and shows that when a default comes private credit shrinks and remains reduced for the subsequent periods.

To summarize the set of facts just reviewed: (1) Defaults and Banking crises tend to happen together (with 64% of banking crises happening together with or right after a default), (2) the banking sector is highly exposed to government debt (with emerging economies banking sector holding on average 30% of their assets in government bonds), and (3) crises episodes are episodes of decreased output and credit.

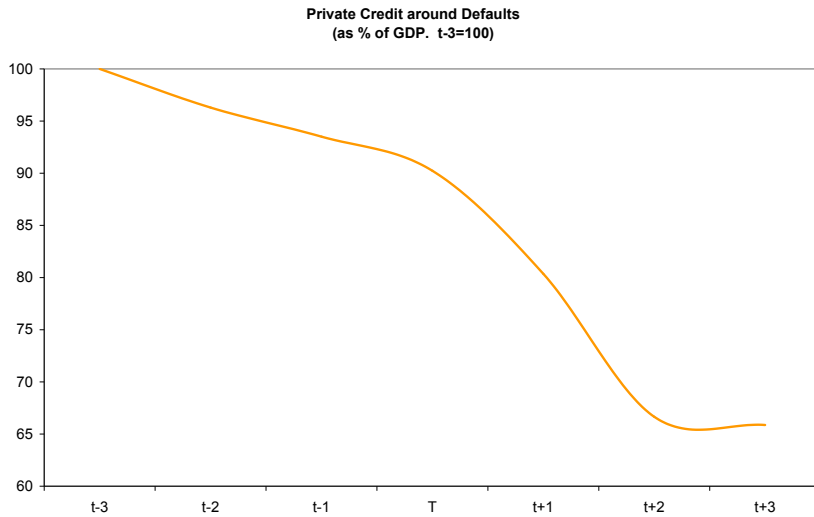


Figure 3: Private Credit. Source: Author’s calculations from IMF IFS data.

### 3 Environment

We analyze an economy under discrete time. There are four players in this economy: households, firms, bankers, and a (benevolent) government. In this framework the households do not have any inter-temporal choice so they only make two decisions: how much to consume and how much to work (i.e., this is just a consumption/leisure problem from the households’ point of view). The production in the economy is conducted by standard neoclassical firms that face only a working capital constraint: they need 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 each period. These bankers start the period with two assets:  $A$  and  $b$ .  $A$  represents an exogenous endowment that the bankers receive every period.<sup>10</sup>  $b$  represents the level of sovereign debt owned

<sup>10</sup>There are a number of ways to interpret this endowment  $A$ . One alternative is to model deposits 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

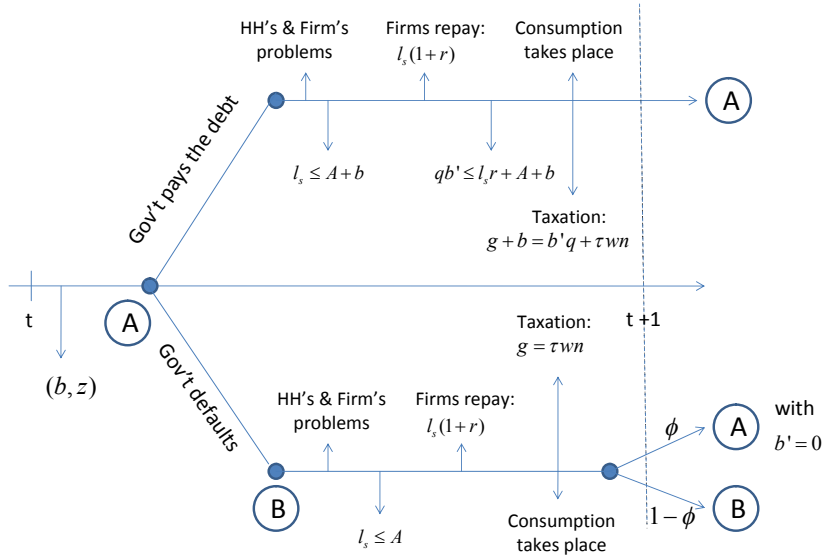


Figure 4: Timing of events.

by the bankers at the beginning of the period (this 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 to do so: labor income taxation, borrowing, and default. We do not assume any kind of commitment technology available to the government: this means that every period the government can default on its debt. This default decision is taken at the beginning of the period and influences the rest of the economic decisions. Therefore 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., not excluded from the credit market) is illustrated in Figure 4 and it proceeds as follows:

- Period  $t$  arrives:
  1.  $z_t$  (the TFP shock) is observed.
  2. Given that the government is not excluded from the credit market the pay-off relevant state variables are the level of debt and the level of the TFP shock:  $(b_t, z_t)$ . We are in node  $\textcircled{A}$
  3. The government makes the default decision:  $d_t \in \{0, 1\}$ 
    - (a) if default is chosen ( $d_t = 1$ ) we move to the lower branch of the tree and the following happens:
      - i. government gets excluded and the credit market consists of only the (intra-period) loan market: firms borrow to meet the working capital constraint and bankers lend ( $l_s$ ) up to the level of their endowment ( $A$ ).
      - ii. firms repay principal plus interests ( $l_s(1 + r)$ ) and all other markets (labor and goods) clear.
      - iii. taxation ( $\tau$ ) and consumption take place.
      - iv. at the end of period  $t$  a re-access *lottery* is played: with probability  $\phi$  the government will re-access next period and get a fresh start ( $b' = 0$ ) and with probability  $1 - \phi$  the government will remain excluded and will start next period in node  $\textcircled{B}$ .
    - (b) if repayment is chosen ( $d_t = 0$ ) we move to the upper branch of the tree and the following happens:

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it is optimal for the household (at the beginning of the period) to give this endowment  $A$  to the members of the household that will use it better: the bankers. Yet another interpretation is to think of the bankers as "international banks":  $A$  represents the flow of funds from the parent bank to its subsidiary.

- i. 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 domestic market ( $l_s$ ) up to the sum of their endowment and the repayed government debt they own ( $A + b$ ).
- ii. firms repay principal plus interests ( $l_s(1 + r)$ ) and the (intra-period) working-capital loan market closes.
- iii. bankers now serve the sovereign bond's market. Each bond is traded at a price of  $q$  and bankers can lend ( $qb'$ ) only up to the total of their resources ( $l_s r + A + b$ ).
- iv. 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:

$$\max_{\{c_t, n_t\}_0^\infty} \sum \beta^t U(c_t, n_t) \quad (1)$$

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

where  $c_t$  stands for consumption,  $n_t$  denotes labor supply,  $w_t$  is the wage rate,  $\tau_t$  is the labor-income tax rate,  $\Pi_t^F$  represents the firm's profits, and  $m$  is a constant spending aiming to capture

the sum of investment and net exports.<sup>11</sup>

Plugging equation (2) into equation (1) the household's problem can be rewritten as:

$$\max_{\{n_t\}_0^\infty} \sum \beta^t U((1 - \tau_t)w_t n_t + \Pi_t^F - m, n_t)$$

and the period-t FOC reads as:

$$U_c (1 - \tau_t)w_t + U_n = 0 \quad (3)$$

Equation (3) can be rearranged into the familiar expression equating the marginal rate of substitution between leisure and consumption to the after-tax wage rate:

$$-\frac{U_n}{U_c} = (1 - \tau_t)w_t \quad (4)$$

### 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 wages bill. In order to do so, firms will take intra-period loans from the bankers. Given these features, the firms' problem can be expressed as:

$$\max_{N_t, l_t^d} \Pi_t^F = z_t F(N_t) - w_t N_t + l_t^d - (1 + r_t)l_t^d \quad (5)$$

$$\text{s.t. } \gamma w_t N_t \leq l_t^d \quad (6)$$

where  $z$  is an aggregate technology shock,  $F(N)$  is the production function,  $l_t^d$  is the demand for working capital loans,  $r_t$  is the rate charged for the loan, and  $\gamma$  is the fraction of the wages bill that must be paid up-front.

The working capital constraint is captured by equation (6). This equation will always hold with equality because firms do not need loans for anything else than paying  $\gamma w_t N_t$ , therefore any

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<sup>11</sup>The constant  $m$  is only added for calibration purposes so that the model can correctly match the consumption-to-output ratio.

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 FOC is:

$$z_t F_N = (1 + \gamma r_t) w_t \tag{7}$$

Condition (7) equates the marginal product of labor to the marginal cost of hiring labor once the financial cost is factored in. Therefore, the optimality conditions from the firm's problem are equation (7) and equation (6) evaluated with equality.

### 3.2.3 Bankers' problem

Every period the bankers participate in two different credit markets: the loans market and the sovereign bonds markets. The working assumption is that they participate in these markets sequentially.<sup>12</sup>

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

$$W(b, z) = \max_{x, l^s, b'} v(x) + \delta E W(b', z') \tag{8}$$

$$s.t. \ x = A + (1 - d)b + l^s r - (1 - d)qb' \tag{9}$$

$$A + (1 - d)b \geq l^s \tag{10}$$

where  $l^s$  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.

$v(x)$  is the period return function of the banker,  $x$  is the end-of-period consumption of the banker,  $\delta$  stands for the discount factor.

Equation (10) captures the timing of the banking sector: the maximum the banker can lend to the firms is the sum of his endowment and the repayment of government debt.

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<sup>12</sup>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 (see Lagos and Wright (2005)).

This problem can be rewritten as:

$$W(b, z) = \max_{l^s, b', \mu} v(A + (1 - d)b + l^s r - (1 - d)qb') + \delta EW(b', z') + \mu[A + (1 - d)b - l^s]$$

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

$$l^s : v'(x)r - \mu = 0 \tag{11}$$

$$b' : -v'(x)q(1 - d) + \delta EW_b(b', z') = 0 \tag{12}$$

$$\mu : A + (1 - d)b - l^s \geq 0 \ \& \ \mu[A + (1 - d)b - l^s] = 0 \tag{13}$$

The envelope condition reads as:

$$W_b(b, z) = v'(x)(1 - d) + \mu(1 - d) \tag{14}$$

Then, rearranging equation (11) we get:

$$r = \frac{\mu}{v'(x)} \tag{15}$$

Combining equations (12), (14) updated one period, and (15), and focusing on the case of  $d = 0$  (when government is not excluded and debt is actually traded) we get:

$$q = \delta E \left\{ \frac{v'(x')}{v'(x)} (1 - d')(1 + r') \right\} \tag{16}$$

To interpret this optimality condition, define the Stochastic Discount Factor (SDF) of the banker as:

$$\delta E \left\{ \frac{v'(x')}{v'(x)} \right\} \equiv \Lambda = SDF \tag{17}$$

and re-write the next period's payoff of the sovereign bond as:

$$v' = (1 - d')(1 + r') \tag{18}$$

This expression shows that in case of default in the next period ( $d' = 1$ ) the lender not only losses his investment in sovereign bonds but also losses the future gains that those bonds would have created had them been repaid, which are summarized in  $r'$ .



Combining (16), (17), and (18) we obtain this standard asset-pricing equation:

$$q = \begin{cases} E\{\Lambda \vartheta'\} & \text{if } d = 0 \\ 0 & \text{if } d = 1 \end{cases} \quad (19)$$

This equation is the condition pinning down the price of debt subject to default risk in this model. In standard sovereign default models with risk neutral foreign lenders,  $\Lambda$  is replaced with the (inverse of the) world's risk free rate, which represents the lenders' opportunity cost of funds. In contrast, here domestic bankers arbitrage the price of today's debt against the expected marginal benefit of further lending.

### 3.2.4 Government Budget Constraint

The government needs to tax labor income to pay for both the exogenous spending and (in case it decides not to default) the debt obligations. Its budget constraint can be expressed as:

$$g + (1 - d_t)B_t = \tau_t w_t n_t + (1 - d_t)B_{t+1} q_t \quad (20)$$

where  $B_t$  stands for debt (with positive values meaning higher indebtedness),  $g$  is the exogenous government spending,  $\tau_t$  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 firm's problem in (5) - (6).
3.  $\{x_t, l_t^s, b_{t+1}\}_{t=0}^\infty$  solve the banker's problem in (8) - (10).
4. Markets clear:

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

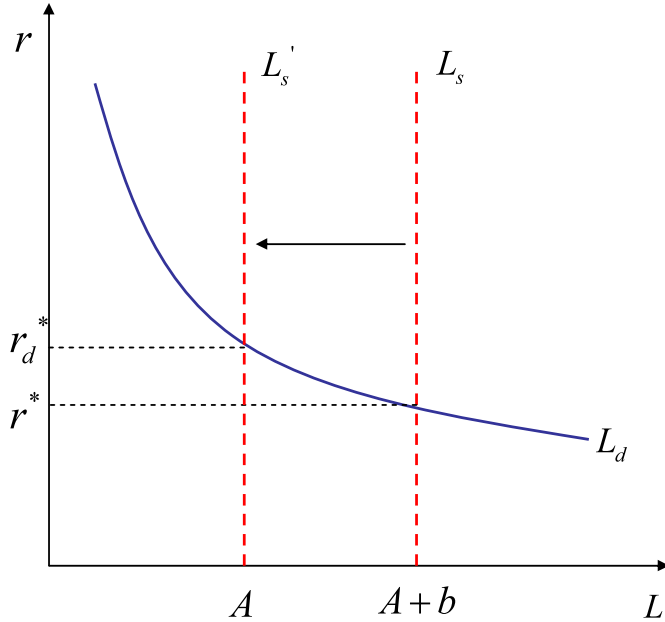


Figure 5: Loan Market in period  $t$ .

and the Aggregate Resources Constraint holds:

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

### 3.3.1 Loan Market Characterization

The main message of the model is to highlight how a sovereign default generates a credit crunch, which in turn shows up as an increase in the borrowing costs for the corporate sector (firms) and a subsequently economic slowdown.

This mechanism puts the financial sector in the spotlight and Figure 5 shows how the private credit market reacts to a sovereign default. Both the demand for loans and the supply for loans can be obtained from the partial equilibrium conditions coming from the firms' and bankers' optimization problems.

Given that the working capital loan is always risk free (because firms are assumed to never default on the loans) the bankers are going to supply inelastically the maximum amount they can. This inelastic supply curve is affected by a default: when the government defaults, bankers' holdings of government debt become non-performing and therefore they cannot be used in the

private credit market. This is graphed as a shift to left of the  $L_s$  curve in Figure 5. All this ends up in firms facing higher borrowing costs:  $r_d^* > r^*$ . 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 where government policies are functions of pay-off relevant state variables: the level of public debt and the technological 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 optimization problem of the government can be recursively written as:

$$\mathcal{V}(b, z) = \max_{d \in \{0,1\}} (1-d)\mathcal{V}^{nd} + d\mathcal{V}^d \quad (21)$$

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

Then:

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

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

Following (8)  $W^i(b, z)$  represents the banker's value function. The household's value function, on the other hand, is defined as:  $V^i = U(c, n) + \beta EV^i(b', z')$ .

Therefore, the value of no default is:

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

subject to:

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

Rewriting the constraints in terms of allocations only we obtain:

$$\begin{aligned}
V^{nd}(b, z) &= U(c, n) + \beta EV^{nd}(b', z') \\
W^{nd}(b, z) &= v(x) + \delta EW^{nd}(b', z') \\
g + b &= \frac{znF_N}{(1 + \gamma r^*)} + \frac{U_n(c, n)n}{U_c(c, n)} + b'q^* \\
c + x + g + m &= zF(K, n) + A \\
x &= (A + b)(1 + r^*) - b'q^*
\end{aligned}$$

where

$$\begin{aligned}
r^* &= \frac{znF_N}{b+A} - \frac{1}{\gamma} \\
q^* &= \delta E \left\{ \frac{v'(x')}{v'(x)} (1 - d')(1 + r') \right\}
\end{aligned}$$

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

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

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

subject to:

$$\begin{aligned}
V^d(z) &= U(c, n) + \beta E \{ \phi V^{nd}(0, z') + (1 - \phi) V^d(z') \} \\
W^d(z) &= v(x) + \delta E \{ \phi W^{nd}(0, z') + (1 - \phi) W^d(z') \} \\
g &= \tau w n && \text{(gov't b.c.)} \\
c + x + g + m &= zF(n) + A && \text{(resources const.)} \\
\left. \begin{aligned}
x &= A(1 + r) \\
r &= \frac{znF_N}{A} - \frac{1}{\gamma} \\
-\frac{U_n}{U_c} &= (1 - \tau)w \\
w &= \frac{zF_N}{(1 + \gamma r)}
\end{aligned} \right\} && \text{(comp. eq. conditions)}
\end{aligned}$$

### 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 plans  $\{c(b, z), x(b, z), n(b, z)\}$  and taxation rule  $\tau(b, z)$ , (ii) an equilibrium pricing function for the sovereign bond  $q(b'; b, z)$ , such that:*

1. *Given the price  $q(b'; b, z)$ , the borrowing and default rules solve the sovereign's maximization problem in (21)*
2. *Given the price  $q(b'; b, z)$  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  $q(b'; b, z)$  and the borrowing and default rules; the taxation rule  $\tau(b, z)$  satisfies the government budget constraint.*
4. *The price equilibrium function satisfies equation (19)*

## 4 Quantitative Findings

### 4.1 Functional Forms and Stochastic Processes

The period utility function of the households is:

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

The above preferences (called GHH after Greenwood et al. (1988)) have been traditionally used in the Small Open Economy - Real Business Cycle literature.<sup>13</sup> These preferences shut-off the wealth effect on labor supply and therefore help avoiding the potentially undesirable effect of having a counter-factual increase in output on default periods.<sup>14</sup>

The return function of the bankers is:

$$v(x) = \frac{x^{1-\sigma_b}}{1-\sigma_b}$$

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:

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

where  $\varepsilon_t$  is an *i.i.d.*  $N(0, \sigma_z^2)$ .

### 4.2 Calibration

The model is calibrated to an annual frequency using data for Argentina from the period 1980-2005. Table 4 contains the parameter values.

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<sup>13</sup>See, for example, Mendoza (1991).

<sup>14</sup>Using GHH preferences the marginal rate of substitution between consumption and labor does not depend on consumption, and therefore the labor supply is not affected by wealth effects. For a related analysis about how important are GHH preferences in generating output drops in the Sudden Stops literature, see Chakraborty (2009).

Curvature of labor disutility	$\omega$	2.5	Frisch wage elasticity
Labor share in output	$\alpha$	0.70	Standard value
Household risk aversion	$\sigma_c$	2	Standard value
Banker risk aversion	$\sigma_b$	0	Risk-Neutral bankers
Probability of redemption	$\phi$	0.50	Mean exclusion spell
Government Spending	$g$	0.15	Gov't Spending/GDP = 20%
Investment + Net Exports	$m$	0.075	$(I + NX)/GDP = 10\%$
Banker's discount factor	$\delta$	0.96	Standard value RBC
Working capital requirement	$\gamma$	0.51	Wages bill/Private credit = 51%
Weight of hh. in planner's obj. function	$\theta$	0.5	Equal weight
Household's discount factor	$\beta$	0.80	Mean Debt/ output $\cong 16\%$
Banker's endowment	$A$	0.2	Mean exposure ratio $\cong 35\%$
TFP autocorrelation coefficient	$\rho$	0.90	GDP autocorrelation
Std. dev. of innovations	$\sigma_z$	2.7%	GDP std. dev.

Table 3: Benchmark Calibration.

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 ( $\alpha$ ) and the risk aversion parameter for the households ( $\sigma_c$ ) are set to 0.7 and 2 respectively, which are standard values in the quantitative macroeconomics literature. Banker's risk aversion  $\sigma_b$  is set to zero to feature risk-neutral bankers. The value of the exogenous spending level  $g$  is set up to 0.15 to match the ratio of General Government Expenditures to GDP for Argentina in the period 1985-2000 of 20% (from 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 0.075 so that the ratio  $(I+NX)/GDP$  generated by the model is equal to the observed ratio, 10%. The working capital requirement parameter ( $\gamma$ ) is taken directly from the Argentine data. In the model  $\gamma$  is equal to the ratio of private credit to wage payments, the data shows that for Argentina this ratio was 51% (for the period 1993-2001).<sup>15</sup>

The discount factor for the bankers (i.e., the lenders) takes a usual value in RBC models with

<sup>15</sup>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).

annual frequency, 0.96. It is important to realize that the exact value of  $\delta$  is not crucial in itself but in how it compares with the household's discount factor (discussed below). The weight that households' utility receives on the planner's overall objective function ( $\theta$ ) is set in the benchmark calibration to 0.5 in order to give all the residents (bankers and households) the same weight. It is crucial to see that if  $\theta$  takes the value of one, then the model features 'international banks' and hence facilitates the comparison with previous literature that focused on external debt and default: this exercise is done as part of a sensitivity analysis, later in the manuscript.<sup>16</sup>

There are two more *above the line* parameters to discuss: the curvature of labor disutility ( $\omega$ ) and the probability of redemption ( $\phi$ ). The value of  $\omega$  is typically chosen to match empirical evidence on 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, González and Sala Lorda (2011) find estimates 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) and conduct some sensitivity analysis later.

The probability of redemption is governed by the parameter  $\phi$ . The evidence collected by Gelos et al. (2004) is that emerging economies remain excluded 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.) to place their debt in domestic markets making domestic exclusion shorter than external exclusion. Therefore the benchmark calibration will be  $\phi = 0.5$ , which given the annual calibration implies a mean exclusion of 2 years. Alternative values for  $\phi$  are considered in the sensitivity analysis section.

The parameters *below the line*  $\{\beta, A, \rho, \sigma_z\}$  are simultaneously determined in order to match a set of meaningful moments of the data. The moments matched by the model are all taken from Argentine data and they are the mean domestic debt to output ratio, the mean exposure of the banking sector to government debt, and the autocorrelation and standard deviation of GDP.

Given that the benchmark calibration features a closed economy the correct debt-to-output

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<sup>16</sup>Setting  $\theta = 1$  features international banks but does not make our model collapse to the ones in Aguiar and Gopinath (2006) and Arellano (2008). The reason is very clear: in our model these international banks are not deep-pocket, but are only able to lend up to  $A + (1 - d)b$ .



ratio to match 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 the Domestic Debt part of it 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 16.5% for the period 1980-2002. As it was documented in section 2 the banking sector of virtually every emerging economy is highly exposed to government debt. The mean *exposure ratio* (defined in section 2) for Argentina was approximately 25%.

The autocorrelation and standard deviation of Argentine GDP were computed at an annual frequency from the time series available from INDEC (the Argentine Census and Statistics Office) for the period 1980-2005. The autocorrelation of the cyclical component of GDP is 0.28 and the standard deviation is 4.11%.<sup>17</sup>

### 4.3 Results

This section examines the performance of the benchmark calibration of the model in accounting for some key statistical moments of business cycles and government debt. Table 5 reports the moments from the simulations of the model and compares them with the moments from Argentine data.

Overall the benchmark calibration of the model is able to account for several salient facts of the Argentine economy, namely a ratio of consumption volatility to output volatility greater than 1, countercyclical sovereign spreads, and a high and positive correlation between output and consumption.<sup>18</sup> All of these moments were not targeted by the calibration process and are reproduced by the model. The benchmark calibration also captures nicely the negative correlation between employment and sovereign spreads, as well as procyclical employment.

<sup>17</sup>The series obtained from INDEC is real GDP, and it was first logged and then H-P filtered using a smoothing parameter of 6.25 (as suggested by Ravn and Uhlig (2002)).

<sup>18</sup>These facts also characterize many other emerging economies, as documented in Neumeyer and Perri (2005).

	Data	Model
$\sigma(c)/\sigma(y)$	1.17	1.82
$\sigma(n)/\sigma(y)$	0.57	0.94
$corr(R_s, y)$	-0.62	-0.81
$corr(c, y)$	0.97	0.99
$corr(N, y)$	0.52	0.99
$corr(R_s, N)$	-0.58	-0.77
Mean output drop	9.40%	8.23%
Mean credit drop	27.09%	8.17%
Default rate	2.56%	1.60%
Mean debt/ output	16.5%	16.84%
Gov't Spending/ output	20%	19.75%
Mean Exposure Ratio	36%	36.12%

Table 4: Simulated Moments and Data.  $R_s$  stands for bond's 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 generated by the model are the difference between the the interest rate paid by the government and the one paid by the private sector.

The model does well at replicating the mean output drop. Data from INDEC indicates that in the recent Argentine default episode GDP fell 9.4 percentage points from trend. The benchmark calibration delivers an average decrease of 8.23 percent. The sovereign default triggers a credit crunch in the model and it in turn generates an output collapse. This collapse is due to a reduced access to the labor input, which is the only variable input in the economy. The fact that the economy cannot resort to a substitute input generates a sharp output decline. It is again important to remark that the mean output drop was not among the *targeted* moments in the calibration procedure.

The credit drop that drives the endogenous cost of default is a novel contribution of our analysis. The benchmark calibration of the model is able to produce a mean credit drop of 8.17% which accounts for 30% of the actual credit drop observed in the 2001-02 Argentine default.

The model does not do well in terms of matching the mean default rate, but this deserves further consideration. According to Reinhart and Rogoff (2009) Argentina has defaulted on its

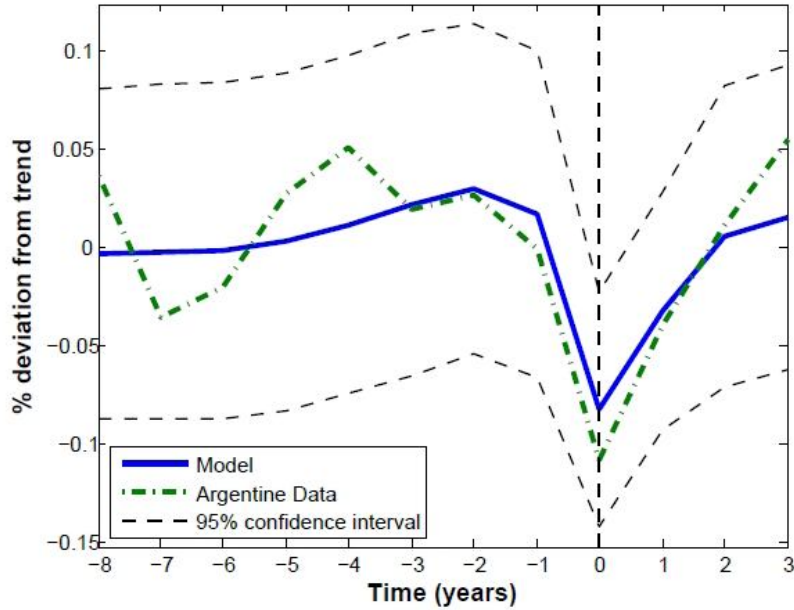


Figure 6: Output around defaults.

domestic debt 5 times since its independence in 1816, implying a default probability of 2.5%. It is typical in quantitative studies of sovereign default to calibrate the models to the observed frequency of default. Other models in the literature when calibrated to obtain the observed default frequency usually do poorly in some key dimensions, like the mean debt ratio.

#### 4.3.1 Output dynamics around defaults

An important result of the paper is to provide a framework able to deliver endogenous output declines in default periods. Figure 4 is constructed from the model simulations in the following way: first, we identify the simulation periods where default happens; second, we construct a time series of 8 years before and 3 years after each default; third, we average across default episodes

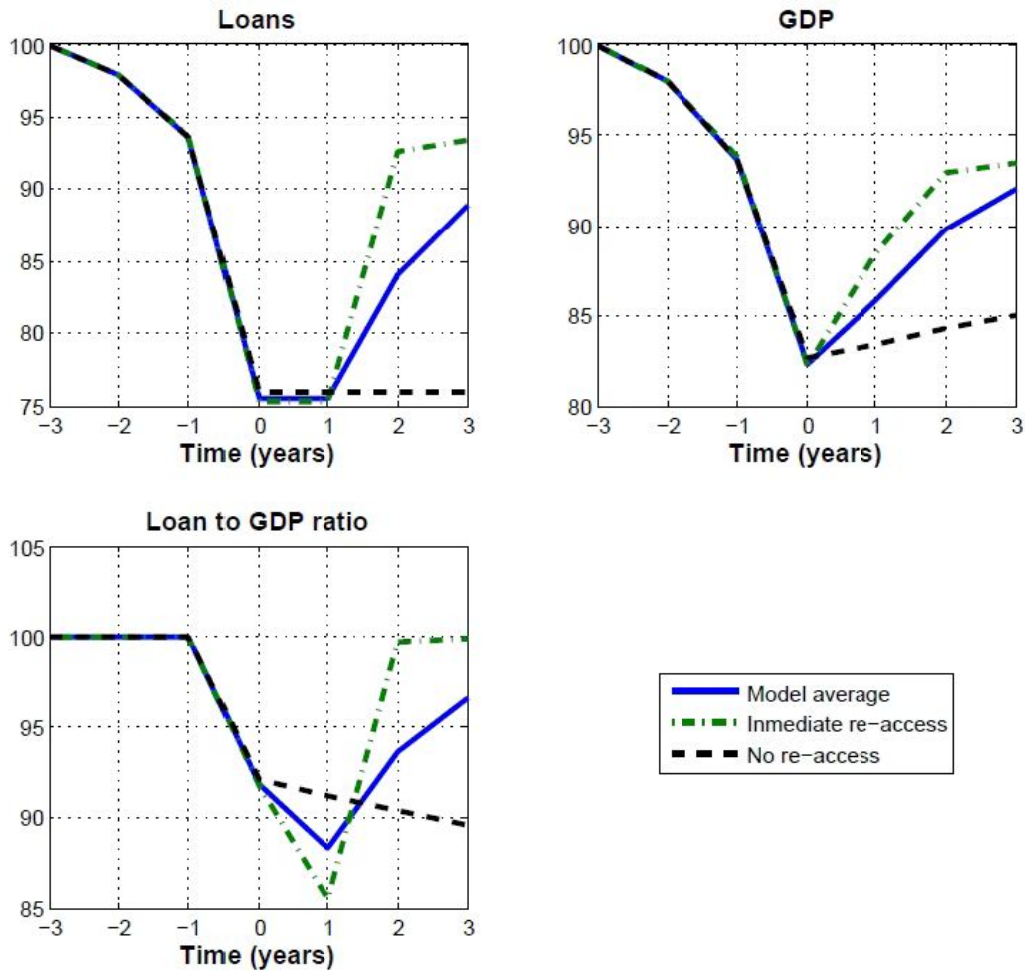


Figure 7: Credit crunch.

to construct a series of the mean output behavior around defaults.

As it is clear from Figure 6 the model features an output decline (and a consequent consumption decline) in the default period. The model is also able to deliver a v-shape behavior of output around defaults: a strategic default is 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 revenues required for repayment.

#### 4.3.2 Endogenous cost of default: Credit contraction

Why does a default generate such a costly output decline? This paper proposes a *credit crunch* explanation: given that bankers hold government debt as part of their assets, when a default

comes a considerable fraction of these assets losses value, therefore their lending ability contracts and as a consequence credit to the private sector diminishes. Given that the productive sector is in need of external financing, a credit crunch translates into an output decline.<sup>19</sup>

Figure 7 shows how a credit crunch looks in the model. The benchmark parametrization of the model is able to produce a collapse in the private sector credit (i.e., working capital loans to firms, in the model).

Figure 7 also shows how the exclusion from the credit market affects the credit availability and consequently output. In the top panels of this figure we can see the workings of a credit crunch: firms are in need of external financing, therefore when loanable funds shrink, output shrinks with them.

We can also see the effect of exclusion from financial markets: if the government remains excluded then 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.

Compared to the behavior observed in the data (i.e. Figure 3 in Section 2) the model is unable to generate any persistence. An interesting extension is to allow the bankers endowment  $A$  to be endogenously chosen: in this way bad states of the nature (where default will sometimes happen) give little incentive to build-up  $A$ . When a default hits, then there is even less incentives to accumulate  $A$  and this (possibly coupled with longer exclusion spells for the defaulting government) leads to lower private credit after a default.

### 4.3.3 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 were already discussed above: output declines because of a credit contraction. The benefits on the other hand come from *reduced* taxation. Figure 8 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

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<sup>19</sup>Bolton and Jeanne (2011) identify this phenomenon as banks becoming *illiquid*.

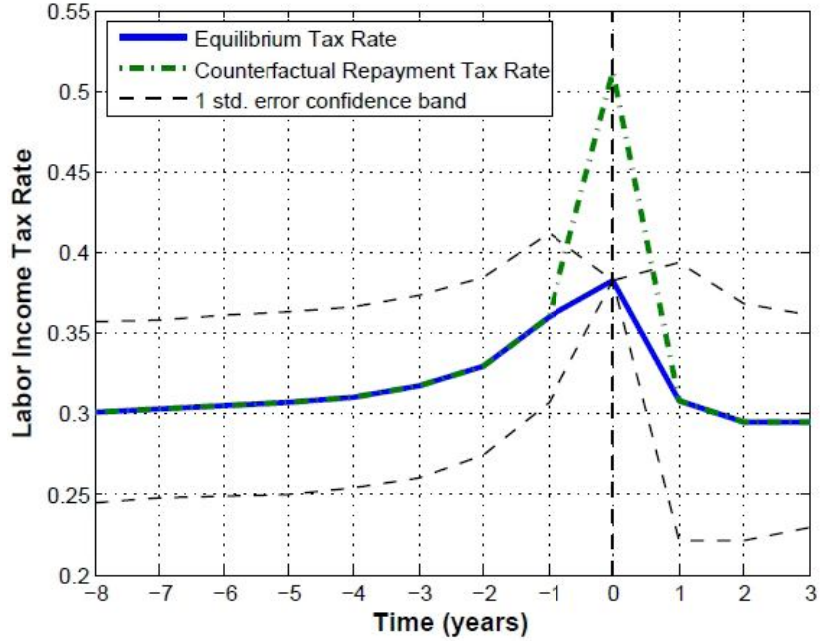


Figure 8: Labor tax rate around defaults.

the government had repaid.

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 13 percentage points on average.

#### 4.3.4 Sovereign bonds market

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

Figure 9 shows the equilibrium default region and the bond price function, respectively. With respect to top panel, the white area represents the repayment area: it is increasing with the level of technology and decreasing with respect to the level of indebtedness. The bottom panel presents the price schedule that the government faces. As it was expected, the price the sovereign receives for each bond increases with TFP and decreases with the total level of indebtedness.

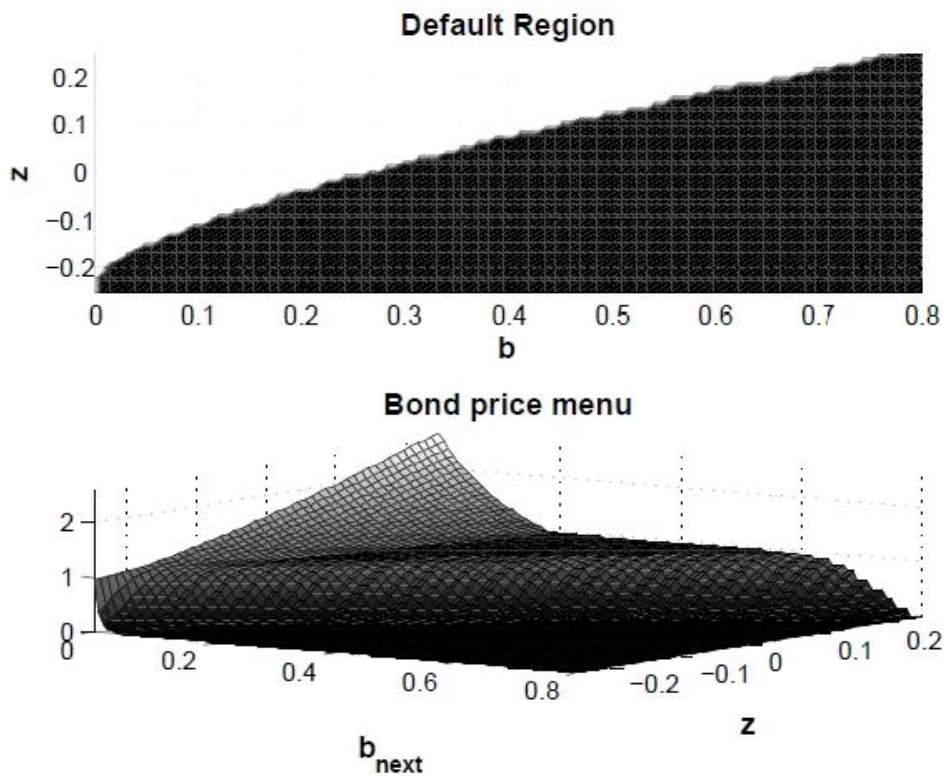


Figure 9:  $d(b, z)$  and  $q(b'; b, z)$ .

Now we turn to the behavior of spreads in the run up to a default. Figure 8 shows that the spreads generated by the model are able to mimic the behavior of the EMBI 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 period before.

#### 4.4 Sensitivity Analysis

In this section we perform a sensitivity analysis to gain a better understanding of how a set of key moments in the baseline calibration react to changes in the underlying parameters. Table

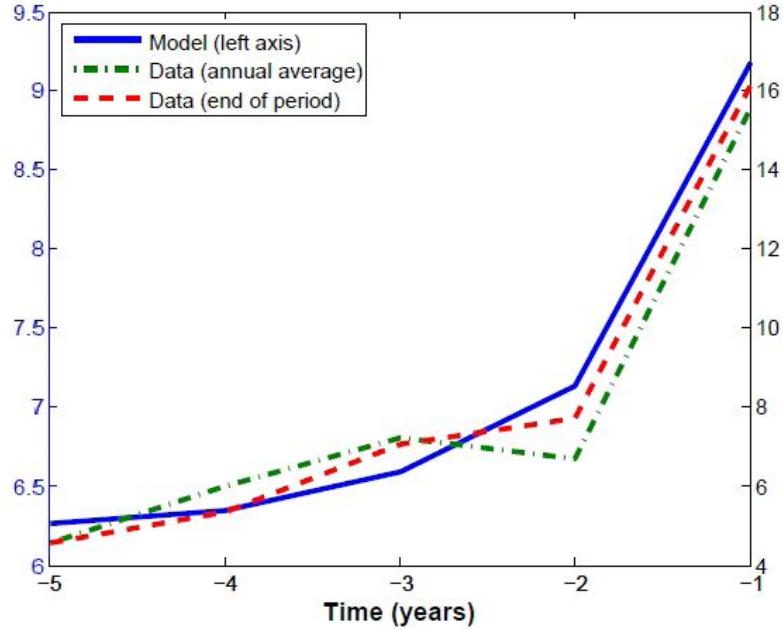


Figure 10: Spreads before a default.

6 summarizes the findings of this exercise.

Let's first study how the model economy reacts to changes in the re-entry probability ( $\phi$ ). If the government could re-access immediately after a default ( $\phi = 1$ ) then the overall costs of a default (exclusion from credit markets are among them) are reduced. A lower default cost makes repudiation more attractive, so we see that for  $\phi = 1$  default is more frequent. Consequently less debt can be sustained in equilibrium. If on the other hand we lower  $\phi$  making re-access less frequent then the exclusion-cost-of-default is larger and the government is able to sustain higher debt ratios. The endogenous cost of default in this paper works through a reduction in credit availability: the higher the debt the government defaults on, the higher the cost, and this we see as we increase the value of  $\phi$ .

Next, let's examine how the model behaves with different values of  $\gamma$ . This parameter governs the tightness of the working capital constraint,  $\gamma \in (0, 1]$ . A high (low) value of  $\gamma$  means that firms need to pay up front a higher (lower) ratio of their wage bill, therefore working capital loans are more (less) important for production. We can see that the model performs as expected: for lower values of  $\gamma$  (cases in which private credit is not so important for production) default



	Moments (in %)					
	Default rate	$E\{b/y\}$	$E\{R_s\}$	Exposure	$y \downarrow$	Credit $\downarrow$
Data	2.5	16.50	7.43	36	9.40	27.09
Benchmark	1.60	16.84	6.17	36.12	8.23	8.17
<i>re-entry (benchmark: <math>\phi = 0.5</math>)</i>						
$\phi = 0.05$	0.73	24.91	4.31	42.93	5.72	6.88
$\phi = 0.1$	0.91	24.81	4.72	44.21	6.06	7.05
$\phi = 1$	1.63	16.53	5.99	36.95	10.02	10.92
<i>w-k constraint (benchmark: <math>\gamma = 0.51</math>)</i>						
$\gamma \rightarrow 0$	0	0	–	0	<i>n.a.</i>	<i>n.a.</i>
$\gamma = 0.1$	0	0	–	0	<i>n.a.</i>	<i>n.a.</i>
$\gamma = 0.3$	2.56	0.04	6.80	0.16	–0.81	0.01
$\gamma = 0.6$	0.75	38.47	4.84	47.10	12.38	14.12
$\gamma = 0.7$	0.27	63.46	4.40	56.13	18.81	19.37
<i>Frisch wage elasticity (benchmark: <math>\omega = 2.5</math>)</i>						
0.5 ( $\omega = 3$ )	3.51	9.52	7.57	24.32	6.84	4.46
1 ( $\omega = 2$ )	1.06	36.09	5.13	49.21	9.29	14.87
<i>Banker's endowment (benchmark: <math>A = 0.2</math>)</i>						
$A = 0.1$	0	109.91	0	75.31	<i>n.a.</i>	<i>n.a.</i>
$A = 0.3$	12.25	0.43	77.13	1.12	–0.35	0.10
$A = 0.5$	0	0	–	0	<i>n.a.</i>	<i>n.a.</i>
<i>HH weight on <math>\mathcal{V}(b, z)</math> (benchmark: <math>\theta = 0.5</math>)</i>						
$\theta = 0$	0	39.96	0	22.22	<i>n.a.</i>	<i>n.a.</i>
$\theta = 1$	0.89	35.16	4.90	48.16	7.40	9.69

Table 5: Sensitivity Analysis.

is not very costly, consequently the government feels tempted to default too often. Creditors understand this and reduce lending in the government bonds market. Therefore we see that for values of  $\gamma \rightarrow 0$ , the mean debt ratio is zero and then the **observed** default rate is also zero. On the other hand, high values of  $\gamma$  make default very costly. Consequently the observed debt ratios are higher and the observed default rates are lower. 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.

When it comes to the Frisch wage elasticity ( $1/(\omega - 1)$ ) the behavior of the model is again as expected. A higher wage elasticity of labor supply implies that when a default comes and firms have to decrease their labor demand (due to higher costs of financing) the decline in equilibrium labor is greater than with a more inelastic labor supply. Therefore (as expected) for lower values of  $\omega$  (higher elasticity) the model features higher output drop at default and can sustain larger debt ratios, and for higher values of  $\omega$  the opposite is true.

Banker's 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 it is more tempted to default when  $A$  is larger. Lenders anticipate this behavior and refrain from lending to the government. This generates a non-monotonic behavior of the equilibrium default rate: for low enough levels of  $A$  (e.g.  $A = 0.1$ ) default is too painful for the firms and therefore the government decides to never default and with this it is able to sustain large debt ratios. Conversely, for large enough levels of  $A$  (e.g.  $A = 0.3$ ) defaults are less painful for the private credit market and therefore the government is more tempted to default (we observe larger default rates) and it is able to sustain lower debt ratios. For even larger levels of  $A$ , everyone understands that debt is not very important for the credit markets and that governments will be tempted to default on it every time they have a chance, therefore nobody lends.

Finally, we examine the role of  $\theta$ , the weight that households receive in the planner's objective function. If  $\theta = 1$  it means the planner only cares about households or (what is the same) bankers are not residents but instead they are international banks. If this is the case we can compare the model against other models of external sovereign debt and default. In that dimension the model does a very good job: it obtains a reasonable default probability (0.90%) and achieves a debt to output ratio close to the data (external debt to output in Argentina was around 36%). On the other extreme if  $\theta = 0$ , then the "planner" only cares about the bankers and given the bankers are the only lenders, default would never be optimal. Therefore the planner can sustain higher debt ratios (higher than in the benchmark calibration).

## 4.5 Discussion of the assumptions

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

**Constant government spending:** in order to make the optimal fiscal policy as simple as possible 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. How to do it? The first thing to do is to make  $g$  valuable: a common approach is to include  $g$  in the household's utility function. Then,  $g$  becomes an extra fiscal policy instrument: the planner understands that higher  $g$  implies either higher  $\tau$  or higher indebtedness, but also takes into account the agents' preferences for  $g$ . Then, when a default comes and consumption declines the planner finds it optimal to decrease  $g$  as well in order to satisfy the intratemporal optimality condition relating private and public consumption. Therefore the model would be able to account for the observed procyclicality of government spending.

**Financial autarky:** the benchmark version of our model is a closed economy where government debt is held by domestic bankers. While this is an attractive environment to study the implications of a sovereign default on the domestic financial sector it comes at the expense of having an unrealistic closed capital account. If we let the government borrow from abroad as well as from the domestic bankers then the model becomes one of domestic and external sovereign debt, a missing piece in the quantitative literature on sovereign defaults. Nonetheless, this extension would bring other forces into play. The possibility of selective defaults can in principle mitigate the negative effect that a sovereign default has on the domestic economy: by defaulting on foreign lenders the government could in principle afford to repay the domestic lenders. Allowing the private sector to borrow from abroad as well will decrease the relevance of the domestic credit market for domestic production. However, as long as a fraction of the domestic firms needs to borrow from domestic sources the mechanism proposed in the model will still play an important role.

**Constant A:** assuming bankers receive a constant endowment 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 towards bringing the model closer to the data. Allowing (for example) for deposits from the households will enrich the environment and make it able to capture another salient feature of emerging economies crises: bank runs. Anticipating the possibility of a sovereign default and fearing banks will not be able to fully repay the deposits, households will run on the banks and therefore put more pressure on the availability of loanable funds in the economy.

## 5 Conclusions

The prevalence of defaults and banking crises is a defining feature of emerging economies. Three facts are noteworthy about these episodes: 1- Defaults and Banking crises tend to happen together (with 64% of banking crises happening together with or right after a default), 2- the banking sector is highly exposed to government debt (with emerging economies' banking sector holding on average 30% of their assets in government bonds), and 3- crises episodes are episodes of decreased output and credit.

In this paper we have provided a rationale for this 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 these bankers to decrease the credit to the productive private sector. This *credit crunch* translates in both reduced and more costly financing for the productive sector, which generates an endogenous output decline.

This paper presents a theory of the transition mechanism of sovereign defaults to the banking sector and the rest of the economy. A methodological contribution of this paper is to present a competing mechanism to endogenize the costs of sovereign defaults: a sovereign default generates a credit crunch, and this credit crunch generates output declines.

The model shows an overall qualitative fit of the data (defaults in equilibrium, v-shape behavior of output around defaults, credit contractions at default). On the quantitative side, several

dimensions are accurately accounted for: countercyclicality of bond spreads, mean default rate, mean output drop.

Some avenues for future research / possible extensions are:

- Incorporating an endogenous banker's net worth accumulation: this extension can in principle generate some persistence in the model and help to capture the time profile of domestic credit better.
- Bank leverage and regulatory policy: banks behavior is intentionally crude in the model (at this point simplifications are necessary to compute a rather complicated Markov Perfect optimal policy problem) but one could think of the potential implications that regulatory policy could have for bank leverage. If government debt (by regulation) is considered risk-free then banks have additional incentives to hold government debt. On the other hand a default not only decreases banks assets but also diminishes their leverage. Then the government faces a meaningful trade-off when considering both its debt position and the default policy.
- Endogenous government spending: making public spending valuable and letting the government optimally chose its level will increase the complexity of the planning problem but could also improve the model's ability to account for the observed procyclicality of government expenditures.
- Political economy of sovereign defaults. A default in this model implies redistribution from bankers (lenders) to households (taxpayers). It would be an interesting extension to study the politico-economic equilibrium that would arise if agents were allowed to vote on the default policies.

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