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Optimal Bailouts in Banking and Sovereign Crises[†]

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Abstract

We study optimal bailout policies in the presence of banking and sovereign crises. First, we use European data to document that asset guarantees are the most prevalent way in which sovereigns intervene during banking crises. 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 the government may find it optimal to extend guarantees over those assets. The key trade-off is the following: larger bailouts relax domestic financial frictions 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) increasing in the severity of the banking crisis. Even though bailouts mitigate the adverse effects of banking crises, we find that the economy is ex ante better off banning bailouts altogether: bailouts are financed with higher government debt, which increases spreads and may trigger defaults – bailouts create a "diabolic loop."

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 recent European debt crisis highlighted the 'diabolic loop' between sovereign risk and bank risk. On the one hand, the Irish bailout of 2008 illustrated how financial risk can be transferred to the government via bailouts and asset guarantees (Acharya, Drechsler and Schnabl, 2014). On the other hand, the Greek debt crisis of 2012 showed how sovereign risk can weaken banks' balance sheets due to overexposure to government debt (Sosa-Padilla, 2018). In this paper, we ask the following question: how much (if at all) should a government intervene to 'save' the domestic banking sector during banking crises, in the presence of this diabolic loop?

We start by reviewing some motivating facts related to the dynamic relationship between sovereign risk, bank risk, and bailouts. We leverage the 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 is higher during 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 during banking crises.* Among European countries, the average share of government guarantees in GDP is four times as large as the average share of capital transfers in GDP during banking crises. This relationship does not hold during normal times. This suggests that the asset guarantees (as opposed to direct capital transfers) are 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 shocks to bank capital, and secondly, we allow the government to extend contingent bailouts to banks. This creates a rich feedback between banking and sovereign risk. On the one hand, sovereign defaults lead to a deterioration of bank balance sheets, reducing the amount of credit that banks extend to the private sector, and thereby reducing output. On the other hand, to mitigate the adverse effects of banking crises, governments optimally choose to bail out banks, leading to increased government debt and sovereign risk. Therefore, bailouts come with a tradeoff: they allow the government to boost liquidity and output during banking crises but they also increase debt and default risk (i.e., there is a 'diabolic loop').

After calibrating the model to match salient moments in the data, we show that the occurrence of a banking crisis increases the default probability (from 0.5 to 0.7 percent annually), resulting in sovereign spreads that are higher (from 0.7 to 0.9 percent) and more volatile (from 0.6 to 1.0 percent). The government finds it optimal to issue bailouts (i.e.

contingent guarantees) that are on average 1.7 percent of GDP during banking crises. These contingent guarantees exhibit clear properties. Other things equal, the fraction of banking losses that the bailouts would cover are: (i) increasing with the severity of the banking crisis, this is because the effects of the bank capital shocks are nonlinear: small shocks have negligible impacts on loans to the private sector, whereas large shocks can lead to severe private credit crunches in the absence of government interventions, (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, and (iii) increasing in aggregate productivity, since the better the aggregate state of the economy is, the more valuable credit is and the cheaper it is to borrow to provide the guarantees.

Our model has implications for the design of institutions that govern bailouts. Is it optimal from an ex ante perspective to allow governments to bail out the banking sector, knowing that this may lead to higher default risk? Using our calibrated model, we find that the costs of bailouts (higher sovereign risk) out-weigh the benefits (ability to increase liquidity during banking crises). Even though the welfare gains of having access to bailouts are state-contingent, we find that for the empirically relevant cases (i.e., economies with moderate to high initial debt levels), the country is better off banning bailouts altogether. This is because governments without access to bailouts face lower interest rates despite sustaining higher levels of debt because they default less frequently.

Related literature. This paper belongs to the quantitative literature on sovereign debt and default, following the contributions of Eaton and Gersovitz (1981), Aguiar and Gopinath (2006) and Arellano (2008). Our work 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 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 uses dynamic quantitative models of sovereign risk to examine how the effects of sovereign risk are amplified through the banking channel. The closest paper to ours is Sosa-Padilla (2018) who studies how a sovereign default affects banks' balance sheets and creates a private sector credit crunch, endogenizing output declines in that way. Bocola (2016) studies the macroeconomic implications of increased sovereign risk in a model where banks are exposed to government debt. His framework takes default risk as given and shows how the anticipation of a default can be recessionary on its own. Perez (2015) also studies the output costs of default when domestic banks hold government debt. Public debt serves two roles in his framework: it facilitates international borrowing and it provides liquidity to domestic banks. In addition to the bank balance sheet effects highlighted in these studies, our paper also incorporates the transmission of banking crises to sovereign crises, which these papers do not consider.[1]

The second strand of the literature to which we are especially related is the one studying the feedback loop between sovereign risk and bank risk, the so called 'doom loop.' Acharya et al. (2014) model a stylized economy where bank bailouts (financed via a combination of increased taxation and increased debt issuance) can solve an underinvestment problem in the financial sector, but exacerbate another underinvestment problem in the non-financial sector. Higher debt needed to finance bailouts dilutes the value of previously issued debt, increases sovereign risk and creates a feedback loop between bank risk and sovereign risk because banks hold government debt in their portfolios. Cooper and Nikolov (2018) and Farhi and Tirole (2018) also study the dynamic interaction between sovereign debt and the banking system and show the conditions (in their respective theoretical models) under which a bailout-induced doom loop may arise.[2] We borrow insights from these papers and focus on the ex ante optimal properties of bailouts using a quantitative model calibrated to recent GIIPS data.

On the policy side, different proposals have been put forward aimed at lowering the fragility of the banking sector and its exposure to sovereign risk. Examples include the implementation of Eurobonds (Favero and Missale, 2012) or the creation of European Safe Bonds (Brunnermeier, Langfield, Pagano, Reis, Van Nieuwerburgh and Vayanos, 2017). These proposals highlight how important it is to have reliable estimates of the dynamic relationship between sovereign risk, bank fragility, and economic activity. We provide a quantification of the role that government bailouts play in these dynamics.[3]

Finally, our paper also relates to the large literature on country bailouts, either from a central authority (like the ECB or IMF) or from another individual country. Contributions inspired by the recent European debt crisis include Gourinchas, Martin and Messer (2020), Azzimonti and Quadrini (2019), Pancrazi, Seoane and Vukotić (2020), Roch and Uhlig (2018), and De Ferra and Mallucci (2020), among others. These authors typically focus on moral hazard concerns and (the lack of) policy coordination. We view our work as complementary to theirs since our focus is on domestic governments bailing out their own

[1]Other quantitative papers that explicitly consider how banks are either affected by or amplify default risk are Boz, D'Erasmo and Durdu (2014), Thaler (Forthcoming), Abad (2019), Mallucci (2015), and Pei (2014).

[2]Recent work on stylized models of bank bailouts and sovereign risk include Gaballo and Zetlin-Jones (2016) and Capponi, Corell and Stiglitz (2020), among others.

[3]The theoretical work on sovereign risk and bank fragility is vast. A notable contribution is Gennaioli, Martin and Rossi (2014) who use a stylized model of domestic and external sovereign debt in which domestic debt weakens the balance sheets of banks. Balloch (2016) uses a similar framework and focuses on banks' demand for government debt for its collateral value. Bolton and Jeanne (2011) study sovereign default and bank fragility in a model of contagion between financially integrated economies.

banking sector and we abstract from moral hazard considerations.[4]

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 calibration of the model, presents the quantitative results, and discusses the properties of the optimal policies. Section 5 discusses the optimality of bailouts. Section 6 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 highlight 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 highly exposed to government debt and this exposure tends to be higher during crises, and *(iii)* the most prevalent form of government intervention (during banking crises) is to issue asset guarantees.

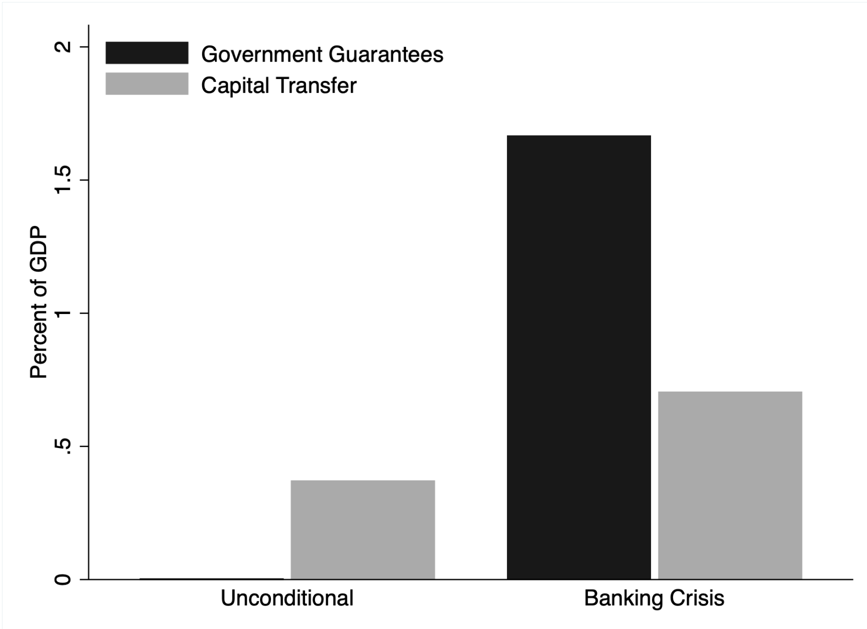
- *Defaults and banking crises tend to happen together.* Balteanu, Erce and Fernandez (2011) build a dataset with 121 sovereign defaults and 131 banking crises for 117 emerging and developing countries from 1975 to 2007. Among these, they identify 36 "twin crises" (defaults and banking crises): in 19 of them a sovereign default preceded the banking crisis and in 17 the reverse was true, which suggest that both directions of causality are likely at play.

- *Banks are exposed to sovereign debt and this exposure is higher during crises.* Gennaioli, Martin and Rossi (2018) report an average bank exposure ratio (net credit to the government as a fraction of bank assets) of 9.3 percent using data from both advanced and developing countries. When they focus only on defaulting countries, they find an exposure ratio of roughly 15 percent. Similarly, 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).

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

[4] Naturally, this paper is also related to the body of work on government bailouts of banks that abstracts from sovereign risk considerations. For recent examples, see Niepmann and Schmidt-Eisenlohr (2013) and Keister (2016).

Figure 1: Government guarantees and capital transfers



- *The most prevalent form of government intervention to alleviate banking crises is the issuance of sovereign guarantees.* Governments in the European Union have intervened mostly in two ways: (i) via asset guarantees and (ii) via capital transfers. Using data from Eurostat, we construct the average net annual change in government guarantees and average capital transfers as a percentage of GDP in the 23 EU countries from 2007 to 2019.[5] Figure 1 shows that governments mostly rely on asset guarantees rather than capital transfers as the way to intervene during banking crises (defined following Laeven and Valencia, 2013). We find that the average change of government guarantees as a fraction of GDP is close to 1.7 percent during banking crises, whereas it is close to zero in the whole sample. We also find that the average share of capital transfers is less different across the two time periods, which suggests that they are a less prominent method of government intervention to alleviate banking crises. In Appendix A, we show that a similar pattern holds for 'contingent liabilities' (a broader definition of asset guarantees).

[5]EU countries in our sample are Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Portugal, Slovenia, Spain, Sweden, the Czech Republic, the Netherlands, and the United Kingdom.

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 bank 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 supply labor to firms, but do not face any intertemporal decisions. Firms hire labor and borrow working capital loans from banks 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 is a benevolent one (i.e., it maximizes household utility). It faces a stream of spending that must be financed and it can also provide contingent guarantees to the banks. To meet its obligations, the government has three instruments: labor income taxation, borrowing, and default.

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, and during this time, the government cannot issue bailouts.

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. The second exogenous state variable, ε, captures the fraction of bank capital that could be lost. We denote $s = \{z, \varepsilon\}$. The third exogenous state variable, A, is the realized level of bank capital: with probability $1 - \pi$ this level is unaffected (and equal to a baseline value, $\overline{A}$); with probability π it is reduced to $(1 - \varepsilon)\overline{A}$.

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

1. The aggregate state s is 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) given the bailout policy, banks decide their loan supply

   i. with probability π, the bank's capital is reduced by ε, and the government disburses the promised bailouts

   ii. with probability $1-\pi$, the bank's capital is unaffected, and the government does not pay any bailouts

(c) all other private decisions take place

(d) the government chooses its borrowing policy $B'(B, s, A)$

4. If $d = 1$, then:

   (a) the government cannot promise bailouts and is excluded from financial markets

   (b) banks decide their loan supply

   (c) with probability π, the bank's capital is reduced by ε

   (d) all private decisions take 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 it regains market access, 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 and 4 above.

3.1 Decision problems given government policy

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

$$\max_{\{c,n\}} \quad U(c, n) \tag{1}$$

$$\text{s.t. } c = (1-\tau)wn + \Pi^F, \tag{2}$$

where $U(c, n)$ is the period utility function, c stands for consumption, n denotes labor supply, w is the wage rate, τ is the labor-income tax rate, and Π^F represents the firms' profits. The solution to the problem requires:

$$-\frac{U_n}{U_c} = (1-\tau)w, \tag{3}$$

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

Firms. The firms demand labor to produce the consumption good. They face a working capital constraint that requires them to pay up-front a certain fraction of the wage bill, which they do with intra-period loans from bank. Hence, the problem is:

$$\max_{\{N,\ell^d\}} \quad \Pi^F = zF(N) - wN - r\ell^d \tag{4}$$

$$\text{s.t. } \gamma wN \leq \ell^d \tag{5}$$

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

Equation (5) is the working capital constraint. This equation will always hold with equality because firms do not need loans for anything else but paying γwN; thus any borrowing over and above γwN would be sub-optimal. Taking this into account we obtain the following first-order condition:

$$zF_N(N) = (1 + \gamma r)w, \tag{6}$$

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

Banks. Banks 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 the value of its loanable 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, which is subject to aggregate shocks. The third component are government guarantees, $T(B, s, A)$ (i.e. the state-contingent bailouts that the government may provide).

The dynamics of bank capital are as follows: every period, bank capital has a reference value of $\overline{A}$, but it is subject to shocks ε, which represent the fraction of bank capital that could be lost. 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 bank's capital is reduced by ε, and with probability $1-\pi$, the bank's capital is unaffected. These dynamics can be summarized as

$$A = \begin{cases} \overline{A} & \text{with probability } 1-\pi \\ (1-\varepsilon)\overline{A} & \text{with probability } \pi. \end{cases} \tag{7}$$

Let $\underline{A}(\varepsilon) = (1-\varepsilon)\overline{A}$. We refer to the event that $A = \underline{A}(\varepsilon)$ and $\varepsilon > 0$ as a banking crisis.[6]

The lending constraint faced by banks is such that it needs to be satisfied in every possible state. This implies that every period the supply of loans is limited by the worst-case scenario of the banks' loanable funds:

$$\ell^s \leq \min_A \{A + b + T(B, s, A)\}. \tag{8}$$

This constraint, in a stylized way, is intended to capture the idea that (a) increased uncertainty about the state of the banking sector can spill over into the real economy and (b) the government can prevent the banking sector shocks from causing contractions in output by issuing bailouts.

When the government has access to credit, the value function of the representative bank is given by

$$\begin{aligned} W^R(b; B, s) = \max_{\ell^s} \mathbb{E}_A & \begin{Bmatrix} \max\limits_{x,b'} & x + \delta \mathbb{E}_{s'|s}\left[(1-d')W^R(b'; B', s') + d'W^D(s')\right] \\ \text{s.t.} & x \leq T(B, s, A) + b - q(B', s)b' + r(B, s, A)\ell^s \end{Bmatrix} \\ \text{s.t. } & (8) \end{aligned} \tag{9}$$

where x is consumption, δ is the banks' discount factor, $r(B, s, A)$ 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 banks take as given. W^d is the value function of the representative bank when the government does not have access to credit, which is given by

$$W^D(s) = \max_{\ell^s, x} x + \delta \mathbb{E}_{s'|s}\left[\theta W^R(0; 0, s') + (1-\theta)W^D(s')\right] \tag{10}$$

$$\text{s.t. } x \leq r_{\text{def}}(s)\ell^s \tag{11}$$

$$\ell^s \leq \underline{A}(\varepsilon) \tag{12}$$

[6] While we describe shocks to A as fluctuations in banks' capital, they could more broadly be interpreted to include: (a) domestic bank runs (as they will affect the funding side of the banks' balance sheet), and (b) global shocks (e.g. 'sudden stops' that may be transmitted through cross-border banking networks).

where θ is the probability that the government regains access to credit and $r_{\text{def}}(s)$ is the interest rate on private loans when the government does not have access to credit. In this case, the banker can provide loans only up to the adverse realization of its loanable funds, given by equation (12).

3.1.1 Characterization of equilibrium given government policies

Hereafter, we focus on bailout policies that take the form:

$$\begin{cases} T = 0 & \text{if } A = \overline{A} \\ 0 \leq T \leq \varepsilon \overline{A} & \text{if } A = (1-\varepsilon)\overline{A}. \end{cases} \tag{13}$$

In other words, the government cannot provide bailouts if the adverse bank capital shock does not materialize, and it can only cover up to the amount of the loss to bank capital if the shock does materialize. In that sense, we also refer to the bailouts as government guarantees.

Loan market. When the government does not have access to credit, banks supply

$$\ell^s_{\text{def}}(s) = \underline{A}(\varepsilon). \tag{14}$$

When the government has access to credit, banks supply

$$\ell^s(B, s) = B + \underline{A}(\varepsilon) + T(B, s, \underline{A}(\varepsilon)). \tag{15}$$

Note that the loan supply does not depend on the realization of A. Instead, given our restrictions on government bailout policies, the total loan supply is determined by the level of government debt (B), the reduced bank capital $\underline{A}(\varepsilon)$, and government transfers T.

The demand for intra-period loans comes from the firms. Combining equations (6) and (5) (with equality) we obtain the following loan demand function:

$$\ell^d(B, s, A) = \gamma \left[\frac{znF_n}{1 + \gamma r} \right]. \tag{16}$$

Note that the loan demand does depend on the realization of A. This is because during a banking crisis ($A = \underline{A}(\varepsilon)$ with $\varepsilon > 0$), the government may need to raise distortionary labor income taxes to pay for the bailouts, affecting equilibrium labor.

It is then straightforward to derive the equilibrium conditions for the loan rate under repay and default:

$$r(B,s,A)=\max\left\{\frac{zn(B,s,A)F_n}{B+\underline{A}(\varepsilon)+T\left(\underline{A}(\varepsilon)\right)}-\frac{1}{\gamma},0\right\} \tag{17}$$

and

$$r_{\text{def}}(s)=\max\left\{\frac{zn_{\text{def}}(s)F_n}{\underline{A}(\varepsilon)}-\frac{1}{\gamma},0\right\}. \tag{18}$$

As was the case in Sosa-Padilla (2018), there is the possibility that the interest rate that clears the loan market in (17) or (18) is not strictly positive. In that case, the equilibrium loan amount is demand determined. Notice that a default shrinks the supply of loanable funds and, other things equal, increases the rate on the working capital loans. This increase in the loan rate comes from two reasons: bonds are not repaid and the government is unable to extend bailouts during defaults.

Government bond market. The bond pricing function satisfies

$$q(B';\ s)=\delta\mathbb{E}_{s'|s}\left\{\left[1-\underbrace{d(B',s')}_{\text{default premium}}\right]\mathbb{E}_{A'}\left[1+\underbrace{r\left(B',s',A'\right)}_{\text{lending discount}}\right]\right\} \tag{19}$$

This expression shows that in the case of a default in the next period, $d(B',s')=1$, the lender loses not only its original investment in sovereign bonds but also the future gains that those bonds would have created had they been repaid. These gains are captured by $\mathbb{E}_{A'}\left[r(B',s',A')\right]$.

3.2 Determination of government policies

The government's optimization problem can be written recursively as:

$$V(B,s)=\max_{d\in\{0,1\}}\left\{(1-d)V^R(B,s)+d\,V^D(s)\right\} \tag{20}$$

where V^R and V^D are the values of repaying and defaulting, respectively. Let $\kappa\equiv(B,s,A)$ denote the complete aggregate state and $\Phi\equiv\{\tau,T,B'\}$ summarize the fiscal policies under repay. The value of repaying is:

$$V^R(B,s)=\max_{\Phi}\mathbb{E}_A\Big\{U\big(c\left(\kappa;\Phi\right),n\left(\kappa;\Phi\right)\big)+\beta\,\mathbb{E}_{s'|s}V\left(B',s'\right)\Big\} \tag{21}$$

subject to:

$$\tau\, w(\kappa;\Phi)\, n(\kappa;\Phi) + B'\, q(B',s) = g + B + T \qquad \text{(gov't b.c.)}$$
$$c(\kappa;\Phi) + x(\kappa;\Phi) + g = zF\left(n(\kappa;\Phi)\right) \qquad \text{(resource constraint)}$$

$$\left.\begin{array}{ll} T = 0 & \text{if } A = \overline{A} \\ 0 \leq T \leq \varepsilon \overline{A} & \text{if } A = \overline{A}(1-\varepsilon) \end{array}\right\} \quad \text{(constraint on } T\text{)}$$

and

$$\left.\begin{array}{l} q(B',s) = \delta\, \mathbb{E}_{s'|s}\Big\{ \left[1 - d(B',s')\right] \mathbb{E}_{A'}\left[1 + r(\kappa';\Phi')\right] \Big\} \\ r(\kappa;\Phi) = \max\left\{ \frac{zn(\kappa;\Phi)F_n}{B + \underline{A}(\varepsilon) + T(\underline{A}(\varepsilon))} - \frac{1}{\gamma}, 0 \right\} \\ -\frac{U_n}{U_c} = (1-\tau)\, w\,(\kappa;\Phi) \\ zF_n = (1 + \gamma\, r\,(\kappa;\Phi))\, w\,(\kappa;\Phi) \\ \ell\,(\kappa;\Phi) = \gamma w(\kappa;\Phi) n(\kappa;\Phi) \\ x(\kappa;\Phi) = T + B - q(B',s)B' + r(\kappa;\Phi)\ell\,(\kappa;\Phi) \end{array}\right\} \quad \text{(comp. eq. conditions)}$$

where $c(\kappa;\Phi)$, $n(\kappa;\Phi)$, $x(\kappa;\Phi)$, $\ell(\kappa;\Phi)$, $w(\kappa;\Phi)$, $r(\kappa;\Phi)$, and $q(B',s)$ represent the equilibrium quantities and prices for the private sector given public policy (under repayment).

The value of default is:

$$V^D(s) = \max_{\tau}\; U\big(c_{\text{def}}\,(s;\tau)\,, n_{\text{def}}\,(s;\tau)\,\big) + \beta\, \mathbb{E}_{s'|s}\left[\theta V\,(0,s') + (1-\theta)V^D\,(s')\,\right] \tag{22}$$

subject to:

$$\tau\, w_{\text{def}}(s;\tau)\, n_{\text{def}}(s;\tau) = g \qquad \text{(gov't b.c.)}$$
$$c_{\text{def}}(s;\tau) + x_{\text{def}}(s;\tau) + g = zF\left(n_{\text{def}}(s;\tau)\right) \qquad \text{(resource constraint)}$$

$$\left.\begin{array}{l} r_{\text{def}}(s;\tau) = \max\left\{ \frac{zn_{\text{def}}(s;\tau)F_n}{\underline{A}(\varepsilon)} - \frac{1}{\gamma}, 0 \right\} \\ -\frac{U_n}{U_c} = (1-\tau)\, w_{\text{def}}\,(s;\tau) \\ zF_n = (1 + \gamma\, r_{\text{def}}\,(s;\tau))\, w_{\text{def}}\,(s;\tau) \\ \ell_{\text{def}}\,(s;\tau) = \gamma w_{\text{def}}(s;\tau) n_{\text{def}}(s;\tau) \\ x_{\text{def}}(s;\tau) = r_{\text{def}}(s;\tau)\ell_{\text{def}}\,(s;\tau) \end{array}\right\} \quad \text{(comp. eq. conditions)}$$

where $c_{\text{def}}(s;\tau)$, $n_{\text{def}}(s;\tau)$, $x_{\text{def}}(s;\tau)$, $\ell_{\text{def}}(s;\tau)$, $w_{\text{def}}(s;\tau)$, and $r_{\text{def}}(s;\tau)$ represent the equilibrium quantities and prices for the private sector given public policy (under default).

3.2.1 Equilibrium definition

A Markov-perfect equilibrium is then defined as follows:

Definition 3.1. A *Markov-perfect equilibrium* for this economy is (i) a set of value functions for the government $\{V(B,s), V^R(B,s), V^D(s)\}$, (ii) a set of government policy rules for borrowing $B'(\kappa)$, taxation $\tau(\kappa)$, bailouts $T(\kappa)$, and default $d(B,s)$, (iii) a set of decision rules and prices from the private sector under repay $\{c(\kappa;\Phi), n(\kappa;\Phi), x(\kappa;\Phi), \ell(\kappa;\Phi), w(\kappa;\Phi), r(\kappa;\Phi)\}$, and under default $\{c_{\text{def}}(s;\tau), n_{\text{def}}(s;\tau), x_{\text{def}}(s;\tau), \ell_{\text{def}}(s;\tau), w_{\text{def}}(s;\tau), r_{\text{def}}(s;\tau)\}$, and (iv) an equilibrium pricing function for the sovereign bond $q(B', s)$, such that:

1. Given prices and private sector decision rules; the borrowing, tax, bailout, and default rules solve the government's maximization problem in (20)–(22).

2. Given the price $q(B', s)$ and government policies, the decision rules and prices of the private sector are consistent with the competitive equilibrium.

3. The equilibrium price function satisfies equation (19).

4 Quantitative Analysis

In this section, 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 describe the properties of the optimal default and bailout policies.

4.1 Functional forms and stochastic processes

The period utility function of the households is given by

$$U(c,n) = \frac{\left(c - \frac{n^{\omega}}{\omega}\right)^{1-\sigma}}{1-\sigma} \tag{23}$$

where σ and ω govern risk aversion and the wage elasticity of labor supply, respectively.

The production function is given by

$$zF(n) \quad \text{with} \quad F(n) = n^{\alpha}. \tag{24}$$

We assume that TFP shocks (z) follow an AR(1) process given by:

$$\log(z_{t+1}) = \rho_z \log(z_t) + \nu_{z,t+1} \tag{25}$$

where $\nu_z \sim N(0, \sigma_z)$. We use the Tauchen method to discretize the TFP shocks in 25 states.

The potential bank capital shocks are assumed to take values that are between 0 and $\bar{\varepsilon}$, and have a cumulative distribution function

$$F_{\sigma_\varepsilon}(\varepsilon) = \frac{1 - \exp(\varepsilon)^{-\sigma_\varepsilon}}{1 - \exp(\bar{\varepsilon})^{-\sigma_\varepsilon}}\,, \tag{26}$$

which is a transformation of the bounded Pareto distribution. We discretize the ε shocks in to four states in a one-sided application of the Tauchen method. The shape parameter, σ_ε, determines the variance of the ε shocks.

4.2 Calibration

A period in the model is assumed to be a year. Table 1 presents the parameter values.

Table 1: Parameters

Parameters	Values	Target/Source
Household discount factor, β	0.81	Default probability: 0.5 percent
Risk aversion, σ	2	Sosa-Padilla (2018)
Frisch elasticity, $\frac{1}{\omega-1}$	0.67	Sosa-Padilla (2018)
Government spending, g	0.15	Gov't consumption (percent GDP): 19.1
Prob. of financial redemption, θ	0.50	Expected exclusion: 2 years
Bankers' discount factor, δ	0.96	Real interest rate: 4 percent
Baseline bank capital, $\bar{A}$	0.28	Bailouts in banking crises (percent GDP): 1.7
Bank capital shock shape, σ_ε	4.26	Standard deviation of output: 3.4 percent
Prob. of banking shock, π	0.03	Banking crisis frequency: 1.8 percent
Labor share, α	0.70	Sosa-Padilla (2018)
Working capital constraint, γ	0.52	Sosa-Padilla (2018)
TFP shock persistence, ρ_z	0.80	Standard value
TFP shock std, σ_z	0.02	Standard value

The household and government's discount factor is set to 0.81 to match a default probability of 0.5 percent. Since our analysis mainly focuses on the European periphery, our target default probability of 0.5 percent is lower than that is used for emerging economies (Aguiar, Chatterjee, Cole and Stangebye 2016) and higher than that for advanced economies (Hur, Kondo and Perri 2018).[7] Government spending g is set to 0.15 to match the median govern-

[7]The default frequency calculated for a panel of 38 advanced and emerging economies during 1970–2017 is 0.5 percent.

ment consumption share of GDP of 19.1 percent in GIIPS (1999–2019). The probability of financial redemption, θ, is set to 0.5, which implies an average exclusion of 2 years.[8]

The bank's discount factor is set to 0.96 to be consistent with a real interest rate of 4 percent. The level of the baseline bank capital, $\overline{A}$, is set to 0.28 so that the model matches the size of bailouts during banking crises, which is around 1.7 percent of GDP as shown in the empirical section. The shape parameter for shocks to bank capital, σ_ε, is set to 4.26 to generate a standard deviation of output that matches the median of 3.4 percent among GIIPS. The parameter that governs the probability of shocks to banks' capital, π, is set to 0.03 so that the model matches the banking crisis frequency of 1.8 percent in a panel of 38 advanced and emerging economies from 1970 to 2017.[9]

There are six parameters that we set externally. Following Sosa-Padilla (2018), we set risk aversion, $\sigma = 2$, and set the value of ω to correspond to a Frisch elasticity of 0.67, both standard values in the literature. Also as in Sosa-Padilla (2018), we set the labor income share $\alpha = 0.7$ and the working capital constraint $\gamma = 0.52$. Finally, we set the persistence $\rho_z = 0.8$ and standard deviation $\sigma_z = 0.02$, which is in the range of the typical values used in the literature.[10] Appendix B presents a sensitivity analysis and shows that our main results are robust to using alternative values for some key model parameters.

4.3 External validity: simulated moments

In this subsection, we examine the fit of the model. Table 2 shows the targeted and untargeted moments from our model simulations and their data counterparts. As is usual in this literature, we report statistics 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).

The model generates spreads that behave reasonably well. The mean and the volatil-

[8]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.

[9]In the data, we follow the classification in Laeven and Valencia (2013), who use banking sector losses and other indicators to identify banking crises. The list of 38 advanced and emerging economies is as in Davis, Mack, Phoa and Vandenabeele (2016). In the model, we define a banking crisis as a non-zero reduction of bank's capital. This occurs with probability $\pi(1 - F_{\sigma_\varepsilon}(\underline{\varepsilon}))$ where $\underline{\varepsilon}$ refers to the lowest non-zero value in our discrete grid for ε.

[10]Previous works on sovereign default with production have parameterized the productivity process in a similar way. For example, Boz et al. (2014) (in a calibration for Spain) estimate the TFP's autocorrelation to be .54 and impose a standard deviation of 2.6%; Hatchondo, Martinez and Roch (2020) (also calibrated to Spanish data) find annualized persistence and standard deviation estimates of .89 and 2%, respectively. Our parameterization of the TFP process (representative of GIIPS) is within these estimates.

Table 2: Simulated moments: model and data

	Model	Data
Default frequency	0.5	0.5
Banking crisis frequency	1.8	1.8
Gov't spending/GDP	19.1	19.1
Bailouts/GDP (banking crisis)	1.7	1.7
Sovereign spread		
mean	0.7	1.2
standard deviation	0.6	1.8
corr(spread,output)	–0.3	–0.7
Debt/GDP	15.5	28.6

Units: percent. Both the standard deviation and the correlation are calculated based on HP-filtered residuals.

ity of the spread are lower than in the data.[11] This is not surprising as the time period from which we compute the data counterpart features the Global Financial Crisis and the European Sovereign Debt crisis. The model also generates countercylical spreads, qualitatively consistent with the data, albeit less so than in the data. The mean debt level in the model simulations is 15.5 percent of GDP, which is below the average domestic government debt/GDP in EU countries, 28.6 percent.[12] Accounting for over 50 percent of this untargeted moment is a reasonably good fit, considering the well known difficulty of sovereign default models with one-period debt in producing sizeable debt ratios at the observed default frequencies.[13]

Table 3 shows that, conditional on experiencing a banking crisis in the previous year, the default probability is 0.2 percentage points higher than the unconditional default frequency of 0.5 percent. This 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

[11] In the model, we compute sovereign spreads in our simulations as the difference between the bond's yield $(1/q)$ and the real rate implied in the banker's discount factor $(1/\delta)$. In the data, the spread is computed as the nominal interest rate on government bonds in GIIPS minus that of Germany, from 1999 to 2019.

[12] This average for domestic government debt is obtained using ECB data for the period 1999–2019 (including debt at all original maturities). It includes all EU countries except for the UK, Greece, Ireland and Latvia due to missing data.

[13] The literature has dealt with this shortcoming in different ways. One example is D'Erasmo and Mendoza (2020) who study optimal domestic and external default using a one-period debt model calibrated to European data. They create a maturity-adjusted debt-to-GDP ratio and report it to be 7.45 percent of GDP. A different approach (e.g., Arellano, 2008) is to target the debt service instead of debt stock. We focus on domestic debt since we model a closed economy.

zone, leading to more frequent defaults.

Table 3: Simulated moments: unconditional and banking crisis

	Unconditional	Banking crisis
Default frequency	0.5	0.7
Sovereign spread		
mean	0.7	0.9
standard deviation	0.6	1.0
Debt/GDP	15.5	16.0
Bailout/GDP	0.9	1.7

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

These "diabolic loop" dynamics naturally translate into sovereign spreads. The unconditional mean spread is 0.7 percent, but conditional on observing a banking crisis, the mean spread increases by 0.2 percentage points. This 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 lender 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 a banking crisis because the risk of default increases.

The last row of Table 3 shows that, on average, the model features larger contingent bailouts during banking crises than unconditionally.[14] This is a distinctive feature of the data, as we documented in Figure 1.

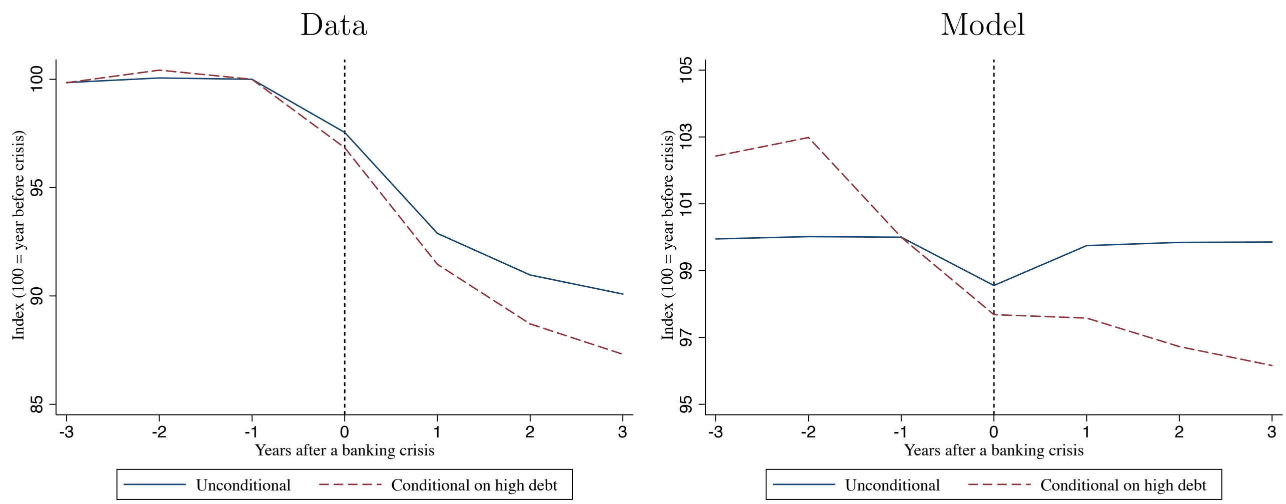
4.4 External validity: dynamics around banking crises

To further validate our model, we examine the behaviour of output and sovereign yields around banking crises. To compute the data counterparts, we construct an annual dataset of real interest rates, GDP, government debt, and banking crisis indicators for the years 1950–2016, using the Jordà, Schularick and Taylor (2017) Macrohistory database. The dataset is for 17 advanced economies that includes Greece, Italy, Portugal, and Spain (but not Ireland).

[14] Consistent with the data, here we are reporting announced bailouts (as a percent of GDP), regardless of whether a banking crisis materializes and bailout transfers are disbursed.

In the absence of government intervention, a banking crisis reduces loanable funds, increases the firms' borrowing costs and decreases output. At the same time, the government can issue contingent guarantees to prop up the supply of loans and mitigate the negative effects of the shocks to bank capital. Therefore, the equilibrium response of output depends on the initial debt level: governments with more debt (less fiscal space) will be limited in how much bank capital losses they can guarantee and will therefore experience a larger output contraction. Figure 2 shows that this model prediction also holds qualitatively in the data. Moreover, both model and data show that banking crises that occur at high debt levels are characterized by protracted output declines. In the model, this is because the high debt governments typically exit the banking crisis deleveraging as they face a worse price menu.[15] This deleveraging translates into lower liquidity in the domestic credit markets in subsequent periods, leading to lower output.

Figure 2: Output around banking crises



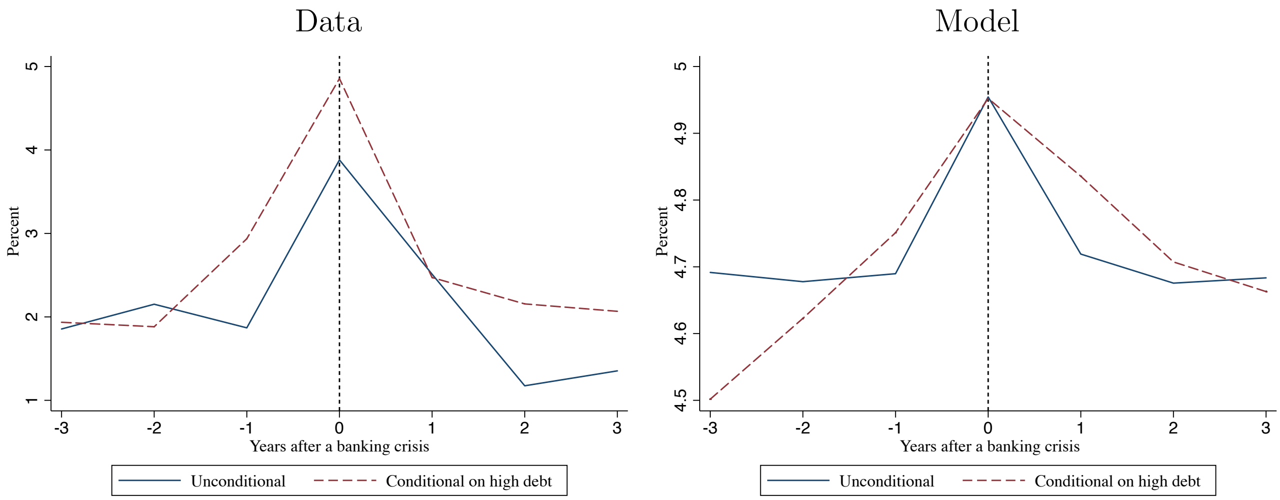
Note: The left (right) panel shows the dynamics of GDP around banking crises in the data (model). The dashed line conditions on high debt (above the 75th percentile).

Furthermore, our theory predicts an increase in sovereign yields during banking crises. The government has an incentive to guarantee against losses to bank capital, which leads to increased borrowing and higher default risk. Figure 3 shows that this prediction of the model is qualitatively consistent with the data. We also see that, both in the model and in the data, when the government suffers a banking crisis with high debt levels, the sovereign yields remain elevated even after the banking crisis has ended. As we explained before,

[15]Even though this deleveraging (i.e. debt decumulation) occurs, the debt *level* itself is larger in banking crises than in normal times (Figure 5).

output remains depressed after a high-debt banking crisis, which implies a lower tax base. In turn, a lower tax base will require a higher (distortionary) tax rate in order to raise a given level of revenue. This makes tax-financing less attractive and default more attractive, for a given level of debt. This translates into higher sovereign yields.

Figure 3: Sovereign yields around banking crises



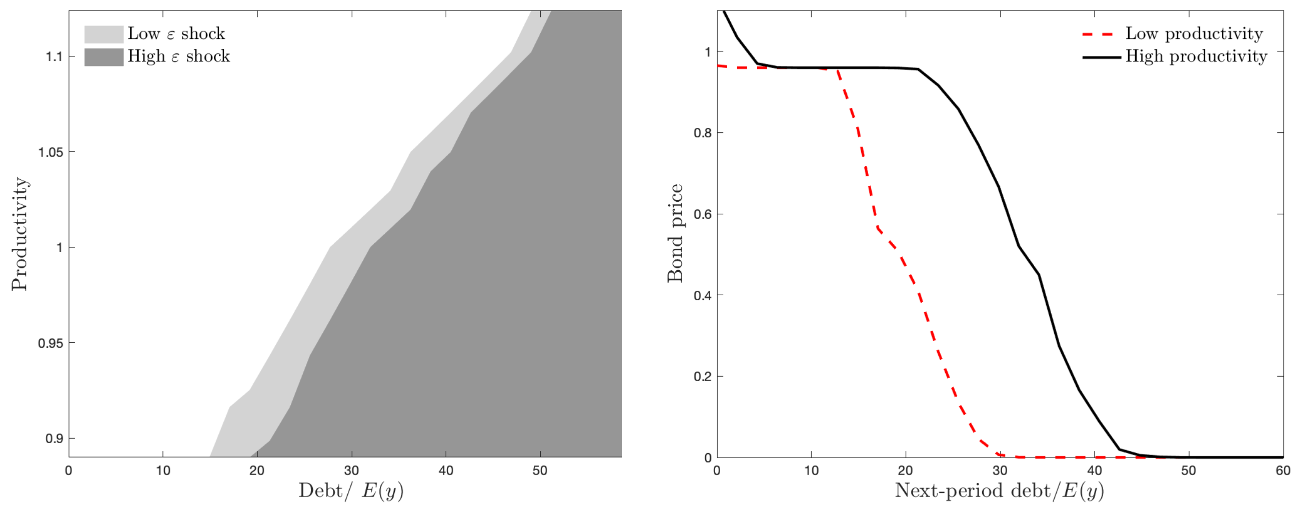
Note: The left (right) panel shows the dynamics of sovereign yields around banking crises in the data (model). The dashed line conditions on high debt (above the 75th percentile).

4.5 Properties of optimal policies

Default incentives, bond prices and debt dynamics. Our model features a rich interaction between debt levels, default incentives, banking crises, and optimal bailout guarantees. Consistent with the 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 4. In addition to this standard finding, we also see that the default set shrinks with higher values of the bank capital shock. This is because severe banking crises can lead to sharp contractions in output in the absence of government bailouts, thus increasing the cost of default.

The price schedule (right-panel of Figure 4) reflects these default incentives. As usual, higher realizations of productivity are associated with better prices (and higher debt capacity). The price schedule demonstrates that borrowing is essentially risk-free for debt ratios below 12 percent. Consequently, starting from zero debt, the economy's debt-to-GDP ratio quickly increases until it reaches 12 percent and then it 'lives' in the region where default risk is small but positive. This can be seen in Figure 5, which plots the histograms of debt-

Figure 4: Default sets and bond prices

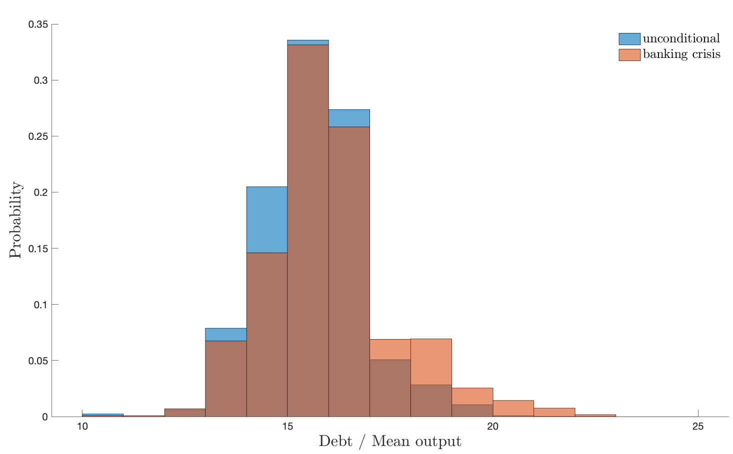


Note: The left panel shows the default sets with the shaded areas indicating default and the white area indicating repayment. The right panel shows the equilibrium bond price schedule.

to-GDP ratios both unconditionally and conditional on banking crises. Since the left tails of these histograms are very long, we choose to truncate them in our plots.

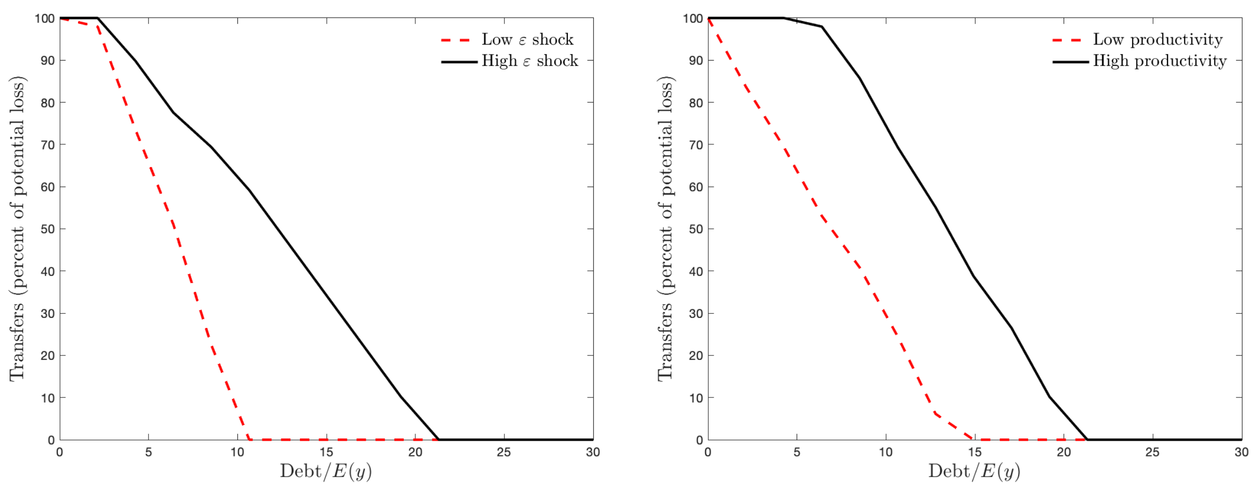
Figure 5 also shows that the debt-to-GDP distribution conditional on a banking crisis is more skewed to the left than the unconditional distribution. Thus, not only do banking crises lead to a higher average debt-to-GDP ratio (Table 3), but they also increase the probability of observing high debt-to-GDP realizations (greater than 20 percent), reinforcing the "diabolic loop" dynamics.

Figure 5: Conditional and unconditional debt distributions



Optimal bailout policies. The ability of the government to issue bailouts depends on the state of the economy in terms of productivity (z) and potential losses to bank capital (ε), in addition to the existing level of debt (B). Here we examine the bailout policy functions generated by our model in order to highlight the role of each of these factors. Figure 6 shows the bailout policy functions expressed as the percent of the potential loss that the government promises to guarantee. Inspecting both panels of this figure, we find the following properties for the bailouts:

Figure 6: 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. $100 \times T(B, s, A)/\left(\bar{A}\varepsilon\right)$).

1. **Increasing in ε.** The larger is the potential loss to banks' capital, the larger is the proportional bailout the government chooses. This is because the impact of financial shocks on the economy are non-linear. As can be seen in equation (17), in the absence of government bailouts, higher values of ε have a disproportionately larger effect on r than lower values of ε (i.e., ε affects r in a convex manner). Thus, the government uses bailout transfers to affect the supply side of the loans' market and keeps the equilibrium interest rate low, especially when the financial shocks are large.

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 increased default risk. This is because when the banking crisis occurs, the bailouts will need to be financed with more borrowing. Therefore, the larger the stock of initial debt the less fiscal space the government has to extend asset guarantees.

3. **Increasing in z.** This intuitive property is due to two forces that go in the same direction. First, the more productive the economy is, the more valuable credit becomes. 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 makes more likely a high productivity shock in the next period, leading to lower default risk, better prices for the government, and a higher borrowing capacity to finance the bailout transfers.

5 On the Optimality of Bailouts

As explained in the previous section, bailouts come with a tradeoff: they allow the government to boost liquidity and output during banking crises but they also increase debt and default risk (i.e., there is a "diabolic-loop"). Having described the properties of our model and the equilibrium bailout policies we proceed to ask: are bailouts desirable?

To answer this normative question, we proceed in two steps. First, we solve a no-bailouts version of our model and compare its simulated moments with those of the baseline model. We find that the model without bailouts features fewer defaults and lower spreads while sustaining higher levels of debt, relative to the model with bailouts. This suggests that, from an ex ante perspective, it may not be optimal to allow for bailouts. Thus, as a second step, we solve for alternative versions of the model in which bailouts are allowed but are restricted in size, nesting both the baseline (with unrestricted bailouts) and the no-bailouts models. We find that, when initial debt is very low, the governments prefer to have unrestricted access to bailouts. However, when governments begin with moderate to high levels of debt, it is beneficial to ban bailouts altogether. We find these results to be remarkable since our analysis abstracts from moral hazard concerns, a well studied reason for which bailouts might not be desirable from an ex ante perspective. We show that the welfare consequences are large.

Table 4 reports simulated moments for the baseline and the no-bailouts versions of our model. As mentioned above, the baseline economy exhibits higher default risk, higher and more volatile spreads, and a lower debt-to-GDP ratio. These statistics reflect that the baseline economy faces worse borrowing terms: it can sustain less debt at higher rates. On the other hand, the lending rate (between banks and firms) is lower in the baseline economy: this is because bailouts increase liquidity and improve borrowing terms for firms. Consequently output falls by less in bad times, which explains the (slightly) lower countercyclicality of spreads when bailouts are possible. Overall, the tradeoff induced by bailouts is clearly captured by these business cycle dynamics.

Table 4: Simulated moments comparison

	Baseline model	Model without bailouts
Default frequency	0.5*	0.3
Sovereign spread		
mean	0.7	0.5
standard deviation	0.7	0.5
corr(GDP, spread)	-0.2	-0.3
Debt/GDP	15.5	26.8
Mean lending rate	0.0	0.2

Units: percent. * denotes targeted moments.

We next examine, from an ex ante perspective, what restrictions, if any, a country should optimally impose on the size of the bailouts. To do so, we modify the constraint on $T(B, s, A)$ as follows:

$$\left.\begin{array}{ll} T = 0 & \text{if } A = \overline{A} \\ 0 \leq T \leq \min\{\varepsilon\overline{A}, \phi\overline{\varepsilon}\overline{A}\} & \text{if } A = (1-\varepsilon)\,\overline{A} \end{array}\right\} \quad \text{(new constraint on } T\text{)}$$

where $\overline{\varepsilon}\,\overline{A}$ corresponds to the largest possible financial shock and $\phi \in [0, 1]$. Setting $\phi = 0$ corresponds to the model with no bailouts and $\phi = 1$ corresponds to the baseline model.

With this modified framework, we compute the ex ante welfare-maximizing levels of ϕ for different levels of initial debt, B_0. First, we solve for $\Lambda(B_0; \phi)$, the permanent increase in consumption that is needed in the no-bailouts economy to make households indifferent between this economy and another with $\phi > 0$. Formally, $\Lambda(B_0; \phi)$ is implicitly defined by

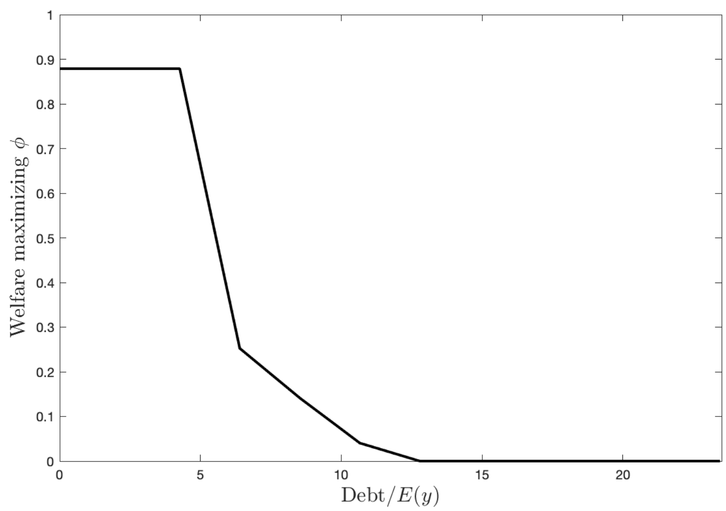
$$\mathbb{E}_s V_\Lambda(B_0, s; 0) = \mathbb{E}_s V(B_0, s; \phi) \tag{27}$$

where the expectation is taken over the ergodic distribution over $s = \{z, \varepsilon\}$ and $V_\Lambda(B_0, s; 0)$ is the value that results from a permanent increase in consumption Λ in the economy with no bailouts.[16] Second, for each level of initial debt, we compute the welfare maximizing value of ϕ.

[16] Appendix C presents the welfare consequences of bailouts for different levels of initial debt, productivity, and bank capital shocks.

Figure 7 shows three regions: (i) for low enough debt, the economy is better off with a large ϕ (around .88) – that is, it is optimal to allow the government to issue bailouts that can fully cover most shocks to bank capital (and even mostly cover the largest shocks), (ii) for intermediate debt levels, it is optimal to restrict considerably the governments' ability to issue bailouts, and (iii) for debt levels above 13 percent of mean output it is welfare increasing to set $\phi = 0$ – it is better to ban the government's ability to issue bailouts. We find the welfare consequences to be large: when a government's initial debt-to-GDP levels are above 13 percent, having access to unrestricted bailouts results in a 2.5 percent welfare *loss* relative to no bailouts.

Figure 7: Optimal bailout restrictions



In summary, the results in this section indicate that for the mean debt level in our simulations (15 percent of GDP), the economy will be better off if the government is not able to issue bailouts. This is a strong result considering that our framework has (i) a benevolent government and (ii) a bailout policy that does not trigger moral hazard concerns. Overall, our results highlight the negative effects of the sovereign-bank nexus (i.e., the "diabolic loop").

6 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 guarantees.

We then write down and solve a general equilibrium model of sovereign default, in which there is a benevolent government that maximizes household welfare by choosing debt, defaults, distortionary taxes, and bank bailouts. The economy is subject to two types of aggregate uncertainty: shocks to firm productivity and shocks to banks' 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 a default is that all existing debt is wiped-out, relaxing the government's budget constraint, and allowing it to reduce distortionary taxes. Our framework is flexible enough to feature defaults triggering banking crises and banking crises triggering defaults: a complete 'doom loop.'

Using the calibrated model, we show that the occurrence of a banking crisis increases the default probability by 0.2 percentage points (from 0.5 to 0.7 percent annually) and raises the level and volatility of sovereign spreads (the latter increases from 0.6 to 1.0 percent). In the model, the government issues contingent guarantees which exhibit clear properties. Other things equal they 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 higher the value of credit and the cheaper it is to borrow to provide the guarantees, and (iii) increasing with the severity of the banking crisis, and this is because the effects of financial shocks are nonlinear: small shocks have negligible impacts on loans to the private sector, whereas large shocks can lead to severe contractionary credit crunches in the absence of government interventions.

Even though bailouts are useful to mitigate the adverse effects of banking crises, we find that from an ex ante perspective, the country is better off banning bailouts altogether. This is because bailouts are financed with higher government debt, which increases spreads and may trigger defaults. In other words, bailouts create a "diabolic loop."

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Appendix

A Contingent Liabilities

In this section, we consider a broader notion of contingent government interventions by looking at the changes in government *contingent liabilities* instead of *government guarantees*. In addition to government asset guarantees, the concept 'contingent liabilities' includes public–private partnerships (PPP) recorded off-balance sheet of the government and liabilities of government controlled entities classified outside of general government. For most countries, *government guarantees* have the largest share in *government contingent liabilities*. Because contingent liabilities are also stocks, we calculate the annual change in contingent liabilities as a share of GDP, and take the average of that ratio across all countries.

Figure A.1: Government contingent liabilities and capital transfers

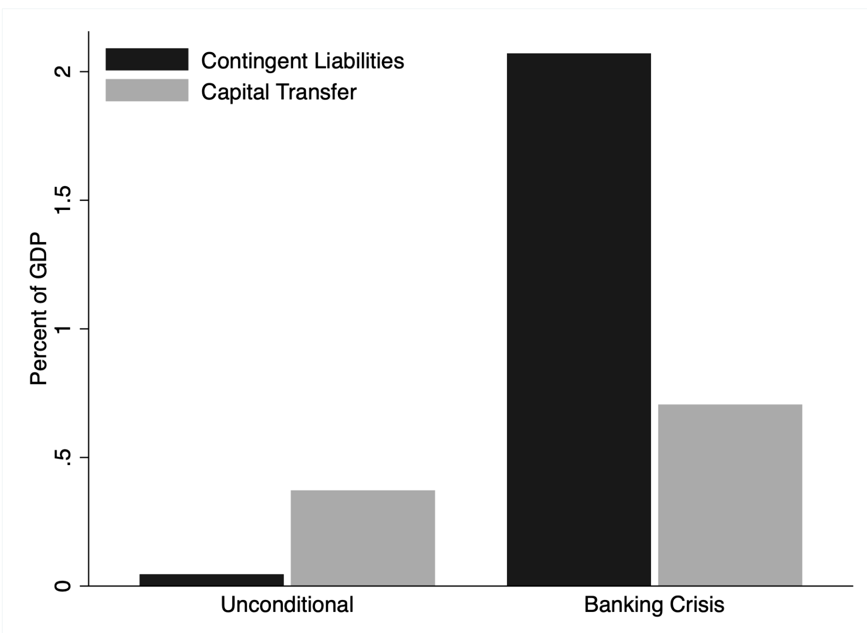


Figure A.1 shows a side-by-side comparison of contingent liabilities and capital transfers in the whole sample and conditional on banking crisis. We obtain a similar pattern as before: contingent liabilities exceed 2 percent during banking crises and they are close to zero unconditionally.

B Sensitivity Analysis

In this appendix, we analyze our model's sensitivity to six parameters, i.e. bank's baseline capital ($\bar{A}$), household discount factor (β), working capital constraint (γ), financial shock shape (σ_ε), probability of bank capital shock (π), and labor share (α). When we change each parameter, keeping all other parameters fixed, we show how the simulated moments change in response. We also show that the main results—that banking crises lead to a higher likelihood of default and higher and more volatile spreads—are robust to these alternative parameter values.

1. **Bank's baseline capital,** $\bar{A}$. During defaults, the government is unable to give bailout transfers to help banks increase their liquidity. As a result, higher values of $\bar{A}$ reduce the cost of default in the model (because it increases the funds available for productive loans). As a result, the simulated model moments are sensitive to this parameter value, as can be seen in Table B.1. Nevertheless, the result that defaults are more likely following a banking crisis, along with higher and more volatile spreads, is robust to these alternative values of baseline capital.

Table B.1: Sensitivity to $\bar{A}$

	Unconditional	Banking crisis
Low $\bar{A}$ ($\bar{A} = 0.26$)		
Default frequency	0.5	0.5
Sovereign spread		
mean	0.7	0.8
standard deviation	0.6	0.8
Debt/GDP	20.4	20.5
Bailout/GDP	0.3	0.5
High $\bar{A}$ ($\bar{A} = 0.30$)		
Default frequency	0.5	1.1
Sovereign spread		
mean	0.7	1.4
standard deviation	0.8	1.8
Debt/GDP	11.6	11.9
Bailout/GDP	1.4	3.1

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

2. **Household discount parameter,** β. Since the government represents the preferences

of the households, a lower discount parameter (corresponding to less patience) results in an increase in both unconditional and conditional default frequencies, as well as spreads (Table B.2). There is also a slight increase in the amount of debt. The result that banking crises are associated with a higher likelihood of default and higher and more volatile spreads is robust to these alternative values.

Table B.2: Sensitivity to β

	Unconditional	Banking crisis
Low β ($\beta = 0.76$)		
Default frequency	0.9	1.1
Sovereign spread		
mean	1.1	1.3
standard deviation	1.0	1.4
Debt/GDP	16.1	16.3
Bailout/GDP	0.8	1.5
High β ($\beta = 0.86$)		
Default frequency	0.3	0.5
Sovereign spread		
mean	0.5	0.7
standard deviation	0.5	0.9
Debt/GDP	15.3	15.4
Bailout/GDP	0.9	1.9

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

3. **Working capital constraint,** γ. The working capital constraint parameter determines the amount of working capital loans that firms demand. Higher values increase the demand for loans, which increases the loans' interest rate. With higher values of γ, we find that the government responds by injecting more liquidity into the financial system by increasing debt and reducing its utilization of bailouts, as shown in Table B.3. These actions reduce the 'diabolic' loop dynamics, making the likelihood of default more similar unconditionally and conditional on banking crises. Nevertheless, following a banking crisis, it is still the case that the government faces higher and more volatile spreads. Overall, we conclude that our results are robust to alternative values of γ.

Table B.3: Sensitivity to γ

	Unconditional	Banking crisis
Low γ ($\gamma = 0.49$)		
Default frequency	0.7	0.9
Sovereign spread		
mean	0.9	1.4
standard deviation	0.9	1.5
Debt/GDP	12.3	12.5
Bailout/GDP	1.1	2.5
High γ ($\gamma = 0.55$)		
Default frequency	0.6	0.6
Sovereign spread		
mean	0.8	0.9
standard deviation	0.7	0.8
Debt/GDP	23.1	23.0
Bailout/GDP	0.2	0.5

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

4. **Probability of bank capital shock,** π. To examine the role of the bank capital shock in our results, we increase π from 3 to 10 percent. In our model, the government promises bailout guarantees in the expectation of a banking crisis and 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. As shown in Table B.4, we find that bailout transfers decrease by about 30 percent when financial crises happen more often. Nevertheless, the result that banking crises lead to more frequent defaults and higher more volatile spreads is robust to this alternative value.

Table B.4: Sensitivity to π

	Unconditional	Banking crisis
Baseline ($\pi = 0.03$)		
Default frequency	0.5	0.7
Sovereign spread		
mean	0.7	0.9
standard deviation	0.6	1.0
Debt/GDP	15.5	16.0
Bailout/GDP	0.9	1.7
High π ($\pi = 0.10$)		
Default frequency	0.6	0.9
Sovereign spread		
mean	0.8	1.0
standard deviation	0.7	1.2
Debt/GDP	16.6	16.7
Bailout/GDP	0.7	1.2

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

5. **Financial shock shape,** σ_ε. Due to the nonlinear effects of financial shocks on the real economy discussed in Section 4.5, the larger the volatility of the potential loss to banking capital, the higher is the need for bailouts. Indeed, Table B.5 shows that higher volatilities are associated with higher bailouts. However, they are also feature a higher default frequency, and higher and more volatile spreads. This is because the model generates a stronger "diabolic loop". The increase in the potential loss to banking capital creates higher incentives for the government to borrow to finance the bailouts, which increases the risk of default. Moreover, the property that banking crises entail higher likelihoods of default and higher and more volatile spreads is robust to these alternative values.

Table B.5: Sensitivity to σ_ε

	Unconditional	Banking crisis
Low σ_ε ($\sigma_\varepsilon = 3.76$)		
Default frequency	0.4	0.4
Sovereign spread		
mean	0.6	0.6
standard deviation	0.5	0.5
Debt/GDP	22.4	22.5
Bailout/GDP	0.2	0.4
High σ_ε ($\sigma_\varepsilon = 4.76$)		
Default frequency	0.7	1.2
Sovereign spread		
mean	1.0	1.6
standard deviation	1.0	1.9
Debt/GDP	12.3	12.5
Bailout/GDP	1.2	2.8

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

6. **Labor share,** α. Similar to the working capital constraint parameter, γ, the labor share parameter determines the amount of working capital loans demanded by firms. As such, changes in α have similar properties as changes in γ. If the labor share increases, the government chooses inject more liquidity into the banking sector by increasing government debt as opposed to relying on bailouts, reducing the "diabolic loop" dynamics. As shown in Table B.6, with a higher labor share, we see that there is no significant difference between the unconditional default risk and the default risk conditional on banking crisis with higher labor share. The opposite dynamics are at work with a lower labor share: the government relies more on bailouts, increasing the "diabolic loop" dynamics where banking crises are associated with spikes in the likelihood of default and higher and more volatile spreads.

Table B.6: Sensitivity to α

	Unconditional	Banking crisis
Low α ($\alpha = 0.67$)		
Default frequency	0.6	0.8
Sovereign spread		
mean	0.8	1.3
standard deviation	0.9	1.6
Debt/GDP	12.2	12.5
Bailout/GDP	1.2	2.6
High α ($\alpha = 0.73$)		
Default frequency	0.6	0.6
Sovereign spread		
mean	0.8	0.9
standard deviation	0.7	0.7
Debt/GDP	22.1	22.0
Bailout/GDP	0.3	0.6

Units: percent. The standard deviation is calculated based on HP-filtered residuals of the spread.

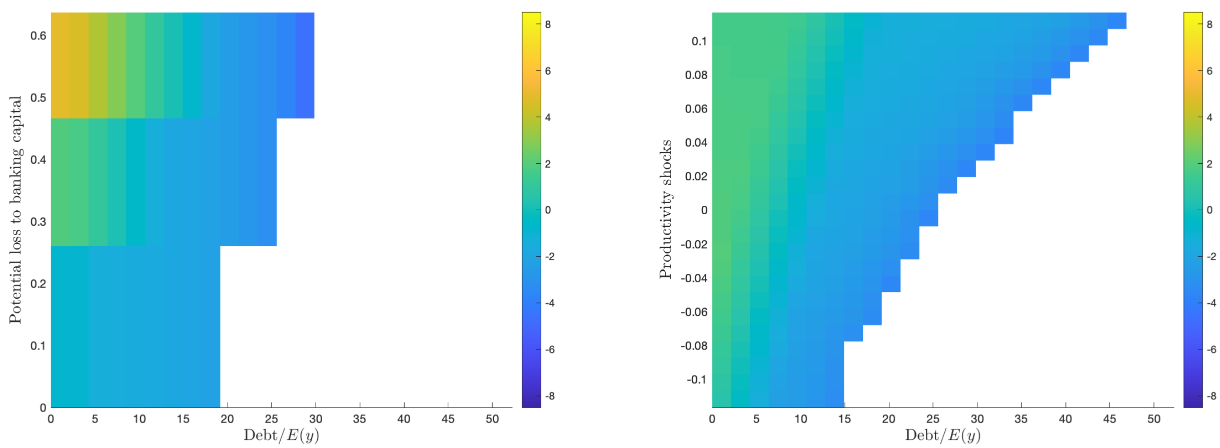
C State-contingent preference for bailouts

In this section, we measure the welfare consequences of having access to bailouts for different points in the state space. Given the state of the economy at the beginning of the period (B, s), we define the conditional welfare gains of bailouts as the proportional increase in the level of consumption that is needed in the no-bailouts model in order to make the households as well off as they would be in the baseline model with bailouts. We denote the welfare gains by $\Lambda(B_0, s_0)$, the consumption in no-bailouts model by c_t^{nb}, and the labor supply in no-bailouts model by n_t^{nb}. Then, $\Lambda(B_0, s_0)$ is implicitly defined by

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t^{nb}(1+\Lambda(B_0, s_0)) - \frac{(n_t^{nb})^{\omega}}{\omega}\right)^{1-\sigma}}{1-\sigma} \quad = \quad E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \frac{(n_t)^{\omega}}{\omega}\right)^{1-\sigma}}{1-\sigma}.$$

Figure C.2 shows the percentage change in welfare measured in consumption equivalents for different levels of initial debt, productivity shocks, and bank capital shocks. The white area represents points in the state space where default is chosen in the baseline model. The left panel shows the welfare gains of bailouts for different values of the bank capital shocks, keeping the productivity at its mean. The lighter regions denote positive welfare gains, which correspond to states with low debt and high bank capital shocks because bailouts ameliorate the reduction in lending to firms. As a consequence of bailouts, there is a rise in the supply of credit which reduces the cost of financing working capital and leads to higher output. However, this gain in welfare becomes smaller at higher levels of debt because the government relies on debt to finance bailouts, which escalates the default risk in the model with bailouts. As a result, for high initial levels of debt, the costs of facing higher sovereign yields outweighs the benefits, causing a loss in welfare.

Figure C.2: Welfare costs and benefits of bailouts



Note: The left (right) panel shows the welfare gains for different values of financial shocks (productivity shocks). Lighter (darker) colors represent the welfare gains (costs) of bailouts. The white area represent points in the state space where default is chosen (in the economy with bailouts).

The right panel of Figure C.2 shows the welfare gains for different values of debt and productivity shocks keeping the loss to banking capital at its average level(which corresponds to a 26 percent loss in bank capital). Similarly, we see positive welfare gains in states with high productivity shocks and low debt levels. Similar to the previous case, we see that for high levels of debt the increased cost of borrowing dominates and having access to bailouts ends up being welfare detrimental.