September 2020

Optimal Bailouts in Banking and Sovereign Crises[†]

Sewon Hur

Federal Reserve Bank of Dallas
sewonhur@gmail.com

César Sosa-Padilla

University of Notre Dame
and NBER
csosapad@nd.edu

Zeynep Yom

Villanova University
zeynep.yom@villanova.edu

[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. We find that the optimal bailouts 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, (ii) increasing in aggregate productivity, and (iii) decreasing in the severity of the banking crisis.

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

[†]We thank Daniele Coen-Pirani, Illenin Kondo, Chengying Luo, and Marla Ripoll for insightful discussions. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Dallas or the Federal Reserve System.

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 as well as to 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.

We start by reviewing some motivating facts related to the dynamic relationship between sovereign risk, bank risk and bailouts. We leverage the vast existing empirical literature to document that *(i) defaults and banking crises tend to happen together*, and *(ii) the banking sectors are exposed to government debt and this exposure increases in crisis times*. We then provide our own empirical evidence to document a third motivating fact, namely that *(iii) 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 other 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.

We then build a model to quantitatively assess the interaction between sovereign risk, bank risk and government bailouts 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) the time clusteing of banking and sovereign crises, (ii) banks' exposure to government debt can increase the sovereign risk, and (iii) 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 determines the level of government spending and contingent bailouts to banks that need to be financed with debt and taxes. The economy is subject to two types of aggregate uncertainty; in addition to firm productivity shocks 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 0.06 percent to 0.47 percent annually), raises the annualized sovereign spread from 0.3 percent to 1.3 percent, and also increases the volatility of spreads. Optimizing governments find it optimal to issue bailouts (i.e. contingent guarantees) that are on average 12 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), and Arellano (2008), among others. Our paper differs from these early papers, in 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), and 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 the benchmark parametrization of the model, presents the quantitative results and discusses the properties of the optimal contigent bailouts. Section 5 concludes.

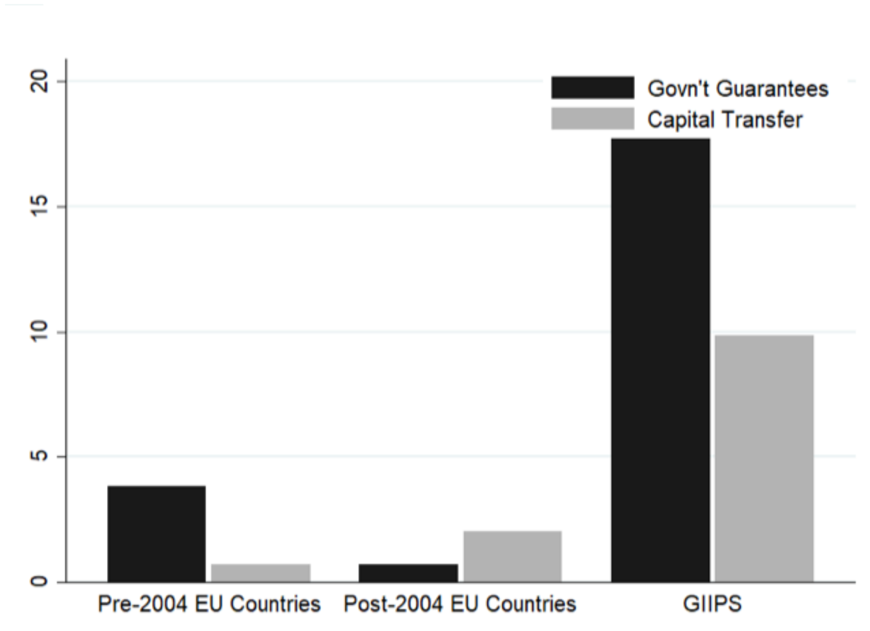
2 Motivating Facts

The nexus between sovereign and banking crises is not a new phenomenon and different aspects of it have been studied previously. In this section we document three features of banking and sovereign debt crises that motivate our study: *(i)* defaults and banking crises tend to happen together, *(ii)* the domestic banking sectors are hihgly exposed to government debt and this exposure increases during crises, and *(iii)* the most prevalent form of government intervention (when trying to alliviate banking crises) is to issue asset guarantees.

- *Defaults and banking crises tend to happen together.* Balteanu et al. (2011) use the dates of sovereign debt crises provided by Standard & Poor's and the systemic banking crises identified in Laeven and Valencia (2012) to build a sample with 121 sovereign defaults and 131 banking crises for 117 emerging and developing countries from 1975 to 2007. Among these, they identify 36 "twin crises" (defaults and banking crises): in 19 of them a sovereign default preceded the banking crisis and in 17 the reverse was true, which suggest that both directions of complementarity are likely at play.

- *Banks are exposed to sovereign debt and this exposure increases during crises.* Gennaioli et al. (2018) report an average exposure ratio (net credit to the government as a fraction of bank assets) of 9.3% when using granular data from Bankscope (which includes banks from both advanced and developing countries). When they focus only on defaulting countries, they find an exposure ratio of roughly 15%. Abad (2019) documents that the banking sectors in Spain and Italy increased their exposure to domestic sovereign debt during the recent European debt crisis (with exposure ratios increasing by 8 percentage points).

Figure 1: Government guarantees and capital transfers



Our own empirical contribution is to document a third motivating fact, regarding how governments intervene during banking crises. Specifically,

- *The most prevalent form of government intervention to alleviate banking crises is the issuance of sovereign guarantees.* The governments in the European Union have intervened mostly in two ways: (i) via asset 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.[1] We find that for GIIPS countries, the average share of the government guarantees is close to 18 percent of GDP, whereas 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.

[1]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.

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 in addition to the bank balance sheet effects triggered by increased sovereign risk, and *government bailouts* which can mitigate the banking crisis but may 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 lending constraint. Additionally, banks are subject to shocks to the value of their capital. 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.

Debt contracts are not enforceable and the government may default on its debt. We assume defaults are total: all debt gets erased. If the government decides to default, it gets excluded from the credit market for a random number of periods.

There are four aggregate 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 follows 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' capital, ε. These shocks are also *iid* and are drawn from $[0, \bar{\varepsilon}]$. Let us denote $s \equiv (z, m, \varepsilon)$.

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:

[2] As explained in Chatterjee and Eyigungor (2012), the presence of these idiosyncratic shocks allows for a robust computation of this class of models.

(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.

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

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

where σ governs the degree of risk aversion. 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 lending constraint which requires that loans to firms do not exceed a fraction γ of the value of banks' resources. These resources amount to the sum of three components: b, A, and T. The first component is the banks' holdings of sovereign bonds, b. The second component is banks' capital, $A(\varepsilon)$, 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

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

Let $\underline{A}(\varepsilon) = \overline{A}(1-\varepsilon)$. We refer to the event that $A = \underline{A}(\varepsilon)$ as a banking crisis.

The lending 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 bankers' loanable resources.

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

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

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

The bond pricing function satisfies

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

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

$$V^c(B, s) = \max_{T \geq 0} \mathbb{E}_A \begin{Bmatrix} \max\limits_{G, B'} & U(G) + \beta_g \mathbb{E}_{s'|s} V^o(B', s') \\ \text{s.t.} & G \leq \tau z F(1, \ell(T; B, s)) - T(A, B, s) + B' q(B', s) - B + m \end{Bmatrix}$$

where $q(B', s)$, the government debt price schedule, is given by equation (7), $\ell(\cdot)$ represents the loans from the equilibrium of the private sector of the economy, and m represents (mean-zero) fiscal revenue shocks. 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

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

4 Quantitative results

In this section, as a numerical illustration, we describe the properties of an appropriately parameterized model. We expect to incorporate a more disciplined calibration in the next draft. We first describe how we set the parameters of the model. Second, we examine the ability of our 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. Finally, we analyze the welfare impact of having access to bailouts. An appendix presents a brief parameter sensitivity analysis.

Table 1: A Priori Parameters

Concept	Value
Risk aversion, σ	2
Government discount factor, β_g	0.91
Bankers' discount factor, δ	0.93
Labor share, $(1-\alpha)$	0.66
Tax rate, τ	0.20
Prob. of financial redemption, θ	0.27
Baseline bank capital, $\bar{A}$	2.70
Lending constraint, γ	0.80
Prob. of banking crisis, π	0.01
m shock std deviation, σ_m	0.02

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 by:

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

where $\nu_z \sim N(0, \sigma_z)$. We use the Tauchen method to discretize the TFP shocks in 11 states.

The potential bank capital shocks are also assumed to follow an AR(1) process given as:

$$\log(\varepsilon_{t+1}) = (1-\rho_\varepsilon)\mu_\varepsilon + \rho_\varepsilon \log(\varepsilon_t) + \nu_{\varepsilon,t+1} \tag{10}$$

where $\nu_\varepsilon \sim N(0, \sigma_\varepsilon)$. We use the Tauchen method to discretize the ε shocks in 3 states.

We model the fiscal reveunue shocks (m) as being *i.i.d.* 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]

Tables 1 and 2 summarize 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

[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 2: Parameters set by simulation

Concept	Value	Target	Target value
TFP shock process			
average, μ_z	0.897	std of output	1.98 %
persistence, ρ_z	0.800	default probability	0.5 %
std deviation, σ_z	0.015	average spread	1.33 %
Financial shock (ε) process			
average, μ_ε	0.000	average spread (crisis)	3.83 %
persistence, ρ_ε	0.300	std of spread	1.44 %
std deviation, σ_ε	0.250	std of spread (crisis)	3.27 %

(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 labor share $(1-\alpha)$ is equal to 2/3. The tax rate is set to 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 standard deviation of the 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.

The parameters describing the banks and banking crises are chosen as follows. The probability of a banking crisis (π) 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 set at 2.7 and 0.8, respectively. The appendix presents a sensitivity analysis for these three parameters (π, $\bar{A}, \gamma$).[5]

Finally, the TFP and financial shock processes are parametrized to approximate various targeted moments. The targeted moments are the volatility of GDP, the default probability and the mean and standard deviation of the spread (both uncondintionally and conditioning on a banking crisis). We target a default probability of 0.5%, which is lower than the default probabilities used for emerging economies (Aguiar et al. 2016) and higher than those for

[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.

[5] Note: in future drafts we plan to calibrate these parameters targeting the banks' exposure ratio and the ratio of credit-to-GDP using data from GIIPS.

Table 3: Simulated moments

	Unconditional	Banking crisis
Default frequency	0.06	0.47
Sovereign spread		
mean	0.31	1.28
standard deviation	1.06	3.15
Debt/GDP	94.54	95.80
Bailout/GDP	-	11.55

Units: percent.

advanced economies (Hur et al. 2018). We use quarterly HP-filtered real GDP data between 1999-2019 for Greece, Italy, Ireland, Portugal and Spain, and focus on the average of these five countries. The spreads are computed using IMF data for the quarterly interest rates of government bonds between 1999-2019 (for the same five countries).[6]

4.2 Simulated moments

Table 3 presents some representative moments from our model simulations. As it is usual in this 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 0.06 percent. This number is in line with previous estimations for the default probability in European countries: these are very rare events. However, conditional on experiencing a banking crises in the previous year, the default probability is about 8 times higher (amounting to 0.47 percent). This sharp increase in the default probability is the "diabolic loop" at work: 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.[7] The un-

[6]We label as the 'banking crisis period' the years comprised between 2008 and 2012 for Greece, Ireland, Portugal and Spain, and the years 2008 and 2009 for Italy. The spread is computed against the interest rate of equivalent German government bonds.

[7]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

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

conditional mean spread is roughly 30 basis points (bps), but conditional on observing a banking crisis, the mean spread increases to 128 bps. This roughly four-fold increase reflects not only the higher likelihood of default, but also a decline in the 'lending discount'. If there is a banking crisis 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 lower: there is higher debt, and therefore higher liquidity in the loan market. So, the sovereign bond becomes a less attractive investment for these two reasons: lower probability of repayment and, in case of repayment, lower overall return. Our simulations also generate higher spread volatility conditional on banking crisis because the risk of default increases.

The mean debt level in the model simulations is roughly 95 percent of GDP. This is close to the mean debt-to-GDP ratio observed in GIIPS for the period 2005-2012.[8] 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). This last result, debt levels increasing in crises times, is consistent with the motivating fact report before: banking sector exposure to government debt increases during crises.

The level of bailouts is around 12 percent of GDP. Figure 1 in our 'motivating facts' section showed that government guarantees amounted to roughly 18 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

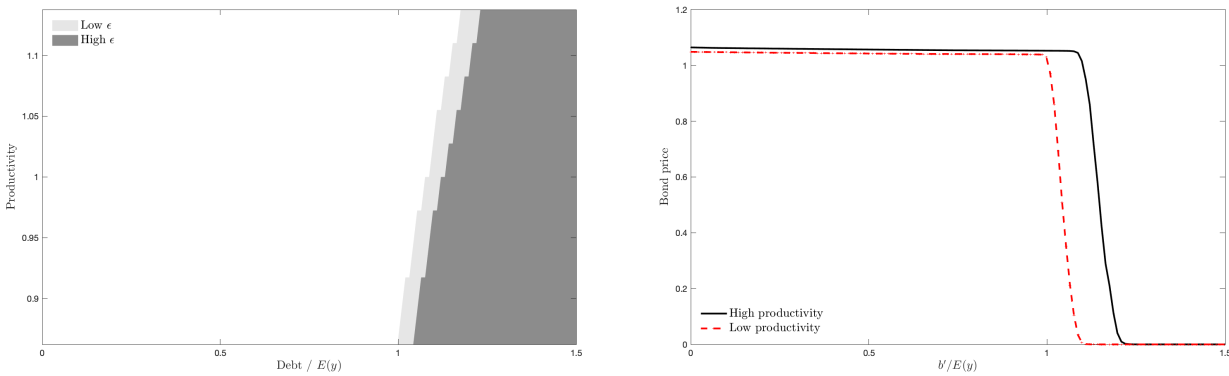
Our model features a rich interaction between debt levels, default incentives, banking crises, and optimal bailout guarantees. Consistent with the standard endogenous default literature, our model also generates default incentives that decrease with the aggregate level of productivity and increase with debt, which can be verified in the left-panel of Figure 2. In addition to 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

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

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

[8] Using the data in Abbas et al. (2014) we compute an average debt-to-GDP ratio of 89 percent among GIIPS.

Figure 2: Default sets and bond prices



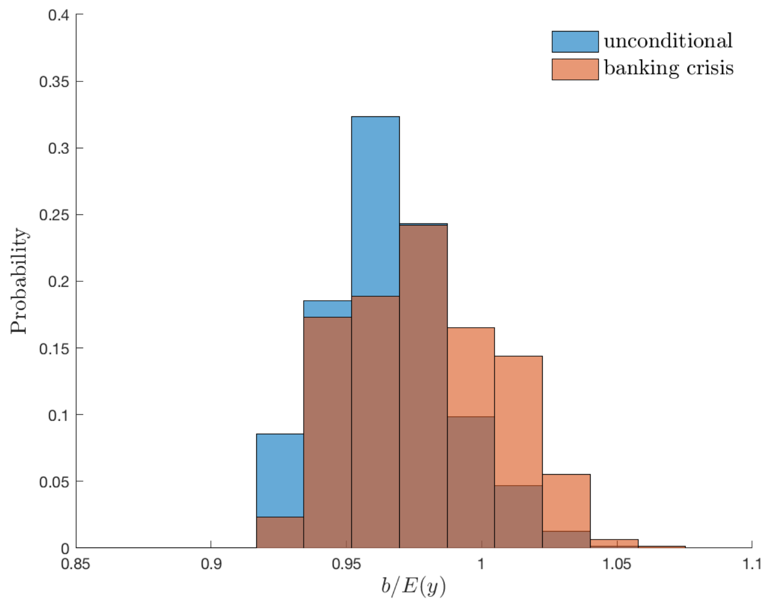
Note: The left panel shows the default sets with the shaded areas indicating default and the white area indicating repayment. Both default sets are computed for the mean value of the m shock. The right panel shows the equilibrium bond price schedule.

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).[9]The price schedule figure demonstrates that borrowing is essentially risk-free for debt ratios below 0.9. Consequently, starting from zero debt the economy's debt-to-GDP ratio quickly increases until it reaches 0.9 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 realizations in our simulations.

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

Figure 3: Conditional and unconditional debt distributions



4.4 Properties of the optimal bailout policies

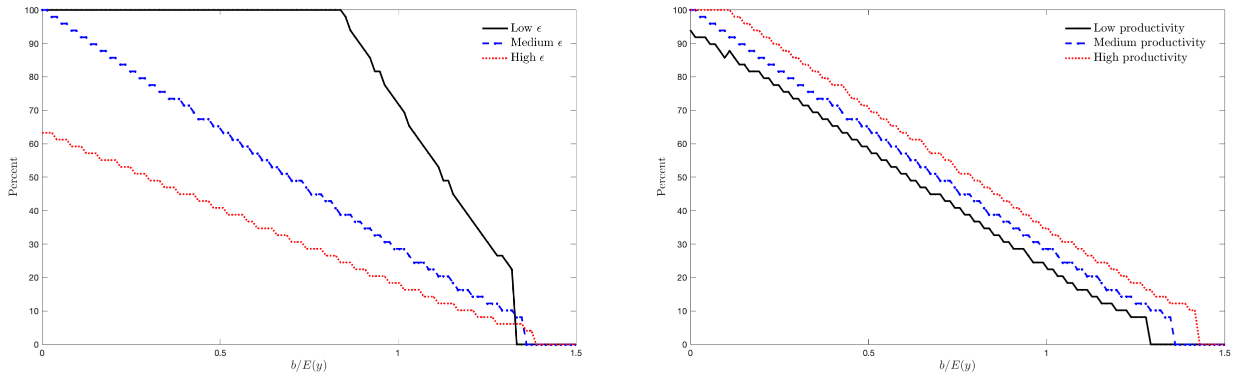
The ability of the government to give transfers to the bankers depends on the state of the economy in terms of TFP, ε, and m shocks, in addition to the existing level of debt. As argued above, the average debt-to-GDP ratio is higher conditional on banking crises because the government tends to borrow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

Since optimal transfers depend on many factors, it is helpful to look at the bailout policy functions generated by our model in order to highlight the role of each of those factors. 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 is harder for the government to give transfers as the debt level increases due to the

Figure 4: Bailout policy



Note: the panels show the bailout policy functions expressed as the percent of the potential loss that the government promises to guarantee (i.e. $100 \times T(A, B, s)/\varepsilon$).

increased default risk. This is because even though the bankers benefit from bailout transfers, they also know that those bailouts will need to be 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 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.

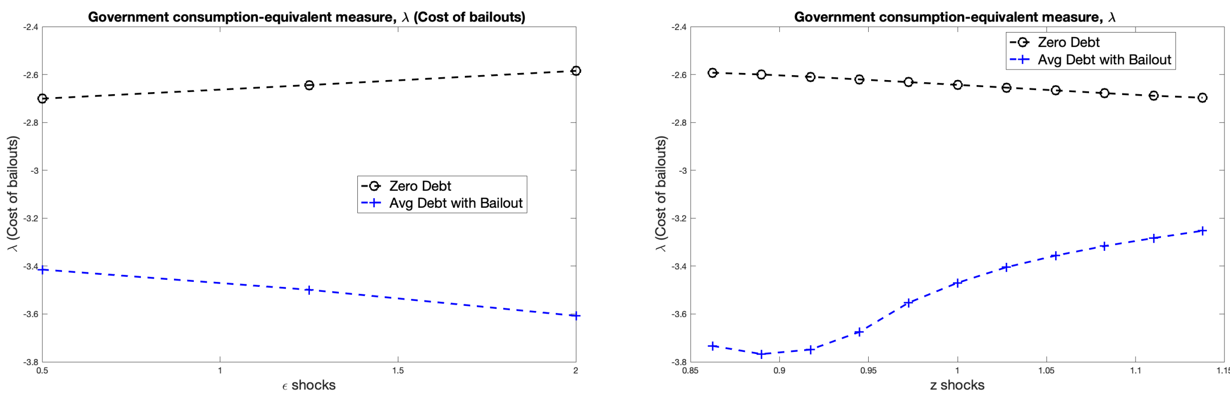
4.5 Welfare effects of bailouts

In this section we examine the welfare effects of bailouts in our model. We compute the conditional welfare change as the following:

$$\lambda(B, s) \quad = \quad \left[\frac{V^o(B, s)}{V^o_{nb}(B, s)}\right]^{\frac{1}{1-\sigma}} - 1 \tag{11}$$

where $V^o(B, s)$ is given by (8) and $V^o_{nb}(B, s)$ is the value of starting the period in good credit standing in the 'no-bailout' economy (which is otherwise identical to the model economy presented in the previous section except that bailouts are not allowed). The left panel of Figure 5 shows the results for different values of financial shocks keeping productivity equal to its mean value and the right panel shows the results for different values of productivity shocks, keeping financial shocks equal to zero.

Figure 5: Welfare costs of bailouts.



Note: The left (right) panel shows the government consumption equivalent measure for different values of financial shocks (productivity shocks).

The first observation is that having the option to bailout the banking sector actually reduces welfare. While bailouts are optimal *ex post*, from an *ex ante* perspective, they reduce welfare by increasing default probabilities and the cost of borrowing and by reducing debt capacity. Second, the bailout option reduces welfare by more when the government intitially starts with sizeable debt (the mean in the simulations) compared to when it starts with zero debt.

Third, we find that when the government starts at the average debt level, bailouts become more costly as the size of the financial shocks increase. However, when the government starts with zero debt, the government consumption-equivalent measure increases (i.e. it becomes less negative) with the financial shocks because the government borrows at the risk free rate and the additional borrowing to finance the bailout does not create an additional default risk. As a result, we find that the level of debt also plays a crucial role in the welfare loss in addition to the shocks through its affect on the default risk.

Finally, we find that when the government starts with the average debt level, bailouts have larger welfare reducing effects as the productivity shock becomes smaller. The reason is that low productivity shocks makes it more expensive to borrow for the government, increasing the cost of financing the bailout transfer. On the other hand, when the government starts with zero debt, the result is the opposite. Again, this is because with no default risk, the government tends to bailout more when the productivity shock is high, which can lead to a faster accumulation of debt.

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 levels of government spending and bank bailouts that need to be financed by using debt and taxes. The economy is subject to two types of aggregate uncertainty: (standard) shocks to firm productivity and 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 and consumption fall. 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 eight-fold (from 0.06 percent to 0.47 percent annually) and raises the level and volatility of sovereign spreads (the latter increase from 30 to 130 annual bps). We find that the simulated level of bailouts (i.e. contingent guarantees) is in the order to 12% of GDP, a number close to what we observe in 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.

References

Abad, Jorge, "Breaking the Sovereign-Bank Nexus," *CEMFI Working Paper*, 2019.

Abbas, SM Ali, Laura Blattner, Mark De Broeck, Ms Asmaa El-Ganainy, and Malin Hu, *Sovereign debt composition in advanced economies: a historical perspective* number 14-162, International Monetary Fund, 2014.

Acharya, Viral, Itamar Drechsler, and Philipp Schnabl, "A pyrrhic victory? Bank bailouts and sovereign credit risk," *The Journal of Finance*, 2014, *69* (6), 2689–2739.

Aguiar, Mark and Gita Gopinath, "Defaultable debt, interest rates and the current account," *Journal of international Economics*, 2006, *69* (1), 64–83.

Aguiar, Mark, Satyajit Chatterjee, Harold Cole, and Zachary Stangebye, "Quantitative models of sovereign debt crises," in "Handbook of Macroeconomics," Vol. 2, Elsevier, 2016, pp. 1697–1755.

Arellano, Cristina, "Default risk and income fluctuations in emerging economies," *The American Economic Review*, 2008, pp. 690–712.

Balteanu, Irina, Aitor Erce, and Laura Fernandez, "Bank crises and sovereign defaults: Exploring the links," *Bank of Spain*, 2011.

Bocola, Luigi, "The pass-through of sovereign risk," *Journal of Political Economy*, 2016, *124* (4), 879–926.

Chatterjee, Satyajit and Burcu Eyigungor, "Maturity, indebtedness, and default risk," *American Economic Review*, 2012, *102* (6), 2674–99.

Cooper, Russell and Kalin Nikolov, "Government debt and banking fragility: The spreading of strategic uncertainty," *International Economic Review*, 2018, *59* (4), 1905–1925.

Correa, Ricardo and Horacio Sapriza, "Sovereign debt crises," 2014.

Eaton, Jonathan and Mark Gersovitz, "Debt with potential repudiation: Theoretical and empirical analysis," *Review of Economic Studies*, 1981, *48* (2), 289–309.

Farhi, Emmanuel and Jean Tirole, "Deadly embrace: Sovereign and financial balance sheets doom loops," *The Review of Economic Studies*, 2018, *85* (3), 1781–1823.

Gennaioli, Nicola, Alberto Martin, and Stefano Rossi, "Banks, government bonds, and default: What do the data say?," *Journal of Monetary Economics*, 2018, *98*, 98–113.

Hur, Sewon, Illenin Kondo, and Fabrizio Perri, "Real interest rates, inflation, and default," 2018.

Laeven, Luc and Fabián Valencia, "Systemic Banking Crises Database: An Update," 2012.

Lizarazo, Sandra, Horacio Sapriza, and Javier Bianchi, "Sovereign Default and Government's Bailouts," Technical Report, Society for Economic Dynamics 2014.

Perez, Diego J., "Sovereign Debt, Domestic Banks and the Provision of Public Liquidity," 2015.

Reinhart, Carmen M and Kenneth S Rogoff, "From financial crash to debt crisis," *The American Economic Review*, 2011a, *101* (5), 1676–1706.

Sosa-Padilla, César, "Sovereign Defaults and Banking Crises," *Journal of Monetary Economics*, 2018, *99*, 88–105.

A Sensitivity analysis

In this appendix, we analyze our model's sensitivity to three parameters, i.e. bank's capital ($\bar{A}$), lending contstraint 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 contractions in its loanable funds. During defaults, the government is unable 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 in Figure 2). Increasing $\bar{A}$ reduces the cost of default in the model (because it increase the funds available for productive loans) and therefore the default probability increases (both conditionally and unconditionally) significantly as shown in Table 4. 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 4: Sensitivity to $\bar{A}$

	Low ($\bar{A} = 2.60$)	Baseline ($\bar{A} = 2.70$)	High ($\bar{A} = 2.80$)
Default frequency	0.03	0.06	10.52
Sovereign spread			
mean	0.24	0.31	14.34
Debt/GDP	136.27	94.54	0.12
Banking crisis			
Default frequency	0.33	0.33	38.19
Sovereign spread			
mean	1.18	1.27	4.76
Debt/GDP	137.83	95.80	1.44
Bailout/GDP	10.95	11.55	11.10

Units: percent.

2. **Probability of a banking crisis, π.** In order to examine the role of the banking crisis probability in our results, we increase π from 1 percent to 2 percent. Table 5 presents the results. While the unconditional default frequency and spread seem to be similar to the baseline 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 costly once the shock hits. In the simulations we find that bailout transfers decrease by more than 50 percent when financial crises happen more often.

Table 5: Sensitivity to π

	Baseline ($\pi = 0.01$)	High ($\pi = 0.02$)
Unconditional		
Default frequency	0.06	0.04
Sovereign spread		
mean	0.31	0.26
Debt/GDP	94.54	115.29
Banking crisis		
Default frequency	0.33	0.12
Sovereign spread		
mean	1.28	0.74
Debt/GDP	95.80	116.09
Bailout/GDP	11.55	5.05

Units: percent.

3. **Lending constraint parameter, γ.** The lending constraint 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 decreases the loans' interest rate. This has an ambiguous effect on the 'lending discount' as $r(\cdot)$ decreases and γ increases. Overall, we find lower default frequencies, lower spreads and higher debt accumulation, as shown in Table 6. Conditional on a banking crisis, the default frequency also decreases with γ and the debt-to-GDP ratios also increase monotonically with γ. Finally, the optimal bailout-to-GDP ratio decreases monotonically as we increase γ (albeit mildly).

Table 6: Sensitivity to γ

	Low ($\gamma = 0.77$)	Baseline ($\gamma = 0.80$)	High ($\gamma = 0.83$)
Unconditional			
Default frequency	1.06	0.06	0.04
Sovereign spread			
mean	1.38	0.31	0.26
Debt/GDP	28.83	94.54	106.35
Banking crisis			
Default frequency	3.62	0.47	0.49
Sovereign spread			
mean	3.79	1.28	1.56
Debt/GDP	30.14	95.80	107.75
Bailout/GDP	12.66	11.55	11.46

Units: percent.