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Optimal Bailouts in Banking and Sovereign Crises[1]

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[PRELIMINARY AND INCOMPLETE]

Abstract

We study the optimal design of bailout policies in the presence of banking and sovereign crises. First, we use European data to document that asset guarantees (i.e. conditional capital injections) are the most prevalent way in which sovereigns intervene in distressed banking sectors. Then, we build a model of sovereign borrowing with limited commitment where domestic banks hold government debt and also provide credit to the private sector. Shocks to the banks' capital can trigger banking crises and so the government may find it optimal to extend guarantees over those assets. The key trade-off is the following: larger bailouts improve domestic financial markets and increase output, but they also imply larger fiscal needs for the government and can lead to increased default risk.

Keywords: Bailouts, Sovereign Defaults, Banking Crises, Conditional Transfers, Sovereign-bank diabolic loop.
JEL classification codes: E32, E62, F34, F41, G01, G15, H63.

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1 Introduction

The European debt crisis that began following the 2007–2008 financial crisis highlighted the diabolic loop between sovereign risk and bank risk. Whereas the Irish bailout of 2008 illustrated how financial risk can be transferred to the government via bailouts and asset guarantees (Acharya et al., 2014), the Greek debt crisis of 2012 showed inversely how sovereign risk can weaken banks' balance sheets due to overexposure to government debt (Sosa-Padilla, 2018). In response to banking crises, governments resort to direct capital transfers or contingent liabilities functioning as sovereign guarantees. In this paper, we focus on the optimal structure of government interventions during banking crises, in the presence of both sovereign and banking crisis risks.

The first part of the paper is empirical. We document that the issuance of sovereign guarantees is the most prevalent form of intervention. Between 2007 and 2016, the average share of government guarantees in GDP is almost twice as large as the average share of capital transfers in GDP for Greece, Ireland, Italy, Portugal, and Spain (GIIPS). A similar pattern holds for countries that joined the EU prior to 2004. This suggests that the contingent liabilities strategy seems to be the more dominant policy for governments when trying to alleviate banking crises.

In the second part of the paper, we build a model to quantitatively assess the interaction between sovereign and bank credit risk by extending Sosa-Padilla (2018)'s framework in two dimensions: firstly, we introduce banking crises that are driven by exogenous shocks to bank capital, and secondly, we study the optimal bailout decision of the government, which can trigger a sovereign debt crisis. Our model can account for several important empirical findings: (i) defaults and banking crises tend to happen together, (ii) after government guarantees and transfers, there is a comovement between bank and sovereign risk, (iii) banks' exposure to government debt can increase the sovereign risk, and (iv) banking and sovereign crises tend to affect the domestic economy by reducing output, employment and the amount of credit that banks extend to the private sector.

Our framework links these dynamics in a general equilibrium model of sovereign default, in which there is a government that plans the level of government spending that needs to be financed by using debt, taxes and transfers to the banks. The economy is subject to two types of aggregate uncertainty; in addition to the shocks to firm productivity there are also shocks to bank's capital. In anticipation of an adverse banking shock, banks reduce lending to the private sector. The sovereign may choose to provide transfers to the banks ex ante, or it may choose to announce guarantees (i.e. conditional transfers) to compensate for the banks' capital losses in the event of a crisis — these are the bailouts in our model. Defaults are costly because the government loses access to debt financing, it loses the ability to issue bailouts, banks' credit to the private sector declines and eventually output falls. The benefit of default is that all existing debt is wiped-out, relaxing the government's budget constraint and allowing it to increase government spending. Our framework is flexible enough to feature defaults trigerring banking crises (as in Sosa-Padilla, 2018 or Perez, 2015), and banking crises triggering defaults (highlighted as empirically relevant by Reinhart and Rogoff, 2011a): a complete 'doom loop.'

Preliminary quantitative results show that the occurance of a banking crisis increases the default probability twelve-fold (from 0.05 percent to 0.63 percent annually) and raises the annualized sovereign spread from 0.3 percent to 1.8 percent, and also increases the volatility of spreads. Optimizing governments find it optimal to issue bailouts (i.e. contingent guarantees) that are on average 11 percent of GDP, a number close to what we observe in the European data. These contingent guarantees exhibit clear properties. Other things equal the fraction of banking losses that the bailouts would cover are: (i) decreasing in the level of government debt, since the more debt the government has, the less fiscal space it has to prop up banking sector assets, (ii) increasing in aggregate productivity, since the better the aggregate state of the economy is, the cheaper it is to borrow to provide the guarantees, and (iii) decreasing with the severity of the banking crisis, and this is because the larger the losses, the more costly it is to finance them, which elevates default risk.

Related literature. Our paper builds on the sovereign default literature developed by Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), Arellano (2008), and many others. Our paper differs from these early papers, in the sense that it presents a model that entails a rich interaction between the government and the financial sector to study the transmission of the risks between these sectors and their implications on the real economy.

Our paper is at the intersection of two strands in the literature. The first looks at how the effects of sovereign risk are amplified through the banking channel. Sosa-Padilla (2018), Perez (2015), Bocola (2016) are recent examples. In addition to bank balance sheet effects, our paper also incorporates the transmission of banking crises to sovereign crises, which these papers do not consider. The second focuses on how banking crises lead to sovereign crises through bailouts. See, for example, Lizarazo et al. (2014), Acharya et al. (2014), Cooper and Nikolov (2018), Farhi and Tirole (2018), and Correa and Sapriza (2014). The main contribution of our paper is to study the optimal banking sector intervention in the presence of both sovereign and banking crisis risks.

The rest of the paper is organized as follows: Section 2 summarizes the stylized facts that motivate the theoretical model presented in the rest of the paper. Section 3 introduces the model. Section 4 explains the numerical solution and discusses the parametrization. Section 5 presents the quantitative results and discusses the properties of the optimal contigent bailouts. Section 6 concludes.

2 Stylized Facts

This section discusses the stylized facts that motivate the theoretical and quantitative analysis presented in the rest of the paper. Our model captures three salient dynamic features of banking and sovereign debt crises: the time clustering of sovereign default and banking crises, the feedback loop between sovereign and banking crises which occur in a short span of time, and the increasing bank exposure to public debt during sovereign debt crises. First, we summarize these stylized facts:

- Gennaioli et al. (2014) and Reinhart and Rogoff (2010, 2011a) document that banking and sovereign debt crises tend to happen together within a short span, which suggest that both directions of complementarity are likely at play. A distressed banking sector induces government bailouts, whose cost increases sovereign default risk. Increased sovereign risk in turn weakens the financial sector by eroding the value of its bond holdings.

- Banks are exposed to public bonds after the government bailouts, which might lead to a banking crisis. Gennaioli et al. (2014) find that banks' bond holdings correlate negatively with subsequent lending during sovereign crises, which could further decrease the total output of the economy.

Our main empirical contribution is to document how governments intervene during banking crises. The governments in the European Union have intervened mostly in two ways: (i) via assets' guarantees, and (ii) via capital transfers. Figure 1 shows the annual average government contingent liabilities and capital transfers as a percentage of GDP in the EU28 counties from 2007 to 2016 using data from Eurostat. Pre-2004 EU countries include Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, Sweden, The Netherlands, and U.K.; Post-2004 EU countries include Bulgaria, Croatia, Cyprus, Hungry, Latvia, Lithuania, Slovenia, Czech Republic, Estonia, Malta, Poland, Romania, Slovakia; GIIPS include Greece, Ireland, Italy, Portugal, and Spain. We find that particularly for GIIPS countries, the average share of the government guarantees is close to 18 percent of GDP, whereas

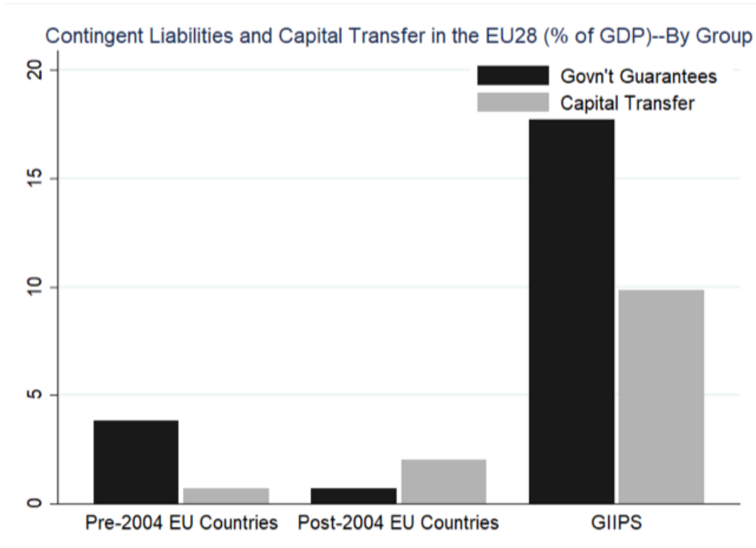

Figure 1: Government guarantees and capital transfers.

the average share of transfers is only around 10 percent. The average share of government guarantees is also higher than that of transfers for pre-2004 countries,

3 Model

We extend the banking and sovereign default model of Sosa-Padilla (2018) in two dimensions: *banking crises* that are driven by exogenous shocks to banking capital and *government bailouts* which can trigger sovereign default crises.

Environment. We consider a closed economy populated by four agents: households, firms, banks, and a government. Households exogenously supply labor to firms, but are otherwise assumed to be hand-to-mouth. Firms hire labor and borrow working capital loans from the banks in order to produce the consumption good. Banks lend to both firms and the government, and are subject to a collateral constraint. Additionally, banks are subject to shocks to the value of their collateral. All income is taxed by the government at rate τ. Finally, the government taxes all income at (a constant) rate τ and chooses policies for public consumption, debt, bailouts, and default to maximize its own welfare.

There are four aggreagte state variables in our model economy: one endogenous and three exogenous. The level of government debt, B, is the endogenous state variable. The first exogenous state variable is aggregate productivity z, which follos a Markov process. Following Chatterjee and Eyigungor (2012), we also introduce an *iid* shock, m, that affects the level of fiscal revenues.[2] Finally, the third (and more novel) exogenous state variable captures shocks to the valuation of banks' collateral, ϵ. These shocks are also *iid* and are drawn from $[0, \bar{\epsilon}]$. Let us denote $s \equiv (z, m, \epsilon)$.

Timing of events. If the government enters the period in good credit standing, then the sequence of events is as follows:

1. The exogenous state variables s are realized.
2. Considering the aggregate state (B, s) the government decides whether to repay $(d = 0)$ or to default $(d = 1)$.
3. If $d = 0$, then:
   (a) The government announces a bailout policy
   (b) Private lending and production take place
   (c) A 'banking crisis' occurs with probability π
      i. If the banking crisis does take place, the government disburses the promised bailouts, and chooses its borrowing policy $B'(b, s)$
      ii. If the banking crisis does not happen, the government doesn't pay any bailouts, and chooses its borrowing policy $B'(b, s)$
4. If $d = 1$, then:
   (a) The government cannot promise bailouts and is excluded from financial markets
   (b) Private lending and production take place
   (c) A 'banking crisis' occurs with probability π
5. All markets clear and consumption takes place

In case the government enters the period in bad credit standing (i.e. it finished the previous period excluded from financial markets), the government regains market access with probability θ. If reaccess is gained, then the timing of events is as above, with an initial debt level of zero. Otherwise, if the government remains excluded, the timing of events amounts to the sequence of stages 1, 4 and 5 above.

[2] As explained in Chatterjee and Eyigungor (2012), the presence of m allows robust computation of this class of models.

3.1 Decision problems given government policy

Households. The representative hand-to-mouth household has preferences given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t u(c_t)$$

where $\beta_h < 1$ is the discount factor and c_t is consumption at time t. The household period utility function is given by

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}.$$

The household has one unit of time, which is supplied inelastically. Its budget constraint is given by

$$c_t = (1-\tau)w_t$$

where w_t is wage income.

Firms. The representative firm hires labor from the household n and demands working capital loans from the banks ℓ to solve:

$$\max_{n,\ell} \quad zF(n,\ell) - wn - r\ell \tag{1}$$

where

$$zF(n,\ell) = zn^{1-\alpha}\ell^{\alpha} \tag{2}$$

and z is a productivity shock. Factor prices are given by

$$w = z(1-\alpha)\ell^{\alpha} \tag{3}$$

$$r = z\alpha\ell^{\alpha-1} \tag{4}$$

since $n = 1$ in equilibrium.

Bankers. Bankers play a vital role in the economy by providing loans to both the government and the firms. They face a collateral constraint which requires that loans to firms do not exceed a fraction γ of the value of banks' collateral. The value of this collateral is comprised of three components: b, A, and T. The first component is the banks' holdings of sovereign bonds, b. The second component is banks' capital, $A(\epsilon)$, which is subject to aggregate shocks. The third component are government guarantees, $T(A, B, s)$ (i.e. the state-continget bailouts that the government may implement).

The dynamics of bank capital are as follows: every period bank capital has a reference value of $\bar{A}$, but it is subject to shocks ϵ. The magnitude of the shock ϵ is realized at the beginning of the period, but the uncertainty regarding whether the shock hits the banks is only resolved at the end of the period: with probability π, the ϵ shock will affect bank capital. These dynamics can be summarized as

$$A = \begin{cases} \overline{A} & \text{with probabilty } 1-\pi \\ \overline{A}-\varepsilon & \text{with probabilty } \pi. \end{cases}$$

Let $\underline{A}(\varepsilon) = \overline{A} - \varepsilon$. We refer to the event that $A = \underline{A}(\varepsilon)$ as a banking crisis.

The collateral constraint faced by the banker is such that it needs to be satisfied state-by-state. This implies that every period loans are limited by the worst-case scenario of the collateral:

$$\ell \leq \gamma \left[\underline{A}(\varepsilon) + b + T(A, B, s)\right]$$

where $T(A, B, s)$ is the bailout policies of the government. When the government has access to credit, the banker's value is given by

$$W^c(b; B, s) = \max_{\ell} \mathbb{E}_A \left\{ \begin{array}{ll} \max\limits_{x,b'} & x + \delta \mathbb{E}_{s'|s}\left[(1-d')W^c(b'; B', s') + d'W^d(s')\right] \\ \text{s.t.} & x \leq T(A, B, s) + b - q(B', s)b' + r(B, s)\ell(1-\tau) \\ & \ell \leq \gamma \left[\underline{A}(\varepsilon) + b + T(A, B, s)\right] \end{array} \right\}$$

where x is consumption, δ is the banker's discount factor, $r(B, s)$ is the interest rate on private loans, $q(B', s)$ is the price of government bonds, and B', T, and d are government policies for debt, bailouts, and default, which the banker takes as given. W^d is the banker's value when the government does not have access to credit, which is given by

$$\begin{aligned} W^d(s) = \max_{\ell} \mathbb{E}_A & \left\{ \max_x \left\{ x + \delta \mathbb{E}_{s'|s}\left[\theta W^c(0; 0, s') + (1-\theta)W^d(s')\right] \right\} \right\} \\ & \text{s.t. } x \leq r^d(s)\ell(1-\tau) \\ & \quad\;\; \ell \leq \gamma \underline{A}(\varepsilon). \end{aligned}$$

where θ is the probability that the government regains access to credit and $r^d(s)$ in the interest rate on private loans when the government does not have access to credit.

3.2 Characterization of equilibrium given government policies

When the government does not have access to credit, bankers supply

$$\ell^d(s) = \gamma \underline{A}(\varepsilon). \tag{5}$$

When the government has access to credit, bankers supply

$$\ell = \gamma(B + \underline{A}(\varepsilon) + T(A, B, s)). \tag{6}$$

The bond pricing function satisfies

$$q(B';\ s) = \delta \mathbb{E}_{s'|s} \left\{ \left[1 - \underbrace{d'(B', s')}_{\text{default premium}} \right] \left[1 + \underbrace{r'(B', s')(1-\tau)\gamma}_{\text{collateral discount}} \right] \right\} \tag{7}$$

3.3 Determination of government policies

Government preferences are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_g^t u(G_t)$$

where G_t is government consumption. Given the option to default, $V^o(B, s)$ satisfies

$$V^o(B, s) = \max \left\{ V^c(B, s), V^d(s) \right\} \tag{8}$$

where V^c is the value of not defaulting, and V^d is the value of default. The value of repayment is given by

$$V^c(B, s) = \max_{T \geq 0} \mathbb{E}_A \begin{cases} \max\limits_{G, B'} & u(G) + \beta_g \mathbb{E}_{s'|s} V^o(B', s') \\ \text{s.t.} & G \leq \tau z f(\ell(T; B, s)) - T(A, B, s) + B' q(B', s) - B + m \end{cases}$$

where $q(B', s)$, the price schedule for government debt, is given by equation (7). We assume that bailout transfers can only occur during banking crisis, i.e. when $A = \underline{A}(\varepsilon)$. In other words, $T(\bar{A}, B, s) = 0$ for all (B, s).

When the government defaults, it is temporarily excluded from capital markets and during this time it is also unable to issue bailouts. The probability that the government regains access to capital markets is θ. The value of default is given by

$$V^d(s) = \max_G u(G) + \beta_g \mathbb{E}_{s'|s}\left[\theta V^o(0,s') + (1-\theta)V^d(s')\right]$$
$$\text{s.t. } G \leq \tau z f(\ell^d(B,s)).$$

4 Quantitative results

In this section, we first describe how we set the parameters of the model. Second, we examine the ability of the benchmark model to account for salient features of the data in GIIPS countries. Third, we show how default incentives interact with shocks to the banking sector and bailouts. Fourth, we study the properties of the optimal bailout policies. Fifth, we analyze the welfare benefits of having access to bailouts. Finally, we present a brief sensitivity analysis to illustrate the effect of different parameter values.

4.1 Parametrization

A period in the model is assumed to be a year. We assume that TFP shocks follow an AR(1) process given as:

$$z_{t+1} = (1-\rho_z)\mu_z + \rho_z z_t + \epsilon_{z,t+1} \tag{9}$$

where $\epsilon_z \sim N(0,\sigma_z)$. We use the Tauchen method to discretize the TFP shocks in 11 states. The potential bank collateral shocks ϵ are assumed to be i.i.d. and discretized to 3 values, where the probability each shock is equal to 1/3. We model the m shocks as being *iid* normal with mean zero and variance σ_m^2. We truncate $m \in [-\bar{m}, \bar{m}]$, impose that $\bar{m} = 2\sigma_m$ and discretize this process on a grid of 7 values. We assume that if the government defaults, then m takes its mean value.[3]

Table 1 summarizes the parameter values used. The risk aversion is set to $\sigma = 2$ as is common in the literature. The discount factors of the bankers and govnernment are set to 0.93 and 0.91, respectively so that lenders (bankers) are more patient than the borrower (government) and so that the model generates reasonably high levels of debt-to-GDP and reasonably low probabilities of default, since our analysis mainly focuses on the European periphery. We assume that the working capital share α is equal to 1/3. The tax rate is

[3] This effectively makes $V^d(s)$ a function of only z and ε. Chatterjee and Eyigungor (2012) instead impose that m takes its minimum value in default, but argue that this is not an important assumption for the convergence of the algorithm.

Table 1: Parameterization

Parameter	Value
Risk aversion, σ	2
Government discount factor, β_g	0.91
Bankers' discount factor, δ	0.93
Working capital share, α	0.33
Tax rate, τ	0.20
Prob. of financial redemption, θ	0.27
Bankers' endowment, $\bar{A}$	2.70
Collateral requirement, γ	0.80
Potential bank collateral shocks, ε	$\{0.5, 1.25, 2.0\}$
Prob. of banking crisis, π	0.01
m shock variance, σ_m	0.02
TFP shock process	
average, μ_z	1.00
persistence, ρ_z	0.90
variance, σ_z^2	0.02

20 percent, which constitutes a conservative estimate of the effective (income) tax rates in GIIPS countries. The probability of financial redemption, θ, is set to 0.27 which implies an average exclusion of 3.5 years.[4]

The parameter values for the TFP process are standard in the sovereign default literature: a persistence of 0.90 and standard deviation of 0.02. The standard deviation of the Chatterjee and Eyigungor (2012) m shock, σ_m is set to 0.02 to generate enough volatility so that the m shock helps to smooth the default decision, but not too much volatility to avoid situations in which the sovereign would default only for non-economic reasons.

Finally, the parameters describing the banks and banking crises are chosen as follows. The probability of a banking crisis is set at 1 percent, to reflect how unlikely these events are in middle-to-high income economies (the unconditional banking crisis probability in all countries, including developing nations, is around 2 percent). The level of the baseline bank capital, $\bar{A}$, and the tightness of the lending constraint, γ, are chosen so that the banks' exposure ratio and the private cost of credit are in line with recent data from GIIPS. The potential banking shocks ε have been set arbitrarily to 0.5, 1.25, and 2.0 to represent modest,

[4]This is a middle ground estimate given the long exclusion spells typically observed after defaults in emerging economies and the relative quick resolution of recent sovereign crises in peripheral Europe.

Table 2: Simulated moments

	Unconditional	Banking crisis
Default frequency	0.05	0.63
Sovereign spread		
mean	0.33	1.82
standard deviation	1.28	4.00
Debt/GDP	96.28	97.60
Bailout/GDP	-	10.97

Units: percent.

moderate, and severe banking shocks, respectively. These parameters are for numerical illustration; in future drafts, we plan to incorporate a more disciplined calibration exercise.

4.2 Simulated moments

Table 2 presents some representative moments from our model simulations. As it is usual in the literature, we report stastistics for periods in which the government has access to financial markets and no defaults are declared (the only exception is the default frequency, for which we use all simulation periods).

We can see that our model produces an unconditional default frequency of 0.05 percent. This number is in line with previous estimations for the default probability in European countries: these are very rare events. However, conditioning on observing a banking crises in the previous year, the default probability is about 12 times higher (amounting to 0.63 percent). This sharp increase in the default probability is the "diabolic loop" working: banking crises trigger payments of contingent bailouts, and therefore imply that governments need to borrow more. This higher level of indebtedness pushes governments into the default risk zone and then we observe much more frequent defaults.

These "diabolic loop" dynamics naturally translate into sovereign spreads.[5] The uncon-

[5] We compute sovereign spreads by comparing the sovereign bond price to the price of a default-free bond of similar characteristics. The price of such a default-free bond is given by

$$q^{nodef}(B';\ s) = \delta \mathbb{E}_{s'|s} \left\{ 1 + r_\ell^{nodef}\left(B', s'\right)(1-\tau)\gamma \right\}$$

where r_ℓ^{nodef} is the loans' interest rate with no default. The sovereign spread can then be defined as

$$spr(B', s) = \frac{q^{nodef}(B', s)}{q(B', s)} - 1.$$

ditional mean spread is roughly 30 basis points (bp), but conditional on observing a banking crisis, the mean spread increases to over 180bps. This roughly six-fold increase reflects not only that defaults are more likely, but also the 'collateral discount' shrinks. If there is a banking crises in period t, then a default is more likely in period $t+1$ and hence the banker charges a higher default premium. Additionally, if in $t+1$ the default is averted, then the interest rate on loans is smaller: there is higher debt, and therefore higher liquidity in the loan market. So, the sovereign bond becomes a less atractive investment for these two reasons: lower probability of repayment and, in case of repayment, lower return. Our simulations also generate higher spread volatility conditional on banking crisis because the risk of default increases.

The mean debt level sustained by the model is roughly 96 percent of GDP. This is not very far from the mean debt-to-GDP ratio observed in GIIPS for the period 2000-2012.[6] Consistent with the intuition provided in the previous paragraphs, we observe that the debt level increases when conditioning on banking crises: these are periods of higher fiscal needs (the government needs to pay the contigent bailouts).

The level of bailouts is around 11 percent of GDP. Figure 1 in our stylized facts section showed that government guarantees amounted to roughly 17 percent of GDP in GIIPS and 4 percent in the pre-2004 EU countries. Our mean bailout-to-GDP ratio, a nontargeted statistic, lies well in between these two data counterparts.

4.3 Default incentives, spreads and debt dynamics

Our model features a rich interaction between debt levels, default incentives, banking crises and optimal bailout guarantees. Consistent with the standard endogenous default literature, our model also generates default incentives that decrease with the aggregate level of productivity and increase with debt, which can be verified in the left-panel of Figure 2. On top of this standard finding, we also see that default sets shrink with high shocks to the banking sector. This is because severe banking crises can lead to severe contractions in the absence of government bailouts, thus increasing the cost of default.

The price schedule (right-panel of Figure 2) reflects these default incentives. As usual, higher realizations of productivity are associated with better prices (and higher debt capacity).[7] The price schedule figure demonstrates that borrowing is essentially risk-free for debt

[6] Using the data in Abbas et al. (2014) we compute an average debt-to-GDP ratio of 72.5 percent for the median GIIPS country.

[7] Note that since we assume that both ε and m shocks are iid, they do not affect the bond price because they do not change the ex-ante default probability.

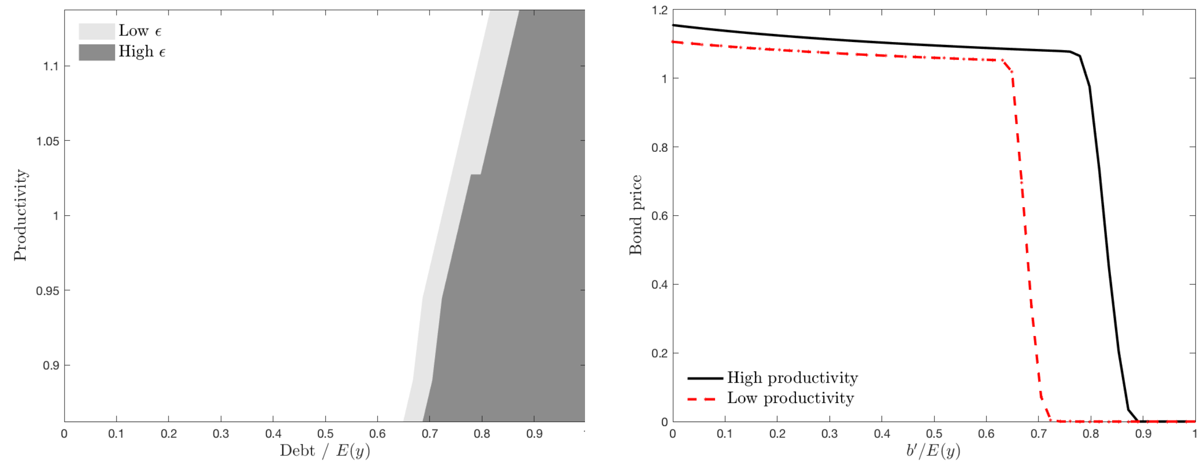

Figure 2: Default sets and bond prices.

Note: The left panel shows the default sets with the shaded areas indicating default and the white area indicating repayment. Both default sets are computed for the mean value of the m shock. The right panel shows the equilibrium bond price schedule.

ratios below 0.6. Consequently, starting from zero debt the economy's debt-to-GDP ratio quickly increases until it reaches 0.6 and then it 'lives' in the region where default risk is small but positive. Figure 3 shows the histograms of debt-to-GDP ratios both unconditionally and conditioning on banking crises. Since the left tails of these histograms are very long, we choose to truncate them in our plots. The debt-to-GDP distribution conditional on a banking crisis is more skewed to the left compared to the unconditional distribution. Together with the results from the simulated moments, we can conclude that banking crises not only lead to higher debt-to-GDP ratios on average, but also generate an increase in the probability of observing very high debt-to-GDP ratios in our simulations.

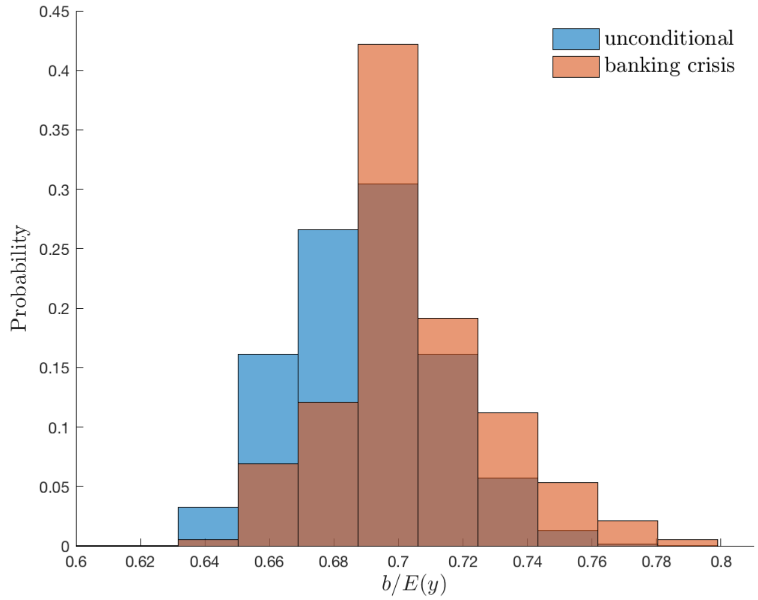

Figure 3: Conditional and unconditional debt distribution

4.4 Properties of the optimal bailout policies

The ability of the government to give transfers to the bankers depends on the state of the economy in terms of TFP, ε, and m shocks (transitory shocks to the government revenue) in addition to the existing level of debt. As argued above, the average debt-to-GDP ratio is higher conditional on banking crises because the government tends to borrow more in order to finance the bailout.

Since optimal transfers depend on many factors as mentioned above it is helpful to look at the policy functions generated by our model in order to pin down the role of each factor. Figure 4 shows the bailout policy functions expressed as the percent of the potential loss that the government promises to guarantee (i.e. $100 \times T(A, B, s)/\varepsilon$). Inspecting both panels of this figure we find the following properties for the bailouts:

1. **Decreasing in ε.** The smaller is the potential damage to the bankers' capital, the larger is the proportional bailout the government chooses. This is completely intuitive: if the potential damage is very large, then it requires a lot of resources, and consequently the government only chooses to cover a small fraction of it. However, if the shock is small enough, it makes sense to guarantee all of it.

2. **Decreasing in B.** While bailout guarantees play an essential role in alleviating the effects of banking crises on the real sector through the provision of higher liquidity, it

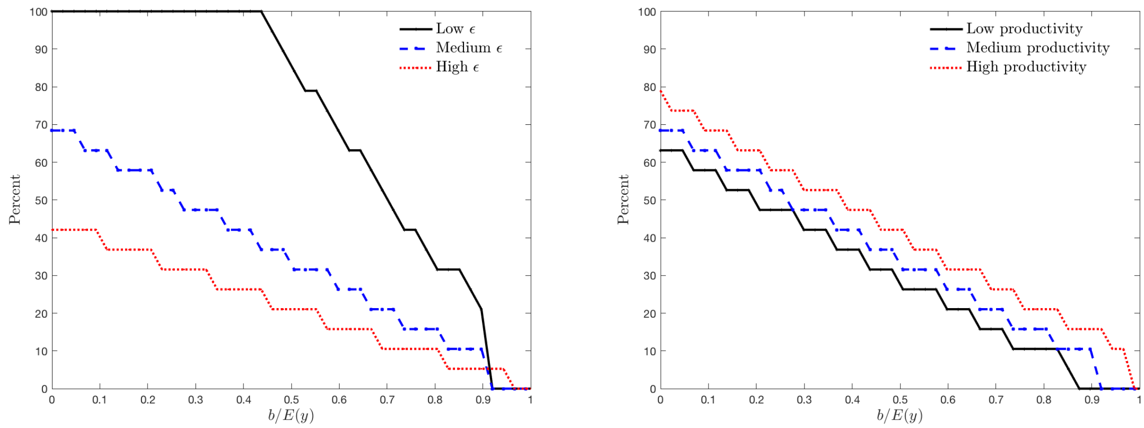

Figure 4: Bailout policy.

Note: The left (right) panel shows the bailout policies as a percentage of the potential shock to bank capital for different levels of ε (z), holding other exogenous state variables at their mean values.

is harder for the government to give transfers as the debt level increases due to the increased default risk. This is because even though the bankers benefit from bailout transfers, they also know that the transfers are financed with more borrowing. Since the bond prices drop sharply as debt increases the government will not be able to roll over its debt at high levels of debt and default becomes a more likely outcome.

3. **Increasing in z.** This intuitive property is due to two forces that go in the same direction. First, the more productive is the economy, the more valuable credit is. Therefore, it makes sense for the government to extend larger guarantees in good times. Second, the cost of borrowing that is necessary to finance the bailout is lower in periods of high productivity. Given the persistence of productivity shocks, a high productivity shock in this period also implies a high productivity shock in the next period, which leads to a lower default risk, better prices for the government and a higher borrowing capacity to finance the bailout transfers.

4.5 Welfare gains of bailouts

In progress.

4.6 Sensitivity analysis

In this section our goal is to analyse how our model is sensitive to three important parameters, i.e. bank's capital ($\bar{A}$), collateral requirement parameter (γ), and the probability of having a banking crisis (π).

1. **Bank's capital, $\bar{A}$.** As mentioned above one of the detrimental costs of default on the financial markets is that it limits the bank's ability to generate loans to the firms due to the loss in its capital. During defaults the government also is not able to give bailout transfers to help banks increase their liquidity. As a result, the government tends to default less often when ϵ shocks are high, which is also portrayed in the default sets. Increasing $\bar{A}$ from 2.7 to 3.0 reduces the cost of default in the model and therefore the default probability increases (both conditionally and unconditionally) significantly as shown in Table 3. Similarly, decreasing $\bar{A}$ generates lower default probability because the decrease in loans leads to a very low output and the government tries to avoid that cost. Default probabilities and debt-to-GDP ratios are also inversely related because if default happens more frequently, less debt is accumulated until the default event in the simulations.

Table 3: Sensitivity to $\bar{A}$

	Baseline ($\bar{A} = 2.70$)	High $\bar{A}$ ($\bar{A} = 3.00$)	Low $\bar{A}$ ($\bar{A} = 2.50$)
Unconditional			
Default frequency	0.05	10.14	0.00
Sovereign spread			
mean	0.33	16.22	0.01
Debt/GDP	96.28	0.13	161.12
Banking crisis			
Default frequency	0.63	42.26	0.04
Sovereign spread			
mean	1.82	6.62	0.04
Debt/GDP	97.60	1.62	161.26
Bailout/GDP	10.96	10.24	8.67

Units: percent.

2. **Probability of a banking crisis, π.** In order to see the role of the banking crisis probability in our results, we increase π from 1 percent to 5 percent. Table 4 presents

the results. While the unconditional default frequency and spread seem to be similar to the benchmark case, we find big differences in the conditional simulations, particularly in the bailout-to-GDP ratios. In our model, the government promises bailout guarantees in the expectation of a banking crisis thus, when the probability of having a banking crisis increases, the government becomes more reluctant to promise guarantees upfront knowing that the financing of that bailout will be very costly once the shock hits. In the simulations we find that there is almost no bailout transfers made when financial crises happen more often.

Table 4: Sensitivity to π

	Baseline ($\pi = 0.01$)	High π ($\pi = 0.05$)
Unconditional		
Default frequency	0.05	0.04
Sovereign spread		
mean	0.33	0.23
Debt/GDP	96.28	118.58
Banking crisis		
Default frequency	0.63	0.03
Sovereign spread		
mean	1.82	0.23
Debt/GDP	97.60	118.56
Bailout/GDP	10.96	0.00

Units: percent.

3. **Collateral requirement parameter, γ.** The collateral requirement parameter is a key parameter that determines the amount of loans that the banks can extend to the firms. Increasing the parameter increases the amount of loans, which leads to a lower collateral discount. A decrease in collateral discount also makes bond price decrease. As a result, we find higher debt accumulation and lower probability of default as shown in Table 5. If there is a banking crisis, default frequency also decreases with high γ and increases with low γ, similar to the unconditional frequencies. Debt-to-GDP ratios conditional on banking crisis also move monotonically with γ, however the optimal bailout-to-GDP is roughly constant in this analysis.

Table 5: Sensitivity to γ

	Baseline ($\gamma = 0.80$)	High γ ($\gamma = 0.85$)	Low γ ($\gamma = 0.75$)
Unconditional			
Default frequency	0.05	0.04	9.52
Sovereign spread			
mean	0.33	0.26	14.63
Debt/GDP	96.28	114.27	0.02
Banking crisis			
Default frequency	0.63	0.37	40.36
Sovereign spread			
mean	1.82	1.20	6.69
Debt/GDP	97.60	115.62	1.71
Bailout/GDP	10.96	11.23	11.01

Units: percent.

5 Conclusion

We study the dynamic relationship between sovereign defaults, banking crises, and government bailouts. We first document that when governments intervene to help distressed banking sectors their most prevalent form of intervention is to extend contingent gurantees.

We then write down and solve a general equilibrium model of sovereign default, in which there is a government that plans the level of government spending that needs to be financed by using debt, taxes and transfers to the banks. The economy is subject to two types of aggregate uncertainty: in addition to the shocks to firm productivity there are also shocks to bank's capital. In anticipation of an adverse banking shock, banks reduce lending to the private sector. The sovereign may choose to announces guarantees (i.e. conditional transfers) to compensate for the banks' capital losses in the event of a crisis — these are the bailouts in our model. Defaults are costly because the government loses access to debt financing, it loses the ability to issue bailouts, banks' credit to the private sector declines and eventually output falls. The benefit of default is that all existing debt is wiped-out, relaxing the government's budget constraint and allowing it to increase government spending. Our framework is flexible enough to feature defaults trigerring banking crises and banking crises triggering defaults: a complete 'doom loop.'

Preliminary quantitative results show that the occurance of a banking crisis increases the default probability twelve-fold (from 0.05 percent to 0.63 percent annually) and raises the annualized sovereign spread from 30 bps to roughly 180bps, and also increases the volatility of spreads. Optimizing government's policies, we find that the simulated level of bailouts (i.e. contingent guarantees) is in the order to 11% of GDP, a number close to what we observe in the European data. These contingent guarantees exhibit clear properties. Other things equal they are: (i) decreasing in the size of the potential losses of the banking sector, and this is because the larger the losses, the more costly it is to finance them which elevates default risk; (ii) decreasing in the level of government debt, since the more debt the government has, the less fiscal space it has to prop up banking sector assets; (iii) increasing in aggregate productivity, since the better the aggregate state of the economy is, the cheaper it is to borrow to provide the guarantees.

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